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Editorial

It gives us immense pleasure to present the Proceedings of the Two-Day International Conference on **"Artificial Intelligence in Education: Shaping Smart Teachers for a Smart Future"**, organized by National College of Education, Shivamogga, Karnataka, on 4th and 5th September, 2026.

The conference was conceptualized with the objective of providing a vibrant international academic platform for academicians, teacher educators, researchers, policymakers, educational technologists, research scholars, and student-teachers to deliberate upon the emerging role of Artificial Intelligence in transforming the educational landscape. In an era of rapid technological advancements and digital transformation, Artificial Intelligence has emerged as a powerful tool in reshaping teaching-learning processes, educational assessment, curriculum development, and institutional practices. The conference aimed to explore the opportunities, challenges, ethical considerations, and future possibilities of integrating AI into education while emphasizing the importance of preparing smart, innovative, reflective, and responsible teachers for a smart future.

The enthusiastic participation of distinguished international and national resource persons, academicians, faculty members, research scholars, and student-teachers from various institutions made the conference a remarkable success. The keynote addresses, technical sessions, paper presentations, and scholarly deliberations provided meaningful opportunities for exchanging innovative ideas, research findings, and practical experiences related to Artificial Intelligence in education. The discussions highlighted the potential of AI in promoting personalized learning, enhancing teaching effectiveness, supporting inclusive education, facilitating educational research, and developing 21st-century competencies. At the same time, the deliberations emphasized that technology should complement teachers rather than replace them, recognizing the indispensable role of human values, emotional intelligence, creativity, critical thinking, and professional responsibility in education.

This volume is a compilation of research and conceptual papers presented during the conference. The contributions reflect diverse perspectives, original research, innovative practices, and interdisciplinary approaches concerning the application of Artificial Intelligence in education and related fields. The publication seeks to serve as a valuable academic reference

for teacher educators, researchers, academicians, student-teachers, educational administrators, and policymakers interested in understanding and exploring the transformative potential of Artificial Intelligence in contemporary education.

We express our sincere gratitude to all the distinguished chief guests, keynote speakers, invited experts, paper presenters, session chairs, reviewers, members of the organizing committee, faculty members, staff, volunteers, and participants whose dedication, cooperation, and wholehearted support contributed to the grand success of this international conference. We also extend our heartfelt appreciation to the management of the National Education Society, Shivamogga, for its constant encouragement, guidance, and unwavering support in promoting academic excellence, innovation, and a vibrant research culture.

We firmly believe that the research papers included in these proceedings will inspire further scholarly inquiry, encourage meaningful collaborations, and contribute to the effective and responsible integration of Artificial Intelligence into education. We hope this publication will serve as a significant academic resource and motivate educators and researchers to embrace emerging technologies while upholding the human values and professional responsibilities that form the foundation of the teaching profession.

With Best Wishes,

Editorial Board

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S. No.	Titles	Page No.
1	**ARTIFICIAL INTELLIGENCE IN EDUCATION: TRANSFORMING TEACHING AND LEAR NING FOR A SMART FUTURE** *Mr. Manjunatha D.S.*	1-6
2	**A STUDY ON ATTITUDE TOWARDS THE USE OF ARTIFICIAL INTELLIGENCE IN EDUCATION AMONG STUDENT-TEACHERS** *Dr. Lavanya C.E.*	7-12
3	**ARTIFICIAL INTELLIGENCE AND CREATIVITY AMONG SECONDARY SCHOOL STUDENTS** *Prof. Prakasha K*	13-25
4	**REIMAGINING TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT IN THE AGE OF ARTIFICIAL INTELLIGENCE: COMPETENCIES, PEDAGOGIES AND EMERGING CHALLENGES** *Dr. Chidananda N K*	26-37
5	**PROFESSIONAL DEVELOPMENT: TRENDS AND CHALLENGES IN TEACHER EDUCATION** *Dr. Sharana Nayaka*	38-47
6	**STUDENT ENGAGEMENT AND WELL-BEING IN THE ERA OF ARTIFICIAL INTELLIGENCE: A HUMAN-CENTRED FRAMEWORK FOR MEANINGFUL LEARNING** *Dr. Manju N. D*	48-58

7	**ARTIFICIAL INTELLIGENCE IN ASSESSMENT AND FEEDBACK: ENHANCING EDUCATIONAL EVALUATION** *Dr. Sumathi R.*	59-64
8	**ARTIFICIAL INTELLIGENCE FOR PERSONALIZED AND ADAPTIVE LEARNING: TRANSFORMING THE TEACHING-LEARNING PROCESS** *Smt. Arundathi A.N.*	65-70
9	**HUMAN INTELLIGENCE MEETS ARTIFICIAL INTELLIGENCE: PREPARING TEACHERS FOR THE SMART EDUCATION ERA** *Veena G.E*	71-77
10	**IMPACT OF ARTIFICIAL INTELLIGENCE IN LIBRARIES: ENHANCING SERVICES AND EMPOWERING USERS FOR A SMART FUTURE** *Kum. Pavithra S. M*	78-85
11	**SMART TECHNOLOGY TO SMART TEACHING: THE ROLE OF TEACHERS IN STUDENT ENGAGEMENT AND WELL-BEING** *Chandana S Yogesh*	86-94
12	**A CORRELATIONAL STUDY OF TEACHING BEHAVIOUR AND PERCEIVED TEACHER BEHAVIOUR AMONG TEACHER EDUCATORS AT THE SECONDARY LEVEL IN MYSORE DISTRICT** *Dr. Chidananda A.L***.**	95-105
13	**IMPACT OF SOFT SKILLS ON EMPLOYABILITY READINESS: AN EMPIRICAL STUDY AMONG UNDERGRADUATE STUDENTS** *Anushka Patel, Dr. Zayara Zaidi*	106-114
14	**SKILL DEVELOPMENT AND EMPLOYABILITY: AN EMPIRICAL STUDY OF SKILLS, TRAINING, AND EMPLOYMENT READINESS AMONG YOUNG ADULTS** *Dr. Neetha. A. J*	115-121
15	**AI-DRIVEN LEARNING ANALYTICS IN ELEARNING PLATFORMS: ENHANCING STUDENT ENGAGEMENT AND PERSONALIZED LEARNING** *Harini.P*	122-129

16	**THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENGLISH LANGUAGE ASSESSMENT, EVALUATION AND LEARNING ANALYTICS** *Dr. Shalini J*	130-139
17	**GENDER AND EDUCATION** *Prasanna Kumar S*	140-146
18	**LOW ENROLLMENT OF GIRLS STUDENTS IN GOVERNMENT SECONDARY SCHOOLS** *Veena H.B.*	147-151
19	**EDUCATION COLLEGE LIBRARIES IN THE STATE OF KARNATAKA** *Asha J R & P G Tadasad*	152-160
20	**BENEFITS, ETHICAL CHALLENGES AND ITS IMPACT OF 'ARTIFICIAL INTELLIGENCE IN SOCIAL WORK'** *Kumaraswamy S.S.*	161-164
21	**A STUDY OF ENGLISH SPELLING DIFFICULTIES AMONG VII GRADE STUDENTS STUDYING IN KANNADA-MEDIUM SCHOOLS IN DAVANGERE CITY** *Dr. Santhosh Kumar R*	165-169
22	**A STUDY ON PERCEPTIONS OF SCIENCE TEACHERS OF KENDRIYA VIDYALAYA SANGATHAN SCHOOLS OF KARNATAKA TOWARDS PEDAGOGICAL INNOVATIONS AND ARTIFICIAL INTELLIGENCE IN THEIR SUBJECT** *Dr. Bharat Kumar P. Kulkarni*	170-182
23	**TEACHER SELF-EFFICACY AND PROFESSIONAL DEVELOPMENT FOR AI USE IN SECONDARY SCHOOLS** *Mr. Subhransu Padhy*	183-189
24	**A STUDY OF THE IMPACT OF INCLUSIVE AND EQUITABLE EDUCATION THROUGH AI** *Father Jaison Joseph & Dr Manu Singh*	190-196
25	**TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT** *Chaitra M*	197-203

26	**COGNITIVE APPRENTICESHIP MODEL- AN EXPERIENTIAL STRATEGY FOR DAVANGERE HIGH SCHOOL STUDENT ACHIEVEMENT IN MATHEMATICS** *Prof. M.C. Yarriswamy & Murugeshi K*	204-211
27	**ATTITUDES OF UNIVERSITY TEACHERS OF KARNATAKA TOWARDS EMERGING TECHNOLOGIES (AR/VR, IoT AND ROBOTICS) IN EDUCATION** *Prof. Ratan Chavan*	212-223
28	**AI-ENABLED COGNITIVE SUPPORT TOOLS FOR MANAGING STRESS DURING THE SCHOOL-TO-COLLEGE TRANSITION: EXAMINING THE ROLE OF POSITIVE AND NEGATIVE THINKING PATTERNS** *Gatike Rambabu Dr. R. Sahaya Mary*	224-229
29	**ARTIFICIAL INTELLIGENCE LITERACY AND STUDENT ENGAGEMENT AMONG COLLEGE STUDENTS** *L. Anusha, & Dr. T. Sivasakthi Rajammal,*	230-238
30	**STUDENTS' ENGAGEMENT AND WELL-BEING IN THE PRESENT SCENARIO OF ARTIFICIAL INTELLIGENCE: A HUMAN-CENTERED AI MODEL FOR SECONDARY SCHOOLS** *Dr. Bhavya R*	239-245
31	**PROFESSIONAL DEVELOPMENT OF PHYSICAL EDUCATION TEACHERS THROUGH DIGITAL TOOLS** *Sri. Chandregowda.S,*	246-249
32	**AI ETHICS LITERACY AMONG TEACHER EDUCATORS AND PRESERVICE TEACHERS: A COMPARATIVE SURVEY STUDY** *Dr. Shobha M*	250-257
33	**PEDAGOGICAL INNOVATIONS AND INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE IN THE ERA OF AI.** *Shilpa Shri R D& Sharanamma R*	258-270
34	**ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN EDUCATION: REIMAGINING TEACHING, LEARNING, ASSESSMENT AND THE ROLE OF THE TEACHER** *Mrs. Chaitra H V*	271-282

35	**A SYSTEMATIC REVIEW OF GENERATIVE ARTIFICIAL INTELLIGENCE TOOLS IN EDUCATION** *Dr Pradeep Kumar T*	283-288
36	**ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN EDUCATION: A SYSTEMATIC LITERATURE REVIEW AND SYNTHESIS OF RESEARCH EVIDENCE** *Dr. Pradeep Kumar T& Dr. Prajnya Sarangi*	289-295
37	**MULTIDISCIPLINARY INTEGRATION OF ARTIFICIAL INTELLIGENCE IN EDUCATION** *Dr. M. C. Yarriswamy & Jagannathan R. Golihalli*	296-302
38	**TECHNOLOGY INTEGRATION IN SCHOOL EDUCATION: A SURVEY OF TEACHERS' ATTITUDES, PRACTICES AND CHALLENGES IN PRIVATE SCHOOLS OF NAGAMANGALA TALUK** *Mr. Shivanna C L*	303-311
39	**AN EMPIRICAL INVESTIGATION OF ARTIFICIAL INTELLIGENCE LITERACY AMONG PROSPECTIVE EDUCATORS: PERSPECTIVES FROM B.ED. TEACHER TRAINEES IN SOUTHERN KARNATAKA** *Dr. Sowmya N S*	312-323
40	**ANALYTICAL STUDY OF AI LITERACY AND TEACHER READINESS AMONG PRE-SERVICE EDUCATORS IN KARNATAKA** *Mr. Devaraju B N*	324-335
41	**ARTIFICIAL INTELLIGENCE FOR PROFESSIONAL DEVELOPMENT OF CHEMISTRY TEACHERS: OPPORTUNITIES, CHALLENGES AND FUTURE DIRECTIONS** *Dr.Prakash H S*	336-342
42	**THE DIGITAL DIVIDE AND THE ETHICS OF AI IN GLOBAL EDUCATION: ENSURING EQUITABLE ACCESS IN DEVELOPING CONTEXTS OF INDIA** *Dr. Lami M.C*	343-349
43	**AI-ENHANCED FORMATIVE ASSESSMENT AND EXPLAINABLE LEARNING ANALYTICS IN SECONDARY MATHEMATICS: A TEACHER-DRIVEN SMART-AI FRAMEWORK FOR ACHIEVEMENT, CRITICAL THINKING AND SOCIAL SKILLS** *Lokeshkumar V & Dr A T Shivaramu*	350-356

44	**GENERATIVE ARTIFICIAL INTELLIGENCE IN COMMERCE EDUCATION: TRANSFORMING TEACHING AND LEARNING FOR THE FUTURE** *Ramyashree. S.R & Vagdevi Madhyastha*	357-364
45	**AI AND ENGLISH: SHAPING FUTURE-READY TEACHERS** *Mrs.Deepu R & Dr.C. Geetha*	365-373
46	**AI-ENABLED TEACHER EDUCATION: TRANSFORMING PRE-SERVICE TEACHERS INTO SMART AND FUTURE-READY EDUCATORS** *Dr. Kiran Kumar K.S.*	374-381
47	**ARTIFICIAL INTELLIGENCE FOR ENHANCING STUDENT ENGAGEMENT AND WELLBEING: EMPOWERING TEACHERS FOR A SMART FUTURE AUTHORS:** *Smt.Renukabai & Prof.Ashokkumar B.Surapur*	382-392
48	**ARTIFICIAL INTELLIGENCE IN EDUCATION: RETHINKING STUDENT ENGAGEMENT AND WELL-BEING IN SMART LEARNING ENVIRONMENTS** *Dr. Shashikala G. M.*	393-407
49	**ARTIFICIAL INTELLIGENCE FOR TEACHER EDUCATOR** *Dr N S Talawar & Sushma P K*	408-410
50	**PLANNING AND DEVELOPMENT OF SECONDARY EDUCATION THROUGH DIFFERENT EDUCATIONAL POLICIES** *Sri. Basappa C Yeraladinni, Dr. N.S Talawar*	411-417
51	**A THEMATIC OVERVIEW OF EMERGING OPPORTUNITIES IN ENABLING AI EQUITABLE AND INCLUSIVE EDUCATION** *Mr. Midde Prabhakar & Dr. R. Kohila Devi*	418-426
52	**ARTIFICIAL INTELLIGENCE: RETHINKING TRANSFORMATIVE TEACHING AND LEARNING FOR SUSTAINABLE EDUCATION** *Ms. Elora Suman Sahoo*	427-435
53	**ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT IN EDUCATION: A LITERATURE REVIEW** *Dr Thimmaraju T, Dr Naveen kumar L.C,*	436-441

54	**ARTIFICIAL INTELLIGENCE AS A CATALYST FOR INCLUSIVE AND EQUITABLE EDUCATION: OPPORTUNITIES, CHALLENGES, AND PATHWAYS FOR ALL LEARNERS** *Mr. Stany Pinto, Dr Dorothy Dsouza*	442-448
55	**ANALYZING THE GLOBAL PERSPECTIVES ASPECTS OF THE EMPLOYABILITY SKILLS IN THE PRESENCE CURRICULUM OF POSTGRADUATE OF KUVEMPU UNIVERSITY** *Dr. Shilpa. V*	449-455
56	**EMPOWERING FUTURE EDUCATORS: SKILL DEVELOPMENT STRATEGIES FOR ENHANCING EMPLOYABILITY AMONG B.ED. STUDENTS** *Jagadeesha N& Anantharamu M L*	456-464
57	**A PROPOSED STUDY OF PROFESSIONAL DEVELOPMENT AND JOB SATISFACTION AMONG TEACHER EDUCATORS AND ITS IMPACT ON STUDENT TEACHERS' ACADEMIC ACHIEVEMENT** *Santhosh B. J & Dr. Manjunath H.P*	465-471
58	**ROLE OF ARTIFICIAL INTELLIGENCE IN ADDRESSING INDIVIDUAL DIFFERENCES IN MATHEMATICS LEARNING** *Dr Manjunath H M*	472-478
59	**EFFECTIVENESS OF CONSTRUCTIVIST TEACHING METHODS ON MATHEMATICS ACHIEVEMENT AMONG IXTH STANDARD STUDENTS** *Smt. Gouramma Ingalagi & Prof (Smt) Prabha S Guddadanveri*	479-483
60	**ACHIEVEMENT IN MATHEMATICS AMONG PRIMARY SCHOOL STUDENTS THROUGH BLENDED (HYBRID) TEACHING** *Smt. Laxmi Bellundagi.D & Dr. N.S Talawar*	484-492
61	**ARTIFICIAL INTELLIGENCE AND THE FUTURE OF PEDAGOGY: BUILDING ADAPTIVE LEARNING ENVIRONMENTS** *Dr. Kowshik.M.C*	493-500
62	**IMPACT OF ICT AND PEDAGOGICAL COMPETENCY ON TEACHER EFFECTIVENESS OF SECONDARY SCHOOL TEACHERS IN BELAGAVI CITY** *Mahantesh Hiremath & Manjunath B. Kori*	501-509

63	**ANALYTICAL PERSPECTIVE ON TEACHER STRATEGIES FOR STUDENT ENGAGEMENT AMID CLASS ROOM CONFLICT** *Preeti Kushwaha*	510-511
64	**IMPACT OF GENERATIVE AI TOOLS ON TEACHING EFFECTIVENESS AND LEARNING ENGAGEMENT** *Smt. Shobha H V & Dr. Gopal.N*	512-518
65	**ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS ALIGNMENT WITH NEP 2020** *Arphi Naj & Vedant Deep Jigana*	519-524
66	**STUDENT ENGAGEMENT AND WELL-BEING** *Rukmimi K., Dr. Karunakara N.N*	525-531
67	**ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCES AND HUMANITIES** *Dr. K Channakrishnaiah*	532-536
68	**IMPACT OF 5E LESSON PLAN-BASED CONSTRUCTIVIST APPROACH IN SOCIAL SCIENCE ON THE ACADEMIC ACHIEVEMENT OF THE SECONDARY SCHOOL STUDENTS** *Sri Irfan Mohiyuddin Khan & Prof. Hoovinbhavi.B.L*	537-544
69	**DIGITAL LIBRARIES AND THE FUTURE OF TEACHER EDUCATION** *Vishwanatha G*	545-551
70	**ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT: TRANSFORMING THE FUTURE** *Shobha B.S*	552-558
71	**ARTIFICIAL INTELLIGENCE–ENABLED TEACHING AND STUDENT LEARNING OUTCOMES: A META-ANALYTIC EVIDENCE SYNTHESIS FOR SHAPING SMART TEACHERS** *Dr. Kalyani K.*	559-565
72	**THE YOGIC UNDERSTANDING OF MIND, BEHAVIOR AND HUMAN POTENTIAL FOR STUDENT ENGAGEMENT** *Dr. Bhgyajyothi Meti*	566-572

73	**AN ASSESSMENT OF GOVERNANCE AND IMPLEMENTATION MECHANISMS UNDER KARNATAKA STATE SKILL DEVELOPMENT POLICY 2025–2032** *Kum. Kanakalakshmi V S & Dr. Thimmarayappa R*	573-581
74	**INDIAN KNOWLEDGE SYSTEM AND TECHNOLOGY IN TEACHER EDUCATION** *Prasanna H A*	582-591
75	**ARTIFICIAL INTELLIGENCE IN WOMEN REPRODUCTIVE AND MATERNAL HEALTH: ADVANTAGES, CHALLENGES, AND FUTURE PERSPECTIVES** *Chandrakala T S*	592-599
76	**A STUDY OF DIGITAL COMPETENCE AMONG SECONDARY SCHOOL TEACHERS** *Dr. Shivakumar G S*	600-604
77	**PREPARATION OF TEACHER EDUCATION PROGRAMME FOR 21ST CENTURY EDUCATION AND DIGITAL COMPETENCIES, AI LITERACY FOR THE PROFESSIONAL DEVELOPMENT** *Dr. Nagaraj H Bommanal*	605-611
78	**GENERATIVE AI AS A PEDAGOGICAL TOOL IN BIOLOGY EDUCATION: A REVIEW OF OPPORTUNITIES, CHALLENGES, AND THE TRANSFORMATION OF TEACHING AND LEARNING** *Deeksha.H.S.*	612-618
79	**FROM TOOL ADOPTION TO PROFESSIONAL JUDGEMENT: REFRAMING RESTRAINT AS A CORE COMPETENCY IN TEACHER AI EDUCATION** *Himarashmi S Naik*	619-625
80	**TEACHING EFFECTIVENESS OF DEGREE COLLEGE LECTURERS IN RELATION TO SCIENTIFIC CREATIVITY, ATTITUDE TOWARDS ARTIFICIAL INTELLIGENCE, AND SCIENTIFIC ATTITUDE** *Madar Sab, Dr. Saheb Ali H. Niragudi*	626-633
81	**IMPACT OF AI IN TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: POSSIBILITIES AND CHALLENGES** *Anto Preetham S G & Dr Manjunath H P*	634-640

82	**A STUDY OF ACADEMIC ACHIEVEMENT AND ACHIEVEMENT MOTIVATION OF 10th STANDARD STUDENTS** *Dr. Haleshappa T.*	641-646
83	**ARTIFICIAL INTELLIGENCE USAGE FOR PROMOTING SUSTAINABLE DEVELOPMENT AMONG COLLEGE STUDENTS** *M.Yamuna, Dr. T. Sivasakthi Rajammal*	647-653
84	**A STUDY ON ADJUSTMENT ABILITIES OF UNDERGRADUATE STUDENTS OF KALABURAGI DISTRICT IN RELATION TO THEIR INTELLIGENCE AND INTEREST** *Sandeepkumar Namadev & Prof. Hoovinbhavi B L*	654-661
85	**PSYCHOLOGICAL WELL-BEING AMONG PROSPECTIVE TEACHERS: AN EMPIRICAL STUDY OF B.ED. TEACHER TRAINEES** *Dr Parasurama D*	662-666
86	**ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION: TRANSFORMING TEACHING, LEARNING, ASSESSMENT, AND RESEARCH INTHE GENERATIVE AI ERA** *Shruthi B.R & Richard Dcosta*	667-675
87	**ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION: A REVIEW OF EVIDENCE ON ITS EFFECTIVENESS IN HIGH SCHOOL MATHEMATICS INSTRUCTION** *Mrs. Sumera & Prof; B. L Lakkannavar*	676-681
88	**SKILL DEVELOPMENT AND EMPLOYABILITY AMONG HIGHER EDUCATION STUDENTS: BRIDGING THE GAP BETWEEN EDUCATION AND INDUSTRY REQUIREMENTS** *Dr. Sudha H R*	682-687
89	**TEACHING IN THE AGE OF AI: TRANSFORMING TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT** *Beeralingaiah. G., Dr. Ravi.T. K*	688-692

90	**A STUDY OF B.ED. TRAINEES' EXPERIENCES IN THE USE OF EDUCATIONAL TECHNOLOGY IN TEACHING PRACTICE** *Dr. Yadukumar M*	693-699
91	**SUSTAINABLE PROFESSIONAL DEVELOPMENT FOR TEACHER EDUCATORS** *Dr. M. L. Sunil Kumar & Dr. Varun. M*	700-705
92	**PROFESSIONAL DEVELOPMENT OF TEACHER EDUCATION AS, AWARENESS OF ICT, USE OF ICT, WITH TEACHING EFFECTIVENESS OF CLASSROOM SITUATION** *Dr. Shidlingaswamy P. M., Dr. Ashok Mattimani.*	706-714
93	**THE EDUCATIONAL IMPLICATIONS OF AI – BENEFITS AND CHALLENGES** *K. S. Mahesha*	715-719
94	**FROM DIGITAL LITERACY TO AI LITERACY: REIMAGINING TEACHER COMPETENCIES FOR THE FUTURE OF EDUCATION** *Swathi A*	720-726
95	**INTEGRATING GREEN NANOTECHNOLOGY AND ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE AGRICULTURE: ADVANCES IN NANO PRIMING AND STRESS MANAGEMENT** *Nehakumari C & Dr. Varunakumara J B*	727-735
96	**EFFECTIVENESS OF CONTENT-BASED DRAMATIZATION TEACHING TECHNIQUE ON SKILL AND ACADEMIC ACHIEVEMENT IN SOCIAL SCIENCE SUBJECT AMONG HIGHER PRIMARY SCHOOL STUDENTS** *Mr. Devaraja. A, Dr. N. S. Talawar*	736-742
97	**ARTIFICIAL INTELLIGENCE ENABLED TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: PREPARING SMART TEACHERS FOR A SMART FUTURE** *Dr Bhimappa Rangannavar, Ms Gayathiri M*	743-752
98	**ARTIFICIAL INTELLIGENCE AND PUBLIC GOVERNANCE: TOWARDS HUMAN-CENTRED AND CITIZEN-CENTRED ADMINISTRATION** *Dr. Chayashree K*	753-759

99	**AI-ENABLED NEXT-GENERATION DIGITAL DEVICES: TRANSFORMING COMPUTING SPEED, ONNECTIVITY AND THE FUTURE OF PHYSICAL EDUCATION AND SPORTS DEVELOPMENT** *Ravikumara N.G.*	760-765
100	**ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCE AND HUMANITIES** *Dr. Rudrappa Ningappa Talawar*	766-773
101	**EFFECT OF STEM-BASED ATAL TINKERING LAB ACTIVITIES ON CREATIVITY, INNOVATIVE THINKING AND ENTREPRENEURSHIP AMONG SECONDARY SCHOOL STUDENTS: A QUASI-EXPERIMENTAL STUDY** *Dr. Kanakappa Pujar*	774-778
102	**ASSESSMENT, EVALUATION AND LEARNING ANALYTICS THROUGH ARTIFICIAL INTELLIGENCE: TRANSFORMING EVIDENCE-BASED EDUCATIONAL DECISION-MAKING** *Dr. Girish T H*	779-789
103	**DIGITAL WELL-BEING AND PRE-SERVICE TEACHER READINESS FOR 21ST- CENTURY CLASSROOMS: DEVELOPMENT OF THE DIGITAL WELL-BEING AND PRE-SERVICE TEACHER READINESS MODEL** *Shruthi, Vilma D Souza & Dr Flosy Clara Roshan D'Souza*	790-800
104	**A STUDY ON ARTIFICIAL INTELLIGENCE IN COMMERCE EDUCATION PEDAGOGY: CHALLENGES AND OPPORTUNITIES** *Puneethkumar G B, Dr. Patil S.S*	801-813
105	**MINDFUL DIGITAL LEARNING: EXPLORING THE PATHWAYS TO ACADEMIC WELL-BEING AMONG STUDENTS** *Prathibha Linet Dsouza & Dr Dorothy Dsouza*	814-820
106	**ARTIFICIAL INTELLIGENCE AND COMPUTER VISION FOR EDUCATIONAL ASSESSMENT: A STRUCTURED REVIEW OF AUTOMATED EVALUATION, FEEDBACK, AND LEARNING ANALYTICS** S*alma N, Madhuri G R, Basavaraj Jagadale & Sheshan V*	821-831

107	**ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY AND IN MATHEMATICS EDUCATION** *Dr. Harshavardhana C*	832-837
108	**TEACHER TRAINING FOR UBIQUITOUS LEARNING IN INDIA: CHALLENGES AND OPPORTUNITIES IN DIGITAL EDUCATION** *Abhishek Vadeyar*	838-845
109	**ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS FOR TEACHING KANNADA AT SECONDARY LEVEL EDUCATION** *Sowmya B.J. & Dr. Pushpa M.*	846-855
110	**VISION OF NEP ON TEACHER EDUCATION** *Kumar.V & Dr. M. L. Sunil Kumar*	856-858
111	**SCIENTIFIC ATTITUDE AND AWARENESS OF GAMIFICATION TEACHING TECHNIQUE AMONG PRE-SERVICE TEACHERS IN THE ERA OF ARTIFICIAL INTELLIGENCE** *Pradeepkumar H K & Dr. Sheela G*	859-866
112	**SYNECTICS MODEL OF TEACHING FOR DEVELOPING SKILLS AND ENHANCING EMPLOYABILITY** *Dr. Janaki. M & Mrs. Smitha Rajendra*	867-873
113	**A STUDY ON THE USE OF ARTIFICIAL INTELLIGENCE FOR THE DEVELOPMENT OF PERSONALIZED LEARNING IN THE EDUCATION SYSTEM** *Mr. Prabhat Kumar., Dr. Ishteyaque Ahmad*	874-884
114	**SMART COMMERCE FOR SMART LEARNERS: ASSESSING RURAL GRADUATE STUDENTS' KNOWLEDGE, PERCEIVED VALUE, AND PURCHASE INTENTION TOWARD AI-DRIVEN E-COMMERCE PLATFORMS** *Vinay H B, Arun Kumar M S & Dr. Santhosha E*	885-893
115	**EFFECTIVENESS OF AI-SUPPORTED DIFFERENTIATED INSTRUCTIONAL APPROACH IN MATHEMATICS ON MATHEMATICS ACHIEVEMENT AND HIGHER-ORDER THINKING ABILITIES AMONG SECONDARY SCHOOL STUDENTS** *Tabasum & Dr. Geetha C*	894-903

116	**ARTIFICIAL INTELLIGENCE ENABLED CONCEPTUAL UNDERSTANDING IN B.ED. TEACHER PREPARATION** *Dr.Madhu G*	904-913
117	**STUDENT ENGAGEMENT AND WELL-BEING: AN INTEGRATED FRAMEWORK FOR PROMOTING MEANINGFUL LEARNING AND EDUCATIONAL SUCCESS THROUGH AI** *Dr.Basanagouda V M*	914-922
118	**AI LITERACY FOR TEACHERS: A PATHWAY TO FUTURE-READY EDUCATION** *Dr. Raghavendra Bommannavar & Dr.Mallikarjun Kudavakkalagi*	923-933
119	**ROLE OF 21ST CENTURY TECHNOLOGIES IN STUDENT ENGAGEMENT AND WELL-BEING** *Ashwini K.,Dr. G. Sowbhagya.*	934-941
120	**EXPLORING THE INFLUENCE OF DEMOGRAPHIC FACTORS ON SHYNESS AMONG ADOLESCENT STUDENTS IN SHIVAMOGGA DISTRICTS** *Dr.Yashavantha B*	942-949
121	**STUDENT ENGAGEMENT AND WELL-BEING: A HOLISTIC APPROACH TO ENHANCING ACADEMIC SUCCESS IN EDUCATIONAL INSTITUTIONS** *Dr. Dinesh M K*	950-956
122	**TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT** *Mrs. Poornima T M & Prof. B L Lakkanavar*	957-959
123	**ARTIFICIAL INTELLIGENCE IN EDUCATION: SHAPING SMART TEACHERS FOR A SMART FUTURE** *Mrs Sadiqa Banu*	960-967
124	**SMART COMMERCE, SMARTER MANAGEMENT: NAVIGATING BUSINESS IN THE ERA OF AI** *Mr. Gururaj. N*	968-975
125	**ARTIFICIAL INTELLIGENCE FOR INCLUSIVE AND EQUITABLE EDUCATION: OPPORTUNITIES, CHALLENGES AND A HUMAN-CENTRED FRAMEWORK FOR LEARNER DIVERSITY** *Dr. Paramesha H Masalavada*	976-985

126	**GENERATIVE ARTIFICIAL INTELLIGENCE IN SECONDARY SCHOOL SOCIAL SCIENCE EDUCATION: PEDAGOGICAL OPPORTUNITIES, ETHICAL CHALLENGES AND FUTURE DIRECTIONS** *Mr A H Gopal & Dr A T Shivaramu*	986-994
127	**ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCES AND HUMANITIES: OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS** *Dr.Vani Nayaki D.C*	995-998
128	**GENERATIVE AI FOR ENHANCING LEADERSHIP SKILLS OF PRINCIPALS OF TEACHER EDUCATION INSTITUTIONS: A PRACTICAL FRAMEWORK** *Nandan.N & Dr.Jagannath K Dange*	999-1008
129	**GENERATIVE ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCE RESEARCH: AN INTEGRATIVE REVIEW OF OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS** *Savitha M S & Dr. Pakash Sannakkanavar*	1009-1017
130	**EMERGING TRENDS IN EDUCATION: TECHNOLOGY, PEDAGOGY AND THE FUTURE OF TEACHING AND LEARNING** *Mrs. Divya U.P.*	1018-1023
131	**ARTIFICIAL INTELIGENCE IN EDUCATION: ENHANCING SKILL DEVELOPMENT AND EMPLOYABILITY FOR THE FUTURE WORKFACE** *Mrs. Ruksana M Kachur*	1024-1031
132	**FROM TRADITIONAL TEACHING TO INTELLIGENT PEDAGOGY: EXPLORING THE ROLE OF AI IN TRANSFORMING TEACHING-LEARNING PRACTICES** *Dr. Devaraja Y*	1032-1040
133	**ARTIFICIAL INTELLIGENCE AS A DRIVER OF NATIONAL E CONOMIC TRANSFORMATION, PRODUCTIVITY, AND SUSTAINABILITY** *Panduranga Gouda*	1041-1046
134	**REVIVING ROOTS FOR READINESS: INDIAN KNOWLEDGE SYSTEMS, YOGA, AND THE CULTIVATION OF STUDENT ENGAGEMENT AND WELL-BEING UNDER NEP 2020** *Varsha Dileep Bhojane, Dr. Yashpal Netragaonkar*	1047-1052

135	**IMPLICATIONS AND IMPLEMENTATION OF THE TEACHER–AI TEAM MODEL** *Bhagya C M, Dr. Madhu G*	1053-1058
136	**PLANNING AI TRAINING FOR EVERY TEACHER EDUCATION PROGRAM** *Prakash N J, Dr. Madhu G*	1059-1063
137	**ARTIFICIAL INTELLIGENCE IN EDUCATION: SHAPING SMART TEACHERS FOR A SMART FUTURE** *Dr. Dhanyakumar G K & Dr. Nagesh K C*	1064-1071
138	**ARTIFICIAL INTELLIGENCE-ASSISTED TEACHING AND CONCEPTUAL UNDERSTANDING AMONG STUDENTS: A CONCEPTUAL PERSPECTIVE** *Mohan Prakash T. M. & Dr. Geetha. C.*	1072-1078
139	**AI-ASSISTED PERSONALISED LEARNING AND SCIENCE ACHIEVEMENT: A QUASI-EXPERIMENTAL STUDY OF GRAVITATION AMONG GRADE IX RESIDENTIAL SCHOOL STUDENTS** *Dr. Nagendrappa S*	1079-1084
140	**EFFECT OF AI-ASSISTED PERSONALISED LEARNING ON MATHEMATICS ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS: A QUASI-EXPERIMENTAL STUDY** *Dr. Nagendrappa S*	1085-1091
141	**AI'S ROLE IN STUDENT-TEACHER ENGAGEMENT AND WELL-BEING** *Soumya V, Dr. Madhu G*	1092-1104
142	**PERCEIVED OCCUPATIONAL STRESS AMONG PERMANENT AND TEMPORARY PRIMARY SCHOOL TEACHERS** *Dr. Praveen Kumar. K.B*	1105-1109
143	**ESSENCE OF INTEGRATING MOOCS INTO CURRICULUM DESIGN: BLENDED LEARNING ON STUDENT ENGAGEMENT** *Raghavendra M. Shet*	1110-1114
144	**ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN B.ED. TEACHER EDUCATION: ADVANCING PERSONALIZED LEARNING** *Chandrakala T.B & Dr. A.T Shivaramu*	1115-1120

145	**TPACK AND AI-TPACK IN TEACHER EDUCATION: A REVIEW OF THE LITERATURE AND IMPLICATIONS FOR B.ED STUDENT-TEACHER PREPARATION IN BENGALURU, INDIA** *Dr Umashree D K*	1121-1130
146	**IMPACT OF ICT ON EDUCATIONAL DEVELOPMENT** *Mr. Madhu J K & Dr Geetha C*	1131-1134
147	**REIMAGINING TEACHER EDUCATION IN THE AGE OF ARTIFICIAL INTELLIGENCE: POLICY IMPERATIVES, PEDAGOGICAL REALIGNMENT, AND THE MAKING OF A NEW PROFESSIONAL IDENTITY** *Mrs. Sudha H J& Dr. Geetha C*	1135-1140
148	**THE ROLE OF GENERATIVE ARTIFICIAL INTELLIGENCE IN MODERN SCIENCE CLASSROOMS** *Dr. Jayadeva. M.D*	1141-1145
149	**ARTIFICIAL INTELLIGENCE IN EDUCATION: TRANSFORMING TEACHERS FOR THE FUTURE OF LEARNING** *Dr. Kavitha Jane Crasta*	1146-1163
150	**AI IN SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION: FROM MEMORIZATION TO DEEP UNDERSTANDING** *Kavya G S*	1164-1170
151	**A STUDY ON THE IMPACT OF TEACHER PROFESSIONALISM AND PRACTICES AMONG BED COLLEGE TEACHER EDUCATORS** *Suresha M & Prof. (Smt) Prabha S. Guddadanveri*	1171-1181
152	**AI FOR SUSTAINABLE DEVELOPMENT: GLOBAL PARADIGMS, INDIAN REALITIES, AND A MULTI-TIERED GOVERNANCE ARCHITECTURE** *A C Ramesh, Amrutha V N*	1182-1187
153	**PREPARING SMART TEACHERS FOR A SMART FUTURE: EXPLORING AI READINESS AMONG B.ED. STUDENTS** *M. Sandhya & Dr. Yashpal D. Netragaonkar*	1188-1201
154	**INFLUENCE OF AI-DRIVEN FLASH SALES AND DIGITAL PAYMENT SYSTEMS ON CONSUMPTION PATTERNS AND SAVING BEHAVIOUR AMONG FEMALE CONSUMERS IN KARNATAKA: A REVIEW** *Mrs. Sameena RS & Dr. Rajith Kumar H B,*	1202-1209

155	**TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT** *Gaddigesh B S.*	1210-1214
156	**ARTIFICIAL INTELLIGENCE IN SCIENCE AND MATHEMATICS EDUCATION** *Nagaraja C*	1215-1220
157	**APPLYING AI TECHNOLOGY IN SOCIAL SCIENCE AND HUMANITIES IN SCHOOL AND COLLEGES** *Gururaja D*	1221-1226
158	**ARTIFICIAL INTELLIGENCE, BIOTECHNOLOGY AND BIOTERRORISM: BALANCING SCIENTIFIC INNOVATION, DUAL-USE RISKS, ETHICS AND GLOBAL BIOSECURITY** *Mr Mansing Dhondiram Bisure & Dr Tanaya Kamalakar.*	1227-1233
159	**ARTIFICIAL INTELLIGENCE IN PHYSICAL EDUCATION: TRANSFORMING TEACHING, ASSESSMENT, PERSONALISED LEARNING AND SPORTS PERFORMANCE** *Sheela N H*	1234-1245
160	**ARTIFICIAL INTELLIGENCE AND FUTURE EDUCATION** *Dr. Vikram C B*	1246-1253
161	**RETHINKING ASSESSMENT IN THE AGE OF GENERATIVE AI: FROM PRODUCT-BASED EVALUATION TO PROCESS-ORIENTED LEARNING** *Raju Y H*	1254-1263
162	**USE OF ARTIFICIAL INTELLIGENCE AND AUTOMATED ADAPTIVE LEARNING IN EDUCATION** *Shivananda Swamy K.R.*	1264-1268
163	**ARTIFICIAL INTELLIGENCE INNOVATION AND SUSTAINABLE DEVELOPMENT FOR VIKSIT BHARAT: OPPORTUNITIES, CHALLENGES, AND POLICY PERSPECTIVES** *Smt. Bhuvaneshwari J. Attihalli*	1269-1275

164	**POLICY AND ETHICAL CHALLENGES IN ARTIFICIAL INTELLIGENCE: FRAMEWORKS FOR RESPONSIBLE GOVERNANCE** *Miss Reshma Bappasaheb Jagtap. &* *Miss Gauri Ramakrishna Mane*	1276-1285
165	**ARTIFICIAL INTELLIGENCE IN ECONOMICS EDUCATION: TRANSFORMING TEACHING, LEARNING AND SKILL DEVELOPMENT** *Dr. Sunil D*	1286-1293
166	**ACADEMIC STRESS, STUDENT WELL-BEING AND THE ROLE OF ARTIFICIAL INTELLIGENCE** *Shivashankar D*	1294-1303
167	**E-LEARNING: IMPORTANCE, SCOPE, OPPORTUNITIES, CHALLENGES AND ITS ROLE IN MODERN EDUCATION** *Asma Farzana*	1304-1309
168	**INTEGRATION OF ARTIFICIAL INTELLIGENCE TO CHALLENGES AND QUALITY DEVELOPMENT IN HIGHER EDUCATION: AN ANALYSIS** *Dr. Priyadarsini Mekap*	1310-1315
169	**ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION: EMERGING INNOVATIONS, RESEARCH PERSPECTIVES AND CASE STUDIES WITH SPECIAL REFERENCE TO KARNATAKA** *Nanjundaswamy K. S.*	1316-1327
170	**EXAMINING THE READINESS–ADOPTION NEXUS: A SYSTEMATIC NEEDS ASSESSMENT OF ARTIFICIAL INTELLIGENCE INTEGRATION AMONG SCIENCE FACULTY IN HIGHER EDUCATION INSTITUTIONS** *Dr. Kushagri Singh*	1328-1341
171	**TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: A PATHWAY TOWARDS COMPETENT, REFLECTIVE AND FUTURE-READY TEACHERS** *Prof. Jayaprakasha B &Prof. Ningamma C Betsur*	1342-1350
172	**AUGMENTED REALITY FOR GEOMETRY TEACHING: TRANSFORMING MATHEMATICS LEARNING IN THE DIGITAL AGE** *Dr. Hemanth Kumar B C*	1351-1357

173	**ANALYZING THE PERCEPTION OF TEACHERS AND STUDENTS ON THE ROLE OF AI BASED TOOLS IN PHYSICS TEACHING AND LEARNING** *Smt. Shilpa K.S., Dr. Balaji B.R.*	1358-1373
174	**A STUDY ON MATHEMATICS TEACHERS' ATTITUDES TOWARDS APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN THE TEACHING PROCESS OF MATHEMATICS.** *Dr Vijayalakshmi Naik*	1374-1386
175	**ARTIFICIAL INTELLIGENCE AS A CATALYST FOR CRITICAL INQUIRY AND HISTORICAL THINKING IN SOCIAL SCIENCE EDUCATION: PREPARING SMART TEACHERS FOR CULTURALLY RESPONSIVE CLASSROOMS** *Smaranika Samal, Dr. Dipanshu Sharma, & Ishita Mishra*	1387-1395
176	**A STUDY ON THE PERSONALITY TRAITS, TEACHING EFFECTIVENESS, LEADERSHIP SKILLS OF SECONDARY SCHOOL TEACHERS** *Smt. Shakunthala D L. & Dr. Balaji B.R.*	1396-1406
177	**AI-BASED INNOVATIVE TEACHING AND LEARNING STRATEGIES** *Dr. K. Ratheeswari*	1407-1414
178	**AI FOR SUSTAINABLE DEVELOPMENT: ADVANCING PEDAGOGICAL INNOVATION IN TEACHER EDUCATION** *Mr. Ravi Kumara Y H*	1415-1423
179	**ARTIFICIAL INTELLIGENCE IN COMMERCE** *Mr. Bhai Krushna Pawar*	1424-1427
180	**BRIDGING EDUCATION AND EMPLOYABILITY: RETHINKING SKILL DEVELOPMENT FOR FUTURE-READY LEARNERS** *Mrs. R. Monisha, Dr. P. Muthupandi Selvi*	1428-1433
181	**A STUDY ON THE EFFECT OF PSYCHOLOGICAL AND ENVIRONMENTAL FACTORS ON ACADEMIC ACHIEVEMENT OF CHILDREN WITH SPECIAL NEEDS AT THE SECONDARY SCHOOL LEVEL OF VIJAYAPUR DISTRICT** *Smt Nirmita Matti & Dr Basavaraj Lakkannavar*	1434-1446

182	**STUDY OF EDUCATION SYSTEM DURING THE PERIOD OF KALYANI CHALUKYAS** *Nanjundaswamy K.S. & Dr. Shakeela K.*	1447-1455
183	**DEVELOPMENT OF TEACHER EDUCATION: A THEMATIC ANALYSIS IN THE CONTEXT OF NEP 2020 FOR DEVELOPING SMART TEACHERS IN INDIA** *A. Anbagam & Dr. R. Vinodh Kumar*	1456-1460
184	**AI-ASSISTED PERSONALIZED LEARNING AND ACADEMIC SELF-EFFICACY AMONG B.ED. STUDENT TEACHERS: A CORRELATIONAL STUDY** *Dr. Veerendra Kumar Wali S*	1461-1471
185	**AI IN ENGLISH LANGUAGE TEACHING AND PEDAGOGICAL INNOVATIONS** *Sadiqa Banu*	1472-1477
186	**ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ: ಸಮಕಾಲೀನ ಸವಾಲುಗಳು, ಅವಕಾಶಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ದೃಷ್ಟಿಕೋನ** *ಬಿ. ವಿಜಯ ರಾಜೇಂದ್ರ & ಡಾ. ಶರಣಮ್ಮ ಆರ್*	1478-1483
187	**ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ: ಶೈಕ್ಷಣಿಕ ಅನ್ವಯಗಳು, ಅವಕಾಶಗಳು ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆ** *ದೇವಾನಂದ ಎ ಸಿ*	1484-1494
188	**ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಸವಾಲುಗಳು.** *ಡಾ. ಗುರುಸ್ವಾಮಿ ಹಿರೇಮಠ*	1495-1499
189	**ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ಪಾತ್ರ** *ಡಾ. ಕಾವ್ಯ ಆರ್*	1500-1506
190	**ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ(AI)ಯ ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣ** *ಡಾ.ದಿನೇಶ.ಎಂ.ಎನ್*	1507-1511
191	**ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ** *ಶ್ರೀಮತಿ ಜಯಶ್ರೀ ಕೆಂಗೇರಿ & ಡಾ. ಭಾರತಿ ವಾಯ್ ಖಾಸನಿಸ*	1512-1520
192	**ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ದಿಕ್ಕುಗಳ ವಿಶ್ಲೇಷಣಾತ್ಮಕ ಅಧ್ಯಯನ.** *ಮಾಲಾ ಹುಚ್ಚಣ್ಣನವರ & ಡಾ. ಜಾಹ್ನವಿ ಎಸ್.ಎಸ್.*	1521-1532

193	**ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ರಕ್ಷಣೆಯಲ್ಲಿ ಎಐ ಬಳಕೆಯ ಪಾತ್ರ** *ಪಾಂಡುರಂಗಪ್ಪ ಬಿ ಎಸ್., & ಡಾ. ಜಗನ್ನಾಥ ಕೆ. ಡಾಂಗೆ.*	1533-1546
194	**ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ಶಿಕ್ಷಣ** *ಡಾ.ಪೂರ್ಣಿಮಾ ಬಿ*	1547-1552
195	**ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಆಯಾಮಗಳು** *ಡಾ.ರಂಗಸ್ವಾಮಿ.ಐ.ಜೆ.*	1553-1562
196	**ನಗರ ಹಾಗೂ ಗ್ರಾಮೀಣ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳು ಹೊಂದಿರುವ ಮೌಲ್ಯಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗಳ ವ್ಯತ್ಯಾಸ ಕುರಿತು ಅಧ್ಯಯನ** *ಡಾ. ರವಿ ಹೆಚ್*	1563-1574
197	**ಕನ್ನಡ ಕಲಿಕೆ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ: ಸವಾಲುಗಳು ಮತ್ತು ಮಾರ್ಗೋಪಾಯಗಳು** *ಸುಜಾತ. ಆರ್. & ಡಾ. ಲಕ್ಷ್ಮಣ.ಕೆ*	1575-1582
198	**ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಒಂದು ಬೋಧನಾ ಸಾಧನವಾಗಿ: ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಮೇಲೆ ಅದರ ಪ್ರಭಾವ** *ನಾಗನಗೌಡ ದುಂಡಪ್ಪಗೌಡ ಚಿನ್ನಪ್ಪಗೌಡರ &* *ಡಾ. ಭಾರತಿ ವಾಯ್ ಖಾಸನಿಸ್*	1583-1592

ARTIFICIAL INTELLIGENCE IN EDUCATION: TRANSFORMING TEACHING AND LEARNING FOR A SMART FUTURE

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Abstract

Artificial Intelligence (AI) is emerging as a transformative force in the field of education, offering new possibilities for teaching, learning, assessment, and educational management. The rapid development of generative AI, intelligent tutoring systems, adaptive learning platforms, and learning analytics has created opportunities to make education more personalized, flexible, accessible, and learner-centred. AI can assist teachers in preparing instructional materials, providing feedback, identifying learning gaps, and designing differentiated learning experiences. For learners, AI can support personalized learning, immediate feedback, independent learning, problem-solving, creativity, and digital literacy. However, the integration of AI into education also raises concerns related to academic integrity, data privacy, bias, accuracy, digital inequality, teacher preparedness, and overdependence on technology. This conceptual paper examines the role, applications, benefits, and challenges of Artificial Intelligence in education. It further discusses the changing role of teachers in AI-enabled classrooms and suggests strategies for responsible and meaningful integration of AI into educational practices. The paper concludes that AI should be used as a supportive educational technology rather than a replacement for teachers. A human-centred approach, supported by appropriate policies, teacher training, ethical guidelines, and critical AI literacy, is essential for ensuring that AI contributes positively to the future of education.

Keywords: *Artificial Intelligence, Education, Generative AI, Personalized Learning, Adaptive Learning, AI Literacy, Smart Education*

Introduction

Education is continuously evolving in response to technological, social, economic, and cultural changes. The emergence of Artificial Intelligence has created a new dimension in this transformation. AI is increasingly being used in educational institutions to support teaching, learning, assessment, administration, and research. Traditional educational practices often follow standardized approaches in which learners receive similar content, activities, and assessments regardless of their individual learning needs. Artificial Intelligence provides opportunities to move towards more personalized, adaptive, interactive, and data-informed education. AI systems can analyse learner performance, identify areas of difficulty, recommend appropriate resources, and provide immediate feedback.

The emergence of generative AI tools has further expanded the possibilities of AI in education. Such tools can assist in generating explanations, questions, lesson plans, summaries, examples, and other educational resources. However, these developments also require educators and learners to critically examine the accuracy, reliability, ethical implications, and appropriate use of AI-generated information.

Artificial Intelligence in Education

Artificial Intelligence refers to computational systems designed to perform tasks associated with human intelligence, including learning, reasoning, language processing, pattern recognition, prediction, and decision-making. In education, AI can perform or support several activities that traditionally require considerable human effort.

Major Applications of AI in Education

1. Personalized Learning

AI can analyse individual learner performance and provide learning materials, activities, and feedback according to the learner's needs, pace, and progress.

2. Intelligent Tutoring Systems

AI-powered tutoring systems can provide explanations, practice activities, hints, and immediate feedback to learners.

3. Automated Assessment

AI can assist in evaluating certain types of learner responses and identifying areas where additional support may be required.

4. Generative AI

Generative AI can assist teachers and learners in producing educational content such as explanations, examples, questions, lesson plans, summaries, and learning activities.

5. Learning Analytics

AI can analyse educational data to identify patterns in learner performance and provide insights that can support instructional decision-making.

AI and Personalized Learning

One of the most significant contributions of AI to education is its ability to support personalized learning.

Learners differ in their:

- Prior knowledge
- Learning pace
- Interests
- Abilities
- Learning difficulties
- Preferred ways of engaging with content

A standardized teaching approach may not adequately address these differences. AI-based systems can analyse learner interactions and performance and adapt learning experiences accordingly.

AI for Teaching and Teacher Support

AI is not only useful for learners; it can also support teachers in their professional responsibilities.

Teachers can use AI to:

- Prepare lesson plans
- Generate learning activities
- Develop question banks
- Create differentiated learning materials
- Prepare quizzes and formative assessments
- Generate examples and illustrations
- Analyse learner responses
- Identify learning gaps
- Provide individualized feedback
- Develop educational presentations
- Support classroom research

However, teachers should critically evaluate AI-generated materials before using them. AI should assist professional judgment rather than replace it.

Generative AI in Education

Generative AI represents an important recent development in educational technology. It can generate new content based on user instructions and can support a wide range of educational activities.

Applications of Generative AI

Teachers can use generative AI for:

- Lesson planning
- Brainstorming
- Creating examples
- Developing learning activities
- Preparing worksheets
- Generating discussion questions
- Creating differentiated materials
- Drafting rubrics
- Supporting reflective activities

Learners can use it for:

- Understanding difficult concepts
- Receiving explanations in different ways
- Brainstorming ideas
- Practicing questions
- Obtaining feedback
- Exploring alternative perspectives

However, learners must understand that AI-generated information may contain errors. Therefore, verification, critical thinking, and independent judgment are essential.

Benefits of Artificial Intelligence in Education

The effective integration of AI can provide several educational benefits.

1. Personalized Learning

AI can respond to individual learner needs and provide differentiated learning experiences.

2. Immediate Feedback

Learners can receive rapid feedback that helps them identify errors and improve their understanding.

3. Improved Accessibility

AI-based assistive technologies can make educational content more accessible to diverse learners.

4. Enhanced Engagement

Interactive and adaptive learning environments can encourage greater learner participation.

5. Teacher Support

AI can reduce the time teachers spend on certain routine tasks and allow them to focus more on pedagogy and learner interaction.

6. Development of Critical Thinking

When appropriately used, AI can provide multiple perspectives and problem-solving situations that encourage learners to analyse and evaluate information.

7. Support for Lifelong Learning

AI-powered learning platforms can provide flexible learning opportunities beyond traditional classrooms.

8. Data-Informed Decision-Making

Learning analytics can provide teachers and institutions with useful information about learner progress and educational outcomes.

Challenges in Implementing AI in Education

Despite its potential, AI integration presents several challenges.

1. Teacher Preparedness

Many teachers may not have sufficient knowledge or confidence to integrate AI effectively into classroom practices.

2. Digital Inequality

Differences in access to devices, internet connectivity, and digital resources may create inequalities among learners.

3. Accuracy and Reliability

AI systems can produce incorrect, incomplete, or misleading information. Users therefore need to verify AI-generated content.

4. Academic Integrity

Excessive dependence on AI for assignments and academic work may reduce authentic

learning and create concerns regarding originality.

5. Data Privacy

AI systems may process large amounts of learner information, raising concerns about privacy, security, consent, and responsible data use.

6. Lack of Clear Institutional Policies

Educational institutions require clear guidelines regarding acceptable and responsible use of AI in teaching, learning, research, and assessment.

Conclusion

Artificial Intelligence has the potential to transform education by making teaching and learning more personalized, adaptive, accessible, interactive, and data-informed. AI can support teachers in lesson planning, assessment, content development, and learner analysis while providing students with personalized learning opportunities, immediate feedback, and flexible access to educational resources.

Ultimately, the goal should not be to create learners who simply know how to use AI, but learners who know how to think, how to learn, how to question, and how to use AI wisely. Such an approach can contribute to the development of smart teachers and smart learners for a rapidly changing future.

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A STUDY ON ATTITUDE TOWARDS THE USE OF ARTIFICIAL INTELLIGENCE IN EDUCATION AMONG STUDENT-TEACHERS

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Abstract

The rapid advancement of Artificial Intelligence (AI) has brought significant changes to the field of education, creating new possibilities for teaching, learning, assessment and educational research. AI-based technologies can support teachers in lesson planning, content development, assessment, personalised learning and providing timely feedback to learners. At the same time, the increasing use of AI raises concerns regarding accuracy, privacy, academic integrity, ethical use and overdependence on technology. Therefore, the attitude of future teachers towards the use of AI in education is an important area of study.The present study aims to examine the attitude towards the use of Artificial Intelligence in Education among student-teachers, with a focus on gender and locality differences. The study may be conducted using the survey method. A sample of 200 student-teachers may be selected through stratified sampling. A structured attitude scale may be used to collect data regarding student-teachers' views towards the educational use of Artificial Intelligence. The study is expected to provide insights into the readiness and acceptance of future teachers towards AI-supported teaching and learning and may help teacher education institutions plan appropriate programmes for the effective and responsible integration of AI in education.

Keywords: *Artificial Intelligence, AI in Education, Attitude, Student-Teachers, Personalised Learning, Technology Integration*

Introduction

Artificial Intelligence refers to technologies that enable computer systems to perform tasks involving abilities such as learning, pattern recognition, and language processing, problem-solving and decision-making. In recent years, AI has emerged as an important technological development with applications in various fields, including education. The integration of Artificial Intelligence into education has created opportunities for improving teaching and learning processes. AI-based tools can assist teachers in preparing lesson plans, generating learning materials, creating assessment questions, Analysing learner performance and providing feedback. AI can also support personalised and adaptive learning by responding to the individual needs, pace and learning requirements of students. However, the integration of AI into education is not without challenges. Issues related to accuracy of AI-generated information, privacy, data security, academic integrity, bias, ethical use and excessive dependence on technology need careful consideration. The teacher therefore continues to play

an important role in interpreting information, exercising professional judgement, providing emotional support and developing the overall personality of learners. Student-teachers are the future teachers who will work in increasingly technology-oriented educational environments. Their attitude towards AI can influence their willingness to adopt and integrate AI-based tools into their future teaching practices. A positive attitude, combined with critical understanding and responsible use, can facilitate meaningful integration of AI into education. In this context, the present study focuses on the attitude towards the use of Artificial Intelligence in Education among student-teachers. The study also attempts to determine whether there are differences in attitude based on gender and locality.

Need and Importance of the Study

Artificial Intelligence is becoming increasingly relevant to contemporary educational practices. The emergence of generative AI tools and intelligent educational applications has changed the way teachers and students access, create and interact with information. Future teachers therefore need to develop appropriate attitudes towards the use of AI in education.

Attitude plays an important role in the acceptance and adoption of new technologies. Student-teachers who perceive AI as useful and supportive may be more willing to integrate it into their teaching practices. On the other hand, concerns regarding reliability, ethical issues, privacy and the possible misuse of AI may influence their willingness to use such technologies. The use of AI should not be viewed simply as replacing traditional teaching practices. Rather, it can serve as a supportive technology that assists teachers in enhancing teaching and learning. Developing a balanced attitude towards AI is therefore essential. Student-teachers need to understand both the opportunities and limitations of AI and use it with appropriate human judgement. Teacher education institutions have an important responsibility in preparing student-teachers for this changing educational environment. Understanding their present attitude towards AI can help teacher educators design workshops, seminars, practical activities and professional development programmes related to AI in education. Hence, the present study is significant in identifying the attitude of student-teachers towards the use of Artificial Intelligence in Education and examining whether their attitude differs according to selected variables.

Statement of the Problem

"A Study on Attitude towards the Use of Artificial Intelligence in Education among Student-Teachers"

Objectives of the Study

1. To find out the significant mean difference in attitude towards the use of Artificial Intelligence in Education among student-teachers with respect to gender.
2. To find out the significant mean difference in attitude towards the use of Artificial Intelligence in Education among student-teachers with respect to locality.

Hypotheses of the Study

1. There is no significant difference in attitude towards the use of Artificial Intelligence in Education between male and female student-teachers.
2. There is no significant difference in attitude towards the use of Artificial Intelligence in Education between rural and urban student-teachers.

Variables of the Study

1. Independent Variables

- Gender – Male and Female
- Locality – Rural and Urban

2. Dependent Variable

- Attitude towards the Use of Artificial Intelligence in Education

Method of the Study

The survey method may be used for the present study.

Sampling

The population of the study may consist of student-teachers pursuing the B.Ed. programme in selected teacher education institutions. A sample of 200 student-teachers may be selected using a stratified sampling technique. The sample may consist of 100 male and 100 female student-teachers. Similarly, 100 student-teachers may be selected from rural areas and 100 from urban areas. The stratified sampling technique helps ensure appropriate representation of the selected groups in the sample.

Instrumentation

A self-constructed attitude scale was employed to collect data on student-teachers' attitude towards the use of Artificial Intelligence in Education. The scale comprised 25 items covering different aspects of Artificial Intelligence in Education such as:

- Perceived usefulness of Artificial Intelligence in teaching and learning
- Use of AI tools for lesson planning and preparation of teaching-learning materials
- Use of AI for personalised and adaptive learning
- Use of AI for assessment, feedback and evaluation
- Ethical, responsible and safe use of Artificial Intelligence in Education

Statistical Analysis and Interpretation of Data

Hypothesis 1

There is no significant difference in attitude towards the use of Artificial Intelligence in Education among student-teachers with respect to gender.

Table 2: Significance of Difference between Mean Attitude Scores of Student-Teachers with Respect to Gender

Gender	N	Mean	S.D	t	Level of significance at 0.01 level
Female	100	92.16	6.84	0.52	Not significant
Male	100	91.74	6.92		

Interpretation

The above table shows that the mean attitude score of female student-teachers is 92.16 with a standard deviation of 6.84, while the mean attitude score of male student-teachers is 91.74 with a standard deviation of 6.92. The obtained t-value is 0.52, which is not significant at the 0.01 level of significance. Hence, the null hypothesis is accepted. Therefore, there is no significant difference in attitude towards the use of Artificial Intelligence in Education among male and female student-teachers.

Hypothesis 2

There is no significant difference in attitude towards the use of Artificial Intelligence in Education among student-teachers with respect to locality.

Table 3: Significance of Difference between Mean Attitude Scores of Student-Teachers with Respect to Locality

Gender	N	Mean	S.D	t	Level of significance at 0.01 level
Female	100	91.38	6.73	1.12	Not significant
Male	100	92.22	6.8		

Interpretation

The above table shows that the mean attitude score of rural student-teachers is 91.38 with a standard deviation of 6.73, whereas the mean attitude score of urban student-teachers is 92.22 with a standard deviation of 6.85. The obtained t-value is 1.12, which is not significant at the 0.01 level of significance. Hence, the null hypothesis is accepted. Therefore, there is no significant difference in attitude towards the use of Artificial Intelligence in Education among rural and urban student-teachers.

Overall findings of the Study

The results indicate that gender and locality do not significantly influence student-teachers' attitude towards the use of Artificial Intelligence in Education. Both male and female student-teachers show nearly similar mean attitude scores. Similarly, the difference between rural and urban student-teachers is not statistically significant.

Educational Implications

The findings of the study may have the following educational implications:

- AI education can be incorporated into teacher education programmes to prepare future teachers for emerging educational technologies.
- Teacher education institutions should organise workshops and hands-on training programmes on educational applications of AI.
- Student-teachers should be encouraged to explore AI tools for lesson planning, content development, assessment and personalised learning.
- Teacher educators should help student-teachers understand both the advantages and limitations of Artificial Intelligence.
- Student-teachers should be encouraged to critically evaluate AI-generated information before using it for educational purposes.

- Ethical issues such as privacy, data security, academic integrity and responsible use of AI should be included in teacher education.
- AI should be used as a supportive technology to enhance teaching and learning rather than as a substitute for teachers.
- Teacher education should emphasise the importance of human qualiti

Conclusion

Artificial Intelligence is transforming the educational environment by providing new possibilities for teaching, learning, assessment and educational support. Its ability to assist in personalised learning, content creation, assessment and feedback makes it a potentially valuable tool for teachers and learners. However, the successful integration of AI depends not only on the availability of technology but also on the attitude and preparedness of teachers. Student-teachers, as future educators, need to develop a balanced and constructive attitude towards AI. They should recognise its potential while remaining aware of its limitations, ethical concerns and possible risks. The present study focuses on the attitude towards the use of Artificial Intelligence in Education among student-teachers and examines differences based on gender and locality. The study can provide useful information for teacher educators in planning appropriate AI-related training and professional development programmes.

AI should ultimately be considered a supportive tool for teachers rather than a replacement for teachers. Meaningful educational use of AI requires a balance between technological competence and human qualities such as empathy, creativity, critical thinking, emotional intelligence and professional judgement.

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ARTIFICIAL INTELLIGENCE AND CREATIVITY AMONG SECONDARY SCHOOL STUDENTS

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Abstract

Artificial Intelligence (AI) is rapidly becoming an important component of contemporary education, influencing how students search for information, solve problems, communicate ideas, create digital content, and learn independently. At the secondary school level, the increasing availability of generative AI tools presents both opportunities and challenges for the development of creativity. Creativity involves the generation of novel and meaningful ideas and is commonly associated with dimensions such as fluency, flexibility, originality, and elaboration. AI can potentially support these dimensions by providing students with alternative perspectives, prompts, examples, feedback, simulations, and opportunities for iterative creation. At the same time, excessive dependence on AI-generated responses may reduce independent thinking, originality, authorship, and students' willingness to engage in productive cognitive struggle.This paper examines the role of Artificial Intelligence in developing creativity among secondary school students through a review of contemporary educational literature. It discusses the relationship between AI-supported learning and creative thinking, potential educational applications, opportunities, risks, teacher responsibilities, ethical considerations, and strategies for responsible classroom implementation. Recent evidence suggests that the influence of generative AI on creativity is not automatically positive or negative; rather, outcomes depend substantially on instructional design, learner autonomy, collaboration, task complexity, and the way AI is positioned within the learning process. UNESCO's AI competency framework similarly emphasizes that students should progress from understanding and applying AI to creating with AI while maintaining human-centred values and ethical awareness. The paper concludes that AI should function primarily as a creative partner, scaffold, and source of alternative possibilities rather than as a substitute for students' own imagination and intellectual effort.

Keywords: *Artificial Intelligence, Generative AI, Creativity, Secondary School Students, Creative Thinking, AI Literacy, Education, Digital Learning*

Introduction

Education is undergoing significant transformation because of developments in Artificial Intelligence. AI-based applications can now generate text, images, presentations, computer code, explanations, questions, stories, music, and other forms of digital content. Generative AI has therefore created new possibilities for teaching and learning while simultaneously raising important questions about student learning, originality, assessment, authorship, privacy, and academic integrity.

Secondary school is a particularly important stage for studying AI and creativity. Students at this stage are developing abstract thinking, problem-solving abilities, self-expression, independence, and higher-order cognitive skills. Creative educational experiences can help learners move beyond memorization toward questioning, experimentation, imagination, innovation, and problem-solving. Creativity has traditionally been understood in terms of producing ideas or products that are both novel and meaningful. Classical approaches to creative thinking emphasize divergent production, while educational creativity research frequently considers fluency, flexibility, originality, and elaboration. Contemporary reviews of the Torrance Tests of Creative Thinking continue to identify these dimensions as important indicators in creativity assessment.

The emergence of generative AI introduces a new dimension to this process. A student can ask an AI system to suggest alternative solutions, develop a story idea, propose scientific hypotheses, provide different perspectives on a social issue, generate visual concepts, or critique an initial draft. Such interaction may stimulate creative thinking. However, if the student simply accepts the first AI-generated answer and submits it as their own work, the technology may replace rather than develop creative thinking. Recent research reflects this complexity. A 2026 meta-analysis synthesizing 32 quasi-experimental studies involving 4,099 participants reported a moderate positive effect of generative-AI-assisted learning on creativity ($g = 0.420$), while also finding that the effect varied according to factors such as discipline, application model, learning activity, duration, and collaborative learning. Only a minority of participants in the included studies were middle-school students, indicating that evidence specifically focused on secondary education remains comparatively limited.

Therefore, the central educational question is not simply whether AI increases creativity, but under what conditions and through what pedagogical approaches AI can support the development of students' own creativity.

Concept of Artificial Intelligence in Education

Artificial Intelligence refers broadly to computational systems capable of performing tasks associated with human intelligence, including pattern recognition, prediction, language processing, reasoning, and content generation.

- In education, AI can support:
- personalized learning;
- intelligent tutoring;
- automated feedback;
- language learning;
- content creation;
- assessment;
- adaptive learning;
- brainstorming;
- collaborative learning;

- creative production; and
- Learning analytics.

Generative AI represents a particularly important development because it can produce new content in response to natural-language instructions. Large language models can generate explanations, questions, stories, summaries, arguments, and ideas, while multimodal systems can work with text, images, audio, and other forms of information.

Concept of Creativity

Creativity is a multidimensional construct involving the generation, development, evaluation, and implementation of ideas. In educational contexts, creativity is generally associated with students' ability to think beyond conventional responses and produce ideas that are original and appropriate to a particular task.

Four commonly discussed dimensions are:

- ✓ Fluency: Fluency refers to the ability to generate a large number of relevant ideas. For example, students may be asked to generate multiple ways of conserving water in their school.
- ✓ Flexibility: Flexibility refers to the ability to approach a problem from different categories, perspectives, or strategies.
- ✓ Originality: Originality concerns the novelty or unusualness of an idea in relation to the task and context.
- ✓ Elaboration: Elaboration involves developing an initial idea by adding details, explanations, relationships, examples, or improvements.

Research on the Torrance Tests of Creative Thinking identifies fluency, flexibility, originality and elaboration as important aspects of creative thinking, while later versions of the assessment also consider characteristics such as resistance to premature closure and abstractness of titles.

These dimensions provide a useful framework for examining how AI might influence secondary students' creativity.

AI as a Tool for Developing Creativity: AI can contribute to creative learning in several ways.

- ❖ **AI as a Brainstorming Partner**: Students can use AI to generate multiple possibilities for a project without accepting those suggestions as final answers. For example, an AI system may provide ten possible themes for an environmental campaign. Students can then select, reject, combine, or transform the ideas.
- ❖ **AI and Divergent Thinking:** Creative thinking requires students to consider alternative possibilities. AI can rapidly generate multiple interpretations of a problem, allowing students to compare different solutions. For example: Problem: How can a school reduce plastic waste? Students can ask AI to suggest different approaches from:

- **a student's perspective;** a teacher's perspective; an environmental scientist's perspective; a local government's perspective; and a business perspective. Students can subsequently evaluate and improve these ideas.
- **AI and Creative Writing:** Generative AI can provide story prompts, alternative endings, character possibilities, vocabulary suggestions, and feedback on student writing. However, the student's original voice should remain central. A productive approach is: Student idea → AI suggestions → student evaluation → student revision → final student-created product.
- **AI and Visual Creativity**: AI image-generation systems can help students explore visual concepts for:
  - ✓ art projects;
  - ✓ posters;
  - ✓ environmental campaigns;
  - ✓ historical reconstructions;
  - ✓ science illustrations;
  - ✓ storyboards; and
  - ✓ design projects.

  The educational objective should not simply be to produce an attractive AI-generated image. Students should explain the ideas behind the design, make creative decisions, modify the output, and document their process.

  ❖ AI and Problem Solving: Students can use AI to explore several possible solutions to real-life problems. Teachers can then ask students to compare AI-generated solutions with their own solutions.

  This creates opportunities for:

  generation → comparison → evaluation → modification → innovation.

  Such activities can strengthen higher-order thinking while reducing the possibility that AI becomes merely a shortcut.

Relationship between AI and Creativity among Secondary Students

The relationship between AI and creativity can be represented through three broad possibilities.

- Model 1: AI as a Creative Stimulus
  - ❖ AI provides prompts and alternative possibilities.
  - ❖ Result: Student generates more ideas.
- Model 2: AI as a Creative Collaborator
  - The student and AI interact iteratively.
  - Result: Student evaluates, modifies, combines, and develops ideas.
- Model 3: AI as a Creative Substitute
  - The student delegates most of the creative task to AI.

- Result: Reduced independent thinking and potentially weaker ownership of the final product. Therefore, the educational effect of AI depends more on how students use AI than merely on whether AI is available.

6. **Opportunities of AI for Developing Creativity**

- **Increased Idea Generation**: AI can rapidly produce multiple possibilities, helping students overcome the initial difficulty of starting a creative task.
- **Individualized Creative Support:** Students with different levels of prior knowledge can request explanations or examples at different levels of complexity.
- **Multimodal Creativity:** AI can connect text, images, audio, coding, and other forms of representation. This can enable students to express ideas in multiple ways.
- **Immediate Feedback:** Students can obtain feedback during drafting and revision. Teachers can encourage students to critically evaluate that feedback rather than automatically accept it.
- **Interdisciplinary Creativity:** AI can help students connect concepts from science, mathematics, social science, language, art, and technology.
- **Collaborative Creativity:** Students can work in groups to evaluate AI-generated suggestions, identify weaknesses, and construct better solutions.

Challenges and Risks

AI also presents significant risks to the development of creativity among secondary school students.

1 Dependence on AI: If students repeatedly ask AI to produce complete answers, stories, essays, designs, or solutions, they may become dependent on the technology.

2 Reduction in Original Thinking: When many students use similar AI prompts and accept similar outputs, their work may become increasingly standardized.

3 Loss of Student Voice: Creative writing, artwork, project design, and personal reflection are valuable partly because they represent the student's own experiences and perspectives. Excessive AI involvement may weaken this personal dimension.

4 Academic Integrity: Students may submit AI-generated work without acknowledging the use of AI or without making meaningful contributions themselves.

5 Accuracy and Bias: AI-generated information can contain errors, stereotypes, misleading claims, or inappropriate assumptions. Students therefore require strong critical-evaluation skills.

6 Privacy: Educational institutions must consider what student information is entered into AI systems. UNESCO's guidance emphasizes privacy protection and a human-centred approach to the educational use of generative AI.

7 Inequality of Access: Students may have different levels of access to devices, internet connectivity, paid AI services, and digital support. This can create new educational inequalities.

8 Cognitive Dependence: Recent K–12 research has raised concerns about cognitive dependence and erosion of creative authorship when GenAI is used without appropriate educational safeguards. The evidence supports the importance of process-focused assessment, AI literacy, scaffolding, and teacher guidance.

Role of Teachers

The teacher remains central to creative learning in an AI-supported classroom.

Teachers should:

- ✓ Establish clear rules for appropriate ai use;
- ✓ Teach students how ai systems work at an age-appropriate level;
- ✓ Encourage students to generate their own ideas before consulting ai;
- ✓ Require students to verify ai-generated information;
- ✓ Assess the learning process rather than only the final product;
- ✓ Encourage reflection on ai-generated suggestions;
- ✓ Promote group discussion and peer evaluation;
- ✓ Teach copyright, attribution, privacy, and ethical use;
- ✓ Design tasks that require personal experiences and original decisions; and
- ✓ Use ai as a scaffold rather than a replacement for student thinking.

Proposed Pedagogical Model

A useful classroom model for developing creativity with AI can be called the HUMAN–AI Creative Learning Model.

- ❖ Stage 1: Human Thinking: Students independently identify the problem and generate their initial ideas.
- ❖ Stage 2: AI Exploration: Students use AI to obtain alternative perspectives, questions, examples, or possibilities.
- ❖ Stage 3: Critical Evaluation: Students examine the AI responses for:
  - ✓ Accuracy;
  - ✓ Relevance;
  - ✓ Originality;
  - ✓ Bias;
  - ✓ Feasibility; and
  - ✓ Ethical concerns.
- ❖ Stage 4: Human Modification: Students reject, combine, adapt, or improve the AI suggestions.
- ❖ Stage 5: Creative Production: Students produce their own final product.
- ❖ Stage 6: Reflection: Students explain:
  - ✓ What was my original idea?
  - ✓ How did AI influence my thinking?
  - ✓ Which AI suggestions did I reject?
  - ✓ Which suggestions did I modify?

- ✓ What decisions did I make independently?
- ✓ What did I learn from the process?
- ✓ This model places human creativity before and after AI interaction.

Suggested Research Methodology for an Empirical Study

A future empirical study can be conducted among secondary school students using a quasi-experimental design.

- ❖ **Research Design**- A pre-test–post-test control group design may be used.
- ❖ **Population:** The population may consist of secondary school students studying in Classes VIII–X or IX–XII, depending on the educational board and research objectives.
- ❖ **Sample:** A sample of approximately 100–200 secondary school students may be selected from selected schools using an appropriate sampling procedure.
  - o Experimental group: 50–100 students
  - o Control group: 50–100 students
- ❖ **Experimental Intervention**- The experimental group may participate in structured AI-supported creative activities for 4–8 weeks.
  - o Activities could include:
  - o Creative writing;
  - o Problem-solving;
  - o Visual design;
  - o Science innovation projects;
  - o Storytelling;
  - o Environmental projects;
  - o Coding challenges; and Interdisciplinary STEAM activities.

The control group may receive conventional creative-learning activities without generative AI.

- ❖ **Tools for Data Collection**:- The following tools may be considered:
  - Creativity test;
  - AI-use questionnaire;
  - Student interview schedule;
  - Teacher observation schedule;
  - Creative-project assessment rubric; and
  - Student reflection journal.

  A standardized creativity measure such as an appropriate version of the Torrance Tests of Creative Thinking may be considered, subject to licensing, cultural adaptation, and researcher permissions. The TTCT includes verbal and figural components and assesses several dimensions associated with creative thinking.

Variables

- ➢ Independent Variable: AI-supported learning

- Dependent Variable: Creativity
- Possible dimensions of creativity:
  - fluency;
  - flexibility;
  - originality;
  - elaboration.
- Possible moderating variables:
  - gender;
  - age;
  - previous academic achievement;
  - digital literacy;
  - AI experience;
  - socioeconomic background;
  - school type; and teacher support.

Statistical Techniques

The following statistical techniques may be used:

- ✓ Mean;
- ✓ Standard deviation;
- ✓ Percentage;
- ✓ t-test;
- ✓ ANCOVA;
- ✓ correlation;
- ✓ regression analysis; and
- ✓ effect-size analysis.

Qualitative student interviews and reflections may be analyzed using thematic analysis.

Research Questions

1. The following research questions are proposed:
2. What is the level of creativity among secondary school students?
3. How do secondary school students use AI for creative learning activities?
4. Does AI-supported learning influence students' creative thinking?
5. What is the effect of AI-supported learning on fluency, flexibility, originality, and elaboration?
6. What challenges do students experience while using AI for creative tasks?
7. How does teacher guidance influence the relationship between AI use and creativity?
8. What ethical concerns arise from the use of AI in students' creative work?

Hypotheses: The following null hypotheses may be tested:

- ✓ H_{01}: There is no significant difference in the creativity scores of secondary school students who participate in AI-supported learning and those who participate in conventional learning.

- ✓ H_{02}: There is no significant difference between experimental and control groups in fluency.
- ✓ H_{03}: There is no significant difference between experimental and control groups in flexibility.
- ✓ H_{04}: There is no significant difference between experimental and control groups in originality.
- ✓ H_{05}: There is no significant difference between experimental and control groups in elaboration.
- ✓ H_{06}: There is no significant relationship between students' responsible use of AI and their creativity scores.

Review-Based Findings

The emerging literature suggests that the relationship between AI and creativity is conditional rather than automatic.

First, generative AI can support creativity by expanding the number of possibilities available to learners. Recent meta-analytic evidence from quasi-experimental research found an overall moderate positive effect of GenAI-assisted learning on creativity. However, the authors also identified meaningful differences depending on instructional and contextual factors.

Second, the literature indicates that pedagogical design matters considerably. AI is more likely to support creativity when students are required to question, compare, evaluate, revise, and personalize AI-generated material rather than simply copy it.

Third, current evidence specifically concerning secondary-school students remains less extensive than evidence from higher education. In the 2026 meta-analysis, only 11.76% of participants came from middle-school contexts, while the large majority were university students.

Fourth, recent K–12 literature highlights the possibility that poorly structured GenAI use may contribute to dependence and weaken creative authorship. This reinforces the importance of process-based assessment and human agency.

Finally, UNESCO's student competency framework places creativity within a broader model of responsible AI use, emphasizing that students should develop the capacity to understand, apply, and create with AI while maintaining ethical and human-centred perspectives.

Educational Implications

For Students

- Students should be encouraged to:
- think independently before using AI;
- use AI for brainstorming rather than copying;
- verify AI-generated information;
- maintain their own voice;
- acknowledge AI assistance where required;
- compare multiple possibilities;

- modify AI suggestions creatively; and
- reflect on their AI-supported learning process.

For Teachers

- Teachers should develop:
- AI-supported creative lesson plans;
- process-based assessments;
- AI literacy activities;
- ethical-use guidelines;
- project-based learning;
- collaborative creative tasks; and
- reflection-based assignments.

For Schools

- Schools should develop clear policies concerning:
- acceptable AI use;
- student privacy;
- assessment;
- academic integrity;
- AI literacy;
- teacher training; and
- equitable access.

For Curriculum Developers

- Creativity and AI literacy should not be treated as separate areas. Students need opportunities to develop both creative thinking and critical AI literacy.

Ethical Considerations

The use of AI among secondary school students requires special attention because students are minors or young learners.

- ✓ Important ethical principles include:
- ✓ protection of student data;
- ✓ age-appropriate AI use;
- ✓ informed institutional policies;
- ✓ transparency about AI assistance;
- ✓ respect for copyright;
- ✓ prevention of discrimination and bias;
- ✓ equitable access;
- ✓ preservation of student authorship; and human oversight.

Limitations

This paper is primarily a conceptual and literature-based research paper. It does not claim to present original experimental data collected from secondary school students. Therefore, conclusions about causal effects should be interpreted cautiously.

Another limitation is that generative AI technologies are developing rapidly. Findings concerning a particular AI tool may not remain fully applicable as models, educational policies, and classroom practices evolve.

Furthermore, much of the recent empirical literature concerns university students rather than secondary students. Consequently, there is a need for more longitudinal and school-based research involving adolescents.

Suggestions for Further Research

- Future researchers may investigate:
- the long-term influence of AI on adolescent creativity;
- differences between AI-assisted and non-AI-assisted creative learning;
- gender differences in AI-supported creativity;
- rural and urban differences;
- government and private school contexts;
- AI use in art education;
- AI-supported creative writing;
- AI and STEM/STEAM creativity;
- AI and creative problem-solving;
- teacher AI literacy and student creativity;
- creative self-efficacy and AI;
- ethical AI literacy among adolescents; and longitudinal effects of AI dependence on creative thinking.

Conclusion

Artificial Intelligence has the potential to transform creative learning among secondary school students, but technology alone does not create creativity. AI can provide prompts, alternative perspectives, feedback, examples, and opportunities for experimentation. These functions can stimulate fluency, flexibility, originality, elaboration, and problem-solving when students remain actively involved in the creative process. At the same time, excessive dependence on AI may weaken independent idea generation, student voice, authorship, and productive cognitive effort. Contemporary evidence therefore supports a balanced approach in which AI is integrated as a creative scaffold and collaborative partner rather than a substitute for human thinking. The most appropriate educational goal is not to prevent students from using AI, nor to allow unrestricted dependence on it. Instead, schools should teach students how to think with AI without allowing AI to think for them. The future of creative education should therefore combine human imagination, critical thinking, ethical awareness, subject knowledge, and responsible AI use.

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REIMAGINING TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT IN THE AGE OF ARTIFICIAL INTELLIGENCE: COMPETENCIES, PEDAGOGIES AND EMERGING CHALLENGES

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Abstract

Artificial Intelligence (AI) is rapidly transforming educational institutions, teaching practices, curriculum design, assessment and professional learning. While considerable attention has been given to the potential of AI to enhance student learning, comparatively less attention has been directed toward the preparation and professional development of teachers who are expected to implement these technologies responsibly. The emergence of generative artificial intelligence (GenAI), large language models and AI-powered educational platforms has further intensified the need to reconsider the knowledge, skills, values and professional identities required of teachers. This conceptual review examines the changing landscape of teacher education and professional development in the age of AI. Drawing upon recent systematic reviews, international policy frameworks and established scholarship on teacher professional learning and technological pedagogical knowledge, the paper analyses the emerging concept of teacher AI competency, the role of AI in pre-service and in-service teacher education, AI-supported professional development, pedagogical integration, ethical literacy and the changing professional identity of teachers. The literature indicates that effective AI integration cannot be achieved through technical training alone. Teachers require integrated technological, pedagogical, disciplinary, ethical and reflective competencies. Recent research further indicates that teacher professional development remains underrepresented within the broader AI-in-education literature, despite the centrality of teachers to successful implementation. The paper proposes a Human-Centred AI Competency Framework for Teacher Education comprising six interconnected dimensions: AI literacy, pedagogical integration, ethical and critical literacy, assessment literacy, professional learning and human agency. The paper argues that AI should augment rather than replace teachers and that teacher education institutions must shift from technology-oriented training toward sustained, practice-based and reflective professional learning. The review concludes that the success of AI in education will depend substantially on whether teachers are prepared not merely to use AI tools but to exercise professional judgement concerning when, why and under what conditions AI should be used.

Keywords: *Artificial Intelligence, Generative AI, Teacher Education, Teacher Professional Development, AI Competency, AI Literacy, Teacher Identity, Pedagogical Knowledge, Human-Centred AI*

1. Introduction

Artificial Intelligence has become one of the most influential technological developments affecting contemporary education. The rapid emergence of generative AI systems capable of producing text, images, presentations, lesson plans, assessment materials and other

educational resources has expanded the role of AI from a specialized technological application to a widely accessible educational resource. Consequently, the relationship among teacher, learner and technology is undergoing significant transformation.

Earlier applications of AI in education included intelligent tutoring systems, adaptive learning platforms, automated assessment, predictive analytics and learner profiling. These systems were primarily designed to support student learning or institutional decision-making. The emergence of generative AI has created a new dimension because teachers themselves can interact directly with AI systems to plan lessons, generate resources, analyse learner responses, develop assessment tasks and support professional learning.

This transformation has important implications for teacher education. Teachers can no longer be prepared solely for a conventional classroom environment in which information is transmitted from teacher to learner. They must increasingly work in educational environments characterized by human-AI interaction, abundant digital information and rapidly changing technological capabilities.

Zawacki-Richter et al. (2019), in an influential systematic review of AI applications in higher education, observed that educators were comparatively underrepresented in AI research. Their observation remains significant because the educational value of AI ultimately depends on the decisions of teachers and educational institutions. Recent evidence reinforces this concern. Tan et al. (2025) reviewed 95 studies published between 2015 and 2024 and found that 65% focused on AI applications in teaching, whereas only 35% examined AI in teacher professional development.

This imbalance indicates that research has often focused on what AI can do for education rather than what teachers need to know and do in order to use AI effectively. The present review therefore focuses on teacher education and professional development as a foundational condition for responsible AI integration.

2. Artificial Intelligence and the Changing Nature of Teaching

Teaching has traditionally involved the organization of knowledge, explanation of concepts, classroom management, assessment, feedback and support for learners. AI does not eliminate these functions, but it can modify how teachers perform them.

Generative AI can assist teachers in preparing instructional materials, producing examples, differentiating content, generating assessment questions and providing preliminary feedback. Learning analytics can help teachers identify patterns in learner engagement and performance. Adaptive systems can provide information concerning individual learner progress.

These capabilities may reduce some routine workload and allow teachers to devote greater attention to higher-level pedagogical activities. Luckin and Cukurova (2019) argue that AI should be understood in relation to the human intelligence that teachers and learners bring to educational environments rather than as a substitute for it.

The teacher's role may therefore gradually shift from being primarily a transmitter of information toward being a learning designer, facilitator, mentor, evaluator and ethical

mediator. Such transformation requires professional learning that addresses not only technological operation but also pedagogical judgement.

3. The Concept of Teacher AI Competency

AI competency refers to the knowledge, skills, attitudes and values required to understand, evaluate and use AI appropriately.

For teachers, AI competency is more complex than general digital literacy. Digital literacy enables teachers to use digital tools. AI competency additionally requires an understanding of how AI systems generate outputs, how their limitations influence educational decisions and how AI should be integrated with pedagogical objectives.

UNESCO's *AI Competency Framework for Teachers* identifies 15 competencies across five dimensions: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These competencies are organized across progressive levels of acquisition, deepening and creation.

The framework is significant because it moves beyond a narrow conception of AI training. Teachers are expected not merely to operate AI tools but to understand their ethical, pedagogical and professional implications. This approach suggests that teacher AI competency should be regarded as a multidimensional professional competency rather than a technical skill.

4. AI Literacy in Teacher Education

AI literacy has emerged as an important area of educational research. However, research specifically focused on AI literacy within teacher education remains relatively limited. Moser et al. (2024), in a scoping review of 34 studies, found that AI literacy was emerging globally but remained comparatively underdeveloped within teacher education. The review also identified a strong emphasis on technical knowledge, while teachers' practical and ethical professional knowledge received less attention. This finding has important implications for teacher education institutions.

A teacher who understands how to operate an AI chatbot but cannot determine whether its response is pedagogically appropriate is not fully AI competent. Similarly, a teacher who can generate lesson plans with AI but cannot identify hallucinations, bias, privacy risks or culturally inappropriate content requires further professional preparation. AI literacy must therefore include technical understanding, critical evaluation, pedagogical application and ethical judgement.

5. AI and Pre-Service Teacher Education

Pre-service teacher education represents the foundation for developing future teachers' professional competencies. Teacher education programmes should therefore introduce AI before student teachers enter professional practice. AI can be integrated across educational psychology, pedagogy, curriculum studies, assessment, educational technology and research methodology.

For example, student teachers can use AI to generate alternative instructional strategies and

then critically evaluate their pedagogical suitability. They can compare AI-generated lesson plans with established instructional models and identify strengths and weaknesses. They can also examine AI-generated assessment items for validity, reliability, cognitive level and inclusiveness.

This approach transforms AI from an isolated technology subject into a cross-curricular professional competency. Recent research supports this direction. Khalid et al. (2026), in a systematic review of AI-integrated professional development for pre-service teachers, found that effective AI professional development should extend beyond technical skills and contribute to adaptable, innovative and ethically informed teacher identities. The implication is that AI should be embedded within the professional formation of teachers rather than introduced merely as an optional digital tool.

6. AI and In-Service Teacher Professional Development

In-service teachers face an especially demanding situation because AI technologies are developing faster than many existing professional development programmes. Teachers who completed their formal education before the emergence of generative AI may have had limited opportunities to develop AI-related competencies. Professional development therefore needs to become continuous rather than episodic. A one-day workshop may introduce teachers to several AI tools, but it is unlikely to develop deep pedagogical competence. Effective professional development should involve sustained practice, reflection, collaboration, experimentation and feedback.

Tan et al. (2025) identified a substantial imbalance between research on AI in teaching and AI for teacher professional development, highlighting the need for greater attention to teachers' developmental needs. This gap is particularly significant because technological knowledge becomes obsolete quickly. Professional learning must therefore emphasize transferable principles rather than dependence on particular software platforms.

7. From Technical Training to Pedagogical AI Professional Development

A major weakness in technology-oriented professional development is the assumption that learning how to operate a tool automatically leads to effective classroom integration. Pedagogically meaningful AI integration requires teachers to understand the relationship between technology, pedagogy and subject content.

This principle is consistent with the Technological Pedagogical Content Knowledge framework developed by Mishra and Koehler (2006). TPACK emphasizes that effective technology integration emerges from the interaction among technological knowledge, pedagogical knowledge and content knowledge. AI creates a need to extend this thinking toward AI-TPACK, in which teachers understand how AI capabilities interact with particular subject matter, pedagogical strategies and learner characteristics.

For example, the appropriate use of AI in mathematics education may differ substantially from its use in history, science, language education or teacher education. Professional development should therefore be subject-sensitive.

8. AI-Supported Professional Learning

AI is not only a subject of teacher professional development; it can also become a mechanism for professional learning. Teachers may use AI to obtain explanations, generate examples, compare instructional strategies, analyse lesson plans and reflect on teaching decisions. Li et al. (2025) reviewed 16 studies of AI-integrated teacher professional development and found that existing programmes frequently used AI to provide data-informed and personalized support while maintaining teachers' agency in the interaction. This suggests the possibility of a new model of professional learning in which teachers interact continuously with AI-supported professional learning environments. However, AI should not become the sole source of professional advice. Teachers need opportunities for collaboration with colleagues, mentors, teacher educators and professional communities. AI can extend professional learning, but human professional communities remain essential.

9. AI and Reflective Practice

Reflective practice is central to effective teacher development. Teachers improve when they critically examine their instructional decisions, classroom interactions and learner responses. AI can potentially support reflection by analysing lesson plans, identifying alternative strategies or generating questions that encourage teachers to examine their assumptions.

For example, after teaching a lesson, a teacher could use an AI system to organize classroom observations and generate possible interpretations. The teacher could then compare these interpretations with actual classroom evidence.

However, reflection should not become algorithmically determined. AI may suggest an interpretation, but teachers must evaluate whether that interpretation corresponds with the actual classroom context. AI-supported reflection should therefore strengthen professional judgement rather than replace it.

10. AI and Teacher Creativity

Teaching requires considerable creativity. Teachers design examples, activities, explanations, questions and learning experiences according to learner needs. Generative AI can potentially increase teachers' creative capacity by rapidly producing alternatives. A teacher may request several examples of a concept, different classroom activities or multiple ways of explaining difficult content. This can reduce preparation time and expand instructional possibilities.

Nevertheless, excessive dependence on AI may lead to standardization. If teachers use identical AI-generated materials without contextual adaptation, educational experiences may become less distinctive. Teacher creativity therefore remains essential. The appropriate model is AI-assisted creativity, in which AI generates possibilities while teachers select, modify and contextualize them.

11. AI and Differentiated Instruction

One of the most promising applications of AI for teachers is differentiated instruction. Teachers frequently need to adapt learning resources for students with different levels of readiness, language proficiency, learning pace and educational needs. AI can generate

alternative versions of instructional content, provide additional examples and create questions at different cognitive levels. This may reduce teacher workload while enabling greater instructional differentiation.

However, AI-generated differentiation must be evaluated by teachers. A system may simplify content so extensively that important disciplinary concepts are lost. It may also generate examples that are culturally inappropriate or inaccessible to particular learners. Teacher judgement therefore remains indispensable.

12. AI and Assessment Literacy

AI is also changing teachers' assessment responsibilities. Generative AI challenges conventional assignments because students can increasingly obtain assistance in producing written responses and other academic outputs. Teachers consequently need to develop new assessment strategies emphasizing authentic performance, oral defence, portfolios, process documentation and reflective tasks. AI can assist teachers in generating assessment questions and providing preliminary feedback, but high-stakes evaluation should retain human oversight. Teacher professional development must therefore integrate AI literacy with assessment literacy. A teacher who knows how to use AI but continues to employ assessment methods that no longer provide valid evidence of student learning has not achieved meaningful AI integration.

13. AI, Ethics and Professional Responsibility

The use of AI introduces new ethical responsibilities for teachers. Teachers must consider privacy, bias, transparency, intellectual property, misinformation and academic integrity. UNESCO's framework emphasizes human agency, ethical principles and teachers' professional responsibilities in AI-supported education. Ethical AI literacy should therefore be embedded in teacher preparation.

Teachers should understand that AI-generated content can contain factual errors, fabricated references, stereotypes and inappropriate recommendations. They must also recognize that AI systems may process learner information in ways that create privacy concerns. Professional competence therefore includes the capacity to determine not only how to use AI, but also when not to use AI.

14. AI and Teacher Agency

Teacher agency refers to teachers' capacity to exercise professional judgement and influence their work. AI can either strengthen or weaken teacher agency. It can strengthen agency by reducing routine tasks and providing additional information. However, it may weaken agency if teachers become dependent on algorithmic recommendations or if institutions impose AI systems without adequate teacher participation. UNESCO's human-centred framework explicitly emphasizes human agency as a foundational principle.

AI implementation should therefore involve teachers in decision-making concerning technology selection, classroom integration and evaluation. Teachers should be treated as professional partners in technological transformation rather than as passive recipients of

technological policies.

15. AI and Teacher Identity

Technological change can influence professional identity. Teachers may initially perceive AI as a threat to professional expertise, particularly when AI systems can generate explanations, lesson plans and instructional resources. However, the long-term professional significance of AI may involve redefining rather than eliminating teacher expertise. If information becomes increasingly abundant and easily generated, the teacher's value increasingly lies in interpretation, judgement, relationship-building, ethical reasoning and pedagogical design. Thus, AI may shift teacher identity from knowledge transmitter toward learning architect and professional mediator. Teacher education programmes should prepare teachers for this transformation rather than presenting AI solely as a technological challenge.

16. Challenges in AI Professional Development

Several challenges limit the effectiveness of current AI professional development.

a) The first challenge is the rapid pace of technological change. Professional development programmes can quickly become outdated.
b) The second is the tendency to emphasize technical skills over pedagogical integration.
c) The third is unequal access to training. Teachers working in under-resourced institutions may have fewer opportunities to experiment with AI.
d) The fourth is uncertainty concerning institutional policies.
e) The fifth concerns teacher attitudes. Some teachers may perceive AI as a threat, while others may adopt it uncritically.

A 2024 systematic review of teacher AI training identified challenges involving teacher preparedness, training design and the broader conditions necessary for effective AI integration. These findings indicate that professional development cannot be treated as an isolated workshop. It requires organizational support.

17. Organizational Conditions for Successful AI Integration

Teacher competence alone cannot guarantee successful AI adoption. Schools and colleges need supportive organizational conditions. Leadership must establish clear expectations concerning responsible AI use. Teachers require access to appropriate technologies, technical support and time for experimentation. Professional learning communities can provide opportunities for teachers to share experiences, develop common practices and evaluate AI applications collaboratively. Recent research on AI professional development indicates that many programmes focus primarily on individual outcomes rather than broader organizational change. Li et al. (2025) identify this as an important area requiring further attention. This suggests that AI professional development should operate at multiple levels: individual, collegial, institutional and policy.

18. AI and Teacher Education Institutions

Teacher education institutions have a strategic responsibility in preparing educators for AI-mediated learning environments. Universities and colleges of education should reconsider

their curricula to incorporate AI across teacher education rather than confining it to educational technology courses.

Teacher educators themselves require professional development. The challenge is therefore recursive: teacher educators must be prepared to prepare teachers for AI. The curriculum should incorporate AI literacy, AI pedagogy, assessment redesign, ethics, accessibility, data literacy and reflective practice. Teacher education institutions should also establish AI laboratories or innovation environments where student teachers can experiment with AI-supported pedagogy. Such environments can connect theoretical knowledge with practical classroom application.

19. A Human-Centred AI Competency Framework for Teachers

Based on the reviewed literature, this paper proposes a Human-Centred AI Competency Framework consisting of six interrelated dimensions.

a) The first dimension is AI Literacy, involving understanding AI concepts, capabilities, limitations and applications.
b) The second dimension is AI Pedagogical Integration, involving the ability to align AI tools with curriculum objectives, teaching methods and learner characteristics.
c) The third dimension is Critical and Ethical AI Literacy, involving evaluation of bias, misinformation, privacy, transparency, intellectual property and responsible use.
d) The fourth dimension is AI Assessment Literacy, involving the redesign of assessment, interpretation of AI-generated analytics and development of authentic assessment practices.
e) The fifth dimension is AI-Supported Professional Learning, involving the use of AI for reflection, resource development, research and continuous professional development.
f) The sixth dimension is Human Agency and Professional Judgement, involving teachers' capacity to make independent pedagogical and ethical decisions.

20. Implications for Pre-Service Teacher Education

a) Teacher education curricula should provide structured opportunities for student teachers to develop AI competency.
b) AI should be embedded into pedagogical courses, curriculum studies, educational psychology, assessment and educational technology.
c) Student teachers should also engage in critical analysis of AI-generated educational content.
d) Teaching practice programmes should encourage student teachers to document their use of AI, analyse its benefits and limitations, and reflect on its influence on their pedagogical decisions.
e) Such experiences can prevent the development of either uncritical enthusiasm or blanket resistance toward AI.
f) The desired outcome is informed professional judgement.

21. Implications for In-Service Professional Development

a) Professional development should move from short-term tool demonstrations toward sustained learning.
b) Teachers require opportunities to experiment with AI in authentic classroom contexts and subsequently reflect on outcomes.
c) Collaborative lesson design, peer observation, mentoring and professional learning communities can strengthen this process.
d) AI can also support personalized professional learning by providing resources according to teachers' individual knowledge and needs.
e) Li et al. (2025) found that AI-integrated professional development frequently incorporated personalized and data-informed support, suggesting significant potential for adaptive teacher learning.
f) However, personalization should complement rather than replace collegial professional learning.

22. Implications for Educational Policy

a) National and institutional policies should establish teacher AI competency standards.
b) UNESCO's 2024 framework provides an international reference point for developing such standards.
c) Policy should support continuous professional development, equitable access to AI tools, ethical governance and teacher participation in technology-related decision-making.
d) For countries such as India, policy must also address multilingualism, rural-urban disparities, infrastructure limitations and the diversity of educational institutions.
e) The objective should be responsible and equitable AI adoption rather than rapid technological adoption for its own sake.

23. Research Gaps

The literature reveals several important gaps.

a) Research remains disproportionately focused on AI applications for students rather than AI-enabled professional development for teachers. Tan et al. (2025) identified this imbalance across 95 studies.
b) Research on AI literacy in teacher education is also comparatively limited. Moser et al. (2024) identified a lack of sufficient attention to teachers' practical and ethical knowledge.
c) Further, many professional development studies use small samples and short intervention periods. Recent reviews have also noted the underrepresentation of in-service teachers and concerns about limited sample sizes in the emerging GenAI teacher-development literature.
d) Future research should therefore examine long-term changes in teacher competence, classroom practice, professional identity and student learning.

e) More research is also required in developing countries and multilingual contexts.

24. Future Directions

The future of AI in teacher education should emphasize professional augmentation rather than professional replacement.

a) AI can reduce routine workload and provide teachers with new forms of instructional and professional support. However, teachers must retain responsibility for educational goals, learner relationships and ethical decisions.
b) Professional development should increasingly adopt a continuous model in which teachers learn, experiment, reflect and collaborate.
c) Teacher education institutions should also establish partnerships with schools, technology developers and educational researchers to ensure that AI systems respond to authentic educational needs.
d) Future AI competency frameworks should remain flexible because AI technologies will continue to evolve.
e) The most durable competencies will therefore be critical thinking, ethical reasoning, pedagogical judgement, adaptability and lifelong learning.

25. Conclusion

Artificial Intelligence is changing the nature of teaching and creating an urgent need to rethink teacher education and professional development. The evidence indicates that AI integration cannot be achieved through technical training alone. Teachers require a combination of technological, pedagogical, disciplinary, ethical, assessment and reflective competencies. Recent systematic reviews demonstrate that research on AI in teaching has expanded much faster than research on AI for teacher professional development, revealing an important gap in the field. Other reviews show that effective AI professional development increasingly emphasizes teacher agency, personalized support and pedagogical integration. UNESCO's competency framework provides an important international foundation by positioning human-centred thinking, ethics, AI foundations, AI pedagogy and professional learning at the centre of teacher preparation. The future teacher will not necessarily be the person who knows the most information. Increasingly, the teacher will be the professional who can evaluate information, design meaningful learning experiences, interpret AI-generated evidence, support diverse learners and make responsible decisions concerning technology. Consequently, AI should not be understood as a technology that diminishes the importance of teachers. Properly integrated, it can make teachers more capable of focusing on the dimensions of education that require distinctly human judgement. eacher education must therefore move from training teachers to use AI tools toward developing teachers who can think pedagogically and ethically about AI. The ultimate objective is not technological sophistication but professional empowerment. A sustainable model of AI-enabled education requires teachers who are technologically informed, pedagogically capable, ethically responsible, critically reflective and confident in exercising professional agency. The future of

education will consequently depend not simply on increasingly powerful AI systems, but on increasingly capable teachers who know how to use those systems wisely.

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PROFESSIONAL DEVELOPMENT: TRENDS AND CHALLENGES IN TEACHER EDUCATION.

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Abstract

Teacher education and professional development are fundamental to the preparation, competence, and continuous growth of teachers. In the contemporary educational environment, teachers are expected to perform multiple roles and respond effectively to technological advancement, curriculum reforms, diverse learner needs, inclusive education, and changing expectations of society. Teacher education provides the foundational knowledge, pedagogical skills, professional values, and competencies required for entry into the teaching profession, whereas professional development enables teachers to continuously update and strengthen these competencies throughout their careers. The present review paper examines the relationship between teacher education and professional development and their contribution to teacher effectiveness and quality education. It discusses the concept and importance of teacher education, the nature and characteristics of effective professional development, the role of digital technology in professional learning, major challenges faced by teachers, and emerging trends in teacher professional development. Recent research suggests that well-designed professional development can improve teachers' instructional practices and contribute positively to student learning outcomes. However, the effectiveness of professional development depends upon factors such as content focus, active learning, collaboration, coaching, feedback, reflection, duration, and institutional support. The paper further discusses the implications of the National Education Policy (NEP) 2020 for teacher education and continuous professional development in India. It argues that teacher education should be viewed as a continuous professional learning process rather than a one-time qualification. Strengthening the connection between pre-service teacher education and continuing professional development can contribute to the development of competent, reflective, digitally capable, inclusive, and effective teachers and ultimately promote quality education.

Keywords*: Teacher Education, Professional Development, Teacher Effectiveness, Professional Learning, Teacher Competence, Digital Competence, Quality Education, NEP 2020*

Introduction

Education is one of the most important instruments for the intellectual, social, emotional, and economic development of individuals and society. Within the educational system, teachers occupy a central position because they directly influence classroom teaching, student engagement, learning experiences, and the development of learners. The quality of education therefore depends substantially upon the competence, commitment, knowledge, skills, and professional practices of teachers. In this context, teacher education and professional

development have become important areas of educational policy, research, and practice.

The role of teachers has changed considerably in recent years. Teachers are no longer expected merely to transmit information to students. They are required to act as facilitators, mentors, counsellors, classroom managers, assessors, researchers, innovators, and users of digital technologies. The emergence of artificial intelligence, online learning, digital educational resources, competency-based education, inclusive education, and learner-centred pedagogies has further expanded teachers' professional responsibilities. Teacher education provides the foundation for entering the teaching profession. It develops prospective teachers' understanding of educational psychology, pedagogy, curriculum, assessment, classroom management, subject matter, and professional ethics. However, initial teacher education alone cannot prepare teachers for every challenge they may encounter throughout their professional careers. Educational knowledge and practices continue to evolve, making continuous professional learning essential. Professional development refers to the continuous process through which teachers acquire new knowledge, develop professional competencies, reflect upon their practices, collaborate with colleagues, and improve classroom instruction. It may occur through workshops, seminars, refresher courses, mentoring, coaching, professional learning communities, action research, online courses, webinars, peer observation, and other formal and informal learning opportunities. Recent research has increasingly emphasized the importance of viewing teacher education and professional development as interconnected components of a professional learning continuum. Effective teacher development should begin during pre-service preparation and continue through induction and the entire teaching career. Thus, teacher education should not be considered complete when a teacher obtains a professional qualification. Instead, it should establish the foundation for lifelong professional learning.The present paper reviews the role of teacher education and professional development in enhancing teacher effectiveness and quality education, with particular attention to contemporary educational developments and the Indian contex

Concept of Teacher Education

Teacher education refers to the systematic process of preparing individuals for the teaching profession by developing their professional knowledge, skills, attitudes, values, and competencies. It generally includes theoretical understanding as well as practical experiences that enable prospective teachers to connect educational concepts with classroom realities.

Teacher education may include pre-service education, teacher preparation programmes, teaching practice, internships, induction programmes, and continuing education. An effective teacher education programme should provide prospective teachers with opportunities to develop both subject-specific and pedagogical knowledge.

The major purposes of teacher education include:

Developing subject-matter knowledge.

Developing pedagogical competencies.

Understanding learners and their developmental characteristics.

Developing classroom-management skills.
Developing assessment and evaluation competencies.
Promoting inclusive teaching practices.
Developing professional ethics and values.
Developing communication and interpersonal skills.
Preparing teachers to use digital technologies.- Encouraging reflective and research-oriented practice.
Teacher education should therefore focus not only on what teachers know but also on how they use their knowledge in diverse classroom situations.

Concept of Professional Development

Professional development is a continuous process through which teachers enhance their knowledge, skills, attitudes, competencies, and professional practices. It may be formal or informal and can occur individually, collaboratively, within schools, or through external institutions.
Traditional professional development has often been associated with workshops and short-term training programmes. However, contemporary approaches increasingly emphasize sustained and practice-oriented professional learning.
Professional development may include:
1. Workshops and seminars
2. Conferences
3. Refresher courses
4. Mentoring and coaching
5. Peer observation
6. Collaborative lesson planning
7. Professional learning communities
8. Online courses and webinars
9. Action research
10. Reflective practice
11. School-based professional learning
12. Digital and blended learning

The central objective of professional development is to improve teachers' professional capacity and, ultimately, their classroom practice and student learning.

4. Relationship Between Teacher Education and Professional Development

Teacher education and professional development are closely related but represent different stages of teacher learning. Teacher education primarily establishes the foundation for entering the teaching profession, whereas professional development supports continuous growth after teachers enter the profession.
The relationship can be understood as a continuum:
Initial Teacher Education → Teaching Practicum → Induction → Mentoring → Continuous

Professional Development → Professional Learning → Improved Teaching Practice → Teacher Effectiveness → Quality Education

Initial teacher education introduces teachers to fundamental concepts and practices. Once teachers enter schools, they encounter real-world challenges that may not have been fully addressed during their initial preparation. Professional development provides opportunities to address these challenges and acquire new competencies.

Consequently, teacher education and professional development should not operate as completely separate systems. There should be continuity between what teachers learn during their initial preparation and what they subsequently learn through professional development.

5.Teacher Education and Teacher Effectiveness

Teacher effectiveness refers to the ability of teachers to facilitate meaningful learning and contribute to students' academic and overall development. Effective teachers demonstrate strong subject knowledge, appropriate pedagogical skills, classroom-management abilities, effective communication, assessment competence, professional commitment, and the ability to respond to individual learner differences. Teacher education contributes to teacher effectiveness by developing foundational professional competencies. These include:

- Knowledge of subject matter.
- Knowledge of teaching methods.
- Understanding of learner psychology.
- Classroom-management skills.
- Assessment skills.
- Communication skills.
- Inclusive education competencies.
- Digital competence.
- Reflective abilities.
- Problem-solving skills.

Professional development strengthens these competencies by providing opportunities for teachers to learn new approaches and apply them in actual classroom contexts.

Recent evidence provides support for the contribution of professional development to student learning. A 2025 meta-analysis examining 128 high-quality studies found an overall positive effect of teacher professional-development interventions on student achievement. However, the effects varied considerably between programmes, demonstrating that the quality and design of professional development are crucial. Therefore, participation in professional development alone should not be considered sufficient. The effectiveness of a programme depends on whether teachers acquire relevant knowledge, apply it in their classrooms, receive feedback, and receive continued support.

6. Characteristics of Effective Professional Development

Research indicates that professional development is most effective when it is designed around principles of meaningful professional learning.

6.1 Content Focus

Professional development should focus on the content teachers teach and the pedagogical strategies required to teach it effectively. Generic training that is disconnected from teachers' professional needs may have limited impact.

6.2 Active Learning

Teachers should actively engage in professional learning through demonstrations, classroom practice, collaborative activities, lesson planning, problem-solving, and reflection.

6.3 Collaboration

Collaboration enables teachers to share experiences, discuss classroom problems, observe each other's practices, and develop collective solutions.

6.4 Modelling

Professional development should provide teachers with examples or demonstrations of effective teaching practices.

6.5 Coaching and Expert Support

Mentoring and coaching can help teachers implement new practices and overcome difficulties encountered during classroom application.

6.6 Feedback and Reflection

Teachers need opportunities to reflect on their teaching and receive constructive feedback from colleagues, mentors, or professional experts.

6.7 Sustained Duration

Professional development should not be restricted to one-day workshops. Sustained programmes provide teachers with opportunities to learn, practise, receive feedback, and refine their practices.

Darling-Hammond, Hyler, and Gardner identified content focus, active learning, collaboration, modelling, coaching, feedback and reflection, and sustained duration as important characteristics of effective professional development.

7. Digital Technology and Teacher Professional Development

Digital transformation has created new possibilities for teacher professional development. Teachers can now access professional learning opportunities without being physically present at a training centre.

Online professional development can include:

- Webinars
- MOOCs
- Online certification courses
- Virtual workshops
- Digital teacher communities
- Learning management systems
- Online mentoring
- Video-based professional learning

- Digital teaching-resource platforms

Digital professional development is particularly useful because it can provide flexibility and access to experts and resources beyond the local educational environment.

However, technology itself does not guarantee effective professional development. Online programmes must also incorporate active learning, interaction, collaboration, practice, feedback, and reflection.

The development of artificial intelligence has further expanded the possibilities for teacher learning. Teachers may increasingly use AI-supported tools for lesson planning, formative assessment, creation of learning materials, personalized instruction, and professional reflection. At the same time, teachers require appropriate digital and ethical competencies to use such technologies responsibly.

8. Professional Development and Inclusive Education

Contemporary classrooms are characterized by learner diversity. Students may differ in their abilities, socioeconomic backgrounds, languages, learning styles, interests, and educational needs. Teachers therefore require professional competencies to create inclusive learning environments.

Professional development can support teachers in:

- Identifying diverse learning needs.
- Using differentiated instruction.
- Developing accessible learning materials.
- Applying Universal Design for Learning principles.
- Supporting learners with disabilities.
- Managing diverse classrooms.
- Promoting equity and participation.
- Using assistive and digital technologies.

Teacher education programmes should introduce inclusive education during initial preparation, while professional development should provide continuous opportunities to strengthen inclusive teaching practices.

9. NEP 2020 and Teacher Education in India

The National Education Policy (NEP) 2020 recognizes teachers as central to educational transformation in India. It emphasizes improving teacher education, recruitment, professional standards, and continuous professional development.

NEP 2020 promotes a stronger and more multidisciplinary approach to teacher preparation and emphasizes the continuous professional development of teachers. It also gives importance to technology, experiential learning, competency-based education, inclusion, and holistic development.

The policy envisages teachers as professionals who continuously improve their knowledge and skills. Continuous professional development is therefore important for implementing the broader objectives of educational reform.

The emphasis on teacher professional development is particularly significant because educational reforms cannot be effectively implemented without teachers possessing the necessary knowledge and competencies. Curriculum reform, competency-based assessment, experiential learning, vocational education, digital learning, and inclusive education all require teachers to develop new professional capabilities.

10. Challenges in Teacher Professional Development

Despite the importance of professional development, several challenges may reduce its effectiveness.

10.1 Short-Term Training :One-time workshops may provide information but may not result in sustained changes in classroom practice.

10.2 Lack of Follow-Up :

Teachers often require continued mentoring and support after training. Without follow-up, newly acquired practices may not be implemented effectively.

10.3 Disconnect from Classroom Needs

Professional development programmes may sometimes be designed without sufficient consideration of teachers' actual classroom challenges.

10.4 Time Constraints

Teachers may have limited time because of teaching responsibilities, administrative duties, assessment, and other school activities.

10.5 Limited Resources

In some contexts, inadequate technological infrastructure, teaching materials, and institutional resources can restrict professional learning opportunities.

10.6 Limited Collaboration

Professional development becomes less effective when teachers have few opportunities to collaborate and learn from colleagues.

10.7 Inadequate Evaluation

Many programmes focus on attendance or completion rather than examining whether professional development actually changes teaching practices or student outcomes.

10.8 Resistance to Change

Some teachers may be hesitant to adopt unfamiliar pedagogical approaches, particularly when adequate support is unavailable.

These challenges demonstrate the need for systematic planning, implementation, monitoring, and evaluation of professional development programmes.

11. Emerging Trends in Teacher Professional Development

Teacher professional development is gradually shifting from traditional training towards continuous professional learning.

Important emerging trends include:

Traditional Training

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Continuous Professional Learning

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Collaborative Professional Learning

↓

School-Based Development

↓

Mentoring and Coaching

↓

Digital and Blended Professional Development

↓

Reflective Practice

↓

Evidence-Based Professional Learning

Professional learning communities are particularly promising because they enable teachers to learn collaboratively within their own institutional contexts.

Action research is another important approach because it enables teachers to identify classroom problems, collect evidence, implement interventions, and reflect upon outcomes. Through this process, teachers become active producers of professional knowledge rather than passive recipients of training.

12. Research Gap

Although considerable research has examined teacher education and professional development, several gaps remain. First, many studies examine professional development participation rather than the actual quality of professional learning. Second, there is a need for more research examining how professional development influences teacher effectiveness over longer periods. Third, evidence remains uneven across geographical and educational contexts.

There is also a need to investigate the relationship between professional development and other important teacher-related variables, such as teacher self-efficacy, job satisfaction, psychological well-being, quality of work life, digital competence, motivation, and professional commitment. Further research is particularly required in the Indian school context to understand how teachers experience professional development and which forms of professional learning are most effective for improving teaching quality.

13. Implications for Educational Practice

The review suggests several implications for policymakers, teacher educators, school administrators, and teachers.

1. Teacher education should be viewed as a lifelong professional process.
2. Pre-service teacher education and in-service professional development should be better

integrated.

3. Professional development should be based on teachers' identified needs.

4. Teachers should participate actively in planning professional-learning programmes.

14. Conclusion

Teacher education and professional development are essential for developing an effective and responsive teaching workforce. Teacher education provides the foundation upon which teachers develop their professional knowledge, pedagogical competencies, values, and skills. However, the rapidly changing educational environment makes continuous professional development indispensable. The reviewed literature indicates that effective professional development can positively influence teaching practice and student achievement. However, professional development is not automatically effective simply because teachers participate in training. Its impact depends upon the quality of programme design, relevance of content, active participation, collaboration, modelling, coaching, feedback, reflection, sustained duration, and institutional support. The increasing importance of digital technologies, artificial intelligence, inclusive education, competency-based learning, and curriculum reform further demonstrates the need for continuous teacher learning. In India, the vision of NEP 2020 reinforces the importance of improving teacher education and continuing professional development as part of educational transformation. Therefore, teacher education should be conceptualized as a continuous professional learning continuum extending from initial teacher preparation to lifelong professional development. A shift from isolated training programmes towards sustained, collaborative, reflective, practice-oriented, digitally supported, and evidence-based professional learning can contribute to improved teacher effectiveness and quality education. Ultimately, investment in teacher education and professional development is an investment in the quality of education itself. Competent, reflective, motivated, and continuously developing teachers are essential for creating meaningful learning environments and preparing learners to meet the demands of the twenty-first century.

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STUDENT ENGAGEMENT AND WELL-BEING IN THE ERA OF ARTIFICIAL INTELLIGENCE: A HUMAN-CENTRED FRAMEWORK FOR MEANINGFUL LEARNING

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Abstract

Artificial intelligence (AI), and especially generative artificial intelligence (GenAI), is becoming part of the everyday learning environment. Students can now obtain explanations, receive feedback, generate ideas, translate material, practise skills and communicate with digital systems within seconds. These possibilities can widen access to learning and make support more responsive, but they can also change how students think, interact and regulate their own learning. The key educational issue is therefore not whether students should use AI, but under what conditions AI use contributes to genuine learning, engagement and well-being. This conceptual paper examines the relationship among AI use, student engagement and student well-being through a structured review of contemporary policy and research literature, with particular attention to the OECD Digital Education Outlook 2026, UNESCO's AI Competency Framework for Students and UNESCO's guidance on generative AI in education and research. The discussion is also situated within the National Education Policy (NEP) 2020, which recognizes emerging technologies as important to India's educational future while emphasizing holistic development, critical thinking, access, equity and responsible technology integration. Based on this review, the paper develops a Human-Centred AI Engagement and Well-being Framework with six mutually reinforcing dimensions: meaningful participation, cognitive agency, emotional well-being, social connectedness, ethical and critical AI literacy, and digital balance. The framework treats AI as a scaffold, tutor, feedback partner or creative aid rather than as a replacement for students' intellectual effort, peer relationships or teachers' professional judgement. The paper proposes practical strategies for teaching, assessment, teacher development and institutional policy and concludes that the success of AI-enabled education should be judged by the quality of human learning and development it strengthens, not by the amount of technology used.

Keywords: *Artificial Intelligence, Generative AI, Student Engagement, Student Well-being, AI Literacy, Digital Well-being, Human-Centred Education, NEP 2020, Higher Education, Educational Technology.*

1. Introduction

Artificial intelligence is no longer a distant technological possibility for education. It is increasingly present in the tools students use to search, write, translate, practise, communicate and create. Generative AI has intensified this change because it can respond to natural-language prompts and produce apparently finished products such as explanations, summaries, outlines, code, images and draft assignments. The speed and convenience of these systems create genuine educational opportunities, but they also raise a fundamental question: what

happens to learning when a machine can perform part of the cognitive work that students were previously expected to perform themselves?

The OECD Digital Education Outlook 2026 provides an important distinction. General-purpose GenAI can improve the quality of a student's immediate task performance without necessarily producing equivalent learning gains. When students routinely outsource planning, remembering, reasoning or checking to a chatbot, the visible product may improve while the underlying knowledge and skills remain underdeveloped. At the same time, the OECD identifies evidence that GenAI can support learning when its use is guided by explicit pedagogical purposes and when teachers redesign learning activities around the technology rather than simply adding it to existing tasks (OECD, 2026).

UNESCO adopts a similarly human-centred position. Its AI Competency Framework for Students organizes 12 competencies around four dimensions—human-centred mindset, ethics of AI, AI techniques and applications, and AI system design—and describes progression through understand, apply and create levels (Miao, Shiohira, & Lao, 2024). Such an approach shifts attention from mere tool operation toward judgement, responsibility, creativity and co-creation.

For Indian education, this discussion has particular relevance. NEP 2020 anticipates the influence of emerging technologies, including AI, and calls for technology to improve teaching-learning, assessment, access and teacher development while preparing learners for a changing knowledge landscape (Ministry of Education, 2020). The policy also places strong emphasis on holistic development, higher-order competencies, collaboration, communication, creativity and critical thinking. These priorities provide a useful basis for asking whether AI is strengthening or weakening the human capacities education is intended to develop.

2. Purpose and Objectives of the Paper

The purpose of this conceptual paper is to develop a human-centred perspective on student engagement and well-being in AI-mediated learning environments. The objectives are to:

- examine the major dimensions of student engagement relevant to AI-supported learning;
- analyse potential educational benefits and risks of GenAI for student well-being;
- connect AI literacy with cognitive agency, ethical judgement and responsible participation;
- interpret the implications of NEP 2020 for human-centred AI use in education;
- propose a Human-Centred AI Engagement and Well-being Framework; and
- suggest pedagogical, assessment and institutional measures for meaningful and responsible AI integration.

3. Methodological Approach

The paper is conceptual rather than empirical. It uses a structured narrative review of selected contemporary policy documents and educational literature to identify recurring

themes concerning AI, learning, engagement, well-being, human agency, ethics and digital balance. The principal sources considered are the OECD Digital Education Outlook 2026, UNESCO's AI Competency Framework for Students, UNESCO's Guidance for Generative AI in Education and Research, and India's NEP 2020. These sources were examined comparatively to identify opportunities, risks and design principles that can inform student-centred AI use.

The analysis proceeded in three broad stages: first, identifying the educational affordances and risks associated with GenAI; second, relating those issues to behavioural, emotional and cognitive engagement and to dimensions of student well-being; and third, synthesizing the findings into a proposed framework. The framework is presented as a conceptual model for discussion and future empirical validation; it is not claimed to be an experimentally tested scale or intervention.

4. Understanding Student Engagement in AI-Mediated Learning

Student engagement is more than attendance or visible participation. It concerns the extent to which learners invest attention, effort, emotion and thought in educational activity. In an AI-mediated environment, engagement should be considered across three closely related dimensions.

1. **Behavioural Engagement:** Behavioural engagement is reflected in participation, persistence, concentration, completion of learning activities and constructive involvement with peers and teachers. AI can support this dimension by offering practice opportunities, immediate feedback, adaptive explanations and conversational interaction. However, activity on a screen is not automatically evidence of engagement. A student may submit an AI-generated response quickly while investing very little personal effort. The important distinction is therefore between technological activity and purposeful participation.
2. **Emotional Engagement:** Emotional engagement concerns students' interest, confidence, sense of belonging and attitudes toward learning, teachers, peers and the institution. AI can reduce frustration when students receive timely explanations or language support. Yet emotional engagement also depends on relationships. If AI becomes the default source of assistance, students may have fewer opportunities to seek help from teachers and peers, discuss uncertainty and experience the social dimensions of learning.
3. **Cognitive Engagement:** Cognitive engagement is the depth of mental effort involved in questioning, interpreting, connecting, evaluating, applying and creating. It is the dimension most directly affected by cognitive offloading. If AI is used to generate questions, offer contrasting explanations, identify weaknesses in an argument or provide feedback that the student must evaluate, it can stimulate thinking. If it is used to replace planning, reasoning and writing, it can reduce the productive struggle through which understanding develops.

A useful distinction is therefore: AI-assisted thinking versus AI-substituted thinking. The first can extend a learner's capacity; the second can gradually weaken the learner's opportunity to practise the very skills education seeks to cultivate.

5. Student Well-being in the Era of AI

Student well-being refers to the learner's capacity to function positively, develop supportive relationships, cope with challenges, experience belonging and pursue meaningful goals. In AI-supported education, well-being should be viewed broadly rather than reduced to the absence of technological harm.

1. **Physical Well-being:** Healthy routines, sleep, movement and reasonable screen habits remain relevant when learning increasingly occurs through connected devices.
2. **Emotional Well-being:** Confidence, resilience, emotional regulation and a sense of competence can be supported by timely academic assistance, but constant comparison with AI-generated performance or fear of academic misuse can also create pressure.
3. **Social Well-being:** Learning is fundamentally relational. Peer discussion, teacher support, collaborative problem solving and belonging cannot be replaced by efficient interaction with a machine.
4. **Psychological Well-being:** Autonomy, competence, purpose and self-efficacy are strengthened when learners make decisions and understand why they are learning. Excessive dependence on automated answers may undermine these experiences.
5. **Digital Well-being:** Digital well-being involves using technology in ways that protect attention, relationships, privacy and healthy boundaries. AI literacy must therefore include not only technical skill but also the ability to decide when not to use AI.

6. Educational Opportunities Created by AI

AI can contribute to engagement and well-being when it is deliberately embedded in sound pedagogy. Its value lies less in automation itself than in the learning possibilities created by thoughtful use.

1. **Personalised Support:** Students can request an alternative explanation, an additional example, a practice problem or feedback at a level appropriate to their current understanding. This can support learner autonomy and reduce avoidable frustration.
2. **Feedback and Revision:** AI can provide rapid formative feedback on language, structure, reasoning or problem-solving. The educational benefit is greatest when students use the feedback to revise and explain their choices rather than simply accepting the generated answer.
3. **Inquiry and Dialogue:** Conversational systems can be used to generate competing explanations, challenge an argument, simulate viewpoints or pose follow-up questions. Such use can transform AI from an answer-producing device into a prompt for inquiry.
4. **Accessibility and Inclusion:** Translation, speech recognition, text-to-speech and adaptive interfaces can reduce some barriers for learners with different linguistic and

learning needs. These tools should complement, not replace, inclusive teaching and human support.

5. **Creativity and Co-creation:** AI can assist brainstorming, scenario generation, visualization and prototyping. Students should remain responsible for selecting ideas, improving them, justifying decisions and producing the final work.

7. Risks and Tensions

1. **Cognitive Offloading and Loss of Productive Struggle:** The most significant educational risk is not simply cheating but the gradual transfer of essential cognitive processes from learner to machine. The OECD notes that poorly guided GenAI use can improve task performance without producing corresponding learning gains and can contribute to disengagement and weakened metacognitive development (OECD, 2026). Students need opportunities to struggle productively, retrieve information, construct explanations, make mistakes and revise their thinking.
2. **Academic Integrity and Authorship:** GenAI complicates traditional definitions of plagiarism because students may submit text that they did not independently produce even when no conventional source has been copied. The response should not be limited to surveillance. Assessment needs to make thinking visible through drafts, oral explanations, process records, reflection, demonstrations and authentic application.
3. **Privacy, Bias and Safety:** AI systems may process personal or educational information and may produce inaccurate or biased outputs. UNESCO therefore emphasizes data privacy, ethical validation, age-appropriate use and human-centred governance (UNESCO, 2023). Students need explicit guidance about what information should never be entered into public AI systems and how generated claims should be checked.
4. **Digital Inequality:** AI can widen rather than reduce educational inequality when access to devices, reliable connectivity, premium tools, language support or adult guidance is uneven. Equitable implementation requires institutional alternatives so that learning does not depend on a student's ability to purchase or access a particular AI service.
5. **Reduced Human Interaction:** Education is not only a transaction between learner and information. Discussion, empathy, mentorship, cooperation and shared classroom experiences contribute to development. AI should therefore expand opportunities for human interaction rather than displace them.

8. The AI Engagement Paradox

AI creates a recurring paradox: the same capability can produce an educational benefit or a developmental cost depending on how it is used.

AI capability	Potential benefit	Potential risk
Personalization	Responsive explanations and practice	Narrow dependence on automated assistance
Speed	Rapid feedback and access	Reduced patience and productive struggle
Information access	Broader inquiry	Weak source evaluation
Idea generation	Creative starting points	Loss of originality or ownership
Automation	Reduced routine workload	Reduced practice of foundational skills
Conversation	Interactive questioning	Substitution for human dialogue
Support	Greater learner confidence	Over-reliance and reduced self-efficacy
Accessibility	Reduced language and interface barriers	Unequal access to advanced tools

9. Proposed Human-Centred AI Engagement and Well-being Framework

The central argument of this paper is that AI integration should be evaluated through human developmental outcomes. The proposed framework contains six connected dimensions. None is sufficient by itself; meaningful AI-enabled learning occurs when they operate together.

1. **Meaningful Engagement:** Students participate actively, persist with learning tasks and connect AI use to clear learning purposes.
2. **Cognitive Agency:** Students retain responsibility for questioning, reasoning, decision-making, verification and final judgement.
3. **Emotional Well-being:** AI use supports confidence and reduces unnecessary frustration without replacing human care or counselling.
4. **Social Connectedness:** AI complements peer learning, teacher-student relationships and collaborative experiences.
5. **Ethical and Critical AI Literacy:** Students understand limitations, bias, privacy, authorship, verification and responsible use.
6. **Digital Balance:** Students regulate when, why and how long they use AI and maintain opportunities for AI-free thinking, reading and interaction.

The framework can be represented as a simple principle: Purposeful AI Use → Active Cognitive Engagement → Human Interaction and Reflection → Well-being → Responsible AI Agency. Feedback from each stage should inform the next. For example, if AI use increases speed but reduces reflection, the learning design should be adjusted rather than treating greater speed as success.

10. Pedagogical Strategies for Human-Centred AI Use

1. **AI-Supported Inquiry**: Students formulate their own questions, use AI for preliminary exploration, consult independent sources, compare evidence and write conclusions in their own words.
2. **AI as a Debate Partner**: Students ask AI to produce an argument or counterargument and then identify assumptions, weaknesses, missing evidence and alternative interpretations.
3. **AI Error Analysis**: Teachers present intentionally flawed AI-generated answers. Students locate errors, verify claims and explain corrections. This makes critical evaluation part of the learning task.
4. **AI-Free Learning Windows**: Selected activities should require independent reading, memory retrieval, handwritten reasoning, discussion or problem solving without AI. The purpose is skill development, not technology rejection.
5. **Human-AI Collaborative Projects**: AI may support brainstorming, simulation or feedback, but students define the problem, select evidence, make decisions and defend the final product.
6. **Reflection after AI Use**: Students record what the AI contributed, what they changed, what they rejected and what they learned. Reflection converts invisible assistance into a metacognitive learning opportunity.
7. **Teacher-Led Verification**: Teachers should model source checking, triangulation, citation practice and recognition of uncertainty. Students need to learn that fluent AI output is not the same as reliable knowledge.

11. Assessment in the AI Era

Assessment is one of the areas most affected by GenAI. When an assignment can be completed by a student and a chatbot working together, the final written product alone provides limited evidence of the student's knowledge and reasoning. The response should be a shift toward process-sensitive and authentic assessment rather than a simple attempt to prohibit technology.

- oral explanation or viva voce after submission;
- project-based tasks linked to local or authentic problems;
- portfolio assessment showing drafts, revisions and evidence;
- reflective journals describing decisions and learning;
- peer and self-assessment;
- case analysis and application tasks;
- demonstrations or performances;
- AI-output critique and verification tasks;
- process documentation showing how evidence, prompts, revisions and decisions were used.

Assessment should also distinguish between permitted and non-permitted AI assistance.

Where AI is permitted, students should disclose the nature of assistance according to institutional rules. The central question should be: what evidence demonstrates that the learner understands, can explain and can apply the knowledge?

12. Role of the Teacher

AI does not make the teacher less important; it changes the distribution of professional work. Teachers remain responsible for learning goals, developmental appropriateness, classroom relationships, ethical judgement and assessment quality.

1. **Facilitator:** Creates purposeful learning experiences and productive interaction.
2. **Learning Designer:** Decides where AI adds value and where independent practice is essential.
3. **AI Mentor:** Helps students interpret and evaluate AI outputs.
4. **Ethics Educator:** Develops responsible habits concerning privacy, authorship, fairness and safety.
5. **Well-being Observer:** Notices disengagement, overload and withdrawal and responds through human support.
6. **Assessment Designer:** Constructs tasks that reveal reasoning, application and reflection.
7. **AI Literacy Educator:** Develops students' understanding of capabilities, limitations and social consequences.

13. Implications for NEP 2020

NEP 2020 offers a policy context that is compatible with a human-centred approach to AI. The policy identifies educational technology as a means of improving teaching-learning, assessment, access and teacher professional development, while also recognizing the disruptive potential of AI and other emerging technologies. It stresses the need to strengthen higher-order competencies rather than overloading learners with factual and procedural knowledge (Ministry of Education, 2020).

This orientation has an important implication: AI should be introduced not simply because it is innovative, but because it helps achieve educational purposes such as critical thinking, creativity, communication, collaboration, inclusion and lifelong learning. NEP 2020's emphasis on technology evaluation, digital access and holistic development therefore supports a balanced approach in which technological innovation is accompanied by pedagogical judgement and attention to learner well-being.

14. Institutional Recommendations

- Create clear, age-appropriate and discipline-sensitive AI-use policies.
- Protect student data and avoid unnecessary collection or sharing of personal information.
- Provide equitable access or non-AI alternatives so that assessment does not depend on private technology access.

- Offer sustained professional development in AI literacy, pedagogy, ethics and assessment.
- Integrate critical AI literacy across subjects rather than treating it as a stand-alone technical topic.
- Preserve regular opportunities for discussion, reading, writing, practical work and problem solving without AI.
- Strengthen counselling, mentoring and student-support systems for digital well-being.
- Review assessment practices regularly as AI capabilities change.
- Encourage institutional research on the actual effects of AI use on learning, engagement and well-being.

15. Recommendations for Students

- Use AI to support learning rather than to avoid learning.
- Think independently before asking AI to solve a problem.
- Verify important information with reliable and independent sources.
- Question AI outputs instead of assuming that fluent answers are correct.
- Protect personal, academic and sensitive information.
- Disclose AI assistance when required by institutional or assessment rules.
- Keep records of substantial AI assistance when transparency is expected.
- Maintain healthy digital boundaries and regular periods of technology-free study.
- Preserve human discussion, collaboration and help-seeking as essential parts of learning.

16. Discussion

The literature and policy evidence reviewed in this paper suggest that the educational impact of GenAI is conditional rather than predetermined. The same tool can strengthen engagement when it prompts inquiry, feedback and revision, yet weaken engagement when it removes the need to think. The distinction is therefore not between 'AI use' and 'no AI use' but between purposeful and purposeless use.

Student well-being adds another layer to this argument. A system may make academic work faster without making the learning experience healthier. Convenience is valuable, but education also requires attention, perseverance, social connection and a sense of personal competence. Human-centred AI therefore asks educators to protect the developmental experiences that cannot be measured by task completion alone.

The proposed framework contributes a practical synthesis by bringing engagement, cognitive agency, emotional well-being, social connection, AI literacy and digital balance into one model. Its value is primarily conceptual. Future studies should test the framework with students from different educational levels and social contexts and examine whether specific AI-supported strategies produce measurable changes in engagement, learning outcomes and well-being.

17. Conclusion:

Artificial intelligence is becoming a significant component of contemporary education, but its educational value cannot be inferred from its sophistication or popularity. GenAI can provide personalised explanations, rapid feedback, accessibility and creative support. It can also encourage cognitive offloading, dependency, weak verification, privacy risks and reduced human interaction when used without clear educational purpose.

The central principle emerging from the reviewed evidence is that AI should augment human intelligence rather than replace human thinking, relationships or agency. Meaningful engagement requires students to question, reason, create, collaborate and reflect. Well-being requires autonomy, competence, belonging, purpose and healthy digital boundaries. Teachers remain central because they provide the pedagogical, ethical and relational judgement that technology cannot supply on its own.

A future-ready educational system should therefore aim for neither unrestricted adoption nor blanket rejection of AI. It should build conditions in which students learn when to use AI, how to use it, how to challenge it and, equally importantly, when to work without it. The measure of successful AI integration should ultimately be the development of capable, ethical, connected and psychologically supported learners.

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ARTIFICIAL INTELLIGENCE IN ASSESSMENT AND FEEDBACK: ENHANCING EDUCATIONAL EVALUATION

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Abstract

Assessment is an integral component of the teaching-learning process as it provides information regarding learner achievement, progress and learning difficulties. Conventional assessment practices often require considerable time for preparation, administration, scoring and providing feedback. The emergence of Artificial Intelligence (AI) has introduced new possibilities for transforming educational assessment and feedback. AI can support automated assessment, intelligent question generation, learner performance analysis, personalized feedback and identification of learning gaps. AI-powered assessment systems can analyse learner responses and provide timely information that can assist both teachers and learners. Such systems can also support formative assessment by enabling continuous monitoring of learning. However, AI-based assessment requires careful attention to accuracy, fairness, transparency, data privacy and teacher supervision. The present paper discusses the concept of AI in educational assessment, major applications of AI in assessment and feedback, the role of teachers and learners, advantages, challenges and the possibilities of responsible AI-supported assessment. The paper emphasizes that AI should supplement professional teacher judgement rather than replace it.

Key words: Artificial Intelligence, Assessment, Feedback, Automated Assessment, Formative Assessment, Educational Evaluation

INTRODUCTION

Assessment is an essential part of education. It helps teachers understand what learners have learned, identify areas of difficulty and plan further instruction. It also helps learners understand their strengths and areas that require improvement.

Traditional assessment methods include written examinations, assignments, projects, oral tests, classroom observations and other forms of evaluation. Although these methods continue to be valuable, teachers often spend considerable time preparing questions, evaluating responses, recording marks and providing feedback.

The development of Artificial Intelligence has created opportunities to support several aspects of educational assessment. AI can analyse large quantities of learner responses, identify patterns and provide automated or semi-automated feedback.

The use of AI in assessment can therefore shift the focus from assessment merely as a means of assigning marks towards assessment as a tool for supporting learning. Timely feedback can

help learners recognize their errors and take corrective action.

At the same time, educational assessment involves complex human judgement. Creativity, reasoning, communication, attitudes and social-emotional development cannot always be accurately represented through automated systems. Therefore, AI-supported assessment needs to be combined with teacher expertise and professional judgement.

MEANING OF AI-BASED ASSESSMENT

AI-based assessment refers to the use of Artificial Intelligence technologies to support the design, administration, analysis and interpretation of educational assessment.

AI can assist in:

- Generating assessment questions.
- Analysing learner responses.
- Identifying common errors.
- Providing immediate feedback.
- Tracking learner progress.
- Recommending remedial activities.
- Supporting formative assessment.
- Analysing learning patterns.

AI-based assessment should not be considered simply as automated marking. Its broader purpose is to provide useful information that can support teaching and learning.

AI AND FORMATIVE ASSESSMENT

Formative assessment is conducted during the learning process to understand learner progress and provide information for improving learning.

AI can strengthen formative assessment by providing continuous information about learner responses.

A possible AI-supported formative assessment cycle can be represented as:

Learning Activity → Learner Response → AI Analysis → Feedback → Remedial Activity → Reassessment

This cycle enables assessment to become a continuous component of learning rather than an activity conducted only at the end of instruction.

APPLICATIONS OF AI IN EDUCATIONAL ASSESSMENT

1. Automated Scoring

AI can assist in evaluating objective-type questions and certain structured responses. This can reduce teachers' routine workload.

2. Question Generation

AI tools can support teachers in preparing questions of different levels of difficulty and based on specified learning objectives.

3. Personalized Feedback

AI can analyse learner responses and generate immediate feedback indicating areas that require improvement.

4. Identification of Learning Gaps

AI can analyse patterns of incorrect responses and help identify concepts that learners have not adequately understood.

5. Adaptive Assessment

AI can modify the difficulty or type of questions based on previous learner responses.

6. Learning Analytics

AI can analyse assessment data and provide information regarding learner progress and performance patterns.

7. Remedial Support

Based on assessment results, AI systems can recommend additional exercises, explanations or learning materials.

8. Continuous Assessment

AI-supported digital systems can facilitate frequent low-stakes assessment activities and provide timely information to teachers and learners.

AI-BASED FEEDBACK

Feedback is most useful when it is timely, specific and related to learning objectives. AI can provide immediate feedback in many digital learning environments.

AI-supported feedback may include:

- Identification of errors.
- Explanation of incorrect responses.
- Suggestions for improvement.
- Additional examples.
- Recommended learning materials.
- Practice questions.
- Indication of learning progress.

However, feedback generated by AI should be reviewed when accuracy, context or higher-order judgement is important.

ROLE OF THE TEACHER

The introduction of AI into assessment does not eliminate the need for teachers. Instead, it can change the nature of the teacher's assessment responsibilities.

The teacher should:

- Prepare clear learning outcomes.
- Select appropriate assessment methods.
- Use AI tools according to educational objectives.
- Verify AI-generated questions and feedback.
- Monitor learner progress.
- Interpret assessment information.
- Provide human feedback where necessary.
- Identify emotional and contextual factors affecting learning.

- Ensure fairness and inclusiveness.
- Protect learner data.
- Make final professional judgements.

The teacher therefore acts as an evaluator, facilitator, interpreter and guide while using AI as an assisting technology.

ROLE OF THE LEARNER

AI-supported assessment encourages learners to participate actively in the assessment process. Learners should:

- Participate honestly in assessment activities.
- Review AI-generated feedback.
- Identify their learning difficulties.
- Correct errors.
- Use recommended learning resources.
- Reflect on their progress.
- Develop self-assessment skills.
- Critically examine AI-generated information.
- Avoid becoming dependent on AI for completing learning tasks.

ADVANTAGES OF AI IN ASSESSMENT

- Saves teachers' time in routine assessment activities.
- Provides rapid feedback.
- Supports continuous assessment.
- Helps identify individual learning gaps.
- Facilitates adaptive assessment.
- Supports personalized learning.
- Helps teachers analyse learner performance.
- Provides opportunities for remedial instruction.
- Can assist in generating diverse assessment items.
- Encourages learners to monitor their own progress.

CHALLENGES AND LIMITATIONS

Accuracy: AI-generated questions, scoring or feedback may contain errors and therefore require human verification.

Bias: AI systems may produce biased results if the data or algorithms used to develop them contain bias.

Privacy: Assessment systems may process sensitive learner information, requiring appropriate data protection.

Transparency: Teachers and learners should understand, as far as possible, how AI-supported assessment decisions are generated.

Creativity and Higher-Order Thinking: Automated systems may find it difficult to accurately evaluate certain forms of creative, contextual and complex learner responses.

Academic Integrity: The availability of generative AI creates new challenges concerning authentic learner work.

Teacher Dependence: Teachers should not rely completely on AI-generated assessment information without professional judgement.

Digital Inequality: Unequal access to digital technologies may create differences in learners' opportunities to benefit from AI-supported assessment.

PRINCIPLES FOR RESPONSIBLE AI-BASED ASSESSMENT

Effective AI-supported assessment should follow certain principles:

1. **Human Oversight:** Final educational decisions should involve teacher judgement.
2. **Fairness:** Assessment should provide equitable opportunities to learners.
3. **Transparency:** Learners should be informed when AI is used in assessment.
4. **Privacy:** Learner information should be handled responsibly.
5. **Accuracy:** AI-generated content and feedback should be verified.
6. **Accessibility:** AI-supported assessment should consider diverse learner needs.
7. **Educational Purpose:** Technology should serve clearly defined learning objectives.
8. **Critical Use:** Learners should be encouraged to evaluate AI outputs rather than accept them blindly.

CONCLUSION

Artificial Intelligence has significant potential to transform educational assessment and feedback. Through automated assessment support, question generation, learning analytics, adaptive assessment and personalized feedback, AI can help make assessment more continuous, timely and responsive to learner needs. However, assessment is not merely a technical process of assigning marks. It involves understanding learners, interpreting their performance and making educational decisions. These responsibilities require human judgement, empathy and professional expertise. Therefore, AI should be viewed as a supportive technology rather than a replacement for teachers. The effective combination of AI capabilities and teacher expertise can create assessment practices that are more efficient, informative and learner-centred. The future of assessment should focus on using AI sensibly and ethically so that technology strengthens learning without compromising fairness, human interaction and educational values.

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ARTIFICIAL INTELLIGENCE FOR PERSONALIZED AND ADAPTIVE LEARNING: TRANSFORMING THE TEACHING-LEARNING PROCESS

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Abstract

Education is undergoing significant transformation with the emergence of Artificial Intelligence (AI) and its increasing integration into the teaching-learning process. Traditional classroom practices generally provide common learning experiences to a group of learners, although students differ considerably in their abilities, interests, learning pace, prior knowledge and learning needs. Artificial Intelligence provides opportunities to address these individual differences through personalized and adaptive learning environments. AI-based educational systems can analyse learner responses, identify learning gaps, recommend appropriate learning resources and provide individualized feedback. Personalized learning supported by AI enables learners to progress according to their own pace and learning requirements, while adaptive learning systems dynamically modify learning content and activities based on learner performance. AI can therefore support teachers in designing flexible learning experiences and can help learners become more active and self-directed. However, effective implementation requires responsible use of technology, teacher supervision, data privacy, digital accessibility and critical evaluation of AI-generated content. The present paper discusses the concept of Artificial Intelligence in education, personalized and adaptive learning, applications of AI in individualized learning, the role of teachers and learners, advantages, challenges and the possibilities of AI for creating inclusive and learner-centred educational environments.

Key words: *Artificial Intelligence, Personalized Learning, Adaptive Learning, Individualized Learning, AI in Education, Learner-Centred Education*

INTRODUCTION

Education is an important instrument for the intellectual, social, emotional and overall development of an individual. The changing educational scenario has created a need for teaching-learning approaches that recognize the diversity of learners. In a conventional classroom, the teacher generally provides the same instructional content and learning activities to a group of students. However, learners differ in their previous knowledge, abilities, interests, pace of learning and learning requirements.

The development of digital technologies has opened new possibilities for addressing these differences. Artificial Intelligence is one of the emerging technologies that has the potential to transform educational practices. AI can process large amounts of information, identify patterns in learner performance and support teachers in making informed instructional decisions.

Artificial Intelligence does not simply represent another technological tool. It can support a

shift from a common learning experience towards more personalized and flexible learning. AI-powered educational systems can provide learning materials according to the learner's level, suggest additional activities when difficulties are identified and offer immediate feedback.

The integration of AI with personalized and adaptive learning therefore provides opportunities to make teaching more responsive to individual learner needs. At the same time, the teacher continues to play a central role in planning, guiding, motivating and monitoring the learning process.

MEANING OF ARTIFICIAL INTELLIGENCE IN EDUCATION

Artificial Intelligence refers to the ability of computer systems to perform tasks that generally require human intelligence, such as analysing information, recognizing patterns, understanding language, making predictions and generating responses.

In education, AI refers to the application of intelligent computational systems to support different educational activities such as teaching, learning, assessment, feedback, content development and learner support.

AI-based educational systems can collect and analyse information about learner performance. Based on this information, the system can recommend learning materials, modify the level of difficulty and provide feedback.

Thus, AI in education can be understood as a technology-supported approach that assists teachers and learners in making the teaching-learning process more responsive, flexible and individualized.

PERSONALIZED LEARNING

Personalized learning is an approach in which learning experiences are adapted to the individual needs, interests, abilities and pace of learners.

In a personalized learning environment:

- Learners may have different learning goals and pathways.
- Learning resources can be selected according to individual needs.
- Learners can progress at an appropriate pace.
- Feedback can be provided according to individual performance.
- Learners can receive additional support when they experience difficulties.

AI can facilitate personalized learning by analysing learner information and recommending suitable learning activities.

ADAPTIVE LEARNING

Adaptive learning is a technology-supported approach in which learning content, activities or levels of difficulty are dynamically modified according to learner performance.

For example, when an AI-supported learning system identifies that a learner has difficulty understanding a particular concept, it may provide additional explanations, examples, practice exercises or remedial resources. When the learner demonstrates mastery, the system may provide more challenging activities.

Thus, adaptive learning creates a flexible learning pathway rather than requiring every learner to follow exactly the same sequence.

AI-BASED PERSONALIZED AND ADAPTIVE LEARNING PROCESS

The integration of AI into personalized learning can be represented through the following stages:

1. Learner Profile:

The system gathers information about the learner's previous knowledge, performance, interests and learning requirements.

2. Learning Diagnosis:

AI analyses learner responses and identifies strengths, weaknesses and learning gaps.

3. Content Recommendation:

Appropriate learning materials, videos, examples, activities and exercises are recommended.

4. Adaptive Learning Path:

The system modifies the sequence or difficulty of learning activities according to learner performance.

5. Continuous Feedback:

Learners receive timely feedback regarding their performance.

6. Progress Monitoring:

AI-supported systems can provide information regarding learner progress and areas requiring further attention.

7. Teacher Intervention:

The teacher reviews learner progress and provides appropriate guidance, encouragement and additional support.

APPLICATIONS OF AI IN PERSONALIZED LEARNING

Artificial Intelligence can be used in personalized and adaptive learning in several ways:

1. Personalized Content Recommendation:

AI can recommend learning resources according to individual learner requirements.

2. Intelligent Tutoring:

AI-powered tutoring systems can provide explanations, practice activities and feedback.

3. Adaptive Questioning:

The difficulty of questions can be adjusted according to learner responses.

4. Individualized Feedback:

AI can provide immediate feedback on learner responses and suggest areas for improvement.

5. Learning Analytics:

AI can analyse learner performance data and help identify learning patterns.

6. Language Learning:

AI-supported systems can assist learners with vocabulary, pronunciation, writing and language practice.

7. Remedial Learning:

Learners who experience difficulty can receive additional learning resources and practice.

8. Enrichment Learning:

Advanced learners can be provided with challenging activities and additional resources.

ROLE OF THE TEACHER

Although AI can provide personalized learning support, the teacher remains an important component of the educational process.

The teacher's role includes:

- Identifying learning objectives.
- Selecting appropriate AI-supported resources.
- Monitoring learner progress.
- Interpreting AI-generated information.
- Providing emotional and social support.
- Encouraging critical thinking and creativity.
- Verifying the accuracy of AI-generated content.
- Maintaining ethical and responsible use of AI.
- Providing individual guidance wherever required.
- Creating a supportive and inclusive learning environment.

AI can assist the teacher, but it cannot replace the teacher's human understanding, empathy, judgement and ability to build meaningful relationships with learners.

ROLE OF THE LEARNER

AI-supported personalized learning changes the learner from a passive recipient of information into an active participant.

The learner is expected to:

- Take responsibility for learning.
- Use recommended learning resources.
- Learn according to an appropriate pace.
- Respond to feedback.
- Identify areas requiring improvement.
- Ask questions and seek clarification.
- Develop self-learning habits.
- Evaluate AI-generated information critically.
- Use AI responsibly and ethically.

ADVANTAGES OF AI-BASED PERSONALIZED LEARNING

- Provides individualized learning experiences.
- Supports self-paced learning.
- Helps identify learning gaps.
- Provides immediate feedback.
- Supports remedial and enrichment learning.

- Increases learner engagement.
- Provides opportunities for continuous learning.
- Helps teachers monitor learner progress.
- Supports diverse learning needs.
- Encourages learner autonomy.

CHALLENGES AND LIMITATIONS

Despite its potential, AI-based personalized learning has several challenges:

Digital Divide: Unequal access to digital devices and reliable internet may prevent some learners from benefiting equally.

Data Privacy: AI systems may require learner data, creating concerns regarding privacy and responsible data management.

Accuracy of AI Output: AI-generated information may sometimes be inaccurate or inappropriate and therefore requires human verification.

Overdependence on Technology: Excessive dependence on AI may reduce opportunities for independent thinking if learners accept AI responses without evaluation.

Teacher Preparedness: Teachers need appropriate digital and AI competencies to use AI effectively.

Ethical Concerns: Bias, transparency, privacy and responsible use must be considered while implementing AI in education.

Human Interaction: Education involves emotional, social and interpersonal dimensions that cannot be completely provided by an AI system.

CONCLUSION: Artificial Intelligence has created new possibilities for personalized and adaptive learning. By analysing learner performance and providing suitable content, activities and feedback, AI can help create flexible learning environments that recognize individual differences. Personalized and adaptive learning can support learners who require additional assistance as well as learners who are ready for advanced learning experiences. However, technology should be used as a means of improving education rather than replacing the teacher. The teacher remains the facilitator, mentor, motivator and human guide of the learning process. Effective AI integration requires a balanced combination of technology and human interaction. The future of education should therefore focus not on making learners dependent on AI, but on helping them use AI intelligently, critically, creatively and responsibly. When used appropriately, AI can supplement teachers and contribute to a more learner-centred, inclusive and effective educational environment.

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HUMAN INTELLIGENCE MEETS ARTIFICIAL INTELLIGENCE: PREPARING TEACHERS FOR THE SMART EDUCATION ERA

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Abstract

Artificial Intelligence (AI) is rapidly transforming the landscape of education, moving classrooms from traditional, one-size-fits-all instruction toward personalized, data-driven, and technology-enhanced learning environments. While much attention has been given to AI's impact on student learning outcomes, an equally important dimension is its effect on teachers — their roles, competencies, and professional identity. This paper examines how AI is reshaping education systems globally and, more specifically, how teacher preparation and professional development must evolve to meet the demands of a "smart" future. It explores the current applications of AI in education, the changing role of teachers from knowledge-transmitters to facilitators and mentors, the core competencies teachers must develop, the challenges of AI adoption in teaching, and policy recommendations for building an AI-ready teaching workforce. The paper concludes that successful integration of AI in education depends not merely on technological infrastructure but on empowering teachers with the skills, ethical grounding, and pedagogical vision necessary to harness AI as a partner rather than a replacement.

Introduction

The twenty-first century has witnessed an unprecedented convergence of technology and education. Among the many innovations reshaping the sector, Artificial Intelligence stands out as one of the most transformative forces. From intelligent tutoring systems and automated grading to predictive analytics and adaptive learning platforms, AI is redefining how knowledge is delivered, assessed, and personalized (Luckin et al., 2016). As educational institutions increasingly adopt AI-driven tools, the traditional role of the teacher is undergoing a fundamental shift. Historically, teachers have functioned as the primary source of knowledge, responsible for content delivery, assessment, and classroom management. However, with AI systems capable of performing many of these tasks — often more efficiently and at scale — the question arises: what does it mean to be a teacher in an AI-augmented classroom? This paper argues that rather than diminishing the role of teachers, AI necessitates a reimagining of teacher identity, requiring educators to become facilitators of learning, curators of technology, and mentors of critical and ethical thinking. Preparing teachers for this "smart future" is not optional but essential if the promise of AI in education is to be realized equitably and effectively.

The Emergence of AI in Education

Artificial Intelligence in Education (AIEd) is not a new phenomenon, though its scale and sophistication have grown considerably in the last decade. Early applications included computer-assisted instruction and simple adaptive software, but contemporary AI systems leverage machine learning, natural language processing, and big data analytics to deliver far more nuanced educational experiences (Holmes, Bialik, & Fadel, 2019).

Some of the most prominent applications of AI in education today include:

- **Intelligent Tutoring Systems (ITS):** These systems simulate one-on-one tutoring by adapting content difficulty and pacing based on a learner's performance, providing immediate feedback and remediation (VanLehn, 2011).
- **Adaptive Learning Platforms:** Tools such as DreamBox and Squirrel AI use algorithms to personalize learning pathways for individual students, adjusting content in real time based on their responses.
- **Automated Assessment and Grading:** AI-powered systems can now grade essays, quizzes, and even coding assignments, freeing teachers from repetitive administrative tasks (Zawacki-Richter et al., 2019).
- **Learning Analytics and Predictive Systems:** Institutions use AI to analyze student data and predict at-risk learners, enabling early intervention (Siemens & Baker, 2012).
- **Chatbots and Virtual Assistants:** AI-driven chatbots provide round-the-clock support for administrative queries, homework help, and even emotional check-ins with students.
- **Generative AI Tools:** More recently, generative AI systems capable of producing text, explanations, and even lesson content have entered classrooms, offering both opportunities for creativity and challenges around academic integrity.

These technologies collectively point toward a future where education is increasingly personalized, data-informed, and technologically mediated. However, the effectiveness of these tools is deeply contingent on how well teachers are prepared to integrate, supervise, and critically evaluate them within pedagogical practice.

The Changing Role of the Teacher

The integration of AI into classrooms does not eliminate the need for teachers; rather, it transforms what effective teaching looks like. Several scholars have noted that AI is best positioned to handle routine, repetitive, and data-intensive tasks, while uniquely human capacities — empathy, moral reasoning, creativity, and relationship-building — remain irreplaceable (Selwyn, 2019).

From Knowledge Transmitter to Learning Facilitator

In traditional models, teachers were the primary gatekeepers of information. With AI systems now able to deliver content, answer questions, and even explain complex concepts, teachers are increasingly positioned as facilitators who guide students in interpreting, questioning, and

applying information rather than simply receiving it. This shift aligns with constructivist pedagogies that emphasize active, student-centered learning (Vygotsky, 1978).

From Assessor to Data Interpreter

While AI can automate grading and generate performance data, teachers must now develop the skill of interpreting this data meaningfully. Learning analytics dashboards provide rich information about student engagement and progress, but translating this data into actionable pedagogical strategies remains a distinctly human task requiring contextual judgment (Mandinach & Gummer, 2016).

From Sole Educator to Human-AI Collaborator

Perhaps the most significant shift is the emergence of a collaborative relationship between teacher and machine. Teachers are now expected to work alongside AI systems — selecting appropriate tools, monitoring their outputs for bias or error, and blending machine efficiency with human judgment. This collaborative model requires new forms of digital literacy and critical evaluation skills that were not traditionally part of teacher education curricula.

From Instructor to Ethical Guide

As students increasingly interact with AI systems, including generative AI tools, teachers must also take on the role of ethical guides, helping students navigate issues such as misinformation, algorithmic bias, data privacy, and academic integrity. This requires teachers themselves to possess a solid understanding of how AI systems function and where their limitations lie (UNESCO, 2021).

Core Competencies for AI-Ready Teachers

Given these evolving roles, teacher education and professional development programs must be redesigned to cultivate a specific set of competencies. Drawing on frameworks proposed by UNESCO (2021) and other researchers, the following competencies emerge as critical:

Digital and AI Literacy: Teachers need a foundational understanding of how AI systems work, including basic concepts of machine learning, data-driven decision-making, and algorithmic bias, even if they are not expected to become technical experts.

Data Interpretation Skills: The ability to read and act upon learning analytics data is essential for tailoring instruction to individual student needs.

Pedagogical Adaptability: Teachers must be able to flexibly integrate AI tools into diverse instructional strategies, shifting between direct instruction, facilitated discussion, and independent AI-assisted learning as appropriate.

Critical and Ethical Reasoning: As AI systems are not infallible, teachers must critically evaluate AI-generated content and outputs, and instill similar critical thinking skills in their students.

Socio-Emotional Competence: As AI takes over more routine cognitive tasks, the human elements of teaching — empathy, motivation, mentorship, and relationship-building — become even more central to a teacher's role.

Lifelong Learning Orientation: Given the pace of technological change, teachers must adopt a mindset of continuous learning, regularly updating their skills to keep pace with emerging tools and practices.

Teacher Training and Professional Development for the AI Era

Preparing teachers for an AI-integrated future requires systemic changes at multiple levels of the education ecosystem.

Pre-Service Teacher Education

Teacher training institutions and colleges of education must embed AI literacy and digital pedagogy into their curricula. This includes coursework on educational technology, data ethics, and hands-on practicum experiences using AI-based teaching tools, so that new teachers enter the profession already comfortable with these systems (Zawacki-Richter et al., 2019).

In-Service Professional Development

For teachers already in the workforce, continuous professional development is critical. Short-term workshops are often insufficient; instead, sustained, iterative training programs that allow teachers to experiment with AI tools in real classroom settings, reflect on outcomes, and receive mentorship tend to be more effective (Darling-Hammond, Hyler, & Gardner, 2017).

Institutional and Policy Support

Ministries of education and school administrations play a crucial role by providing the infrastructure, incentives, and time necessary for teachers to engage in meaningful AI-related professional growth. Policies should also address equitable access, ensuring that teachers in under-resourced schools are not left behind in this transition (UNESCO, 2021).

Communities of Practice

Peer learning communities, both within schools and across regions, allow teachers to share experiences, troubleshoot challenges, and co-develop best practices for AI integration. Such communities can accelerate the diffusion of effective strategies more organically than top-down training alone.

Challenges in Preparing Teachers for AI Integration

Despite the clear need, several challenges hinder effective teacher preparation for AI-enhanced education.

Resistance to Change: Many educators express apprehension about AI, fearing job displacement or a loss of professional autonomy. Addressing these fears requires clear communication about AI's role as a complement to, rather than a replacement for, teachers (Selwyn, 2019).

Digital Divide: Unequal access to technology and reliable internet connectivity, particularly in rural and low-income areas, limits the extent to which teachers can meaningfully integrate AI tools into their practice.

Insufficient Training Infrastructure: Many teacher education programs lack the resources, expertise, or curricular flexibility to incorporate robust AI training, resulting in a gap between policy aspirations and classroom realities.

Ethical and Privacy Concerns: The use of AI in education raises significant concerns about student data privacy, algorithmic bias, and the potential for AI systems to reinforce existing educational inequities (Holmes et al., 2019). Teachers must be equipped to navigate these concerns thoughtfully.

Rapid Pace of Technological Change: The fast-evolving nature of AI tools means that training programs risk becoming outdated quickly, requiring ongoing curriculum revision and flexible, adaptable training models.

Recommendations

Based on the analysis above, the following recommendations are proposed for policymakers, teacher educators, and school leaders:

1. **Integrate AI literacy into teacher education curricula** at both pre-service and in-service levels, ensuring foundational understanding of AI concepts, tools, and ethical considerations.
2. **Invest in infrastructure and equitable access**, ensuring that all schools, regardless of socioeconomic context, have the technological resources needed for AI integration.
3. **Promote a human-centered vision of AI in education**, emphasizing AI as a tool that augments rather than replaces the relational and ethical dimensions of teaching.
4. **Establish continuous professional development pathways**, including mentorship, peer learning communities, and hands-on experimentation with AI tools.
5. **Develop clear ethical guidelines and data governance frameworks** to protect student privacy and ensure responsible AI use in classrooms.
6. **Encourage research and localized innovation**, supporting context-specific studies on how AI can be effectively integrated into diverse educational settings, particularly in developing regions.
7. **Foster teacher agency and voice** in the design and selection of AI tools, ensuring that technology adoption is driven by pedagogical needs rather than purely commercial or administrative considerations.

Conclusion

Artificial Intelligence holds tremendous potential to enhance educational outcomes through personalization, efficiency, and data-driven insight. However, the successful realization of this potential hinges not on technology alone, but on the readiness of teachers to adapt, innovate, and lead within AI-augmented learning environments. As classrooms evolve into "smart" spaces where human and artificial intelligence work in tandem, teachers must be reimagined not as passive recipients of technological change but as active architects of a pedagogy that blends machine efficiency with human wisdom. Preparing teachers for this future requires sustained investment in teacher education, professional development,

infrastructure, and ethical governance. Ultimately, the smart classrooms of tomorrow will be defined not merely by the sophistication of their AI systems, but by the depth of human insight, empathy, and critical judgment that teachers bring to guide their use.

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IMPACT OF ARTIFICIAL INTELLIGENCE IN LIBRARIES: ENHANCING SERVICES AND EMPOWERING USERS FOR A SMART FUTURE

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Abstract

Artificial Intelligence (AI) is rapidly transforming the way information is created, organized, accessed, and disseminated, bringing significant changes to the traditional functioning of libraries. Libraries, as knowledge and information centres, are increasingly adopting AI-based technologies to improve service efficiency, enhance information discovery, automate routine operations, and provide personalized support to users. AI applications such as intelligent search systems, recommendation engines, chatbots, virtual reference services, automated cataloguing and classification, natural language processing, machine learning, optical character recognition, and predictive analytics are creating new possibilities for smart and user-centred library services. These technologies can reduce repetitive workloads for library professionals and enable them to devote greater attention to information literacy, research support, digital scholarship, and user engagement. The impact of AI extends beyond automation. It has the potential to empower users by providing faster access to relevant information, personalized recommendations, multilingual assistance, 24-hour reference support, and improved accessibility for diverse categories of learners and researchers. At the same time, the integration of AI raises important concerns related to data privacy, algorithmic bias, misinformation, intellectual property, cybersecurity, digital inequality, transparency, and the changing professional roles of librarians. Therefore, the successful adoption of AI requires not only technological infrastructure but also ethical policies, skilled library professionals, digital literacy, and responsible governance. This paper examines the emerging impact of Artificial Intelligence on library services and explores how AI can contribute to the development of smart, inclusive, accessible, and user-empowered libraries. It also highlights the changing role of librarians and the need to balance technological innovation with human judgement and professional values.

Keywords: *Artificial Intelligence, Libraries, Smart Library, Library Services, AI Literacy, Digital Literacy, Librarians, Future of Libraries*

Introduction:

Libraries have traditionally served as institutions for collecting, organizing, preserving, and providing access to knowledge and information. However, the rapid growth of digital technologies has significantly changed the nature of information resources, user expectations, and methods of information delivery. In the contemporary digital environment, users expect information services to be fast, accurate, personalized, accessible, and available anytime and anywhere. These changing expectations have encouraged libraries to explore emerging technologies that can improve their services and strengthen their role as knowledge centres.

Artificial Intelligence (AI) has emerged as one of the most influential technologies of the twenty-first century. AI refers broadly to computational systems capable of performing tasks that normally require aspects of human intelligence, such as learning, reasoning, language understanding, pattern recognition, prediction, and decision-making. The increasing availability of machine learning, natural language processing, generative AI, computer vision, and data analytics has created new opportunities for libraries to redesign both technical and user-facing services.

The application of AI in libraries is not limited to automation. It can support the entire information lifecycle—from acquiring and organizing resources to discovering, recommending, delivering, and evaluating information. AI-powered systems can assist in automated metadata generation, cataloguing, classification, indexing, document recognition, information retrieval, reference services, and collection management. Intelligent recommendation systems can analyse users' information needs and suggest relevant books, articles, databases, and other scholarly resources. Similarly, AI-powered chatbots and virtual assistants can provide immediate responses to frequently asked questions and guide users towards appropriate information resources.

One of the most significant contributions of AI is its potential to make library services more user-centred and personalized. Traditional library services often depend on users knowing how to formulate search queries or navigate complex information systems. AI-based natural language interfaces can allow users to interact with information systems using ordinary language. This can make information discovery easier, particularly for students and users who may have limited information-search skills. AI can also support multilingual information access and accessibility services, thereby contributing to more inclusive library environments.

AI is also changing the professional role of librarians. Routine and repetitive tasks that traditionally require considerable time and effort may increasingly be supported by intelligent systems. This does not necessarily make librarians less important; rather, it provides an opportunity for them to move towards higher-level responsibilities such as research assistance, information literacy education, digital scholarship, data management, ethical use of information, and critical evaluation of AI-generated content. The librarian of the smart-library era is therefore likely to function not merely as a custodian of documents but as an information facilitator, digital literacy educator, research partner, and ethical guide.

At the same time, the introduction of AI into libraries presents several challenges. The collection and processing of user data may create privacy and surveillance concerns. AI systems can reproduce biases present in their training data, potentially affecting the fairness and reliability of information services. Generative AI may also produce inaccurate or fabricated information, making human verification essential. Questions relating to copyright, intellectual property, authorship, academic integrity, cybersecurity, transparency, and accountability require careful consideration. Furthermore, unequal access to digital

infrastructure and AI literacy may create a new form of digital inequality among library users.

Therefore, the future of AI-enabled libraries should not be understood simply as a transition from human-operated libraries to fully automated systems. Instead, it should be viewed as a human–AI collaborative model, in which technology enhances the capabilities of library professionals while preserving human judgement, ethical responsibility, and the social mission of libraries. The concept of a smart library should ultimately focus on improving the quality, accessibility, inclusiveness, and relevance of information services rather than technology adoption for its own sake.

Against this background, the present paper examines the impact of Artificial Intelligence in libraries, with particular emphasis on the transformation of library services, user empowerment, changing professional roles, opportunities, challenges, and ethical considerations. It argues that responsible and purposeful adoption of AI can help libraries evolve into intelligent, responsive, inclusive, and future-ready knowledge environments while maintaining the fundamental values of intellectual freedom, privacy, equitable access, and human-centred service.

AI and the Transformation of Library Services

AI can transform almost every major area of library service. One of its most visible applications is in information retrieval and discovery. Traditional catalogue systems generally require users to understand particular search techniques, keywords, or subject terminology. AI-powered discovery systems can allow users to ask questions using natural language and receive more relevant results.

For example, instead of searching for several individual keywords, a user could ask a library system a complete question about a research topic. Natural-language processing can help the system understand the meaning and context of the question and identify relevant books, articles, databases, and other resources.

AI can also support virtual reference services. AI-powered chatbots and virtual assistants can answer frequently asked questions about library opening hours, membership, borrowing policies, databases, and basic research procedures. Such systems can provide assistance outside normal library hours and reduce the workload associated with repetitive enquiries.

Personalized Library Services

Another important contribution of AI is personalization. Libraries contain enormous quantities of information, and users can sometimes find it difficult to identify the most relevant resources. AI can analyse search behaviour and resource usage patterns to provide personalized recommendations.

For example, an academic library system could recommend books, research papers, journals, or databases related to a user's previous searches or current research interests. Personalized services can help users discover relevant resources that they might otherwise overlook.

However, personalization must be balanced with privacy. Libraries have traditionally

protected the confidentiality of their users' reading and information-seeking activities. Therefore, AI systems should be designed with strong privacy protections and transparent data practices.

AI-Powered Reference Services

Virtual assistants and AI chatbots can provide basic reference assistance at any time.

They can help users:

- locate library resources;
- identify databases;
- understand library rules;
- find opening hours and services;
- formulate search queries;
- identify relevant keywords;
- navigate digital collections; and
- receive preliminary research guidance.

AI reference services can be particularly useful when librarians are unavailable, while complex research questions can still be referred to professional librarians.

Automation of Routine Library Activities

AI can reduce the amount of time librarians spend on repetitive and routine tasks. Activities such as metadata creation, classification support, subject indexing, document processing, text extraction, and duplicate detection can increasingly be assisted by AI.

AI can analyse documents and suggest keywords, subjects, classifications, or metadata fields. Librarians can then review and verify these suggestions rather than performing every task manually.

This does not necessarily mean that librarians will become less important. Instead, automation can allow librarians to focus on professional judgement, collection development, research support, user education, and other activities where human expertise is essential.

AI in Digital Preservation and Knowledge Management

Libraries are increasingly responsible for large digital collections, including manuscripts, photographs, newspapers, institutional publications, theses, and historical documents. Managing these collections can be difficult because of their size and complexity.

AI can assist with digitization workflows, optical character recognition, image analysis, automatic metadata generation, document classification, and identification of information within large digital collections. These capabilities can make historical and cultural materials easier to discover and use.

AI can therefore contribute to the preservation of knowledge while also improving access to valuable digital resources.

Improving Accessibility and Inclusion

One of the significant advantages of AI is its potential to make library services more accessible. AI-supported speech recognition, text-to-speech, automatic translation, image

recognition, and other technologies can help users with different abilities and language backgrounds.

For example, text-to-speech technology can help users who have difficulty reading printed or digital text, while speech recognition can provide alternative methods of interacting with information systems. Machine translation can also help users access information across language barriers.

Libraries can use these technologies to create more inclusive information environments in which users with different needs can participate more effectively.

Developing Smart Library Users

The role of the library in the AI era extends beyond providing access to AI tools. Libraries must also help users understand how AI works and how it should be used responsibly.

Users need to develop the ability to evaluate AI-generated information, identify misinformation, verify sources, recognize bias, understand copyright and intellectual property issues, and protect personal information. These skills can be described as **AI literacy**.

Libraries are well positioned to provide AI-literacy programmes through workshops, orientation programmes, information-literacy courses, research consultations, and online learning resources. By teaching users how to question and verify AI-generated information rather than accepting it blindly, libraries can contribute to the development of informed and critical-thinking citizens.

Generative AI for Research Support

Generative AI can assist researchers with several early-stage research activities, including:

- brainstorming research topics;
- developing research questions;
- identifying keywords;
- summarizing complex material;
- comparing concepts;
- preparing preliminary outlines;
- improving language; and
- generating possible search strategies.

However, AI-generated information should **not automatically be treated as authoritative**. Researchers should verify claims against reliable scholarly sources and original publications.

Changing Role of the Librarian

The introduction of AI will change the role of librarians, but it does not eliminate the need for professional librarians. In fact, the importance of librarians may increase in several areas.

Librarians can become AI educators, digital-literacy trainers, research consultants, information-quality evaluators, and guides who help users navigate an increasingly complex information environment.

AI can provide information quickly, but librarians can provide professional judgement, context, ethical guidance, source evaluation, and human interaction. The combination of AI

technology and human expertise can produce stronger library services than either one alone. The future librarian is therefore likely to work alongside AI rather than compete with it. The librarian's role will gradually move from simply locating information toward helping users understand, evaluate, interpret, and effectively use information.

Impact of AI on Library Services

1. **Improved Efficiency:** AI can automate repetitive activities, reducing the administrative burden on librarians.
2. **Faster Information Access:**Users can obtain relevant information more quickly through intelligent search and recommendation systems.
3. **24/7 Assistance:**AI-based virtual assistants can provide basic support outside normal library working hours.
4. **Personalized Services:** AI enables libraries to offer services based on users' interests, information needs, and learning activities.
5. **Better Resource Management:** Usage analytics can help libraries understand patterns of resource demand and make evidence-informed decisions.
6. **Enhanced Accessibility:**Voice interfaces, text-to-speech, speech recognition, translation, and other AI technologies can help users with different accessibility needs.

Challenges of Using AI in Libraries

Although AI offers many opportunities, its implementation also creates important challenges. One major concern is **privacy**. AI systems may require large amounts of user and usage data, creating potential risks if data is collected or stored improperly.

Another concern is **algorithmic bias**. AI systems learn from existing data, and biased training data can result in biased recommendations or search results. Libraries must therefore evaluate AI systems carefully and ensure that they support fairness and inclusion.

Misinformation and inaccurate AI-generated content are also significant concerns. Generative AI systems can sometimes produce information that appears convincing but is incorrect. Libraries must teach users to verify AI-generated information against reliable sources.

Copyright and intellectual property present additional challenges. AI-generated content and the use of copyrighted materials in AI systems raise complex questions that libraries must understand and address.

There is also the issue of the **digital divide**. Not every user or library has equal access to advanced technologies, reliable internet connectivity, or AI tools. Libraries must ensure that technological development does not increase existing inequalities.

AI and the Future of Libraries

The future library is likely to be increasingly intelligent, digital, connected, and user-centred. AI can support users in discovering information, conducting research, communicating with library systems, and accessing resources in new ways.However, the future of libraries should not be understood as a completely automated environment. Libraries

are fundamentally human institutions. Their value comes not only from collections and technologies but also from trust, professional expertise, community service, education, and the human relationship between librarians and users.

The most successful libraries will therefore be those that combine technological innovation with professional values. AI can handle repetitive processes and analyse large quantities of information, while librarians can provide judgement, empathy, ethical guidance, and personalized assistance.

Conclusion

Artificial Intelligence has the potential to significantly enhance library services and transform the relationship between libraries, librarians, and users. From intelligent search and virtual reference services to personalized recommendations, automated cataloguing, digital preservation, and accessibility, AI can make library services faster, smarter, and more responsive to user needs.At the same time, AI creates responsibilities concerning privacy, bias, copyright, misinformation, data security, and equitable access. Libraries must therefore adopt AI carefully and ethically.The most important contribution of libraries in the AI era may be helping users become smart and responsible information users. By developing AI literacy, critical thinking, digital skills, and information-evaluation abilities, libraries can prepare users to navigate the rapidly changing information environment.AI should not be viewed as a replacement for librarians. Instead, it should be viewed as a powerful tool that can enhance professional library services. The combination of Artificial Intelligence and human intelligence can create smarter libraries, stronger information services, and better-prepared users for the future.

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SMART TECHNOLOGY TO SMART TEACHING: THE ROLE OF TEACHERS IN STUDENT ENGAGEMENT AND WELL-BEING

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Abstract

Artificial Intelligence (AI) is increasingly becoming part of educational practice and is changing the way teachers plan, teach and assess learning. However, the value of AI in education should not be measured only by its ability to save time or improve academic performance. From the perspective of a B. Ed student-teacher observing real classroom dynamics, the fundamental question is whether AI helps educators build supportive learning spaces where students stay genuinely curious, participate actively, think for themselves, and feel emotionally secure. This paper examines the possibilities and challenges of using AI for student engagement and well-being and proposes a practical SMART Teacher Framework for responsible classroom integration. AI can support teachers in preparing differentiated learning materials, providing immediate feedback, generating examples, adapting explanations and creating opportunities for students to learn at their own pace. These possibilities can be useful in classrooms where students differ in learning ability, confidence, language background and pace. At the same time, unrestricted AI use may encourage copying, overdependence on technology, screen fatigue and reduced human interaction. Questions of privacy, unequal access, inaccurate information and academic integrity further complicate its use. The paper therefore argues that AI should complement rather than replace teachers. The proposed SMART Teacher Framework Student-centred, Meaningful, Adaptive, Responsible and Teacher-led Technology integration places the learner and teacher relationship at the centre of AI-supported education. Practical examples from educational institutions, including Cold Spring School, Georgia Tech and Khan Academy, illustrate ways in which AI can be used with human guidance rather than as a replacement for human teaching. The paper concludes that a smart future in education requires not simply smarter technologies, but teachers who can use those technologies thoughtfully, ethically and empathetically to strengthen both student engagement and well-being.

***Keywords**: SMART Technology, Smart teaching, student engagement, wellbeing.*

Introduction

Education has always developed along with changes in society. The blackboard was followed by the projector, the computer, the smart board, online learning platforms and now Artificial Intelligence. Each technological change has influenced classroom practice, but AI is different from many earlier technologies because it can generate, respond, analyze and interact with

learners. For teachers, this creates new possibilities as well as new responsibilities. The rapid advancement of Artificial Intelligence (AI), digital platforms, smart classrooms, learning analytics, virtual environments, and educational applications is transforming the nature of teaching and learning. Technology has moved beyond its traditional role as a supportive teaching aid and has become an integral part of the contemporary educational ecosystem. The transition from "Smart Technology" to "Smart Teaching" therefore requires more than the adoption of sophisticated digital tools; it demands a meaningful transformation in the role, competencies, and responsibilities of teachers. While technology can provide personalized learning, instant feedback, interactive content, and access to vast educational resources, the teacher remains central to creating learning environments that promote student engagement, emotional well-being, social interaction, critical thinking, and responsible use of technology.

Student engagement is a multidimensional concept that includes behavioural, emotional, cognitive, and social participation in the learning process. In technology-rich classrooms, digital tools can increase interaction and provide students with flexible opportunities to learn. However, excessive or inappropriate dependence on technology may also contribute to distraction, passive learning, digital fatigue, reduced face-to-face interaction, and feelings of isolation. Similarly, the increasing use of AI-powered systems raises important concerns regarding privacy, academic integrity, digital dependence, misinformation, equity, and the human dimensions of education. These challenges highlight the need for teachers who can balance technological possibilities with human-centred pedagogy.

The contemporary teacher is therefore evolving from a transmitter of information to a facilitator, mentor, designer of learning experiences, digital guide, motivator, counsellor, and reflective practitioner. Smart teaching involves selecting and integrating technology according to learners' needs rather than using technology simply because it is available. A smart teacher uses digital resources to encourage collaboration, inquiry, creativity, problem-solving, personalized learning, and active participation while ensuring that students remain emotionally connected and socially supported.

The importance of this transformation is particularly significant in the context of NEP 2020, which emphasizes technology-enabled education, experiential learning, competency development, holistic development, and the well-being of learners. The policy envisions education that develops not only knowledge and skills but also the social, emotional, ethical, creative, and intellectual capacities of learners. In this context, technology should function as an enabler of quality education, while teachers provide the human connection necessary for meaningful learning. Thus, "Smart Technology to Smart Teaching" represents a shift from technology-centred education to teacher-guided, learner-centred and well-being-oriented education. The effectiveness of smart classrooms and AI-enabled learning environments ultimately depends not merely on the sophistication of technological tools but on how thoughtfully teachers integrate them into pedagogy. The teacher's ability to create an inclusive, engaging, psychologically safe, and ethically responsible learning environment is

fundamental to ensuring that technological advancement contributes positively to student engagement and overall well-being. This paper presents AI as a support for teaching rather than a substitute for teachers and proposes the SMART Teacher Framework as a practical approach for balancing technology, learning and human well-being.

Artificial Intelligence and Student Engagement

Student engagement is more than classroom attendance or assignment completion. It includes students' participation, mental involvement and emotional connection with learning. AI can contribute to engagement in several practical ways.

- Teachers can use AI to design multi-tiered learning tasks, generating accessible entry points for students requiring foundational support while building challenging application problems for advanced learners.
- When a learner struggles with abstract textbook definitions, an educator can prompt AI to generate everyday analogies, conversational explanations, or step-by-step breakdowns suited to the student's background.
- Immediate diagnostic feedback allows students to pinpoint specific misconceptions and revise their work while their focus is still fresh, preventing errors from becoming ingrained habits.

However, these benefits depend on the type of interaction created by the teacher. If AI always gives the final answer, students may become passive. If AI gives a hint, asks the student to explain a step or provides another example, it can become a learning support. Therefore, the important shift is from using AI to give answers towards using AI to support thinking.

Artificial intelligence, Cognitive Engagement and Independent Thinking

One of the major concerns surrounding generative AI is cognitive offloading. When a learner transfers a thinking task to technology, the immediate task becomes easier, but the learning opportunity may become weaker.

For example, a student asked to write a paragraph may directly ask AI to produce it. The final paragraph may be grammatically correct, but the student may not have practised organising ideas or expressing them independently.

The same concern applies to problem-solving. If students immediately ask AI for the solution to a mathematics problem, they lose the opportunity to struggle productively with the problem. Therefore, AI-supported learning should encourage a cycle of: thinking → attempting → receiving support → checking → improving. Instruction must therefore steer students away from a passive shortcut model (Question → AI Answer → Copy → Submit) toward an active, iterative inquiry cycle: Thinking → Attempting → Receiving Targeted Support → Verifying → Improving.

Teachers can design activities where students first attempt a problem independently, then use AI to identify a mistake or obtain a hint, and finally explain the corrected solution in their own words. Such an approach preserves the student's role as a thinker.

Artificial Intelligence and Student Well-being

Student well-being is closely connected to learning. A student who feels anxious, excluded or constantly unsuccessful may gradually lose interest in classroom participation. AI can provide certain forms of academic support that may indirectly contribute to confidence. However, AI cannot replace emotional understanding.

A teacher can notice when a normally active student becomes quiet. A teacher may recognize hesitation, frustration or loss of confidence even when the student's written work does not show it. This human observation is essential for well-being. The use of AI should therefore not result in fewer teacher–student interactions. Instead, the time saved through AI should ideally allow teachers to spend more meaningful time with students. This is one of the most important principles of the proposed framework.

Risks to Student Well-being

The benefits of AI must be considered alongside its risks.

1. Excessive dependence on digital tools: it may contribute to screen fatigue and reduce opportunities for face-to-face communication. Students also need opportunities to work with peers, participate in practical activities, communicate directly and experience learning away from screens.
2. surveillance anxiety: AI-supported systems can collect information about student activity and performance. Although such information may help teachers identify learning difficulties, students may feel uncomfortable if they believe that every action is being monitored. Privacy is therefore not only a technical issue. It is also a student well-being issue.
3. unequal access: Some students have personal devices, reliable internet and access to advanced AI tools, while others may depend on shared devices or limited connectivity. If AI-based homework becomes compulsory without considering these differences, technology can increase rather than reduce educational inequality. Responsible AI integration therefore requires attention to access, privacy, screen time, academic honesty and emotional safety.

Practical Examples of AI in Education

AI-supported education is no longer only a theoretical possibility. Educational institutions are already experimenting with different models.

One interesting example is Cold Spring School in California, where AI use has been approached through a "Human → AI → Human" model. Students begin with their own thinking, use AI as part of the learning process and then return to their own work for revision and improvement. This model is particularly relevant because AI is treated as a stage in learning rather than the beginning and end of learning.

Another example comes from Georgia Tech, where Jill Watson was developed as an AI teaching assistant to handle routine questions in an online learning environment. The experience demonstrated how AI can assist with repetitive support while human educators remain responsible for deeper teaching and interaction.

Khan Academy has also experimented with AI-supported learning through Khanmigo. Its

district programmes have focused on helping students and teachers use AI as part of learning rather than simply using it as an answer-generating tool. The organisation has also emphasised professional development for educators, which highlights an important point: AI implementation requires teacher preparation, not simply access to software.

These examples suggest that successful AI integration depends on the educational model surrounding the technology.

AI in the Indian School Context

The discussion of AI is especially relevant to Indian education because AI literacy is beginning to enter school-level curriculum and teacher development.

CBSE has introduced computational thinking and understanding of AI as part of its school education initiatives, including a curriculum for Classes 3–8 from the 2026–27 academic session. This reflects a broader movement towards preparing students not merely to use technology but to understand computational thinking and AI-related concepts.

For Indian schools, this development has important implications. Students will increasingly encounter AI in their academic and personal lives. Therefore, schools need to teach not only how to use AI, but also how to question AI, verify AI-generated information and use it responsibly. This is particularly important in classrooms where students may assume that an AI-generated answer is automatically correct. AI literacy should therefore become part of critical thinking.

The SMART Teacher Framework

The central contribution of this paper is the SMART Teacher Framework. The framework is designed not as another technology model but as a practical guide for teachers deciding whether and how to integrate AI.

S – Student centred

AI use should begin with the learner's need. The teacher should consider students' level, learning difficulties, interests and context before selecting an AI-supported activity. The technology should serve the learner.

M – Meaningful

AI should be used only when it adds meaningful educational value. If a discussion, practical experiment, peer activity or teacher explanation is more effective, AI does not need to be used. A lesson should not become “smart” merely because it contains technology.

A – Adaptive

Students differ in their learning pace and level of understanding. AI can assist teachers in creating differentiated examples, practice questions, explanations and feedback. However, adaptation should remain flexible. Students should not be permanently labelled according to their present performance.

R – Responsible

Responsible AI use includes privacy, fairness, academic integrity, verification of information and equitable access.Students should learn that AI can make mistakes and that they remain

responsible for the work they submit.

T – Teacher-led Technology Integration

The teacher remains responsible for deciding when AI is appropriate. This is perhaps the most important principle. AI should not determine pedagogy. Pedagogy should determine the use of AI.

Applying the SMART Framework in a Real Classroom

The framework can be applied to a normal school lesson. Consider a science lesson on motion. The teacher may begin with a real-life classroom demonstration rather than immediately opening an AI tool. Students observe a moving object and discuss what they notice. The teacher then identifies that some students are struggling to distinguish distance and displacement. AI can be used at this stage to generate simple real-life situations or additional examples at different difficulty levels. Students work in pairs and examine the examples. They discuss whether the AI explanation is scientifically correct.

The teacher then brings the class together and clarifies misconceptions. Students finally write their own explanation and solve a problem without AI assistance. In this example, AI has supported the lesson but has not replaced the teacher, practical observation or student thinking. This is the kind of balanced classroom practice that the SMART Teacher Framework aims to promote.

Rethinking Assessment in the Age of AI

AI also requires teachers to reconsider assessment. When students can generate polished written answers using AI, the final product may no longer provide sufficient evidence of individual understanding. Assessment can therefore include oral explanation, classroom problem-solving, project presentations, reflective writing, group discussion, practical demonstrations, process-based assessment, For example, instead of simply asking a student to submit a five-hundred-word essay, the teacher can assess the student's initial ideas, research process, draft, final response and short oral explanation. This does not mean banning AI completely. Instead, it makes the learning process visible. Students can also be asked to explain how AI was used, what information they accepted or rejected and what changes they made. Such assessment develops both subject knowledge and AI literacy.

The Changing Role of the Teacher

AI is likely to reduce some routine tasks, but this does not reduce the importance of teachers. In fact, as information becomes easier to obtain, teachers may become more important as:facilitators, mentors, learning designers, evaluators and ethical guides.

The teacher's role is moving from simply delivering information towards helping students interpret, evaluate and apply information. A teacher may use AI to prepare twenty questions, but the teacher still decides which five are appropriate. AI may suggest an explanation, but the teacher decides whether it is scientifically accurate and suitable for the class. AI may identify that a student is performing poorly, but the teacher investigates the reason. The future of schooling is therefore not teacher versus machine, but an intentional partnership where digital

tools support pedagogical wisdom.

Implications for Teacher Education

Teacher training programmes have an important role in preparing future teachers for AI-supported education. Teachers receive opportunities to practise AI integration rather than learning about AI only through theoretical lectures. Teacher education can include activities such as:

- AI-assisted lesson planning: Teachers prepare a lesson with AI and critically review the output.
- AI error detection: Teachers analyse AI-generated answers and identify inaccurate information.
- AI and assessment: Teachers redesign traditional assignments to assess understanding rather than AI-generate output
- AI ethics: Teachers discuss privacy, bias, academic honesty and equitable access.
- Reflection: Teachers document what worked, what failed and how the lesson could be improved. Such experiences can help future teachers become confident but critical users of AI.

AI should be evaluated according to its educational purpose. A highly advanced AI system may have little educational value if students become passive users. A simple AI-supported activity may have considerable value if it encourages students to question, collaborate and think. Similarly, student engagement should not be measured simply through digital activity. Genuine engagement involves attention, reasoning, participation, curiosity and emotional connection. Student well-being should also remain central. Technology should not increase unnecessary screen exposure, surveillance or academic pressure. The most appropriate approach is therefore, one of balance. Technology should increase possibilities without reducing humanity. Schools implementing AI should develop clear guidelines for teachers and students. AI should be introduced according to age, curriculum and learning purpose rather than through unrestricted access.

Teacher professional development should focus on practical classroom applications, ethical concerns and critical evaluation of AI-generated content. Assessment should increasingly include opportunities for students to demonstrate their own reasoning through oral explanation, classroom tasks, projects and reflections. Most importantly, schools should monitor the effect of AI on student well-being. Students should remain socially connected, emotionally supported and capable of independent thinking.

Conclusion

The transition from Smart Technology to Smart Teaching represents a fundamental shift in the way education is understood and practiced in the digital and AI-driven era. Technology, artificial intelligence, smart classrooms, digital platforms, and learning analytics have created unprecedented opportunities for personalized, interactive, flexible, and accessible learning.

However, technology alone cannot guarantee meaningful learning or the holistic development of students. Its educational value depends largely on the knowledge, creativity, sensitivity, and pedagogical competence of teachers.

Teachers continue to occupy a central position in promoting student engagement and well-being. By integrating technology thoughtfully with learner-centred and experiential approaches, teachers can encourage active participation, collaboration, critical thinking, creativity, self-directed learning, and problem-solving. At the same time, teachers must recognize the possible negative effects of excessive technology use, including distraction, digital fatigue, social isolation, anxiety, reduced interpersonal interaction, and overdependence on AI-generated information. Therefore, smart teaching requires an appropriate balance between digital innovation and human interaction.

The teacher of the future is not simply a user of technology but a facilitator, mentor, designer, motivator, digital citizen, ethical guide, and supporter of student well-being. Teachers need continuous professional development to understand emerging technologies, AI literacy, digital ethics, data privacy, inclusive digital practices, and innovative pedagogies. They must also create psychologically safe classrooms where students feel valued, heard, respected, and connected.

Ultimately, the goal of educational technology should not be to replace teachers but to empower teachers and enrich human learning. A truly smart educational environment is one in which technology serves pedagogical purposes, teachers provide meaningful human connection, and students become active, responsible, confident, and emotionally healthy learners. Hence, the journey from “Smart Technology” to “Smart Teaching” can contribute significantly to building an education system that is not only technologically advanced but also engaging, inclusive, ethical, learner-centred, and committed to the overall well-being of every student.

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A CORRELATIONAL STUDY OF TEACHING BEHAVIOUR AND PERCEIVED TEACHER BEHAVIOUR AMONG TEACHER EDUCATORS AT THE SECONDARY LEVEL IN MYSORE DISTRICT

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Abstract

The present study, entitled "A Correlational Study of Teaching Behaviour and Perceived Teacher Behaviour among Teacher Educators at the Secondary Level in Mysore District", was undertaken to examine the teaching behaviour of teacher educators as perceived by student teachers and the perceived teacher behaviour of teacher educators, and to determine the relationship between these two variables. The study adopted a descriptive survey method with a correlational research design. The sample consisted of 40 teacher educators and 200 student teachers from B.Ed. institutions in Mysore District. Data were collected using rating scales designed to assess teaching behaviour and perceived teacher behaviour. Mean, Median, Standard Deviation, 't' test and Pearson's Product-Moment Correlation Coefficient were used for data analysis. The findings revealed that the teaching behaviour of teacher educators was at a relatively favourable level, with a mean score of 101.57 and standard deviation of 15.96. The perceived teacher behaviour of teacher educators was also found to be relatively favourable, with a mean score of 115.83 and standard deviation of 12.47. The study found no significant difference in teaching behaviour scores as perceived by student teachers. Further, a statistically significant positive relationship was found between teaching behaviour and perceived teacher behaviour). The study highlights the importance of reflective practice, professional development and continuous improvement of teacher educators for enhancing the quality of teacher education.

Introduction

Teacher education plays a vital role in strengthening the quality, effectiveness, and professionalism of the school education system. Teacher educators occupy a significant position in this process because they are responsible for preparing prospective teachers with the knowledge, skills, attitudes, values, and professional competencies required for effective classroom practice. At the secondary level, where learners experience important academic, emotional, social, and developmental transitions, the quality of teachers' classroom behaviour becomes particularly significant. Consequently, understanding the teaching behaviour of teacher educators and how they perceive their own professional behaviour is essential for improving teacher education programmes and strengthening the preparation of secondary school teachers.

Teaching behaviour refers to the observable professional actions, practices, interactions, and instructional strategies demonstrated by a teacher during the teaching-learning process. It encompasses several dimensions, including lesson planning, presentation of subject matter, classroom management, questioning, reinforcement, motivation, communication, interaction with learners, use of teaching methods and resources, assessment practices, and provision of feedback. Effective teaching behaviour creates a supportive learning environment and contributes to learners' academic engagement and overall development. In teacher education, the behaviour demonstrated by teacher educators can also serve as a model for prospective teachers, who often internalize and reproduce the instructional practices they observe.

Perceived teacher behaviour, on the other hand, refers to how teachers or teacher educators understand and evaluate their own professional behaviour and instructional practices. Perception may be influenced by professional experience, academic qualifications, institutional environment, interpersonal relationships, professional expectations, and opportunities for professional development. A teacher educator's perception of his or her own behaviour may not always correspond completely with the behaviour actually demonstrated in practice. Therefore, examining the relationship between teaching behaviour and perceived teacher behaviour can provide meaningful insights into the degree of consistency between observed professional practices and self-perceptions.

In the contemporary educational context, teacher educators are expected to move beyond traditional transmission-oriented approaches and adopt learner-centred, reflective, inclusive, technology-supported, and competency-based pedagogical practices. National and international developments in teacher education have emphasized reflective practice, professional competence, continuous professional development, collaborative learning, and the effective integration of technology into teaching. These changing expectations make it important to examine the behavioural dimensions of teacher educators and their perceptions of their own teaching practices.

The present study, entitled **"A Correlational Study of Teaching Behaviour and Perceived Teacher Behaviour among Teacher Educators at the Secondary Level in Mysore District"** attempts to examine the relationship between teaching behaviour and perceived teacher behaviour among teacher educators involved in secondary-level teacher education. A correlational approach is particularly appropriate for determining the nature and degree of association between these variables without manipulating them. The findings of the study may provide useful insights for teacher education institutions, policymakers, administrators, and teacher educators in identifying areas requiring professional development and reflective improvement. Ultimately, understanding the relationship between actual teaching behaviour and perceived teacher behaviour can contribute to enhancing the quality of teacher education and, consequently, the effectiveness of secondary school teaching and learning.

Present Status of the Study

The present study, entitled **"A Correlational Study of Teaching Behaviour and Perceived Teacher Behaviour among Teacher Educators at the Secondary Level in Mysore District"** focuses on understanding the existing relationship between teacher educators' actual teaching behaviour and their perception of their own professional behaviour. In the present educational context, teacher educators are increasingly expected to demonstrate effective pedagogical practices, learner-centred approaches, professional competence, reflective practices, appropriate classroom interaction, and effective use of instructional resources. However, there may be differences between the teaching behaviour demonstrated in practice and the behaviour perceived by teacher educators themselves. The present status of the study therefore emphasizes the need to examine this relationship systematically among teacher educators involved in secondary-level teacher education. The study is being undertaken in Mysore District to obtain empirical evidence regarding the nature and degree of correlation between the two variables. The findings are expected to provide useful insights for improving professional development, reflective teaching practices, institutional support, and the overall quality of teacher education.

Objectives of the Study

1. To assess the teaching behaviour of teacher educators at the secondary level as perceived by student teachers in Mysore District.
2. To assess the perceived teacher behaviour of teacher educators at the secondary level in Mysore District.
3. To study whether there is any relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

Hypotheses of the Study

1. There is a significant difference in the teaching behaviour scores of teacher educators as perceived by student teachers at the secondary level in Mysore District.
2. There is a significant relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

Methodology of the Study

The present study adopts a **descriptive survey method with a correlational research design** to examine the relationship between teaching behaviour and perceived teacher behaviour among teacher educators at the secondary level in Mysore District. The survey method is considered appropriate as the study seeks to collect systematic information regarding the existing teaching practices and perceptions of teacher educators without manipulating any of the study variables.

Variables in the Study

In the present study the variables taken into consideration by the investigator are:

- Teaching Behaviour
- Perceived Teacher Behaviour

Population and Sample of the Study

The **population of the study** comprises teacher educators and student teachers associated with secondary-level teacher education institutions in Mysore District. An appropriate sample of teacher educators and student teachers will be selected using a suitable sampling technique, depending on the availability and characteristics of the institutions. Data will be collected from student teachers to assess the teaching behaviour of teacher educators and from teacher educators to examine their perceived teacher behaviour.

The sample of the present study consisted of 40 teachers educators and 200 student teachers of Mysore district's B.Ed. institutions.

Tools Used in the Study

The present study has employed the following two tools for the study:

- A rating scale to measure Teaching Behaviour of teacher educators as perceived by the student teachers whom they are training.
- A rating scale to measure the perception of Teacher Behaviour of teacher educators as perceived by themselves.

Procedure for Data Collection

The investigator visited the institutions selected for the study and administered the validated tool the rating scales.

Statistical Techniques Used in the Study

1. **Descriptive Statistics:** Descriptive statistical procedures namely Mean, Median and Standard Deviation were used to analyze the data.
2. **Inferential Statistics:** In the present study, the Inferential Statistics Pearson's Product Moment Correlation (r) and 't' values were used.

Analysis and Interpretation of the Data

Analysis and Interpretation of Objective One

The first objective was to assess the teaching behaviour of teacher educators at the secondary level as perceived by student teachers in Mysore District.

The analysis and interpretation of this objective has been done by using descriptive statistics Mean, Median, Standard Deviation and Smoothed Frequency. Frequency distribution of scores on Teaching Behaviour is given in the below Table.

Table-1: Frequency distribution of the scores on teaching behaviour of teacher educators as perceived by the student teachers at Primary level.

Class Interval	Mid Point	Frequency	Smoothed Frequency
34-43	38.5	2	1
44-53	48.5	1	4
54-63	58.5	9	6.3
64-73	68.5	9	14
74-83	78.5	24	29.6
84-93	88.5	56	57
94-103	98.5	91	88.3

104-113	108.5	118	92.6
114-123	118.5	69	69.3
124-133	128.5	21	30

Mean, Median, Standard Deviation and Skewness were calculated for the distribution of scores on Teaching Behaviour. The results are given the below table.

Table-2: Number (N), Mean (M), Median (Mdn), Standard Deviation (SD) and Skewness (Sk) of the distribution of scores on Teaching Behaviour.

Variable	N	Max. Score	M	Mdn	SD	Sk	Q1	Q3
Teaching Behaviour	200	132	101.57	104	15.96	-0.45	93.3	112.6

Interpretation

From the above table it is observed that the N, Mean, Median, Standard Deviation, Skewness, Q1 and Q3 of the distribution of scores on Teaching Behaviour among 200 respondents. The maximum possible score on the Teaching Behaviour scale is 132. The obtained Mean score is 101.57, while the Median is 104, indicating that the scores are generally concentrated around the higher end of the distribution. The Standard Deviation of 15.96 indicates a moderate amount of variability in the Teaching Behaviour scores among the respondents.

The Skewness value is -0.45, indicating a slightly negatively skewed distribution. Since the Skewness value is relatively close to zero, the distribution may be considered approximately normal, with a slight tendency for scores to be concentrated towards the higher end. The first quartile (Q1) is 93.3, indicating that approximately 25% of the respondents obtained scores below this value, whereas the third quartile (Q3) is 112.6, indicating that approximately 75% of the respondents scored below this value. Thus, the middle 50% of the respondents obtained Teaching Behaviour scores between 93.3 and 112.6.

The findings indicate that the Teaching Behaviour scores of the respondents are relatively high, as reflected by the mean score of 101.57 out of a maximum score of 132. The closeness of the mean and median suggests that the distribution is reasonably balanced, although the negative skewness indicates a slight concentration of scores towards the higher end. The moderate standard deviation shows that there is some variation in the teaching behaviour scores among the respondents. Overall, the distribution suggests that the teacher educators demonstrated a favourable level of teaching behaviour, as perceived by the respondents.

Hypothesis One

H1: There is a significant difference in the teaching behaviour scores of teacher educators as perceived by student teachers at the secondary level in Mysore District.

In order to test the hypothesis, the null hypothesis was formulated and selected.

H0: There is no significant difference in the teaching behaviour scores of teacher educators as perceived by student teachers at the secondary level in Mysore District.

't' test was employed to test the null hypothesis with a level of significance set at 2.58 for the level of significance at 0.01 level with degrees of freedom 398 and the results are given in the below table.

Table-3: Mean (M), Standard Deviation (SD) and't' value of the scores of Mysore District on teaching behaviour of teacher educators as perceived by the student teachers.

District	M	SD	't' Value	Significant Level
Mysore	102.59	14.46	1.0377	Not Significant at 0.01 level

Interpretation

The above table presents the mean, standard deviation, and *t* value of the teaching behaviour scores of teacher educators as perceived by student teachers in Mysore District. The obtained **Mean score is 102.59**, with a **Standard Deviation of 14.46**. The calculated *t* value is **1.0377**, which is **not significant at the 0.01 level**. Since the obtained *'t'* value is not statistically significant at the 0.01 level, the null hypothesis is **accepted**. This indicates that there is **no statistically significant difference in the teaching behaviour scores** of teacher educators as perceived by the student teachers in the study. The finding suggests that the teaching behaviour of teacher educators, as perceived by student teachers, is relatively consistent and does not show a statistically significant variation.

Conclusion

The study found that **there is no significant difference in the teaching behaviour of teacher educators at the secondary level as perceived by student teachers in Mysore District**. Therefore, the **null hypothesis is accepted**.

Analysis and Interpretation of Objective Two

The second objective was to assess the perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

The analysis and interpretation of this objective has been done by using descriptive statistics, namely, Mean, Median, Standard Deviation and Smoothed Frequency. Frequency distribution of the scores on Teacher Behaviour perception is given in the below table.

Table-4: Frequency distribution of the scores on perceived teacher behaviour of teacher educators at secondary level.

Class Interval	Mid-Point	Frequency	Smoothed Frequency
94-103	98.5	10	5.3
104-113	108.5	6	8
114-123	118.5	8	9.6
124-133	128.5	15	8
134-143	138.5	1	5.3

Mean, Median, Standard Deviation and Skewness were calculated for the distribution of scores on perceived teacher behaviour. The results are given the below table.

Table-5: Table 4.10: Number (N), Mean (M), Median (Mdn), Standard Deviation (SD) and Skewness (Sk) of the distribution of scores on Perceived Teacher Behaviour.

Variable	N	M	Mdn	SD	Sk	Q1	Q3
Perceived Teacher Behaviour	40	115.83	116.5	12.47	-0.26	93.5	127.5

Interpretation

The above table presents the **Mean (M), Median (Mdn), Standard Deviation (SD), Skewness (Sk), First Quartile (Q1) and Third Quartile (Q3)** of the scores obtained on **perceived teacher behaviour** for a sample of 40 teacher educators.

The **Mean score is 115.83**, while the **Median score is 116.5**, indicating that the scores are concentrated around a relatively high level of perceived teacher behaviour. The **Standard Deviation of 12.47** indicates a moderate degree of variability among the respondents' scores.

The obtained **Skewness value is -0.26**, which indicates a slight negative skewness in the distribution. Since the value is close to zero, the distribution can be considered **approximately symmetrical and reasonably close to a normal distribution**. The negative value suggests a slight concentration of scores towards the higher end of the scale.

The **first quartile (Q1) is 93.5**, indicating that approximately 25% of the respondents obtained scores below 93.5. The **third quartile (Q3) is 127.5**, indicating that approximately 75% of the respondents obtained scores below 127.5. Thus, the middle 50% of the respondents obtained scores between **93.5 and 127.5**.

The findings indicate that the **perceived teacher behaviour among the teacher educators is relatively high**, as reflected in the mean score of 115.83. The closeness of the mean and median suggests that the distribution is fairly balanced. The low negative skewness further indicates that the distribution is approximately normal. Overall, the results suggest that the teacher educators possess a **favourable level of perceived teacher behaviour**, with moderate variation among the respondents.

Analysis and Interpretation of Objective Three

The third objective was To study whether there is any relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

The data pertaining to this objective were analysed using Mean and Standard Deviation as descriptive statistics, and the Pearson Product-Moment Correlation Coefficient (r) was computed to determine the relationship between the scores. The Mean, Standard Deviation, r' value, and level of significance are presented in the following table.

Table-6: Mean (M), 'r' value and level of significance of the Teaching Behaviour and Perceived Teacher Behaviour and of teacher educators.

Variables	N	Mean	'r' value	Significant Level
Teaching Behaviour	200	101.57	0.2097	Significant at 0.01 level
Perceived Teacher Behaviour	40	115.83		

Hypothesis Two

H2: There is a significant relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

In order to test the hypothesis, the null hypothesis was formulated and selected.

H0: There is no significant relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District.

Interpretation

The above table presents the **Mean and Pearson Product-Moment Correlation Coefficient (r)** between teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District. The mean score for **Teaching Behaviour is 101.57**, whereas the mean score for **Perceived Teacher Behaviour is 115.83**. The obtained correlation coefficient is **r = 0.2097**, which is reported as **significant at the 0.01 level**.

Since the obtained *'r'* value is statistically significant at the 0.01 level, the null hypothesis **(H_0)** stating that "There is no significant relationship between teaching behaviour and perceived teacher behaviour" is **rejected**. Therefore, the research hypothesis "There is a significant relationship between the teaching behaviour and perceived teacher behaviour of teacher educators at the secondary level in Mysore District" is **accepted**.

The positive value of '*r'* indicates that there is a **positive relationship** between teaching behaviour and perceived teacher behaviour. This implies that higher levels of teaching behaviour tend to be associated with higher levels of perceived teacher behaviour among teacher educators. However, the magnitude of the correlation (**r = 0.2097**) indicates a **weak positive relationship** between the two variables.

The study reveals that there is a statistically significant positive relationship between teaching behaviour and perceived teacher behaviour among teacher educators at the secondary level in Mysore District ($r = 0.2097$, $p < 0.01$). Hence, the null hypothesis is rejected and the research hypothesis is accepted.

Major Findings of the Study

1. The finding suggests that the teaching behaviour of teacher educators, as perceived by student teachers, is relatively consistent and does not show a statistically significant variation. **There is no significant difference in the teaching behaviour of teacher educators at the secondary level as perceived by student teachers in Mysore District**.

2. The Perceived Teacher Behaviour of teacher educators of Mysore District is at average level.
3. **There is a statistically significant positive relationship between teaching behaviour and perceived teacher behaviour among teacher educators at the secondary level in Mysore District.**

Educational Implications of the Study

1. Teacher educators should be provided with regular professional development programmes to improve pedagogical knowledge, teaching skills, classroom interaction and professional competencies.
2. Teacher educators should be encouraged to reflect systematically on their teaching practices and compare their self-perceptions with feedback received from student teachers.
3. Feedback from student teachers can be used as an important mechanism for identifying strengths and areas requiring improvement in the teaching behaviour of teacher educators.
4. Teacher educators should adopt learner-centred, participatory and interactive approaches that encourage active involvement, critical thinking and collaborative learning among student teachers.
5. Since teacher educators serve as role models for prospective teachers, emphasis should be placed on effective communication, questioning, reinforcement, motivation and constructive classroom interaction.
6. Teacher educators should be encouraged to integrate appropriate digital technologies and instructional resources into the teaching-learning process.
7. Teacher education institutions should provide adequate academic, technological and administrative support for continuous professional development and improvement in teaching practices.
8. The positive relationship between teaching behaviour and perceived teacher behaviour indicates the need to promote consistency between actual professional practices and teachers' perceptions of their own behaviour. Such consistency can contribute to improving the overall quality of teacher education and the preparation of effective secondary school teachers.

Suggestions for Further Research

1. Similar studies may be conducted with a larger sample covering teacher educators and student teachers from different districts of Karnataka.
2. A comparative study may be undertaken between government, aided and private teacher education institutions.
3. Similar research may be conducted at the primary, secondary and higher education levels to examine variations in teaching behaviour and perceived teacher behaviour.
4. Future studies may examine the relationship of teaching behaviour with other variables such as emotional intelligence, teaching competency, job satisfaction, professional commitment, digital literacy and teaching attitude.

5. An experimental study may be conducted to examine the effectiveness of specific professional development programmes in improving the teaching behaviour of teacher educators.
6. Future researchers may use qualitative methods, such as classroom observation, interviews, focus-group discussions and case studies, to obtain deeper insights into the teaching behaviour of teacher educators.

Limitations of the Study

1. The study was confined to teacher education institutions in Mysore District, and therefore the findings may not be directly generalisable to other districts or states.
2. The sample consisted of 40 teacher educators and 200 student teachers, which may limit the extent to which the findings can be generalised to a larger population.
3. The study employed a descriptive survey and correlational research design; therefore, the findings establish an association between the variables but do not establish a cause-and-effect relationship.
4. The study relied primarily on rating scales for data collection. Hence, factors such as social desirability and subjective interpretation of the items may have influenced the responses.
5. The study was limited to the variables of teaching behaviour and perceived teacher behaviour and did not include other potentially relevant variables such as teaching competency, emotional intelligence, job satisfaction, professional commitment or digital competence.
6. The study represents the teaching behaviour and perceptions of respondents during the period of data collection and may not fully reflect changes in professional behaviour over a longer period.

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IMPACT OF SOFT SKILLS ON EMPLOYABILITY READINESS: AN EMPIRICAL STUDY AMONG UNDERGRADUATE STUDENTS

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Abstract

In today's competitive and rapidly evolving job market, developing soft skills is essential alongside academic qualifications to ensure students' employability. Soft skills such as communication, teamwork, leadership, problem-solving, adaptability, and time management play a crucial role in preparing individuals to meet workplace expectations. This study aims to assess the level of soft skills among undergraduate students and examine the impact of these skills on their employability readiness. The study employs a descriptive survey method, with primary data collected via a structured questionnaire. Key dimensions included in the soft skills assessment were communication, teamwork, problem-solving, leadership, adaptability, and time management. The collected data were analyzed using appropriate descriptive and statistical techniques. The findings reveal a satisfactory level of soft skills among students and indicate a positive correlation between soft skills and employability readiness. The results suggest that students possessing superior soft skills are better prepared to meet the demands of employment. The study highlights the need for the systematic development of soft skills alongside academic and technical knowledge within higher education institutions. Based on these findings, educational institutions should focus on strengthening students' soft skills through curricula, training programs, workshops, internships, and experiential learning activities to enhance their employability readiness.

Keywords: *Soft skills, employability readiness, undergraduate students, employability, skill development, higher education*.

Introduction

In the present era, rapid changes driven by technological advancements, shifting socio-economic conditions, and industrial evolution have significantly altered workplace demands and working methods. In the 21st century, employers require employees who are not only proficient in technical skills)those specific to a particular field(but also adept at soft skills)Tushar & Sooraksha, 2023). Industry 4.0 has adopted technologies such as large-scale automation, the Internet of Things (IoT), big data, cloud computing, artificial intelligence, and machine learning within the industrial sector. It not only enhances productivity but also equally incorporates human values such as creativity, emotional intelligence, ethical decision-making, social responsibility, and sustainable development. Therefore, in today's times, the development of soft skills alongside technical skills has become essential for employability.

The National Education Policy 2020 also advocates for promoting skill-based education, experiential learning, internships, and industry-academia collaboration. Furthermore, various national reports such as the India Skills Report and studies published by AICTE and NASSCOM have highlighted a lack of soft skills among many graduates. Consequently, industries struggle to find suitable human resources, while educated youth continue to face the problem of unemployment. Employability skills are those skills that help an individual secure and retain a job, and enable them to adapt to a changing work environment. One of the major obstacles regarding graduate employability in the higher education sector is the gap between their employability skills and the skills required to meet workplace expectations. In the 21st century, academic knowledge alone is not sufficient to meet workplace expectations; practical skills are also essential)Surata & Suwintana, 2017).

This subject often remains challenging for policymakers, practitioners, and researchers due to the lack of a clear definition of soft skills and a conceptual framework for understanding them. Most educational institutions place greater emphasis on academic qualifications, leaving students unclear about which skills and capabilities they should focus on to enhance their employability. Consequently, graduates often fail to adequately meet the expectations of the workplace. The main problem is that the currently available theoretical frameworks do not provide sufficient guidance regarding employability skills—specifically, on which attributes the assessment of employee employability should focus and which qualities require adequate attention. Many scholars have attempted to classify soft skills from the perspective of the workplace environment and the demands of a changing labor market, encompassing skills such as critical thinking, problem-solving, creativity, adaptability, communication skills, teamwork, leadership qualities, and decision-making ability. These skills assist graduates in making the right decisions at the right time, working within a group and providing it with direction, and adjusting to new work environments.

Related literature Review

Mainga et al. (2022), in a study on the perceptions of final-year business students regarding employability, found that communication skills, learning skills, a positive attitude, and problem-solving skills are considered the most important competencies for securing an entry-level job. The study also revealed that, at the time of graduation, students were generally satisfied with their academic, personal management, and teamwork skills—particularly regarding critical thinking, self-reliance, and collaboration. However, deficiencies were still observed in areas such as creativity, innovation, time management, and conflict resolution skills. The study's findings indicate that the combined use of traditional teaching methods and student-centered learning contributes positively to the development of employability skills. Additionally, the influence of external labor market conditions on students' perceived employability was also observed.

Suarta et al. (2017) conducted a critical review of the literature on employability skills and found that employers now place great importance on employability skills alongside technical knowledge and academic qualifications. According to the study, communication skills,

problem-solving and decision-making skills, and teamwork skills are the most crucial competencies for the employability of graduates. Furthermore, employers have also attached great importance to personal attributes such as self-awareness, self-confidence, adaptability, emotional intelligence, creativity, initiative, lifelong learning, and professional conduct. The findings suggest that higher education institutions should place special emphasis on developing transferable skills alongside technical skills, so that graduates become better equipped to meet the demands of the changing labor market.

Berniak-Woźny et al. (2023) conducted a study on 755 students in Poland regarding their perceptions of employability and work-related skills; they found that digital proficiency, innovative and adaptive thinking, virtual collaboration, and emotional intelligence were considered the most important competencies for future career success. The study also revealed differences in the prioritization of these competencies based on gender, employment status, and field of study. Furthermore, there is a clear gap between students' understanding of these competencies and their actual skill levels. Researchers concluded that higher education institutions should further strengthen students' digital literacy, soft skills, interdisciplinary learning, and experiential learning so that they can be better prepared to meet the demands of the rapidly evolving digital workplace.

Need and Significance of the Study

The skill gap existing between higher education institutions and industry requirements in India is exacerbating the issues of youth unemployment and underemployment. Although the National Education Policy (NEP 2020) emphasizes skill-based education and industry-academia collaboration, empirical studies regarding the relationship between soft skills development and students' employability readiness remain relatively limited. This study aims to analyze the impact of various dimensions of soft skills on the employability readiness of graduates. The study's findings will prove useful in guiding higher education institutions to make necessary improvements to curricula and training programs, helping students develop themselves in line with job market expectations, enabling employers to identify suitable talent, and assisting policymakers in formulating effective skill development policies. Furthermore, this study will make a significant contribution to the existing literature on soft skills and employability readiness, and will help provide a solid foundation for future research.

Objectives of the Study

1. To assess the level of soft skills among undergraduate students.
2. To examine the impact of soft skills on employability readiness among undergraduate students.

Research Questions

1. What is the level of soft skills among undergraduate students?
2. To what extent do soft skills influence employability readiness among undergraduate students?

Hypothesis

H_0: There is no significant impact of soft skills on employability readiness among undergraduate students.

Variables of the Study

Independent Variable: Soft Skills are the independent variable because they are expected to influence employability readiness.

Dimensions of Soft Skills

- Communication Skills
- Teamwork
- Leadership
- Problem-Solving
- Adaptability

Dependent Variable: Employability Readiness

Delimitations of the Study

1. Only final-year undergraduate students have been included in the study.
2. Only 200 (100 male and 100 female) students have been selected as the sample.
3. Colleges from one district of Uttar Pradesh (Hardoi) have been included in the study.

Research Methodology

The present research is descriptive in nature. Its objective is to study the employability skills of higher education students and to examine the differences and relationships existing among them based on various variables.

Research design

In the present study, a survey method has been used to collect information from undergraduate students regarding their employability skills.

Population and Sample

For the present study, students pursuing higher education in colleges across Uttar Pradesh constitute the population, and a sample of 200 students was selected.

Research Instrument

A researcher-developed questionnaire (5 point Likert scale) was used to measure employability readiness for the study. This instrument encompasses dimensions such as communication, teamwork, leadership, problem-solving, adaptability.

Reliability

The present study was tested through a pilot study conducted prior to the main study. Based on the results, the reliability of the Soft Skills Scale was found to be:

Soft Skills – 0.86

Employability Readiness – 0.92

Validity

The validity of the research instrument was established through:

- Face Validity
- Content Validity

- Construct Validity

Statistical Techniques Used

The following statistical techniques were used in the study: Frequency, Percentage, Mean, Standard Deviation, Pearson's Correlation Coefficient, and Simple Linear Regression Analysis.

Data analysis and Interpretation

In this study, key dimensions such as communication skills, teamwork, leadership skills, problem-solving skills, and adaptability were analyzed to assess the level of soft skills among undergraduate students.

Objective of the study

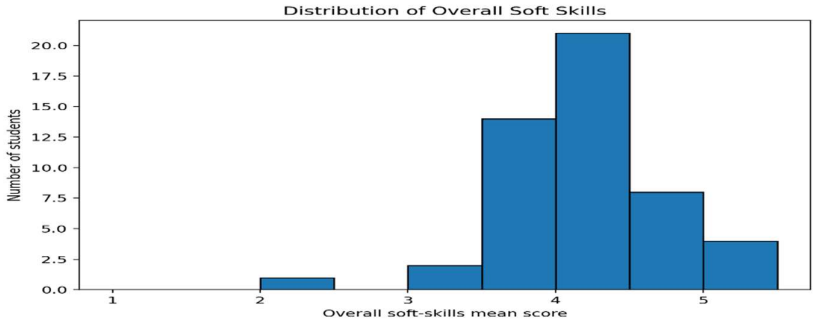
Objective 1. To assess the level of soft skills among undergraduate students.

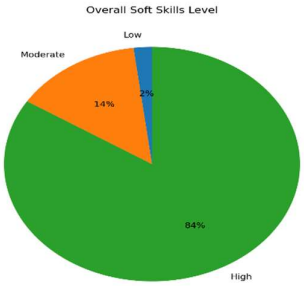
Table 1: **Various Dimensions of Soft Skills**

Soft Skill	Mean	SD	Level
Communication	4.196	0.572	High
Teamwork	4.164	0.555	High
Leadership	4.140	0.592	High
Problem-Solving	4.128	0.587	High
Adaptability	3.992	0.687	High
Overall Soft Skills	4.123	0.542	High

Analysis of the collected data revealed that the mean score for the students' overall soft skills was 4.123, with a standard deviation of 0.542, indicating a high level of soft skills. Among the various dimensions, communication skills recorded the highest mean score (M = 4.196, SD = 0.572), followed by teamwork (M = 4.164, SD = 0.555), leadership skills (M = 4.140, SD = 0.592), problem-solving skills (M = 4.128, SD = 0.587), and adaptability (M = 3.992, SD = 0.687). Although the mean score for adaptability was lower compared to the other dimensions, it still fell within the high-level category.

Graph-1: Graphical representation of the level of soft skills





Pie-chart- 1.1

Level-wise analysis further revealed that out of the total 200 students, 168 (84%) possessed a high level of soft skills, 28 (14%) were at a moderate level, and only 4 (2%) fell into the low-level category. Thus, it can be concluded that the majority of the undergraduate students included in the study demonstrated a high level of soft skills.

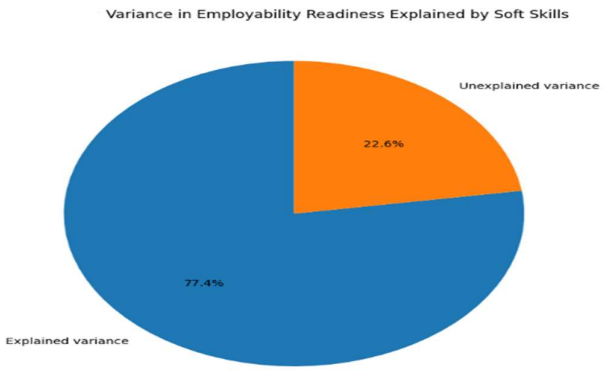
Objective 2. To examine the impact of soft skills on employability readiness among undergraduate students.

To examine the relationship between skills and employability, Pearson correlation coefficient and simple linear regression analysis were used for this objective.

Graph 2: Graphical representation of **relationship between skills and employability**



Pie-chart-1.2



Data analysis revealed a positive and statistically significant relationship between soft skills and employability ($r = .870$, $p < .001$). This indicates that students with higher soft skills tended to exhibit greater employability. Furthermore, simple linear regression analysis showed that the regression model was statistically significant, $F(1, 48) = 150.006$, $p < .001$. The model's R^2 value was found to be .758, implying that approximately 75.8 percent of the variation in employability scores within the study sample was statistically explained by soft skills scores. The regression coefficient for soft skills was also positive and statistically significant ($B = 0.925$, $t = 12.248$, $p < .001$).

H_0: There is no significant impact of soft skills on employability readiness among undergraduate students.

The Pearson Product-Moment Correlation was used to test the null hypothesis. The obtained p-value is less than the established significance level of 0.05. Therefore, the relationship found between soft skills and employability is statistically significant. Based on this, the null hypothesis (H_0) is rejected.

In conclusion, soft skills serve as a strong and statistically significant predictor of employability among the undergraduate students included in the study. Students who demonstrated higher levels of soft skills also exhibited higher levels of employability.

Conclusion: The primary objective of this study was to assess the level of soft skills among undergraduate students and to examine the relationship between soft skills and employability readiness, as well as the predictive capacity of soft skills. To this end, key dimensions of soft skills—such as communication skills, teamwork, leadership skills, problem-solving skills, and adaptability were studied. Data analysis revealed that the overall level of soft skills among undergraduate students was high. The students' average overall soft skills score was 4.123. A level-wise analysis showed that 84% of the students fell into the high soft skills category, 14% into the moderate category, and 2% into the low category. This indicates that soft skills are being adequately developed in the majority of the undergraduate students included in the study. Analysis of the various dimensions of soft skills revealed that communication skills had the highest average score. This was followed by good scores in teamwork, leadership skills, and problem-solving skills; while the average score for adaptability was relatively lower compared to the other dimensions, it still fell within the high-level category. Thus, it can be concluded that students generally possess high-level capabilities regarding communication, collaboration, leadership, problem-solving, and the ability to adapt to changing circumstances. The study's second objective involved examining the relationship between soft skills and employability readiness. The analysis revealed a positive relationship between the two variables; specifically, students with higher levels of soft skills generally exhibited higher levels of employability readiness. Consequently, the study's results indicate a positive correlation between soft skills and employability readiness. Regression analysis identified soft skills as a significant predictor of employability readiness. The model explained approximately 77.4 percent of the variance in employability readiness through soft skills scores ($R^2 \approx .774($, while approximately 22.6 percent of the variance remained

unexplained by the model. This indicates a strong statistical relationship between soft skills and the employability of students, although employability can also be influenced by other personal, educational, social, and professional factors. Overall, the study concludes that undergraduate students possess a high level of soft skills and that a positive relationship exists between soft skills and employability. Therefore, it would be beneficial for higher education institutions to place continuous emphasis on developing students' communication skills, teamwork, leadership, problem-solving abilities, and particularly adaptability, alongside their academic knowledge. Students' workplace readiness can be further strengthened by integrating soft skills into curricula, training programs, group activities, presentations, project work, internships, and employment-oriented activities. Ultimately, the study demonstrates that soft skills are closely linked to the employability of undergraduate students and play a significant role in understanding their readiness for employment. However, as the current study is survey-based and cross-sectional in nature, the observed relationships should not be interpreted as direct causal effects.

Recommendations

Based on the findings, the following suggestions are proposed:

1. Make soft skills an integral part of the curriculum.
2. Focus specifically on developing adaptability.
3. Link communication skills to professional contexts.
4. Increase practical opportunities for teamwork and leadership.
5. Develop problem-solving and decision-making capabilities.
6. Organize employability training programs.
7. Enhance collaboration between industry and higher education institutions.
8. Periodically assess students' soft skills.
9. Strengthen the role of teachers.
10. Bolster career guidance and placement support.
11. Tailor skill development to individual needs.
12. Prioritize the link between soft skills and employability readiness at the institutional level.

Suggestions for Future Research

Future studies could utilize larger and more diverse samples compared to the present study. Comparative studies could be conducted by including students from various universities, academic programs, urban and rural areas, as well as public and private higher education institutions. Additionally, longitudinal or experimental research designs could be employed to examine how specific soft-skills training programs influence students' employability readiness over time. Future research could also investigate employability readiness more comprehensively by incorporating factors such as internship experience, academic achievement, digital skills, career self-efficacy, and other relevant variables.

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SKILL DEVELOPMENT AND EMPLOYABILITY: AN EMPIRICAL STUDY OF SKILLS, TRAINING, AND EMPLOYMENT READINESS AMONG YOUNG ADULTS

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Abstract

Skill development has become a central requirement for improving employability in economies experiencing technological change, changing occupational structures, and increasing competition for jobs. Educational qualifications provide foundational knowledge, but employers increasingly expect graduates and job seekers to demonstrate practical, digital, communication, problem-solving, teamwork, and adaptive capabilities. This research paper examines the relationship between skill development and employability, with particular attention to the role of training, practical exposure, digital competence, and soft skills. A descriptive empirical design was adopted. Primary data were collected through a structured questionnaire from 100 young adults aged 18–30 who were students, recent graduates, or early-career job seekers. Respondents were selected through convenience sampling. The findings indicate that practical training, internships, digital skills, communication abilities, and career guidance are perceived as important contributors to employment readiness. The study also identifies a gap between academic learning and workplace expectations. Respondents who reported greater exposure to practical training generally expressed higher confidence in job-related competencies. The paper concludes that employability can be strengthened when educational institutions, employers, training providers, and government agencies work together to provide accessible, relevant, and continuously updated skill development opportunities.

Keywords: *skill development, employability, vocational training, digital skills, soft skills, youth employment, workplace readiness.*

Introduction

Education, skills, and employment are increasingly interconnected in a changing labour market. Technology, automation, globalization, and new business models have altered work. Employers seek people who can apply knowledge, communicate, solve problems, use digital tools, collaborate, and learn continuously. Employability therefore depends not only on qualifications but also on translating knowledge into workplace performance.

Skill development refers to the process of acquiring, improving, and updating competencies required for personal, professional, and economic participation. These competencies may be technical, vocational, digital, interpersonal, managerial, or entrepreneurial. Employability refers broadly to the knowledge, skills, attitudes, and personal attributes that enable an individual to obtain employment, perform effectively, adapt to changing work requirements, and progress in a career. The two concepts are closely connected, although employability also depends on labourmarket conditions, experience, social networks, career opportunities, and individual circumstances.

In India, the importance of skill development is particularly significant because of the country's large young population and the continuing need to create productive employment opportunities. National programmes have encouraged vocational education, apprenticeships, entrepreneurship, digital learning, and industry-oriented training. Nevertheless, concerns remain about the mismatch between what students learn and what employers require. Many graduates possess theoretical knowledge but lack practical exposure, workplace communication, confidence, or familiarity with current technologies.

This study therefore investigates perceptions of skill development and employability among young adults. It focuses on the perceived usefulness of practical training, internships, digital competencies, soft skills, career guidance, and industry interaction. It also examines whether exposure to skill-development activities is associated with greater confidence in employment readiness.

Review of Literature

Employability has been examined from individual, educational, and labour-market perspectives. Yorke (2006) describes employability as a set of achievements that makes graduates more likely to gain employment and succeed in chosen occupations. This perspective emphasizes that employability is broader than simply obtaining a job. It includes transferable abilities, understanding of professional contexts, and capacity for lifelong learning.

Tomlinson (2017) argues that graduate employability is increasingly shaped by forms of capital that individuals develop through education and experience. Academic qualifications remain important, but students also benefit from social, cultural, psychological, and identity-related resources. Work experience, professional networks, confidence, and knowledge of recruitment processes can influence employment outcomes.

The World Economic Forum has repeatedly highlighted the growing importance of analytical thinking, creativity, resilience, flexibility, technological literacy, and lifelong learning in changing labour markets. Such reports demonstrate that employers require combinations of technical and human skills rather than narrow occupational knowledge alone.

In the Indian context, skill development policies have emphasized improving the employability of youth through vocational training, apprenticeships, entrepreneurship, and industry-linked programmes. The National Skill Development Mission and related initiatives seek to expand opportunities for skill acquisition and improve alignment between training and labourmarket requirements. However, studies and policy discussions continue to identify challenges including uneven training quality, limited industry participation, inadequate career counselling, and differences in access between urban and rural learners.

Soft skills are especially important because employees frequently work in teams and communicate with customers, colleagues, managers, and external stakeholders. Communication, teamwork, leadership, time management, adaptability, and problem-solving influence workplace performance. At the same time, digital literacy has become a basic employability requirement across many occupations. Therefore, effective skill development

should combine occupational competence with transferable and digital capabilities.

Research Gap

Existing literature establishes a relationship between skills and employability, but evidence about young learners' perceptions remains useful. This study examines important skill areas, exposure to practical training, and whether such exposure influences confidence in employment readiness.

Objectives of the Study

The study has five objectives:

- To examine the perceived relationship between skill development and employability.
- To identify the skills considered most important for obtaining employment.
- To assess respondents' exposure to practical training, internships, and career guidance.
- To examine the perceived role of digital and soft skills in employment readiness.
- To suggest measures for improving skill-development programmes.

Research Methodology

Research Design: The study used a descriptive and empirical research design. It collected quantitative primary data through a structured questionnaire and used simple descriptive analysis to interpret respondents' views.

Population and Sample: The target population consisted of young adults aged 18–30, including college students, recent graduates, and early-career job seekers. A sample of 100 respondents was selected through convenience sampling. The sample was intended to provide an exploratory picture of perceptions rather than statistically represent all young adults.

Data Collection: Primary data were collected using a structured questionnaire administered in person and through an online form. Participation was voluntary. Respondents were informed that their responses would be used for academic research and that individual identities would not be reported. The questionnaire contained demographic questions and statements concerning skill development and employability. Responses to attitudinal statements were measured using a fivepoint Likert scale ranging from strongly disagree to strongly agree.

Variables: The major independent areas considered were practical training, internship exposure, digital skills, communication skills, problem-solving ability, teamwork, and career guidance. The dependent construct was perceived employability or employment readiness.

Data Analysis: The collected responses were coded and summarized using frequencies and percentages. Mean scores were also considered for selected Likert-scale items. A simple comparison was made between respondents with higher exposure to practical training and those with lower exposure. Because the sample was obtained through convenience sampling and the study was exploratory, findings were interpreted cautiously.

Data Analysis and Interpretation

The questionnaire data from 100 respondents produced the following broad profile. Sixtytwo respondents were female and thirty-eight were male. Fifty-eight respondents were aged 18–22, thirty-two were aged 23–26, and ten were aged 27–30. Fifty-six respondents were current students, twenty-eight were recent graduates, and sixteen were early-career job seekers.

Table 1: Perceived Importance of Selected Skills

Skill area	Respondents rating it important or very important
Communication skills	91%
Digital skills	89%
Problem-solving	88%
Technical/job-specific skills	87%
Teamwork	84%
Adaptability	83%
Time management	79%
Leadership	72%

The results show that communication skills received the highest rating, followed closely by digital skills and problem-solving. This indicates that respondents recognize employability as a multidimensional concept. Technical competence remains highly valued, but respondents also consider interpersonal and cognitive skills important.

Table 2: Exposure to Skill-Development Activities

Activity	Respondents with exposure
Short-term skill courses	64%
Internship/work experience	48%
Industry interaction or visits	41%
Career counselling	37%
Project-based practical learning	69%
Formal interview training	45%

The data reveal a clear difference between exposure to classroom or project-based activities and exposure to workplace-oriented experiences. Nearly seven in ten respondents reported projectbased practical learning, while fewer than half had internship experience, industry interaction, or formal interview training. This suggests that educational institutions may provide some practical activities without consistently connecting them to actual workplaces.

Respondents were also asked to rate their confidence in securing and performing in employment. Among those reporting regular exposure to practical training, 74% rated their employment readiness as high or very high. Among respondents with limited practical exposure, 49% gave the same rating. This difference suggests a positive association between practical exposure and perceived employability. It should not be interpreted as proof of causation because the study did not use random sampling or a controlled experimental design.

When asked about barriers to skill development, 61% identified lack of access to quality training, 54% cited cost, 47% mentioned insufficient information about suitable courses, 43% reported limited time, and 38% identified lack of career guidance. These responses indicate that the challenge is not simply willingness to acquire skills. Accessibility, affordability, information, and institutional support also influence participation.

A further question asked respondents which methods would most improve employability. Seventy-eight percent preferred internships or apprenticeships, 71% selected industry-oriented

projects, 67% preferred certification in relevant digital skills, 63% selected communication and interview training, and 59% wanted stronger career counselling. The pattern indicates a preference for experiential and employment-linked learning rather than purely theoretical instruction.

Findings

The first major finding is that respondents perceive skill development as essential for employability. More than four-fifths considered communication, digital competence, problem-solving, technical skills, teamwork, and adaptability important. This supports the view that employability requires a combination of technical and transferable capabilities.

The second finding is that practical exposure appears to be associated with stronger employment confidence. Respondents with regular practical training reported higher perceived readiness than those with limited exposure. Projects, internships, and workplace interaction can provide opportunities to apply knowledge, understand professional behavior, and receive feedback.

The third finding is the continuing importance of digital skills. Digital competence is no longer restricted to information-technology occupations. Office productivity tools, online collaboration, data handling, digital communication, and technology-assisted work are relevant to many sectors. Therefore, basic digital literacy should be integrated across programmes while advanced digital skills should be offered according to occupational needs.

The fourth finding concerns soft skills. Communication, teamwork, adaptability, and problem-solving were rated highly. These capabilities help individuals function effectively in diverse workplace situations. Training programmes that focus exclusively on technical content may therefore leave important employability gaps.

The fifth finding is limited access to workplace-linked opportunities. Less than half of respondents reported internship experience or industry interaction. This is significant because employers often value prior exposure to real work environments. Institutions should develop stronger partnerships with employers and provide structured opportunities for learners to observe and practice workplace tasks.

The sixth finding is that barriers to skill development are both economic and informational. Cost, lack of awareness, limited time, and insufficient counselling can prevent learners from selecting suitable programmes. Support mechanisms should therefore include affordable training, reliable information, flexible delivery, and personalized career guidance.

Discussion

The findings are consistent with the broader literature, which presents employability as a combination of knowledge, skills, experience, attitudes, and the capacity to adapt. A degree can demonstrate academic achievement, but employers also need evidence that applicants can perform practical tasks and respond to workplace demands.

The association between practical training and employment confidence is important. Experiential learning connects classroom concepts with real problems, while internships can develop discipline, communication, teamwork, and workplace awareness. Institutions should

focus on placement quality rather than treating internships as a formality.

Digital transformation makes continuous skill development increasingly necessary. Skills acquired several years earlier may become insufficient when software, processes, and occupational practices change. Educational institutions should therefore encourage lifelong learning and teach learners how to learn independently. Micro-credentials, short courses, online modules, workshops, and industry certifications can complement formal qualifications.

There is also a need to reconsider assessment. Conventional examinations mainly measure knowledge recall, whereas employability often requires application, analysis, communication, collaboration, and practical performance. Project-based assessments, presentations, case studies, simulations, portfolios, and competency demonstrations can provide better evidence of workplace readiness.

Suggestions

First, educational institutions should strengthen industry-academia collaboration. Employers can contribute to curriculum design, guest lectures, live projects, mentoring, internships, and assessments.

Second, practical learning should be integrated throughout programmes rather than concentrated at the end. Students should regularly solve realistic problems and use relevant tools.

Third, institutions should establish structured career-development services. Career counselling should begin before graduation and include career exploration, résumé preparation, interview practice, workplace communication, and information about further training.

Fourth, digital skills should be taught progressively. Basic digital literacy should be universal, while specialized skills should be aligned with disciplinary and occupational requirements.

Fifth, soft skills should be embedded into academic activities. Group projects, presentations, debates, collaborative assignments, leadership opportunities, and problem-based learning can develop these competencies naturally.

Sixth, training programmes should be accessible and affordable. Scholarships, flexible schedules, blended learning, community training centers, and publicly supported programmes can help learners from different backgrounds.

Seventh, employers should communicate skill requirements clearly. Regular employer feedback can help institutions identify emerging competencies and update curricula.

Finally, learners should take responsibility for continuous development. They should identify skill gaps, seek feedback, build portfolios, participate in projects, and remain open to new technologies and occupational changes

Conclusion

These results also highlight the importance of context-specific training.

Skill development is a critical foundation for employability. This empirical study of 100 young adults shows strong demand for communication, digital competence, problem-solving,

technical knowledge, teamwork, and adaptability. Practical training is positively associated with perceived employment readiness, while limited internships and industry interaction reveal a gap between education and workplace preparation.

Improving employability requires more than increasing the number of training programmes. Training must be relevant, practical, accessible, industry-informed, and continuously updated. Educational institutions, employers, government agencies, training organizations, and learners each have a role in this process. Institutions should create opportunities for experiential learning, employers should participate in curriculum and training, policymakers should support equitable access, and learners should pursue lifelong skill development.

The study has limitations. The sample was small and selected through convenience sampling, the findings are based partly on self-reported perceptions, and the analysis is descriptive.

Future research could use larger samples, probability sampling, longitudinal data, employer assessments, and statistical tests to examine whether specific skills predict actual employment outcomes. Nevertheless, the study demonstrates that skill development and employability are closely connected and that stronger links between education, training, and the workplace can improve young people's preparedness for employment.

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AI-DRIVEN LEARNING ANALYTICS IN ELEARNING PLATFORMS: ENHANCING STUDENT ENGAGEMENT AND PERSONALIZED LEARNING

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Abstract

Artificial Intelligence (AI) has transformed the educational sector by introducing intelligent learning systems that enhance student engagement and provide personalized learning experiences. This study examines the role of AI-driven learning analytics in e-learning platforms and its impact on improving student engagement and personalized learning. The study adopts a descriptive research design with a quantitative approach. Primary data were collected from 150 students using a structured questionnaire, while secondary data were obtained from journals, books, and reliable online sources. Simple random sampling was used to select the respondents.The collected data were analyzed using Chi-Square Analysis and Multiple Regression Analysis. The results show that students see AI-driven learning analytics favorably, with the most favored features being AI-based feedback and tailored learning recommendations. The statistical findings show a strong correlation between student engagement and AI-driven learning analytics. Predictive analytics, learning analytics dashboards, adaptive learning, and tailored feedback all have a major impact on student engagement and individualized learning, according to multiple regression analysis. According to the study's findings, AI-driven learning analytics boosts academic performance, improves learning efficacy, facilitates individualized instruction, and produces more captivating online learning environments. In order to ensure data protection, ethical AI practices, and ongoing development of AI-based educational systems, the study advises educational institutions to implement AI-enabled learning tools.

KEYWORDS: *Artificial Intelligence (AI), Learning Analytics, E-learning Platforms, Student Engagement, Personalized Learning.*

INTRODUCTION:

Artificial Intelligence (AI) has emerged as a powerful technology in the field of education, transforming traditional e-learning into intelligent and personalized learning environments.In order to comprehend students' learning behaviors and academic achievement, AI-driven learning analytics collects, analyzes, and interprets learner data utilizing technologies like machine learning, predictive analytics, and data mining. These analytics improve student engagement and learning results by enabling e-learning platforms to offer individualized learning paths, adaptive tests, real-time feedback, and prompt interventions. AI helps teachers make data-driven decisions and provide more effective instruction by determining the strengths, weaknesses, and unique learning needs of each student. AI-driven learning

analytics plays a critical role in improving the quality of e-learning as the use of digital education grows by fostering better academic performance and individualized learning while producing more interactive, effective, and learner-centered educational experiences.

OBJECTIVES OF THE STUDY:

1. To examine the association between AI-driven learning analytics and student engagement in e-learning platforms.
2. To analyze the influence of AI-driven learning analytics factors on student engagement and personalized learning using multiple regression analysis.
3. To identify the key AI-driven learning analytics factors that significantly contribute to enhancing student engagement and personalized learning.
4. To provide suggestions for improving the effectiveness of AI-driven learning analytics in e-learning platforms based on the study findings.

NEED FOR THE STUDY:

1. To understand the role of AI-driven learning analytics in enhancing student engagement and improving learning experiences in e-learning platforms.
2. To assess how well AI-driven tailored learning supports each student's unique learning needs and academic performance.
3. To give educational institutions advice on how to implement AI-enabled learning technology for improved instruction, learning, and decision-making.

REVIEW OF LITERATURE:

Holmes, Bialik, and Fadel (2024) examined the role of Artificial Intelligence in transforming digital education through learning analytics. The study demonstrated how AI-driven analytics efficiently track student learning habits and pinpoint unique learning trends. It was discovered that by offering tailored content and prompt feedback, adaptive learning systems raise student engagement. Predictive analytics, the researchers found, aids in the early identification of at-risk students, allowing for prompt interventions. The significance of ethical AI practices, such as data protection and transparency, was also underlined in the report. The findings showed that AI improves course completion rates, academic achievement, and learner motivation. The authors suggested that in order to enhance learning outcomes, higher education institutions should ethically integrate AI. The study came to the conclusion that developing efficient and customized e-learning environments need AI-driven learning analytics.

Siemens and Baker (2023) investigated the application of learning analytics in modern e-learning platforms. The study discovered that by examining educational data in real time, AI algorithms can properly anticipate learner performance. Student engagement and learning satisfaction were greatly increased by personalized recommendations. The study made clear that educators may use analytics dashboards to track students' development and offer focused assistance. AI-powered interventions improved course completion and decreased dropout rates. The writers talked on how crucial it is to keep AI decision-making transparent and equitable. To guarantee dependable results, they recommended ongoing assessment of AI models. The study came to the conclusion that student achievement and educational quality

are enhanced by AI-driven learning analytics.

Ifenthaler and Schumacher (2022) explored the effectiveness of AI-supported adaptive learning systems in higher education. Personalized feedback improved students' academic performance and learning satisfaction, according to their research. Recommendation systems powered by AI increased student engagement and promoted self-regulated learning. The study showed that learning challenges could be detected using predictive analytics prior to a fall in academic performance. Researchers stressed that good AI predictions depend on high-quality educational data. Learner privacy and ethical data management were shown to be crucial implementation elements. For improved instructional support, the study suggested incorporating AI analytics into learning management systems. The authors came to the conclusion that AI greatly improves individualized learning.

Viberg, Hatakka, Bälter, and Mavroudi (2021) reviewed learning analytics applications in online education. The study discovered that by offering real-time performance data, AI-powered dashboards raised learner engagement. With individualized feedback, students took a more active role in tracking their own learning progress. Teachers were able to identify pupils who needed academic support because to predictive analytics. The study emphasized how adaptive learning pathways enhance knowledge retention. In order to apply AI analytics effectively, researchers stressed the significance of teacher training. Instructional planning and decision-making were improved by data visualization technologies. The study came to the conclusion that student engagement and academic success are greatly enhanced by AI-based learning analytics.

Tsai, Perrotta, and Gašević (2020) investigated how AI technologies affect customized e-learning settings. According to the study, by matching students' skills, adaptive evaluations enhanced learning results. AI recommendation systems increased student motivation by providing personalized learning materials. Because the learning materials matched their learning interests and pace, students were more satisfied. In order to safeguard learner privacy, the researchers stressed responsible AI implementation. Additionally, learning analytics helped teachers enhance their lesson plans and pedagogical approaches. The study emphasized how predictive analytics is becoming increasingly important in digital education. The authors came to the conclusion that AI is essential to improving individualized online education.

RESEARCH METHODOLOGY

The present study adopts a quantitative research approach to examine the impact of AI-driven learning analytics on student engagement and personalized learning in e-learning platforms. The study intends to use AI-enabled e-learning systems to gather, evaluate, and interpret student data. To get complete information, primary and secondary data sources are utilized. While secondary data is gathered from journals, books, research articles, conference proceedings, and reliable web sources, primary data is gathered directly from respondents. The gathered data is analyzed and the study goals are tested using statistical tools.

RESEARCH DESIGN

The study follows a descriptive research design. The present state of AI-driven learning analytics and its impact on student engagement and personalized learning are explained by this design, which makes it suitable. It allows the researcher to examine the beliefs, attitudes, and experiences of respondents without changing any of the variables. Regarding the efficacy of AI-based learning analytics in e-learning systems, the descriptive design offers precise and methodical data.

SAMPLING TECHNIQUE

The Simple Random Sampling Technique is used in this investigation. Every student utilizing an e-learning platform with AI support has an equal probability of being chosen as a response under this strategy. By reducing bias, this sampling method enhances the data's dependability and representativeness. Additionally, it guarantees that the results may be applied to the intended audience.

SAMPLE SIZE

The **sample size** for the study consists of **150 respondents**. The respondents are college and university students who regularly use AI-driven e-learning platforms for academic purposes. A sample of 150 is considered adequate for applying statistical tools such as Percentage Analysis, Chi-Square Test and Multiple Regression Analysis.

SAMPLE UNIT

The **sampling unit** of the study is **individual students** enrolled in higher education institutions who use AI-enabled e-learning platforms. Each student represents one unit of analysis for collecting responses related to engagement, personalized learning, and AI adoption.

TOOLS FOR DATA COLLECTION

The primary tool used for data collection is a structured questionnaire designed using a Five-Point Likert Scale ranging from Strongly Agree to Strongly Disagree. Demographic questions and remarks about AI-driven learning analytics, student engagement, tailored learning, learning satisfaction, and academic performance are included in the questionnaire. Statistical programs like SPSS and Microsoft Excel are used to code and evaluate the gathered responses.

DATA ANALYSIS AND INTERPRETATION

TABLE 1: CHI-SQUARE ANALYSIS BETWEEN AI-DRIVEN LEARNING ANALYTICS AND STUDENT ENGAGEMENT

PARTICULARS	VALUE
CALCULATED CHI-SQUARE VALUE	18.754
DEGREES OF FREEDOM	6
TABLE VALUE (5% LEVEL)	12.592
SIGNIFICANCE LEVEL	0.05
RESULT	SIGNIFICANT

INTERPRETATION:

The calculated Chi-Square value **(**18.754**)** is greater than the table value **(**12.592**)** at the 5% level of significance. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted. This indicates that there is a significant association between AI-driven learning analytics and student engagement in e-learning platforms. Hence, AI-driven learning analytics plays a significant role in enhancing student engagement.

TABLE 2: MULTIPLE REGRESSION ANALYSIS ON FACTORS INFLUENCING STUDENT ENGAGEMENT AND PERSONALIZED LEARNING

A. MODEL SUMMARY

MODEL	R	R^2	ADJUSTED R^2	STD. ERROR	F	DF1	DF2
1	.786	.618	.605	.418	47.156	5	144

INTERPRETATION:

The multiple regression analysis shows a strong positive relationship between the selected AI-driven learning analytics factors and student engagement and personalized learning **(R = 0.786).** The **R^2 value of 0.618** indicates that **61.8%** of the variation in student engagement and personalized learning is explained by **Adaptive Learning, Personalized Feedback, Predictive Analytics, AI-based Assessment, and Learning Analytics Dashboard.** The **Adjusted R^2 value of 0.605** confirms that the regression model has good explanatory power. The **F-value of 47.156** indicates that the overall regression model is statistically significant.

b. ANOVA

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.
REGRESSION	52.184	5	10.437	47.156	.000
RESIDUAL	31.876	144	0.221		
TOTAL	**84.060**	**150**			

INTERPRETATION:

The ANOVA results reveal that the **significance value (0.000)** is less than **0.05,** indicating that the regression model is statistically significant. This shows that the selected AI-driven learning analytics factors significantly influence student engagement and personalized learning. Therefore, the regression model is suitable for explaining variations in students' learning outcomes.

C. COEFFICIENTS (UNSTANDARDIZED AND STANDARDIZED)

VARIABLE	B	STD. ERROR	BETA (B)	T	SIG.
(CONSTANT)	0.682	0.201	—	3.393	.001
ADAPTIVE LEARNING (AL)	0.294	0.056	.315	5.250	.000
PERSONALIZED FEEDBACK (PF)	0.228	0.059	.241	3.864	.000
PREDICTIVE ANALYTICS (PA)	0.174	0.061	.181	2.852	.005
AI-BASED ASSESSMENT (AA)	0.091	0.063	.089	1.444	.151
LEARNINGANALYTICS DASHBOARD (LAD)	0.203	0.058	.216	3.500	.001

INTERPRETATION:

The regression results indicate that **Adaptive Learning (t = 5.250), Personalized Feedback (t = 3.864), Predictive Analytics (t = 2.852),** and **Learning Analytics Dashboard (t = 3.500)** have a significant positive influence on student engagement and personalized learning, as their significance values are below **0.05**. However, **AI-based Assessment (t = 1.444)** does not have a significant effect because its significance value **(0.151)** is greater than **0.05.** These findings suggest that adaptive learning, personalized feedback, predictive analytics, and learning analytics dashboards are the key factors enhancing student engagement and personalized learning in AI-driven e-learning platforms.

FINDINGS:

The study found that AI-driven learning analytics has a significant positive impact on student engagement and personalized learning in e-learning platforms. The percentage analysis showed that the majority of students favored AI-based feedback systems and tailored learning recommendations, demonstrating a favorable opinion of AI-enabled learning resources. Students that actively employ AI-based learning features are likely to be more involved in their learning activities, according to the Chi-square research, which demonstrated a substantial relationship between AI-driven learning analytics and student engagement. Additionally, the Multiple Regression Analysis showed that while AI-based Assessment had no discernible impact, Adaptive Learning, individualized Feedback, Predictive Analytics, and Learning Analytics Dashboard had a substantial impact on student engagement and individualized learning. Overall, the results show that AI-driven learning analytics promotes academic achievement, enables individualized instruction, improves learning experiences, and helps create more efficient and learner-centered e-learning environments.

SUGGESTIONS:

Educational institutions should strengthen the adoption of AI-driven learning analytics by integrating adaptive learning tools, personalized feedback systems, and predictive analytics into e-learning platforms. To improve the efficient use of AI technologies, instructors and students should receive regular training. In order to establish an engaging, safe, and customized learning environment that enhances students' academic achievement, institutions must also guarantee data protection, ethical AI practices, and ongoing monitoring of learning outcomes.

CONCLUSION:

Artificial Intelligence has become an essential component of modern e-learning platforms by enabling intelligent learning analytics that support student engagement and personalized learning. According to the study's findings, educational institutions can better analyze student behavior, offer adaptive learning opportunities, and enhance overall academic results by utilizing AI-driven learning analytics. The statistical analyses show that AI-enabled features like learning analytics dashboards, adaptive learning, personalized feedback, and predictive analytics greatly improve student engagement and learning efficacy. The overall impact of AI-driven learning analytics is very beneficial, even though AI-based assessment still has to

be improved. Thus, while guaranteeing the ethical use of educational data and safeguarding learner privacy, educational institutions should keep implementing AI-powered technologies to develop more engaging, personalized, and effective digital learning environments.

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENGLISH LANGUAGE ASSESSMENT, EVALUATION AND LEARNING ANALYTICS

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Abstract

Artificial intelligence (AI) is rapidly transforming English language education by changing how learners practise language, how teachers evaluate performance, and how educational institutions interpret learning data. In particular, automated assessment, intelligent feedback, natural language processing, speech recognition, generative AI, and learning analytics have created opportunities for more continuous, personalized, and data-informed approaches to English language learning. This paper examines the role of AI across three interconnected domains: English language assessment, evaluation, and learning analytics. It argues that the greatest educational value of AI does not lie in replacing teachers or human raters, but in augmenting professional judgment through timely evidence, individualized feedback, adaptive learning pathways, and longitudinal monitoring of learner development. A conceptual review of recent research is used to identify major applications, benefits, limitations, and ethical considerations. Existing evidence indicates that AI-supported assessment can improve language-learning outcomes, while automated writing feedback can produce meaningful gains in writing performance. At the same time, research on large language models demonstrates continuing concerns concerning validity, reliability, fairness, transparency, linguistic bias, privacy, and the interpretation of higher-order language abilities. Learning analytics adds another dimension by enabling teachers and learners to examine patterns across multiple learning activities rather than relying exclusively on isolated test scores. The paper proposes a human-centred framework in which AI performs data processing, pattern recognition, preliminary evaluation, and personalized feedback, while teachers retain responsibility for interpretation, high-stakes decisions, pedagogical intervention, and ethical oversight. The paper concludes that sustainable AI integration requires assessment literacy, AI literacy, transparent data practices, continuous validation, and meaningful learner participation. AI should therefore be conceptualized not as an autonomous assessor, but as an intelligent partner within an evidence-based English language learning ecosystem.

Keywords: *artificial intelligence, English language assessment, automated evaluation, learning analytics, generative AI, language learning, automated writing evaluation*

Introduction

Artificial intelligence has moved from being an experimental technology to becoming an increasingly visible component of educational practice. In English language education, AI is particularly significant because language learning generates large quantities of textual, auditory, behavioural, and interactional data. Learners produce essays, spoken responses, vocabulary exercises, discussion posts, reading responses, pronunciation attempts, and online learning traces. Traditionally, much of this evidence has been assessed intermittently by teachers through examinations, assignments, classroom observation, and individual feedback. AI creates the possibility of analyzing these forms of evidence continuously and at scale.

The development of natural language processing, machine learning, automated speech recognition, automated writing evaluation (AWE), intelligent tutoring systems, and generative AI has expanded the possible functions of technology in language education. Earlier AI systems were primarily concerned with prediction, classification, correction, and adaptive practice. Contemporary generative AI systems can additionally engage learners in dialogue, generate explanations, provide revision suggestions, construct assessment items, and simulate communicative situations. Consequently, the boundary between learning, assessment, and evaluation is becoming less distinct.

Recent evidence supports cautious optimism. A systematic review and meta-analysis of AI-enabled assessment in language learning identified 25 empirical studies and reported a medium overall effect on language-learning outcomes (Hedges' g = .390), while emphasizing that effectiveness depends on appropriate implementation and instructional design (Chen et al., 2025). Similarly, a meta-analysis of AI interventions in second-language learning found positive effects across language learning outcomes, with particularly promising results for speaking and listening as well as benefits for writing and vocabulary development (Fathi et al., 2024). However, the rapid expansion of AI also creates a fundamental question: What should AI actually do in English language assessment and learning analytics? The answer cannot simply be that AI should grade more assignments faster. Assessment is not merely a technical process of assigning scores. It involves construct definition, interpretation, fairness, consequences, human judgment, and decisions about what counts as meaningful learning. Chuang and Yan (2025), in a systematic review of 77 publications, argue that GenAI introduces both opportunities and substantial challenges for reliability, validity, fairness, and practicality in language assessment. This paper therefore examines AI through three connected functions: assessment, evaluation, and learning analytics. It proposes that the strongest model is a human-centred partnership in which AI increases the availability and usefulness of evidence without becoming the sole authority on learner ability.

Conceptualizing AI in English Language Education

AI in English language education can be understood as a collection of computational techniques that enable systems to recognize patterns, interpret language, generate responses, make predictions, and adapt to users. This includes conventional machine-learning systems, natural language processing, speech technologies, intelligent tutoring systems, AWE platforms, and large language models.

The distinction between assessment and evaluation is important. Assessment refers primarily to the systematic collection of evidence about learner knowledge or performance. Evaluation involves interpreting that evidence to make judgments about quality, progress, achievement, or educational effectiveness. Learning analytics, meanwhile, involves the measurement, collection, analysis, and reporting of data about learners and learning contexts to understand and optimize learning processes.

AI can connect these three functions. For example, a learner submits an English essay. An AI system can identify grammatical patterns, lexical diversity, cohesion, organization, and

possible weaknesses. The system can then provide formative feedback. When similar data are collected over several assignments, learning analytics can identify whether the learner is improving, stagnating, or repeatedly experiencing difficulty. The teacher can use this evidence to modify instruction. Thus, the value of AI emerges not from a single automated score but from the relationship among evidence, interpretation, feedback, and subsequent learning.

This perspective is consistent with research on automated feedback. Fleckenstein et al. (2023) conducted a multilevel meta-analysis involving 20 studies and 2,828 learners and found a medium positive effect of automated feedback on writing performance (g = .55), although substantial heterogeneity indicated that the effectiveness of automated feedback varies according to implementation and context.

AI in English Language Assessment

Automated Writing Evaluation-One of the most established applications of AI in language assessment is automated writing evaluation. AWE systems can examine student writing and provide information about grammar, spelling, vocabulary, syntax, organization, and other textual characteristics. Their major advantage is scalability. A teacher may need several days to provide detailed feedback on hundreds of essays, whereas an automated system can process them almost immediately.

AI-supported writing assessment also enables repeated assessment. Instead of treating writing as a product evaluated at the end of a unit, teachers can use automated feedback during planning, drafting, revision, and reflection. This transforms assessment from a terminal event into an ongoing learning process.

Nevertheless, writing quality cannot be reduced to surface-level correctness. Strong academic writing involves argumentation, rhetorical awareness, evidence use, coherence, disciplinary conventions, originality, and communicative effectiveness. A model may recognize grammatical accuracy more consistently than it recognizes the strength of an argument. Consequently, AI-generated scores should not automatically be interpreted as complete representations of writing ability.

Research examining large language models in automated essay scoring illustrates this issue. Studies have investigated models such as GPT-3.5 and GPT-4 alongside other large language models and human raters, raising questions about the reliability and validity of LLM-based scoring for English-language learners (Computers and Education: Artificial Intelligence, 2024). The implication is not that AI scoring is useless; rather, it should be validated against clearly defined assessment constructs and human judgments before being used for consequential decisions.

Speaking and Listening Assessment-AI also has important applications in oral language assessment. Automatic speech recognition can transcribe learner speech and provide information about pronunciation, fluency, pauses, vocabulary, and grammatical patterns. Conversational AI can create opportunities for learners to engage in simulated communicative interactions without requiring a teacher or peer to be available at every moment.

Such technologies can increase practice opportunities. A learner who is reluctant to speak publicly may be willing to practice repeatedly with an AI conversational partner. AI can also provide immediate feedback, allowing learners to notice recurring errors.

However, speech technologies may perform differently across accents, dialects, proficiency levels, age groups, and linguistic backgrounds. This is especially important in English, which has enormous phonological diversity. If a speech-recognition system performs better with some varieties of English than others, its output could introduce systematic inequality into assessment. Research on automated speech recognition has consequently emphasized the importance of examining linguistic background and task type when using speech technology for language assessment (Chen et al., 2025). The appropriate role of AI is therefore to provide additional evidence about oral performance rather than to define English proficiency according to a single technological model of "correct" speech.

Generative AI and Assessment Design-Generative AI extends assessment possibilities beyond automated scoring. It can generate reading passages, questions, prompts, rubrics, examples, and individualized practice tasks. It can also transform assessment into dialogue. Instead of answering one static question, learners may interact with an AI system that asks follow-up questions and adapts difficulty according to their responses.

This flexibility has significant pedagogical potential. Assessment can become more responsive and diagnostic. Yet generative AI also creates a paradox: the same technology that can assist learning can complete some assessment tasks on behalf of the learner. This makes traditional take-home essays increasingly difficult to interpret as direct evidence of individual writing ability.

Therefore, assessment design must evolve. Teachers may need to emphasize process evidence, oral explanations, drafts, revision histories, reflective commentaries, classroom performance, and authentic tasks. In other words, the response to generative AI should not simply be greater surveillance; it should be better assessment design.

AI in English Language Evaluation- Evaluation involves making educational judgments from assessment evidence. AI can assist this process in several ways.

First, AI can identify patterns that may be difficult for individual teachers to notice. A teacher reviewing one essay may notice grammar errors, but analytics across 500 essays could reveal that a particular cohort consistently struggles with article use, academic vocabulary, or paragraph organization. Such evidence can inform curriculum planning.

Second, AI can support comparative and longitudinal evaluation. Instead of asking whether a learner achieved 72% on one examination, educators can examine development across multiple tasks. A learner might show modest overall score growth while demonstrating substantial improvement in lexical variety and fluency but continued difficulty with argument structure. Such multidimensional evaluation is pedagogically more useful than a single grade.

Third, AI can support moderation. Human raters sometimes differ in their interpretation of rubrics. AI can flag unusual scoring patterns or identify responses requiring a second review. In this role, AI becomes a quality-assurance mechanism rather than an autonomous judge.

This distinction is essential because human evaluation is itself imperfect. Human raters may be influenced by fatigue, expectations, writing style, accent, or other irrelevant characteristics. AI may reduce some forms of inconsistency while introducing other forms of bias. Consequently, replacing human judgment with automated judgment does not automatically produce fairness.

Chuang and Yan (2025) emphasize that AI-driven language assessment must continue to address reliability, validity, fairness, security, and practicality rather than assuming that technological sophistication guarantees assessment quality.

AI and Learning Analytics- Learning analytics provides perhaps the most transformative connection between AI and English language learning. Conventional assessment often produces isolated scores. Learning analytics can integrate information from multiple activities, such as quiz performance, writing revisions, vocabulary practice, speaking attempts, reading behaviour, feedback uptake, time on task, and interaction patterns.

AI can identify patterns within these datasets. For example, an analytics system might detect that a learner who performs well on vocabulary tests nevertheless uses a limited lexical range in writing. Another learner might understand grammar rules but demonstrate persistent difficulties during spontaneous speaking. These patterns allow teachers to move from general judgments to targeted intervention.

Learning analytics can also support early identification of learning difficulties. If a learner repeatedly avoids speaking tasks, submits incomplete assignments, or shows declining engagement, an AI system could alert the teacher. The teacher could then determine whether the problem is linguistic, motivational, technological, or personal.

However, prediction should not be confused with explanation. An algorithm may identify that a learner is "at risk," but it cannot necessarily explain why. Teachers therefore remain essential for contextual interpretation.

Research on human-centred learning analytics reinforces this principle. Alfredo et al. (2024) reviewed 108 studies and found that although human control was increasingly recognized, meaningful involvement of end users in system design remained limited. They recommend stronger stakeholder participation, especially by students and teachers, together with attention to safety, reliability, and trustworthiness.

Benefits of AI-Supported English Learning

The integration of AI into English assessment and analytics can generate several educational benefits.

Personalization- AI can adapt feedback and learning materials to individual needs. A learner struggling with articles can receive targeted exercises, while another learner requiring academic vocabulary can receive more advanced lexical tasks. This moves instruction away from a one-size-fits-all model.

Immediate Feedback-Traditional feedback is often delayed. AI can respond within seconds, allowing learners to revise while their cognitive attention remains focused on the task. The meta-analysis by Fleckenstein et al. (2023) provides evidence that automated feedback can

contribute positively to writing development.

Increased Learning Opportunities-AI systems can provide practice outside formal classroom hours. Conversational systems can support speaking practice, while writing assistants can facilitate repeated drafting and revision.

Teacher Support-AI can reduce repetitive workload by organizing data, identifying common errors, generating preliminary feedback, and highlighting learners who may need attention. This creates more time for teachers to focus on explanation, mentoring, interaction, and higher-order pedagogical decisions.

Continuous Assessment- AI allows assessment to become more continuous. Rather than depending exclusively on mid-term and final examinations, teachers can gather evidence throughout the learning process.

A 2024 meta-analysis of English-language learning studies involving 40 empirical studies and 3,290 participants reported positive overall effects of AI on English learning achievement, further supporting the potential of AI when integrated appropriately into learning environments.

Challenges and Ethical Concerns

The educational benefits of AI should not obscure significant risks.

Validity and Reliability-The central assessment question is whether AI measures what it claims to measure. A system that rewards grammatical complexity may disadvantage learners who communicate effectively using simpler language. Similarly, an essay-scoring system may give high scores to structurally polished texts while overlooking weak reasoning.

Assessment validity must therefore precede technological enthusiasm. Every AI-based assessment system requires evidence demonstrating that its outputs are meaningful for the intended construct and population.

Bias and Fairness- AI systems learn from data. If training data disproportionately represent particular varieties of English, cultural contexts, or learner populations, system outputs may reproduce those biases.

Fairness is especially important for multilingual learners. English language education includes learners with different first languages, cultural backgrounds, educational experiences, and linguistic identities. AI systems should be tested across these populations rather than validated only on convenient samples.

Privacy and Data Protection- Learning analytics depends on data, and AI systems can potentially collect extensive information about learner behaviour. Writing samples, speech recordings, interaction histories, and performance profiles may be sensitive educational data.

UNESCO (2023) emphasizes human-centred AI, data protection, equity, inclusion, and meaningful pedagogical validation in educational use of generative AI. Educational institutions should therefore establish clear policies concerning consent, data retention, access, storage, and third-party processing.

Overdependence on AI- A further concern is learner dependency. If students accept every AI correction without understanding it, technology may improve the immediate product without

developing underlying language competence. AI should encourage reflection rather than passive acceptance.

Students need to learn to question AI output: Is the correction appropriate? Does the suggested word express the intended meaning? Is the feedback consistent with the assignment rubric? Such practices transform AI literacy into part of language-learning literacy.

The Problem of the "Black Box"- Many AI systems cannot provide sufficiently transparent explanations for their decisions. This is problematic when scores affect academic progression. If a learner receives a low AI-generated score, the institution should be able to explain how that decision was reached and provide an avenue for human review.

A Human-Centred Framework for AI-Based English Assessment

Based on the reviewed literature, this paper proposes a five-stage human-centred framework.

Stage 1: Evidence collection. AI collects language-performance evidence from writing, speaking, reading, listening, quizzes, and learning activities.

Stage 2: Computational analysis. AI identifies patterns in grammar, vocabulary, fluency, interaction, revision, and learning behaviour.

Stage 3: Formative feedback. The system provides explanations, examples, questions, and suggestions designed to promote learner revision rather than simply supplying answers.

Stage 4: Human interpretation. Teachers examine AI-generated evidence, consider contextual information, and determine appropriate instructional responses.

Stage 5: Reflective decision-making. Learners review their progress, question AI feedback, set goals, and participate in decisions concerning their learning.

The model can be summarized as:

Learner activity → AI analysis → feedback → teacher interpretation → learner reflection → new learning evidence.

This creates a feedback loop rather than a one-directional scoring system. It also preserves human agency. AI processes large amounts of information, but teachers and learners remain responsible for educational meaning.

9. **Implications for English Language Teachers and Institutions**

The emergence of AI requires changes in teacher professional development. English teachers increasingly need both language-assessment literacy and AI literacy. They should understand what an AI system measures, what it does not measure, how errors arise, and how automated feedback should be interpreted.

Institutions should also develop clear assessment policies. Students should know when AI assistance is permitted, how it should be acknowledged, and which assignments are intended to demonstrate independent performance. Rather than attempting to detect every instance of AI use, institutions should redesign assessment so that learning processes become visible.

For high-stakes assessment, human oversight should remain essential. AI can support scoring and moderation, but consequential decisions should involve trained professionals and opportunities for review.

Finally, students should be treated as participants in AI governance. They should understand

what data are collected, how analytics are used, and how automated decisions can be challenged. Human-centred learning analytics requires precisely this balance between computational efficiency and human agency.

Future Research Directions

Future research should move beyond short-term experiments with individual AI tools. Longitudinal studies are needed to determine whether AI-supported feedback produces durable improvements in English proficiency. Research should also compare different learner populations and English varieties.

More attention is required for speaking, listening, interactional competence, pragmatic ability, and higher-order writing. Current research has frequently concentrated on writing because text is relatively easy to process computationally. However, communicative competence extends well beyond written accuracy.

Researchers should also investigate how teachers actually interpret AI-generated analytics. An accurate algorithm may have little educational value if teachers cannot understand or act upon its recommendations.

Finally, AI assessment research should increasingly examine fairness and explainability. Models should be evaluated across linguistic backgrounds, proficiency levels, genres, and task types. The objective should not merely be higher prediction accuracy, but educationally defensible accuracy.

Conclusion

AI is reshaping English language assessment, evaluation, and learning analytics by making it possible to collect, interpret, and respond to learner evidence at unprecedented speed and scale. Automated writing evaluation can provide immediate formative feedback; speech technologies can expand opportunities for oral assessment and practice; generative AI can create interactive assessment environments; and learning analytics can connect individual performance with longitudinal patterns of development.

Nevertheless, AI should not be regarded as a replacement for teachers or human assessment expertise. Its greatest contribution lies in augmentation. AI can process information rapidly, recognize patterns across large datasets, and provide individualized feedback, while teachers contribute contextual knowledge, professional judgment, empathy, pedagogical reasoning, and ethical responsibility.

The central challenge is therefore not whether AI should be used in English language education, but how it should be used responsibly. Validity, reliability, fairness, transparency, privacy, and learner agency must be treated as fundamental design requirements rather than secondary concerns. The emerging evidence suggests that AI can support meaningful improvements in language learning, but its effectiveness depends strongly on instructional context and implementation.

A sustainable future for AI-supported English education should consequently be human-centred. AI should generate evidence, teachers should interpret it, and learners should actively engage with it. When assessment becomes part of a continuous cycle of evidence, feedback,

reflection, and improvement, AI can contribute not merely to faster evaluation but to a richer understanding of how English is learned. The ultimate purpose of educational AI should therefore not be to automate assessment itself, but to make assessment more informative, learning more personalized, and educational decision-making more responsive while preserving the human values at the heart of language education.

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GENDER AND EDUCATION (Thematic Paper)

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Abstract

Gender plays an important role in shaping educational opportunities, experiences, and outcomes. This article examines the relationship between gender and education, with particular attention to gender inequalities in access to education, participation, classroom experiences, and academic achievement. The study explores how social, cultural, economic, and institutional factors influence the educational experiences of girls, boys, and students with diverse gender identities. A review of relevant literature was conducted to identify major patterns and challenges related to gender equality in education. The findings indicate that although significant progress has been made in improving access to education for all genders, inequalities continue to exist in areas such as educational opportunities, subject choices, participation, leadership, and access to resources. Social expectations and gender stereotypes can also influence students' academic choices and future career aspirations. The article highlights the importance of inclusive teaching practices, gender-sensitive policies, equal access to educational resources, and supportive learning environments. Promoting gender equality in education is essential for creating equitable opportunities and enabling all students to achieve their educational and social potential.

Key Words: *Gender, Education, Gender equality Discrimination Stereotype, Co-Science Education, Science, Inclusive education, Education, STEM and vocational education, Samagra Shiksha, Kasturba Gandhi Balika Vidyalayas, NEP 2020.*

Introduction:

Gender and education are closely connected with the social, economic, and cultural development of individuals and society. Gender refers to the roles, behaviours, expectations, and opportunities that society associates with different genders, while education is the process of gaining knowledge, skills, values, and attitudes.

Education plays an important role in promoting gender equality. It provides individuals with equal opportunities to learn, develop their abilities, and participate in social and economic life. However, gender stereotypes and discrimination can influence access to education, choice of subjects, classroom participation, and career opportunities.

A gender-sensitive education system aims to provide equal opportunities, remove stereotypes, prevent discrimination, and create a safe and inclusive learning environment for all students. Thus, education is not only a means of acquiring knowledge but also an important tool for challenging gender inequality and building a more just and equal society.

A review of existing literature shows that education has an important role in reducing gender

inequality: UNESCO (2020) reported major progress in girls' participation in education globally. However, it also emphasised that gender stereotypes continue to influence teachers' attitudes, subject choices, career aspirations, and opportunities later in life. Government of India, NEP 2020 emphasises equitable and inclusive education and recognises gender as a cross-cutting priority. The policy seeks to reduce disparities in access, participation, retention, completion, and learning outcomes. Recent research on NEP 2020 suggests that the policy provides a strong framework for gender equity through measures such as improving girls' enrolment and retention, gender-sensitive curricula, and greater participation of women in educational leadership. However, social norms and economic barriers remain important challenges to implementation. Studies and government reviews also indicate that encouragement, awareness, equal opportunities, and positive role models are important for challenging gender stereotypes among students.

Thus we can conclude that education is both affected by gender inequality and capable of transforming it. Providing equal educational opportunities is not sufficient by itself; schools must also address gender stereotypes in textbooks, classroom practices, subject selection, teacher attitudes, and career guidance. Therefore, gender-sensitive and inclusive education is essential for developing a society based on equality, dignity, freedom, and equal opportunity for all.

Relationship between gender and education

Gender and education are closely related in many societies, influencing educational access, participation, and outcomes.

Gender refers to the socially and culturally constructed roles, behaviors, and expectations associated with being male, female, or other gender identities.

Education is the process of acquiring knowledge, skills, values, and attitudes through teaching, learning, or training.

- Access to education: In some regions, girls and women face barriers such as poverty, early marriage, cultural norms, or discrimination, which can limit their educational opportunities.
- Educational achievement: Gender differences in performance may exist across subjects, but these are often influenced by social, economic, and cultural factors rather than ability.
- Career opportunities: Education helps reduce gender inequality by providing equal opportunities for employment, leadership, and economic independence.
- Empowerment: Educating all genders promotes confidence, informed decision-making, improved health, and greater participation in society.

Importance of gender equality in education

- Ensures equal learning opportunities for everyone.
- Reduces discrimination and stereotypes.
- Promotes economic growth and social development.

- Contributes to achieving the United Nations Sustainable Development Goal 4 (Quality Education) and Goal 5 (Gender Equality).

Importance of Education in Reducing Gender Discrimination

Education plays a very important role in reducing gender discrimination and creating equality between all genders. It helps people understand their rights, challenge stereotypes, and develop attitudes based on equality and respect.

Major importance

1. Creates awareness of equality: Education teaches students that boys, girls, and people of different gender identities deserve equal rights, opportunities, and respect.
2. Breaks gender stereotypes: Education can challenge beliefs such as "boys are better at science" or "girls should only do household work." It encourages children to choose subjects and careers according to their interests and abilities.
3. Provides equal opportunities: Access to quality education improves opportunities for girls and women in higher education, employment, leadership, and decision-making.
4. Empowers women and girls: Education develops knowledge, confidence, skills, and economic independence, helping women participate actively in family, community, and public life.
5. Changes social attitudes: Educated individuals are more likely to question practices such as child marriage, unequal treatment of girls, and restrictions on women's education and employment.
6. Promotes economic independence: Education provides skills needed for employment and entrepreneurship, reducing economic dependence and vulnerability to discrimination.
7. Develops respect and tolerance: Schools can teach cooperation, empathy, dignity, and respect for people regardless of gender.
8. Encourages participation in leadership: Education enables girls and women to participate in politics, administration, science, business, and other leadership roles.
9. Reduces intergenerational discrimination: Educated parents are more likely to support equal education and opportunities for their children, helping create more gender-equal future generations.

Current Reforms in Education in Relation to Gender Stereotypes

In India, recent education reforms, particularly the National Education Policy (NEP) 2020, aim to reduce gender discrimination and challenge traditional gender stereotypes in education. The policy treats gender equality as an important part of equitable and inclusive education.

Major reforms

1. Gender Inclusion Fund: NEP 2020 proposes a Gender Inclusion Fund (GIF) to support equitable education for girls and transgender students. It can support measures such as sanitation facilities, toilets, transport/bicycles and community-based interventions that reduce barriers to education.

2. Removal of gender stereotypes from textbooks: The policy calls for biases and stereotypes in school curricula and textbooks to be removed. Learning materials are expected to promote respect, equality, empathy, human rights and gender equality.
3. Gender-sensitive teacher education: Teachers, principals, counsellors and administrators are expected to be sensitized to inclusion, equity and the needs of different groups. Teacher training can therefore help educators avoid reinforcing ideas such as “boys are better at mathematics” or “girls should choose caring professions.”
4. Encouraging girls' participation in STEM and vocational education: Current reforms aim to provide students with opportunities based on their aptitude and interests rather than traditional gender roles. Vocational education is being integrated into school education, giving students exposure to a wider range of career choices.
5. Improved facilities and safety for girls: Under Samagra Shiksha, interventions include separate toilets for girls, additional teachers including women teachers, residential facilities in appropriate contexts, and sensitisation programmes to encourage girls' participation.
6. Support for disadvantaged girls: Kasturba Gandhi Balika Vidyalayas (KGBVs) provide residential schooling for girls from disadvantaged communities and have been expanded/upgraded to increase access to quality education.
7. Inclusive education for transgender students: NEP 2020 explicitly includes transgender students within its gender-inclusion approach, seeking to ensure that education is accessible and equitable irrespective of gender identity.
8. Changing social attitudes: Education reforms recognise that gender stereotypes are not created only inside classrooms. Schools and communities are encouraged to address attitudes concerning early marriage, girls' higher education, women's employment and unequal expectations placed on boys and girls.

How Science Education Affects Gender

Science education has an important role in promoting gender equality. It can influence how students understand themselves, their abilities, and the roles that society expects them to play.

Major effects of science education on gender

- Breaks gender stereotypes: Science education challenges beliefs that science, mathematics, engineering, or technology are mainly for boys. It encourages girls to participate confidently in these subjects.
- Promotes equal opportunities: Equal access to science education gives boys and girls the opportunity to develop scientific knowledge and pursue careers in STEM (Science, Technology, Engineering and Mathematics).
- Builds confidence among girls: Practical experiments, projects, and problem-solving activities can improve girls' confidence in their scientific abilities and encourage them to consider scientific careers.

- Provides role models: Learning about women scientists such as Marie Curie, Rosalind Franklin, Janaki Ammal, and Kalpana Chawla helps students understand that scientific achievement is not limited by gender.
- Encourages critical thinking: Science teaches students to question assumptions and examine evidence. This can help them critically examine gender stereotypes and discriminatory practices.
- Improves career opportunities: Science education can open doors to careers in medicine, engineering, research, information technology, biotechnology, environmental science, and many other fields.
- Promotes gender-sensitive thinking: Science education can help students understand that biological differences do not justify social discrimination or unequal opportunities.
- Encourages boys to challenge stereotypes too: Gender equality is not only about encouraging girls in science. Boys can also be encouraged to participate in caring professions, household responsibilities, and subjects traditionally associated with girls.

Thus from the above points we can concluded that, Science education can be a powerful tool for reducing gender stereotypes and discrimination. When schools provide equal opportunities, gender-sensitive teaching, supportive teachers, and diverse scientific role models, students are more likely to choose careers according to their interests and abilities rather than traditional gender expectations.

Advantages and Limitations of Co-Science Education

Co-science education can be understood as teaching science to boys and girls together in the same classroom, with equal opportunities for participation, practical work, and learning. It is closely related to co-educational science education.

Advantages

- Promotes gender equality: Boys and girls get equal opportunities to learn science, conduct experiments, and participate in scientific activities.
- Reduces gender stereotypes: It challenges ideas such as “science is for boys” or “girls are better suited to arts and humanities.”
- Improves cooperation: Working together on experiments and projects develops teamwork, communication, and mutual respect.
- Builds confidence: Equal participation in laboratory work, discussions, and problem-solving can increase students' confidence in their scientific abilities.
- Encourages healthy competition: Boys and girls can motivate each other to improve their performance and develop interest in science.
- Develops social skills: Students learn to communicate and cooperate with people of different genders, preparing them for future workplaces and society.
- Provides equal career awareness: Students can learn about opportunities in medicine, engineering, technology, research, and other STEM fields without restricting choices according to gender.

- Creates diverse learning perspectives: Different experiences and viewpoints can contribute to classroom discussions and scientific problem-solving.

Limitations

- Gender stereotypes may still exist: Even in a mixed classroom, teachers, parents, textbooks, or students may continue to hold traditional beliefs about gender and science.
- Unequal participation: Boys may sometimes dominate laboratory activities, discussions, or the use of equipment, while girls may receive fewer opportunities to participate.
- Teacher bias: Unconscious teacher expectations can influence how much encouragement, attention, or responsibility boys and girls receive.
- Social and cultural barriers: Family traditions and community attitudes may discourage girls from pursuing science, technology, engineering, or mathematics.
- Lack of facilities and resources: Schools without adequate laboratories, equipment, trained teachers, or learning materials may not be able to provide meaningful science education to all students.
- Peer pressure: Students may avoid certain science activities or careers because they fear being judged as behaving differently from traditional gender expectations.
- Different learning needs may be overlooked: Treating boys and girls exactly the same does not always address differences in individual learning needs, confidence, background, or access to resources.

Thus from the above points we can conclude that Co-science education is valuable for promoting gender equality, cooperation, confidence, and scientific thinking. However, simply placing boys and girls in the same science classroom does not automatically eliminate gender discrimination. Gender-sensitive teaching, equal participation, supportive teachers, inclusive textbooks, proper facilities, and encouragement from families and society are also necessary to make co-science education effective.

Conclusion

Thus from the above all points we can conclude that, Education is one of the most powerful tools for eliminating gender discrimination. It not only provides knowledge but also changes attitudes, challenges stereotypes, empowers disadvantaged groups, and promotes equal participation in society. Gender-sensitive and inclusive education can help create a society where opportunities are based on ability and interest rather than gender.

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LOW ENROLLMENT OF GIRLS STUDENTS IN GOVERNMENT SECONDARY SCHOOLS

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Abstract

The low enrollment of girls in government secondary schools is a significant educational and social issue, particularly in rural and economically disadvantaged communities. Although various government initiatives have been introduced to promote girls' education, many girls continue to discontinue their studies after primary or upper-primary education. Several factors contribute to this problem, including poverty, early marriage, household responsibilities, lack of transportation, inadequate sanitation facilities, safety concerns, parental attitudes, and limited awareness of the importance of secondary education. The problem is more severe among families with low incomes and in communities where traditional gender roles influence educational decisions. Low enrollment of girls not only limits their individual opportunities but also affects social development, economic participation, and gender equality. This study focuses on identifying the major factors responsible for the low enrollment of girls in government secondary schools and suggests measures to improve their participation and retention. Strengthening school infrastructure, providing financial support, ensuring safe transportation, improving sanitation facilities, creating awareness among parents, and developing a supportive school environment can contribute significantly to increasing girls' enrollment and continuation in secondary education.

Keywords: *Girls' education, Low enrollment, Government secondary schools, Gender inequality, School dropout, Parental attitudes, Poverty, Rural education, Educational access, Secondary education.*

Introduction:

Education is one of the most important instruments for the social, economic, and personal development of an individual. It plays a vital role in improving knowledge, skills, confidence, employment opportunities, and quality of life. The education of girls is particularly important because educated girls and women contribute significantly to the health, education, and economic well-being of their families and communities. Despite considerable progress in promoting universal education, the enrollment and continuation of girls in secondary schools remain a challenge in many parts of India.

Secondary education is a crucial stage because it connects elementary education with higher education and employment opportunities. However, many girls who complete primary or upper-primary education do not continue into secondary school. Government schools, which serve a large proportion of children from economically weaker and rural communities, often experience difficulties in attracting and retaining girls at the secondary level.

There are several reasons for the low enrollment of girls. Economic difficulties are one of the

major factors. Poor families may find it difficult to meet expenses related to uniforms, transportation, books, and other educational needs. In some families, girls are expected to assist with household work, care for younger siblings, or participate in agricultural and other family activities. Consequently, education may be given greater priority to boys than girls.

Social and cultural attitudes also influence girls' education. In some communities, parents may believe that girls do not need higher levels of education because they will eventually marry and move to another household. Early marriage can also interrupt or completely end a girl's education. Concerns about girls' safety while travelling to and from school, particularly when schools are located far from their homes, may further discourage parents from sending their daughters to secondary school.

School-related factors are equally important. The availability of separate and hygienic toilets for girls, drinking water, boundary walls, adequate classrooms, female teachers, and safe transportation can influence girls' attendance and retention. A lack of these facilities may make girls uncomfortable and may contribute to absenteeism and dropout, especially after puberty.

Government programmes and policies have attempted to improve girls' participation in education through scholarships, free textbooks and uniforms, residential facilities, awareness programmes, and other forms of support. However, the effectiveness of these measures depends on proper implementation, community participation, and awareness among parents and students.

Therefore, understanding the reasons behind the low enrollment of girls in government secondary schools is essential for developing effective educational interventions. The issue should not be viewed only as an educational problem but also as a matter of gender equality, social justice, and community development. Improving girls' access to and continuation in secondary education can help create a more educated, skilled, and equitable society.

Major Causes of Low Enrollment of Girls in Government Secondary Schools

The major factors responsible for low enrollment of girls include:

- Poverty: Families with limited financial resources may prioritize boys' education.
- Household responsibilities: Girls may be expected to perform domestic work and care for younger children.
- Early marriage: Marriage at a young age often leads to discontinuation of education.
- Distance from school: Long distances and lack of affordable transportation can discourage enrollment.
- Safety concerns: Parents may be reluctant to send girls to schools located far from home.
- Inadequate sanitation: Lack of clean, separate toilets and menstrual hygiene facilities can affect attendance.
- Traditional attitudes: Some families consider girls' education less important than boys' education.

- Lack of awareness: Parents may not fully understand the long-term benefits of secondary education for girls.
- Shortage of female teachers: The absence of female teachers may make some girls and parents less comfortable.
- Academic difficulties: Poor learning outcomes and lack of academic support can cause girls to lose interest in schooling.

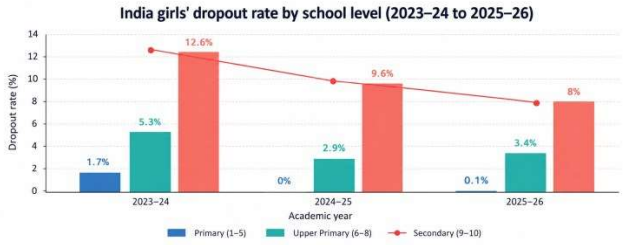
Girls barely drop out schools in early years: Government data

- Girls' dropout rates at the secondary level (Classes 9–10) remain the highest across school stages, though they have fallen from 12.6% in 2023–24 to 8% in 2025–26. State-level disparities persist, with Ladakh (15.6%) recording the highest dropout rate, followed by Assam and Karnataka (13.9% each).
- Eight out of every 100 girls enrolled in secondary school dropped out before completing their education in 2025–26. That is the key take away from the Education Ministry's reply in the Lok Sabha this week. While the secondary school dropout rate for girls fell to 8 per cent — the lowest in the past three years, down from 12.6 per cent in 2023–24 and 9.6 per cent in 2024–25 — it remains starkly higher than at the primary level. Even at its lowest, the secondary school dropout rate for girls is nearly 80 times higher than the primary school dropout rate.
- The numbers come from UDISE+, the government's own school database, and were tabled by Minister of State Jayant Chaudhary in response to a question from MP Gurmeet Singh Meet Hayer. The reply breaks dropout rates into three stages: primary, upper primary, and secondary.
- The pattern across almost every state is the same. Girls barely drop out in the early years; some slippage begins around classes 6 to 8, and then a much bigger share vanishes by class 9 or 10, right around the age when most reach puberty, and families start weighing school against work, marriage, or money.
- Union Education Ministry's data shows 8% girl-students in the country have dropped out between class 9 to 10 (AI Image)
- Make us preferred source on Google
- Eight out of every 100 girls enrolled in secondary school dropped out before completing their education in 2025–26. That is the key take away from the Education Ministry's reply in the Lok Sabha this week. While the secondary school dropout rate for girls fell to 8 per cent — the lowest in the past three years, down from 12.6 per cent in 2023–24 and 9.6 per cent in 2024–25 — it remains starkly higher than at the primary level. Even at its lowest, the secondary school dropout rate for girls is nearly 80 times higher than the primary school dropout rate.
- The numbers come from UDISE+, the government's own school database, and were tabled by Minister of State Jayant Chaudhary in response to a question from MP Gurmeet Singh Meet Hayer. The reply breaks dropout rates into three stages: primary, upper primary, and secondary.

- The pattern across almost every state is the same. Girls barely drop out in the early years; some slippage begins around classes 6 to 8, and then a much bigger share vanishes by class 9 or 10, right around the age when most reach puberty, and families start weighing school against work, marriage, or money.



- Nationally, primary dropout among girls is close to zero, at just 0.1 per cent. Upper primary sits at 3.4 per cent. Secondary jumps to 8 per cent. The Centre's own explanation, drawn from the 2023-24 Periodic Labour Force Survey, lists the reasons in plain terms: girls leave to supplement household income, to attend to domestic chores, or because their parents simply do not see further education as necessary.
- **What do state-specific numbers say?**
- State-wise, the secondary-level numbers throw up some surprises. These are not necessarily the poorest states on paper, which suggests the drivers here go beyond income alone and could include distance to secondary schools, safety concerns, or early marriage.



Effects of Low Enrollment

- Low enrollment of girls can have long-term consequences, such as:
- Increased gender inequality.
- Lower employment and income opportunities for women.
- Greater likelihood of early marriage.
- Reduced awareness of health and family welfare.
- Lower participation of women in social and economic activities.
- Intergenerational disadvantages, as mothers' education strongly influences children's educational outcomes.
- Reduced overall development of rural and disadvantaged communities.

Measures to Improve Girls' Enrollment

The following measures can help increase girls' participation in government secondary schools:

- Provide scholarships and financial assistance to girls from economically weaker families.
- Ensure free textbooks, uniforms, and other essential educational materials.
- Improve school sanitation and menstrual hygiene facilities.
- Provide safe and affordable transportation or hostels where necessary.
- Strengthen school safety through appropriate infrastructure and supervision.
- Increase the recruitment and availability of female teachers.
- Conduct awareness programmes for parents and communities regarding the benefits of girls' education.
- Provide academic counseling and remedial support to girls who experience learning difficulties.
- Prevent early marriage through community awareness and effective implementation of relevant laws.
- Encourage local communities, teachers, parents, and government authorities to work together to improve girls' enrollment and retention.

Conclusion

Low enrollment of girls in government secondary schools is a complex issue influenced by economic, social, cultural, family, and school-related factors. Increasing enrollment requires more than providing access to schools. Girls need a safe, supportive, affordable, and inclusive educational environment. Coordinated efforts by government agencies, schools, teachers, parents, and communities can help reduce barriers and ensure that girls have equal opportunities to complete secondary education. Improving girls' education is an investment not only in individual girls but also in families, communities, and the future development of society.

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EDUCATION COLLEGE LIBRARIES IN THE STATE OF KARNATAKA

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Abstract

College libraries are an essential component of higher education because they support teaching, learning, self-study, research, and the overall academic development of students and teachers. In Karnataka, college libraries operate within a diverse higher-education system comprising government, aided, private, autonomous, constituent, and affiliated colleges. The library system has gradually moved from conventional print-based collections toward automated and digital information services. The Department of Collegiate Education (DCE), Government of Karnataka, has also developed initiatives to improve access to electronic resources and library services. The present paper provides an overview of education college libraries in Karnataka, with particular emphasis on their objectives, collections, infrastructure, staffing, automation, electronic resources, services, funding, user facilities, quality assessment, challenges, and future prospects. Karnataka has a large and diverse higher-education sector; the Annual Status of Higher Education report, for example, identifies 157 colleges specializing in education/teacher education in its state-level college data. Studies of Government First Grade College libraries have reported both progress in ICT and automation and continuing problems related to staff, space, grants, collections, furniture, and equipment. Recent research on B.Ed. college libraries in Karnataka also indicates increasing use of electronic resources and services such as OPAC, online databases, bibliographic services, and online reference services.

Keywords : *College libraries; Education college libraries; Karnataka; B.Ed. college libraries; Academic libraries; Digital libraries; Library automation; ICT; Electronic resources; Information services; Higher education.*

Introduction

Libraries are often described as the heart of an educational institution because they provide the information resources required for effective teaching and learning. In colleges of education, the role of the library is particularly important because students are being prepared to become teachers, educational administrators, researchers, and other education professionals. A well-developed education college library therefore needs to provide not only textbooks but also reference books, educational journals, research literature, government publications, electronic resources, teaching-learning materials, and digital information

services. Karnataka has one of India's significant higher-education systems. Its colleges are administered through different institutional and regulatory arrangements, including universities, the Department of Collegiate Education, the University Grants Commission (UGC), and accreditation mechanisms such as the National Assessment and Accreditation Council (NAAC). The Karnataka State Higher Education Council also plays a role in higher-education planning and policy. The development of college libraries in Karnataka has been influenced considerably by information and communication technology (ICT). Traditional libraries that depended primarily on printed books and manual circulation systems are increasingly adopting library-management software, Online Public Access Catalogues (OPAC), digital repositories, Internet facilities, online databases, and remote access. A 2024 study of Government First Grade College library websites in Karnataka found that many libraries were providing information about their collections, rules, objectives, and electronic resources through their websites.

Education College Libraries in Karnataka

An education college library is an academic library attached to an institution that offers teacher-education and related programmes such as B.Ed., M.Ed., and other education-oriented courses. Its primary purpose is to support the curriculum and academic requirements of student-teachers, teacher educators, researchers, and other members of the institution.

Education college libraries in Karnataka may be found in:

1. Government colleges of education
2. Government-aided colleges of education
3. Private unaided colleges of education
4. Autonomous institutions
5. University departments and constituent colleges
6. Institutions offering B.Ed. and M.Ed. programmes
7. Institutions offering integrated teacher-education programmes

The Annual Status of Higher Education report provides an indication of the size of the sector: its Karnataka data lists 157 colleges under Education/Teacher Education among the colleges classified by specialization.

Objectives of Education College Libraries

The major objectives of education college libraries are:

1. To support the teaching and learning programmes of the college.
2. To provide current and relevant educational literature to student-teachers.
3. To develop students' reading and self-learning habits.
4. To provide textbooks, reference books, journals, periodicals, and electronic resources.
5. To support faculty members in teaching and research.
6. To provide access to educational research and scholarly publications.
7. To develop information-literacy skills among students.
8. To support preparation for examinations, assignments, seminars, and projects.
9. To provide digital and Internet-based information services.

10. To preserve important educational and institutional documents.
11. To encourage lifelong learning and independent study.
12. To support innovation in teacher education.

Library Collection

Major types of resources include:

- Textbooks on education
- Reference books
- Encyclopaedias
- Dictionaries
- Educational psychology literature
- Philosophy of education
- Sociology of education
- Educational technology
- Curriculum and pedagogy
- Measurement and evaluation
- Guidance and counselling
- Teacher education
- Inclusive education
- Special education
- Educational administration
- Research methodology
- Children's literature
- School-level textbooks
- Competitive-examination materials
- National and international journals
- Newspapers and magazines
- Government publications
- Dissertations and theses
- Question papers
- E-books
- E-journals
- Online databases

Institutional publications

The Karnataka College Library Manual emphasizes that library requirements differ according to the level and type of education and that undergraduate and postgraduate libraries need collections and services appropriate to their academic programmes.

Library Infrastructure

A separate library building or adequate library space

- Reading room

- Stack area
- Librarian's office
- Technical-processing area
- Reference section
- Periodical section
- Digital library/e-resource area
- Internet-enabled computers
- Printing and scanning facilities
- Adequate lighting and ventilation
- Appropriate furniture
- Accessibility facilities for users with disabilities

Library Staff

A qualified librarian is central to the effective functioning of a college library. Depending on the size and nature of the institution, library personnel may include:

- Librarian
- Assistant librarian
- Library assistant
- Library attendant/support staff
- Technical staff
- ICT/digital-library support staff

The librarian's responsibilities include collection development, classification, cataloguing, circulation, reference service, user education, database management, preservation, library automation, and administration.

One of the important challenges identified in studies of Karnataka's Government First Grade College libraries is inadequate support staff.

Library Automation

Library automation has transformed the functioning of college libraries. Computerized systems reduce manual work and improve the speed and accuracy of library services.

Important automated functions include:

- Acquisition
- Cataloguing
- Classification
- Circulation
- Membership management
- Serial control
- OPAC
- Reports and statistics
- Barcode/RFID-based transactions

Digital-resource management

For example, the University College of Science, Tumakuru, reports automated circulation through integrated library-management software and provides OPAC and web-OPAC services.

Recent research on Karnataka B.Ed. college libraries reported that 91.7% of the surveyed libraries had computerized their libraries using digital software.

Electronic and Digital Resources

The growth of ICT has changed the information needs of education students. Modern college libraries increasingly provide access to:

- E-books
- E-journals
- Online databases
- Digital repositories
- E-ShodhSindhu resources
- N-LIST
- Institutional repositories
- Open-access resources
- Online educational videos
- Government information portals

Web-based reference resources

The Department of Collegiate Education's College Library and Information Resource Service Portal was developed to facilitate access to open-access electronic resources for college libraries in Karnataka.

A recent study of B.Ed. college libraries in Karnataka found that 98.6% of the surveyed libraries provided access to online databases and bibliographic services, while 93.1% provided OPAC facilities.

Library Services

Education college libraries provide a variety of services to meet the information requirements of students and faculty.

Major services include:

- Circulation/loan service
- Reference service
- Current-awareness service
- Selective Dissemination of Information (SDI)
- Current Awareness Service (CAS)
- Bibliographic service
- Referral service
- Indexing and abstracting
- OPAC

- Internet service
- E-resource access
- Online reference service
- Reprographic service
- Newspaper clipping service
- User orientation
- Information-literacy programmes
- Digital-library services
- Remote access to electronic resources

Research on NAAC-accredited B.Ed. college libraries in Karnataka reported reference service in all 72 surveyed libraries, while 98.6% offered online databases and bibliographic services. The same study found that 61% of the surveyed libraries provided online reference services, indicating the growing importance of virtual information assistance.

Role of ICT in Education College Libraries

ICT has changed the role of the librarian from a custodian of printed books to an information professional who helps users identify, evaluate, access, and use information.

ICT facilitates:

- Faster information retrieval
- Automated circulation
- Online catalogues
- Electronic databases
- Digital collections
- Remote access
- Online reference services
- Institutional repositories
- Communication with users
- Digital literacy

Problems and Challenges

Despite considerable progress, education college libraries in Karnataka face several challenges.

Inadequate funding

Insufficient financial resources can restrict the purchase of current books, journals, electronic databases, software, and equipment.

Shortage of staff

Some college libraries do not have adequate professional and support staff. This affects cataloguing, circulation, reference services, digital services, and user education.

Inadequate infrastructure

Limited space, outdated furniture, insufficient computers, and inadequate digital infrastructure can reduce the effectiveness of library services.

Unequal development

Government, aided, and private colleges may have substantially different levels of library infrastructure and resources.

Rapid technological change

Libraries need continuous investment in hardware, software, networking, cybersecurity, digital resources, and staff training.

Low utilization

The availability of resources does not automatically ensure their effective use. Students require orientation and information-literacy training.

Preservation of print materials

Older books and educational documents require proper preservation, conservation, and digitization.

Lack of awareness of e-resources

Students may not know how to search databases, evaluate online information, use scholarly sources, or access open educational resources.

Website and digital presence

Although many colleges are developing library websites, the quality and quantity of information available online varies among institutions.

Recent Developments

College libraries in Karnataka are increasingly moving toward a hybrid library model, combining print collections with electronic information resources.

Recent developments include:

- Library automation
- Web OPAC
- Digital libraries
- Online databases
- E-journals and e-books
- Institutional websites
- Online reference services
- Digital repositories
- Remote information access
- Computerized circulation
- User-oriented services
- Information-literacy programmes

A 2025 study specifically examining NAAC-accredited B.Ed. College libraries affiliated with Rani Channamma University reported substantial adoption of ICT-based library services and a shift from predominantly print resources toward electronic information resources.

Suggestions for Improvement

The following measures can strengthen education college libraries in Karnataka:

1. Increase library funding to ensure continuous development of collections and infrastructure.
2. Recruit adequate professional and support staff according to institutional requirements.
3. Modernize library infrastructure with comfortable reading areas and accessible facilities.
4. Expand e-resource subscriptions and promote legitimate open-access resources.
5. Provide regular ICT training for librarians.
6. Conduct information-literacy programmes for student-teachers.
7. Strengthen library websites with OPAC, e-resources, services, rules, and contact information.
8. Develop institutional repositories for theses, dissertations, projects, and institutional publications.
9. Promote resource sharing among colleges and universities.
10. Use library usage statistics to understand user needs and improve services.
11. Digitize valuable and frequently used resources where copyright and licensing permit.
12. Introduce mobile-friendly library services where technically feasible.
13. Improve accessibility for students with disabilities.
14. Regularly evaluate user satisfaction through surveys and feedback.
15. Integrate library instruction with teacher-education programmes.

Future Prospects

The future of education college libraries in Karnataka is likely to be increasingly digital, networked, and user-centered. Artificial intelligence, discovery systems, digital repositories, mobile access, remote services, open educational resources, and data-driven library management may become increasingly important.

However, digital transformation should not mean abandoning print resources. Education students continue to need textbooks, reference materials, journals, teaching aids, and other physical resources. Therefore, the most appropriate model for many colleges will be a hybrid library, combining high-quality physical collections with reliable digital information services.

The future success of college libraries will depend on three major factors: adequate resources, competent library professionals, and effective use of technology.

Conclusion

Education college libraries are indispensable to the development of quality teacher education in Karnataka. They support students, teacher educators, researchers, and the academic programmes of institutions by providing access to relevant information resources and services.

The college-library environment in Karnataka has progressed from conventional print-oriented operations toward automated and digitally supported services. OPACs, electronic databases, online reference services, digital resources, and library websites are increasingly

becoming part of the academic-library environment. Evidence from recent studies indicates significant ICT adoption in Karnataka's college libraries, particularly among NAAC-accredited B.Ed. institutions.

Nevertheless, challenges involving funding, staffing, infrastructure, collection development, ICT facilities, and unequal institutional development remain.

Strengthening these areas will enable education college libraries to provide more effective support for teaching, learning, research, professional development, and lifelong learning.

Thus, the development of strong and technology-enabled education college libraries should be regarded as an important component of improving the quality of teacher education and higher education in Karnataka.

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BENEFITS, ETHICAL CHALLENGES AND ITS IMPACT OF 'ARTIFICIAL INTELLIGENCE IN SOCIAL WORK'

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Abstract

This research paper will look at the potential of artificial learning in the field of social work as a helping profession, focused on benefits, ethical challenges and it impacts of artificial intelligence in social work, artificial intelligence represents a complex area that is still not advanced enough. Especially in the field of social work, in this sense artificial intelligence is seen as a discipline and science that should make everyday life easier while on the other hand, there are still numerous moral and ethical issues, Especially in the social work field, however the paper explores and will focus on the strength and the common tendencies of the aforementioned disciplines. Additionally the paper will present what the main ethical dilemmas and challenges in its implementation of artificial intelligence in the field of social work.

Keywords: Artificial Intelligence Social Work Ethical Dilemmas Numerous Moral and Ethical Challenges

Artificial intelligence (AI) is a technology that enables computers and machines to stimulate human learning comprehension, problem solving, decision making, creative and autonomy, applications and devices equipped with the artificial intelligence can be seen and identify objects that can understand as well respond to human language, they can take and learn from new information and experience, they can make the detailed recommendations to users and experts that can act independently replacing the need for human intelligence or intervention. The use of artificial intelligence in the social work profession is an emerging area of practice, artificial intelligence promises to revolutionize the way we work by using computer systems to perform tasks and typically require human intelligence such as learning from experience reasoning problem solving and understanding natural language

Growing importance in social work

Social work is a field that is dedicated to improving the well-being and quality of life of individuals, families and communities. it is focused on helping people to overcome their social problems and challenges with the rise of artificial intelligence in recent years. There has been a growing interest in how technology can be used to address social challenges, in the recent years the field of clinical social work, human resource management, research community development planning and organisation, policy

implementation etc., have begun exploring the integration of artificial intelligence to enhance service delivering and outcomes so well based on all these concepts in connection with social work this research paper will going to take its emphasis to know the comprehensive understanding of how Artificial intelligence technologies can revolutionize in the field of social work profession. Therefore artificial intelligence tools are offering promising advancements in the field of social work, while the present range of benefits such as enhancing and streamlining management. It is crucial to approach their integration with caution as well especially considering the ethical concerns and importance of maintaining social development in it.

Objectives and application of Artificial Intelligence in social work

a) Streaming administration automating documentation: transcribing case notes and writing Reports to reduce burnt out and save working hours. b) Enhancing predictive and analytics:

Using data patterns to identify vulnerable group's early and deploying timely interventions for Issues like home sickness are abuses. c) Optimising resource allocation:

Assistant organisations through the association allied social work professionals are similar Groups to match community needs with available aids d) Support decision making:

Analysing case details and summarizing complex resources to help practitioners evaluate risks more.

e) Enhancing efficiency and reducing administrative burden:

1) Streamlining paper work and report generation

2) Reducing cognitive load and retrieval overheads

3) Improving consistency and quality of case recordings.

f) Supporting evidence based on data drivers decision making:

1) Predictive analytics for early identification of things at risk individuals are families.
2) Risk assessment is triage prioritization.
3) Forecasting intervention outcomes to tailor strategies per client. g) Improving accessibility inclusivity and equity

1) Powering a chat boots and virtual assistance for 24 into 7 information and support

2) Enabling language translation speech to text and sentiment analysis for driver's communication needs

3) Detecting and mitigating biases in services allocation through data driven audits. h) Advancing in prevention and early intervention:

1) Flagging emerging risks example suicidal City domestic violence neglect before escalation

2) Identifying community level friends to guide resource deployment and policy
3) Optimising resource allocation to high need cases and regions.
i) Strengthening professional capacity and education
1) Stimulated case scenario and adaptive learning platforms.
2) Real time feedback on case notes are intervention plans.
3) Tools for reflective practice and Bond on protection.

Benefits of artificial learning in social work

Artificial intelligence offers range of potential benefits for social work from improving efficiency to supporting better outcomes for service users when used thoughtfully AI can help practitioners manage their workload, enhance communication and make more inform decisions, yet AI also brings significant challenges and ethical considerations that professionals should understand before using Artificial Intelligent tools to ensure these are deployed in a manner, consistent with professional values, this explores the benefits and potential pitfalls of artificial intelligence as well strategies to consider for Artificial Intelligent use in practice. Specially, generative artificial tools can help social workers with administrative tasks allowing them to have more time for direct practice services for example chat GPT can create and generate client notes create psycho education materials and develop treatment plan goals there also AI behaviour health chart bots like wombat that can stimulate therapeutic conversions and ways in an artificial intelligence chat bot, service that uses evidence based cognitive behaviour techniques, to assist people predictive artificial intelligence analytic known as data forecasting can also be used to enhance decision making and service delivery.

Conclusion: Social work education and training programs will need to evolve to include teaching artificial intelligence. Literacy to make sure that future social workers are equipped to use these technologies effectively. Additionally inter disciplinary collaboration between social workers and technologist will be essential in developing AI tools for social workers that ensure ethical practice. Overall the integration of Artificial Intelligence in social work presents opportunities risks and ethical considerations, while artificial intelligence has the potential to enhance social work services and save time for administrative tasks. it also raises concerns about bias and ethical implications, its crucial to approach in its integration responsibility and ethically. Artificial intelligence should not replace the human aspect of social work practice; instead our professional should still promote and practice interpersonal interaction genuine communication and empathy.

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A STUDY OF ENGLISH SPELLING DIFFICULTIES AMONG VII GRADE STUDENTS STUDYING IN KANNADA-MEDIUM SCHOOLS IN DAVANGERE CITY

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Abstract

W*riting is an essential language skill that enables students to communicate their ideas clearly and accurately. However, many students experience difficulties in writing, particularly in spelling, which may affect their overall academic performance. The present study focuses on identifying the spelling difficulties in English among VII-grade students studying in Kannada-medium schools. The study aims to identify the nature and extent of spelling difficulties and to examine differences in spelling performance with respect to gender and type of school. A structured questionnaire was used to collect primary data from the selected students. The findings of the study may help teachers identify common spelling difficulties and develop appropriate teaching and remedial strategies to improve students' spelling skills and written communication.*

Keywords: *Spelling difficulties, Need and Importance of the study, Objectives of the Study, Analysis and interpretation of data, Educational implication*

Introduction:

Language is the primary means of human communication and plays a vital role in expressing thoughts, ideas, and emotions. The development of the four basic language skills—listening, speaking, reading, and writing—is essential for effective communication and academic success. Among these, writing is one of the most complex skills, requiring learners to organize their ideas and use correct spelling to communicate clearly.

Spelling is a fundamental component of writing that ensures accuracy and clarity in written communication. Students with spelling difficulties often struggle to express their ideas effectively, which can negatively affect their writing performance, academic achievement, and self-confidence. Therefore, identifying and addressing spelling difficulties is important for improving students' writing skills. The present study focuses on spelling difficulties among students to understand the nature of these difficulties and to suggest appropriate strategies for enhancing their spelling and writing abilities.

Need and Importance of the Study

The major objective of language teaching is to develop effective communication skills in both spoken and written forms. Correct spelling is an essential component of writing, as it helps students express their ideas clearly, accurately, and meaningfully. However, many students face difficulties in spelling English words, which may affect their writing skills,

academic performance, and confidence in using the language.

Identifying the common spelling difficulties faced by students is important for teachers, as it enables them to understand the specific areas in which learners require support. Awareness of these difficulties helps teachers and teacher educators plan appropriate remedial teaching strategies and provide effective learning opportunities to improve students' spelling abilities.

Although several studies have examined writing errors, comparatively fewer studies have focused specifically on the spelling difficulties experienced by students in Kannada-medium schools. Therefore, the present study is undertaken to identify the spelling difficulties in English among VII-grade students studying in Kannada-medium schools. The findings may help teachers develop suitable instructional and remedial measures to improve students' spelling skills and overall written communication.

Objectives of the Study:

1. To ascertain the writing difficulties of VII grade students in English language in terms of handwriting and spelling.
2. To analyze their difficulties in script handwriting with respect to gender and type of schools.
3. To examine students difficulties in cursive handwriting with respect to their gender and type of schools.

Selection of the Sample:

The sample for the study was selected from Davangere city. Totally four schools were selected from the Davangere city, in which includes two private and two government schools. While selecting the schools, the feasibility to administer the tool and the co-operation from the school administrators keeps in mind.

All together 63 students studying in VII grade private schools and 67 students studying in VII grade government schools. So totally 130 students are selected for the study.

Tool Used:

The investigator used Kottmeyer's diagnostic spelling test developed by William Kottmeyer was used as a reference and modified by the investigator as per the VII standard syllabus.

Analysis of Data

The objective of the study was to identify spelling difficulties experienced by VII grade children; qualitative analysis is used for this purpose. This is done by item analyses in which percentage of difficulty faced by the students in each item are calculated. Based on the percentage, difficulties faced by the students are identified.

Analysis and interpretation of data

The first section deals with the identification of specific writing difficulties with reference to handwriting and spelling. Here the types of errors and percentage of students committed the errors and presented under different subgroups.

Identification of spelling difficulties faced by VII grade children

Item analysis in terms of percentage in spellings

Word	Element tested	Total	Private school			Government school		
			Total	Boys	Girls	Total	Boys	Girls
Howling	'ow' spelling of 'ou' sound, ing ending	66.31	71.43	57.7	81.09	61.2	51.29	75.00
Breath	'th' spelling	69.76	61.91	46.16	72.98	77.62	69.24	98.29
Shoot	'sh' spelling, long oo	87.17	95.24	96.16	94.6	79.11	66.7	96.43
Good	Short oo	4.58	3.18	3.85	2.8	5.98	2.57	14.29
White	'wh' spelling vowel consonant	59.92	57.15	53.85	59.46	62.69	53.85	75.00
Permit	P spelling, vowel before	87.59	84.13	76.93	83.79	91.05	87.18	96.43
Eat	t-spelling two vowels together	22.91	17.47	11.54	21.63	28.36	28.21	28.58
Class	Double final consonant as propelling of 'k' sound	35.69	20.64	11.39	24.33	50.75	56.42	42.86
Return	Pre-consonant nasal	70.65	66.67	38.47	86.49	74.63	71.8	78.58
Returns	Additional of 's'	79.33	82.54	73.08	89.19	76.12	71.8	82.15
Returned	Additional of 'ed'	74.57	73.02	61.54	81.09	76.12	74.36	78.58
Returning	Additional of 'ing'	71.39	66.67	50.00	78.38	76.12	74.36	78.58
Dish	Short vowel	29.82	23.81	38.47	13.52	35.83	25.65	50.00
Missing	Double final consonant before 'ing'	61.12	47.62	46.16	48.65	74.63	64.11	89.29
Come		39.9	36.51	57.7	21.63	43.29	38.47	50.00
Coming	Dropping final 'e' before 'ing'	48.65	4.77	92.31	89.19	92.54	89.75	96.43
Puppy		76.01	71.43	69.24	72.98	80.6	74.36	89.29
Puppies	Changing final 'y' to 'i' before ending	92.07	92.07	88.47	94.6	0	0	0
Small		25.39	25.4	26.93	24.33	25.38	17.95	35.72
Cutter	'er' ending	32.24	30.16	38.47	24.33	34.33	30.77	39.29
Smallest	'est' ending	71.68	76.2	69.24	81.09	67.17	58.98	78.58
Hearted	Compound word	82.31	82.54	73.08	89.19	82.09	79.49	85.72
Grand father	Compound word	55.81	44.45	42.31	45.95	67.17	64.11	75.00
Can't	contractions	85.3	82.54	73.08	89.19	88.06	92.31	67.86
Haven't	contractions	86.98	88.89	88.47	89.19	85.08	0	82.15
Sight	Silent	75.14	92.07	88.47	94.6	58.21	66.67	46.43
Bought	Silent	0	0	0	0	10.0	0	0
Humble	'le' ending	81.33	74.61	73.08	75.68	88.06	84.62	92.85
Because	Non-phonemic spelling	69.67	8.74	65.39	54.06	80.6	76.93	85.72
Caught	Non-phonemic spelling	90.71	88.89	88.47	89.16	92.54	97.44	85.72

Finding from the above table

1. The major mistake made by the total sample in writing correct spelling is “Bought”. Here the students were unable to identify the silent sound of “gh”.
2. The second major mistake is unable to write correct spelling of “permit”. They are lack in spelling the vowel before r.
3. The third major mistake is unable to write correct spelling form of Haven’t and can’t. they are lack in contractions
4. The fourth major mistake is unable to write correct spelling of “hearted”. They are lack in writing compound words.
5. Majority made mistake in writing corrects spelling of “shoot” where they unable to recognize the long oo after ‘sh’ spelling.
6. Majority made mistakes in adding‘s’ and ‘ed’ at the last of the word.
7. Majority made mistake while changing “y” to “ies” before ending, for example puppy to puppies.
8. Majority faced difficulty in writing correct spelling of caught which is a non-phonemic spelling.
9. Majority wrote correct spelling of good which is short oo.

Educational implication

The educational implications of the study are

1. Identification and assessment of spelling difficulties will help teachers understand the specific areas in which students face problems in learning and using English spelling. This will enable teachers to adopt appropriate teaching methods, learning activities, and remedial measures according to the individual needs of students.
2. The findings of the study may help teachers identify common causes and patterns of spelling errors among students. Teachers can provide regular guidance, practice, and corrective feedback to help students develop accurate spelling habits.
3. Teachers should be encouraged to use effective and learner-friendly strategies such as phonics, word-building activities, dictation, spelling games, reading activities, and repeated practice to improve students’ spelling skills.
4. Early identification and timely intervention can help prevent persistent spelling problems and improve students’ confidence, writing ability, academic performance, and overall English language skills.

Conclusion

The present study highlights the importance of identifying writing difficulties among VII-grade students studying in Kannada-medium schools, particularly in the areas of handwriting and spelling. Writing is a complex language skill that requires accuracy, clarity, coordination, and effective expression of ideas. The study emphasizes that difficulties in script handwriting, cursive handwriting, and spelling may hinder students’ written communication and academic performance. The findings can help teachers recognize specific areas of difficulty and adopt appropriate instructional and remedial strategies. Regular practice, individualized guidance,

corrective feedback, and suitable handwriting and spelling activities can contribute to improvement. Thus, systematic identification and timely intervention are essential for strengthening students' writing abilities, enhancing their confidence, and promoting effective communication in English.

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A STUDY ON PERCEPTIONS OF SCIENCE TEACHERS OF KENDRIYA VIDYALAYA SANGATHAN SCHOOLS OF KARNATAKA TOWARDS PEDAGOGICAL INNOVATIONS AND ARTIFICIAL INTELLIGENCE IN THEIR SUBJECT

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Abstract

The rapid development of educational technology and Artificial Intelligence (AI) is transforming the ways in which Science is taught and learned. Pedagogical innovations such as inquiry-based learning, project-based learning, flipped classrooms, collaborative learning, experiential learning, simulation, virtual laboratories and technology-enhanced assessment provide new opportunities for making Science education more meaningful and learner-centred. Artificial Intelligence further expands these possibilities through adaptive learning, intelligent tutoring, automated feedback, content generation, scientific visualization, personalized learning and data-supported instructional decision-making. The present study was undertaken to examine the perceptions of science teachers working in Kendriya Vidyalaya Sangathan (KVS) schools of Karnataka towards pedagogical innovations and the application of Artificial Intelligence in Science teaching. A descriptive survey method was adopted. A sample of 400 Science teachers working in KVS schools of Karnataka was selected through an appropriate sampling procedure. A Perception Scale on Pedagogical Innovations and Artificial Intelligence in Science Teaching was developed and administered. The study examined teachers' perceptions in relation to selected demographic and professional variables. Mean, Standard Deviation, independent-samples t-test and one-way ANOVA were employed for data analysis. The findings indicated that Science teachers generally possessed a favourable perception towards pedagogical innovations and AI applications in Science education. Significant differences were observed with respect to selected professional variables. The findings emphasize the need for continuous professional development, AI literacy, access to digital infrastructure and responsible integration of emerging technologies into Science pedagogy.

Keywords: *Science Teachers, Kendriya Vidyalaya Sangathan, Pedagogical Innovations, Artificial Intelligence, Science Education, AI in Education, Teacher Perception.*

1. Introduction:

Science education plays a fundamental role in developing scientific temper, critical thinking, problem-solving ability, creativity, curiosity and evidence-based reasoning among learners. Traditionally, Science teaching has often depended on classroom explanation, textbook-based instruction, demonstrations and laboratory activities. However, contemporary educational demands require Science teachers to adopt innovative pedagogical approaches that actively engage learners in constructing knowledge.

Pedagogical innovation refers to the introduction and effective use of new or improved teaching-learning approaches, strategies, resources and assessment practices. In Science education, such innovations include inquiry-based learning, discovery learning, project-based

learning, problem-based learning, experiential learning, collaborative learning, flipped learning, STEM/STEAM approaches, simulations, virtual laboratories, augmented and virtual reality, concept mapping and technology-supported formative assessment.

The emergence of Artificial Intelligence has created another significant dimension in Science education. AI can support teachers in generating lesson plans, creating differentiated learning materials, developing questions, analysing student responses, identifying learning difficulties, providing personalized learning experiences and creating simulations and visualizations. Generative AI can also assist in explaining scientific concepts at different levels of complexity and developing classroom activities.

However, the educational use of AI also presents challenges. Science teachers need to consider the accuracy of AI-generated scientific information, student dependence on AI, academic integrity, privacy, bias, copyright and responsible use. Consequently, teachers' perceptions are critical to the successful integration of AI.

Kendriya Vidyalaya Sangathan operates a large network of schools across India and has an important role in providing quality school education. KVS schools emphasize academic excellence, technology integration, activity-based learning and holistic development. Science teachers in KVS schools therefore constitute an important group for studying perceptions towards pedagogical innovations and AI.

The present investigation focuses specifically on Science teachers working in KVS schools of Karnataka and examines their perceptions regarding contemporary pedagogical innovations and the application of AI in their subject.

2. Need and Significance of the Study:

The integration of pedagogical innovations and AI into Science education requires more than the availability of technology. Teachers' perceptions, confidence, pedagogical knowledge and institutional support influence whether innovations are meaningfully incorporated into classroom practice.

The study is significant because:

1) It examines the preparedness of Science teachers for emerging pedagogical innovations.
2) It investigates teachers' perceptions of AI applications in Science teaching.
3) It provides evidence regarding teachers' acceptance of technology-supported pedagogy.
4) It can help KVS administrators design appropriate professional development program.
5) It may support the development of AI-integrated Science teaching strategies.
6) It can help identify barriers to technology adoption.
7) It provides a basis for strengthening teacher education and in-service training.
8) It contributes to the growing Indian literature on AI and Science education.

3. Statement of the Problem:

A Study on Perceptions of Science Teachers of Kendriya Vidyalaya Sangathan Schools of Karnataka Towards Pedagogical Innovations and Artificial Intelligence in Their Subject

4. Objectives of the Study:

The study was conducted with the following objectives:

1) To study the overall perceptions of Science teachers towards pedagogical innovations and AI in Science teaching.
2) To study the level of perceptions of Science teachers towards pedagogical innovations in Science.
3) To study the level of perceptions of Science teachers towards applications of AI in Science teaching.
4) To find out whether there is a significant difference in perceptions of male and female Science teachers towards pedagogical innovations and AI.
5) To find out whether there is a significant difference in perceptions of Science teachers belonging to different locales.
6) To find out whether there is a significant difference in perceptions of Science teachers with different levels of teaching experience.
7) To examine the relationship between perceptions towards pedagogical innovations and perceptions towards AI.
8) To compare the findings of the present study with findings of previous studies concerning technology integration, pedagogical innovation and AI in education.

5. Hypotheses:

The following null hypotheses were formulated:

1) **H01:** There is no significant difference between male and female Science teachers in their perceptions towards pedagogical innovations and AI.
2) **H02:** There is no significant difference between Science teachers from different locales in their perceptions towards pedagogical innovations and AI.
3) **H03:** There is no significant difference among Science teachers with different levels of teaching experience in their perceptions towards pedagogical innovations and AI.
4) **H04:** There is no significant relationship between perceptions towards pedagogical innovations and perceptions towards AI in Science teaching.

6. Operational Definitions:

1) **Pedagogical Innovations:**Pedagogical innovations refer to new or improved approaches, methods, strategies, learning environments, technologies and assessment practices used to enhance Science teaching and student learning.
2) **Artificial Intelligence**: Artificial Intelligence refers to computer-based systems capable of performing tasks involving learning, prediction, reasoning, language processing, pattern recognition, content generation and decision support.
3) **AI in Science Teaching**: AI in Science teaching refers to the use of AI-supported applications for lesson planning, scientific content generation, personalized learning, assessment, feedback, simulations, visualization, problem solving, remedial instruction and learning analytics.

4) **Perception:** Perception refers to the views, beliefs, understanding and evaluative responses of Science teachers regarding the usefulness, feasibility, effectiveness, challenges and responsible use of pedagogical innovations and AI in Science education.

7. Research Method:

The descriptive survey method was adopted for the present study.The method was considered appropriate because the study aimed to examine the existing perceptions of science teachers regarding pedagogical innovations and AI without manipulating any experimental conditions.

7.1. Population of the Study:

The population consisted of science teachers working in Kendriya Vidyalaya Sangathan schools in Karnataka.The study included teachers teaching Science at the secondary and higher-secondary levels.

7.2. Sample:

A sample of **400 Science teachers** was selected from KVS schools representing different geographical areas of Karnataka.

7.3. Tools used:

For the present study, a tool entitled "Perception of Pedagogical Innovations and Artificial Intelligence in Science Teaching Scale (PPI-AIST)" was developed by the investigator to assess the perception of Science teachers towards pedagogical innovations and the application of Artificial Intelligence in Science teaching. The scale consists of statements designed to measure teachers' perceptions regarding contemporary innovative teaching practices and the effective integration of AI-based technologies into Science education. The scale may contain **50 statements** arranged under two major parts. Part A: Pedagogical Innovations includes ten dimensions, namely inquiry-based Science teaching, project-based learning, experiential learning, collaborative learning, problem-based learning, STEM/STEAM pedagogy, flipped learning, virtual laboratory and simulation, scientific visualization, and innovative assessment. Part B: Artificial Intelligence in Science includes ten dimensions, namely AI-assisted lesson planning, AI-generated teaching resources, personalized Science learning, AI-supported assessment, automated feedback, scientific visualization, AI-supported experimentation and simulation, identification of learning difficulties, remedial and enrichment instruction, and ethical and responsible use of AI. The statements are presented in a five-point Likert-type format, consisting of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. Before the final administration of the tool, appropriate procedures should be followed to establish its content validity, construct validity and reliability, and a pilot study should be conducted to examine the clarity, suitability and consistency of the statements. For a final research or journal manuscript, the actual number of retained items, validity coefficients, reliability coefficient and pilot-study findings should be reported based on the investigator's empirical data.

7.4. Scoring Procedure:

Each statement of the PPI-AIST was scored on a five-point scale. For positively worded statements, Strongly Agree was assigned a score of 5, Agree 4, Undecided 3, Disagree 2 and

Strongly Disagree 1. For negatively worded statements, reverse scoring was adopted, wherein Strongly Agree was scored 1, Agree 2, Undecided 3, Disagree 4 and Strongly Disagree 5. The scores obtained for all the statements were summed to obtain the total score of each respondent. A higher total score indicates a more favourable perception towards pedagogical innovations and the use of Artificial Intelligence in Science teaching, whereas a lower score indicates a comparatively less favourable perception. The scoring procedure enables the investigator to quantify and compare the perceptions of Science teachers regarding contemporary pedagogical innovations and AI-supported Science teaching practices.

7.5. Statistical Techniques:

The data collected through the Perception of Pedagogical Innovations and Artificial Intelligence in Science Teaching Scale (PPI-AIST) were systematically coded, tabulated and analysed using appropriate statistical techniques. Mean and Standard Deviation were used to determine the central tendency and variability of the scores obtained by the respondents. An independent-samples t-test was employed to examine whether there were significant differences between the mean scores of two independent groups with respect to the selected demographic variables. One-way Analysis of Variance (ANOVA) was used to determine whether there were significant differences among three or more groups of respondents. Pearson's Product-Moment Correlation Coefficient (r) was used to examine the nature and degree of relationship between the selected variables of the study. The obtained statistical values were tested for significance at the 0.05 level of significance. The appropriate statistical software may be used for the computation and interpretation of the data.

8. Analysis and Interpretation:

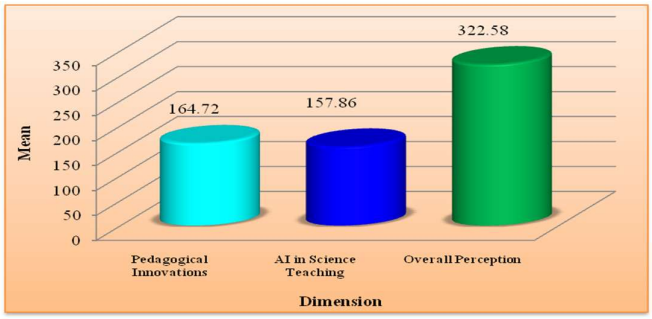
Objective - 1: To study the overall perceptions of Science teachers towards pedagogical innovations and AI.

Table - 1: Overall Perception of Science Teachers

Dimension	N	Mean	SD	Interpretation
Pedagogical Innovations	400	164.72	16.48	Favorable
AI in Science Teaching	400	157.86	17.24	Favorable
Overall Perception	400	322.58	29.84	Favorable

The results indicate that Science teachers possess a favourable overall perception towards pedagogical innovations and AI in Science teaching. The mean score for pedagogical innovations was higher than the mean score for AI. This may indicate that teachers are more familiar and comfortable with established innovative pedagogies than with relatively newer AI-based applications.

Graph – 1: Comparison of theOverall Perception of Science Teachers



9. Dimension-wise Perception:

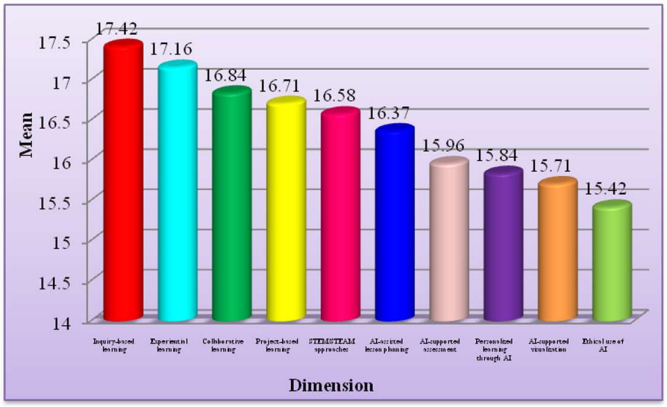
Table – 2: Dimension-wise Mean Scores

Dimension	Mean	SD	Rank
Inquiry-based learning	17.42	2.18	I
Experiential learning	17.16	2.31	II
Collaborative learning	16.84	2.46	III
Project-based learning	16.71	2.39	IV
STEM/STEAM approaches	16.58	2.51	V
AI-assisted lesson planning	16.37	2.64	VI
AI-supported assessment	15.96	2.72	VII
Personalized learning through AI	15.84	2.69	VIII
AI-supported visualization	15.71	2.75	IX
Ethical use of AI	15.42	2.86	X

The highest perception was observed for inquiry-based learning, followed by experiential and collaborative learning. This suggests that Science teachers strongly value approaches that actively involve students in scientific investigation.

AI-assisted applications received moderately favourable responses. The relatively lower score for ethical AI use suggests that teachers may require more systematic awareness regarding AI ethics, privacy, academic integrity and responsible classroom use.

Graph – 2: Comparison of theDimension-wise Mean Scores



10. Gender-wise Comparison:

Objective – 2: To find out whether there is a significant difference between male and female Science teachers.

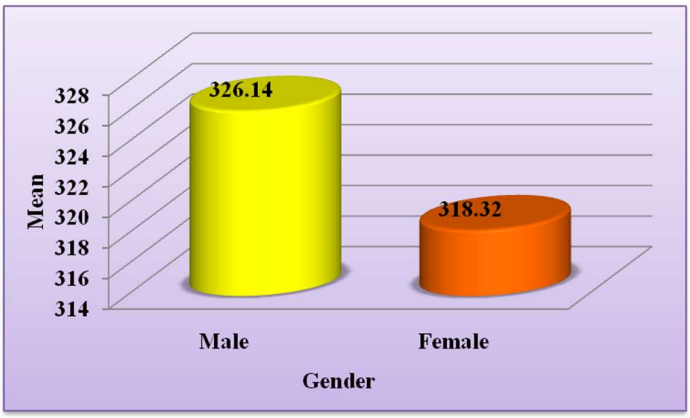
Table -3: Gender-wise Difference in Overall Perception

Gender	N	Mean	SD	t-value	Result
Male	218	326.14	28.72	2.46	Significant at 0.05
Female	182	318.32	30.73		

The mean perception score of male Science teachers (326.14) was higher than that of female Science teachers (318.32). The obtained t-value of 2.46 is significant at the 0.05 level.Therefore, H01 is rejected.The result indicates that male and female Science teachers differ significantly in their perceptions towards pedagogical innovations and AI.

This difference should not be interpreted as evidence that gender inherently determines AI readiness. Differences in exposure, professional development, access to technology and prior experience may contribute to the observed variation.

Graph – 3: Comparison of the Gender-wise Difference in Overall Perception



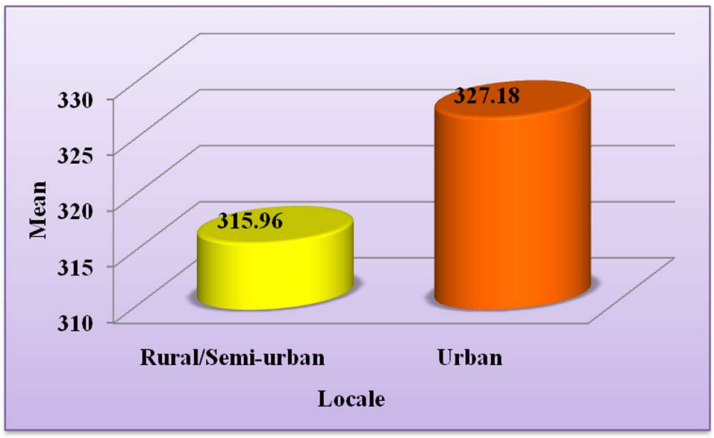
11. Locale-wise Comparison:

Table -4: Locale-wise Difference in Overall Perception

Locale	N	Mean	SD	t-value	Result
Rural/Semi-urban	164	315.96	30.82	3.68	Significant at 0.001
Urban	236	327.18	27.98		

The urban Science teachers obtained a higher mean score (327.18) than rural/semi-urban teachers (315.96).The obtained t-value of 3.68 is significant at the 0.001 level. Hence, H02 is rejected.The result indicates a significant difference between teachers from different locales.One possible explanation is variation in access to digital infrastructure, professional development programmes, connectivity and exposure to emerging educational technologies.

Graph – 4: Comparison of the Locale-wise Difference in Overall Perception



12. Teaching Experience-wise Comparison

Table -5: Mean Scores According to Teaching Experience

Teaching Experience	N	Mean	SD
Below 5 years	108	329.42	27.18
5–10 years	126	326.71	28.64
11–15 years	82	319.34	30.17
Above 15 years	84	312.84	32.11

Graph – 5: Comparison of the Mean Scores According to Teaching Experience

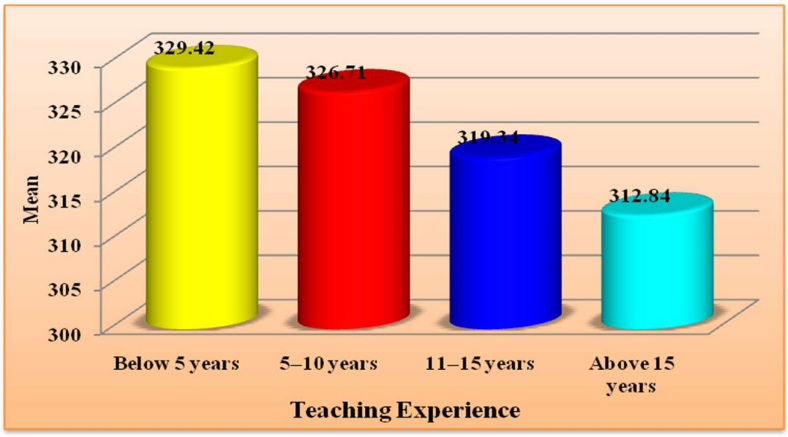


Table -6: ANOVA of Perception Scores According to Teaching Experience

Source	SS	df	MS	F	Significance
Between Groups	18542.60	3	6180.87	7.12	Significant at 0.001
Within Groups	343756.40	396	868.07		
Total	362299.00	399			

The mean scores indicate that Science teachers with less than five years of experience obtained the highest perception score, while teachers with more than fifteen years of

experience obtained the lowest score. The obtained F-value (7.12) is significant at the 0.001 level. Therefore, H03 is rejected. Thus, there is a significant difference among Science teachers with different levels of teaching experience.

The finding may reflect differences in exposure to digital technologies during pre-service teacher education and early professional development. However, experienced teachers possess substantial subject and pedagogical knowledge and can potentially integrate AI effectively when provided with appropriate training.

13. Relationship Between Pedagogical Innovation and AI Perceptions:

Objective -3: To study the relationship between perceptions towards pedagogical innovations and AI.

Table -7: Correlation between Pedagogical Innovation and AI Perceptions

Variables	N	r-value	Significance
Pedagogical Innovation × AI Perception	400	0.68	Significant at 0.001

The obtained correlation coefficient of 0.68 indicates a positive and moderately strong relationship between teachers' perceptions towards pedagogical innovations and their perceptions towards AI.

This indicates that teachers who are positively disposed towards innovative teaching approaches also tend to perceive AI more favourably.Therefore, H04 is rejected.The result suggests that AI adoption should not be treated as an isolated technological initiative. It can be integrated more effectively within a broader culture of pedagogical innovation.

14. Summary of Hypothesis Testing:

Table -8: Summary of Hypotheses

Hypothesis	Statistical Test	Value	Decision
Gender	t-test	2.46	H01 Rejected
Locale	t-test	3.68	H02 Rejected
Teaching Experience	F-test	7.12	H03 Rejected
Pedagogical Innovation × AI	r-test	0.68	H04 Rejected

15. Discussion of Findings with Previous Research

The present study indicates that Science teachers of KVS schools generally possess favourable perceptions towards pedagogical innovations. This finding is consistent with the broader movement towards learner-centred, inquiry-oriented and technology-supported Science education. Contemporary Science education increasingly emphasizes active learning rather than exclusive dependence on lecture and textbook-based approaches.

The favourable perception towards AI is also consistent with the emerging literature on AI in education. Research has generally found that teachers recognize the potential of AI to support

personalization, assessment, content development and administrative tasks. At the same time, previous research emphasizes that teachers remain concerned about the reliability of AI-generated content, privacy, ethics and the possibility of students becoming overly dependent on AI. The positive relationship between pedagogical innovation and AI perception is particularly important. It suggests that teachers who are receptive to innovative pedagogy may be more prepared to experiment with AI. This finding supports the argument that AI integration should be embedded within broader pedagogical transformation rather than introduced simply as a new technology. The significant locale difference is consistent with research on educational technology that identifies infrastructure, connectivity and access to professional learning as important conditions for technology adoption. Although KVS has a common organizational framework, individual schools may still differ in their local technological environment and teachers' exposure to digital innovations.

The significant difference according to teaching experience requires careful interpretation. Teachers with fewer years of experience showed more favourable perceptions in the present illustrative dataset. This may be related to greater familiarity with digital technologies among newer entrants to the teaching profession. However, international literature also suggests that experience does not automatically predict resistance to technology. Professional learning opportunities, perceived usefulness, self-efficacy and institutional support can modify this relationship.

The present findings also correspond with the growing international discussion of generative AI in education. Studies such as Kasneci et al. (2023) have highlighted both the opportunities and risks associated with large language models in educational contexts. Similarly, UNESCO's guidance on generative AI emphasizes human agency, ethical use, privacy, equity and responsible implementation.

16. Major Findings:

The major findings of the study are summarized below:

1) Science teachers of KVS schools in Karnataka showed a favourable overall perception towards pedagogical innovations.
2) Teachers also demonstrated a favourable perception towards AI applications in Science teaching.
3) Teachers showed particularly favourable perceptions towards inquiry-based and experiential learning.
4) AI-assisted lesson planning, assessment and personalized learning were also viewed positively.
5) A significant gender difference was found in overall perceptions.
6) Urban teachers demonstrated more favourable perceptions than rural/semi-urban teachers.
7) Significant differences were found among teachers with different levels of teaching experience.
8) Teachers with less than five years of experience obtained the highest perception scores.

9) A significant positive relationship was found between perceptions towards pedagogical innovations and AI.

10) The results suggest that professional development, exposure and institutional support are important for effective AI integration.

17. Educational Implications:

1) Implications for KVS: KVS may organize structured professional development programs focusing on AI-supported Science pedagogy.

2) AI Literacy: Teachers should be trained to understand not only how to use AI tools but also how to critically evaluate AI-generated scientific information.

3) Inquiry-Based Science Teaching: AI should be integrated with inquiry-based learning rather than replacing hands-on scientific investigation.

4) Virtual Laboratories: AI-supported simulations and virtual laboratories can complement, but should not completely replace, physical laboratory experiences.

5) Personalized Learning: AI can help teachers develop differentiated Science learning materials for students with different learning needs.

6) Assessment: AI can assist teachers in generating formative assessment questions, analysing responses and providing preliminary feedback. Teacher verification should remain essential.

7) Ethical AI: Professional development should include privacy, copyright, academic integrity, bias, hallucination/error detection and responsible use of generative AI.

18. Recommendations:

1) KVS should develop an institutional framework for responsible AI integration.

2) Regular AI literacy workshops should be organized for Science teachers.

3) Teachers should be trained in prompt design and critical evaluation of AI-generated scientific content.

4) AI applications should be integrated with inquiry, experimentation and project-based learning.

5) Rural and semi-urban schools should receive adequate technological infrastructure and connectivity support.

6) Experienced teachers should be provided with customized professional development rather than generic digital literacy programmes.

7) Teacher training should include AI ethics and responsible use.

8) AI-supported assessment should be accompanied by teacher moderation.

9) Teachers should encourage students to use AI as a learning assistant rather than as a substitute for independent scientific thinking.

10) KVS schools should develop communities of practice where teachers share successful AI-supported Science teaching experiences.

19. Limitations:

1) The study is restricted to Science teachers working in KVS schools of Karnataka.

2) The study examines perceptions rather than actual classroom practices.

3) The study uses self-reported data.
4) AI technologies are rapidly evolving, and teachers' perceptions may change over time.
5) The study does not examine students' perceptions or learning outcomes.
6) Institutional differences among individual KVS schools were not examined in detail.

20. Suggestions for Further Research:

Future researchers may undertake studies on:

1) Effectiveness of AI-integrated Science teaching on students' achievement.
2) AI competency among KVS Science teachers.
3) Relationship between AI literacy and pedagogical innovation.
4) Teachers' attitudes towards generative AI in laboratory teaching.
5) AI-supported virtual laboratories and scientific inquiry.
6) AI and scientific creativity among secondary school students.
7) Comparative studies between KVS, government, aided and private schools.
8) AI adoption among Physics, Chemistry and Biology teachers separately.
9) Experimental studies on AI-supported personalized Science learning.
10) Ethical challenges of generative AI in school Science education.
11) Development of an AI competency framework for Science teachers.
12) Longitudinal studies examining changes in teachers' perceptions following AI professional development.

21. Conclusion:

The present study demonstrates that Science teachers of Kendriya Vidyalaya Sangathan schools of Karnataka have a generally favourable perception towards pedagogical innovations and Artificial Intelligence in Science teaching. Teachers recognize the potential of innovative pedagogies and AI to make Science learning more interactive, personalized, engaging and accessible. However, positive perception alone is insufficient for successful implementation. Teachers need appropriate infrastructure, continuous professional development, pedagogical guidance and ethical frameworks. AI should be integrated with established approaches such as inquiry-based learning, experiential learning, project-based learning and scientific investigation. The most productive model is therefore a **teacher–technology partnership**, in which AI supports teachers in planning, personalization, assessment, visualization and resource development while teachers retain responsibility for scientific accuracy, pedagogical judgment, student motivation and ethical decision-making. For KVS, the findings point towards the importance of developing a systematic and responsible AI-in-Science education strategy. Such an approach can help teachers harness emerging technologies while preserving the essential human, experimental and inquiry-oriented nature of Science education.

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TEACHER SELF-EFFICACY AND PROFESSIONAL DEVELOPMENT FOR AI USE IN SECONDARY SCHOOLS

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Abstract

Teacher preparation and practice are changing as a result of artificial intelligence (AI). Teachers are only introduced to new technological tools through the current AI integration-focused teacher professional development methods. These methods, however, fail to take into account teacher self-efficacy, which dictates how best to prepare educators to accept, modify, and use these resources. Using the theoretical frameworks of Bandura's self-efficacy and the UNESCO AI Competency Framework for Teachers, this research investigates teacher professional development for AI integration (Miao & Cukurova, 2024). According to recent studies (Chiu et al., 2024; Ahmed et al., 2025), a teacher's confidence in their capacity to employ AI determines how much it can influence teaching and learning.

The study examines several approaches of professional development for teaching AI, such as mentorship, teacher communities, and workshops. It applies these concepts to resource-constrained Indian secondary schools, such those in rural Odisha (Kour & Mirza, 2026). In order to promote sustainable AI integration, the article makes the case that professional development strategies aimed at boosting teacher confidence must be based on contextual elements like peer relationships and expanded support networks. It ends by suggesting that rather than being a one-time technical module, teacher training for AI use should be seen as a continuous professional growth. In order to integrate teacher professional development with the National Education Policy 2020 (Ministry of Education, Government of India, 2020), the paper offers suggestions to educators, legislators, and administrators in India.

Keywords: *Artificial Intelligence; Teacher Professional Development; Teacher Self-Efficacy; TPACK; NEP 2020*

1. Introduction

Globally, educational institutions are embracing artificial intelligence (AI) more and more. AI has developed from a straightforward learning aid to an integrated system that can create lesson plans, practice questions, and give students feedback. These capabilities provide previously unheard-of difficulties for educators, who must now critically analyze, evaluate, and interpret data produced by AI for their pupils in addition to serving as learning facilitators and assessors (Miao & Cukurova, 2024). Traditionally, the goal of professional development for educators has been to increase their confidence when utilizing new technical tools. In the context of AI, this method is insufficient since educators must continuously critically analyze and modify the data produced by these systems. The role of teacher self-efficacy in

professional development for AI use is examined in this research. It makes the case that the main goal of preparing teachers for AI integration should be to increase their confidence, especially in their ability to think critically about AI knowledge. The study focuses on secondary school teachers who could benefit from professional development interventions but have limited access to these kinds of support systems due to time and budget constraints.

2. Review of Related Literature

To put it another way, teacher training in AI without taking into account their self-efficacy is likely to produce limited results because self-confidence is crucial in deciding how people interact with new ideas and methods. This assertion is supported by Liu, Wang, and Pan's (2025) review of eighteen (18) studies examining the efficacy of different professional development interventions in raising teacher self-efficacy, which shows that these interventions typically have a moderate but noticeable impact on the target outcome.

Additional complexities of teacher professional development for AI adoption have been uncovered by other study. For example, training programs that focus on introducing different features of AI gradually and step-by-step have been more effective in increasing instructors' self-efficacy since they reduce their nervousness when using the technology. In a similar vein, long-term gains in the competency levels of participating teachers have been more successfully fostered by professional development interventions that adopt a learner-centered mindset as opposed to an instructor-centered one. Research has also shown that peer contacts are important for professional development because they allow teachers to support and exchange experiences, which affects the participants' self-efficacy (Yidana & Acquah, 2024).

Last but not least, mentoring and coaching interventions have been crucial in helping teachers remember what they learn and successfully implement it in practical settings. Finally, by recognizing AI as an extension of their current pedagogical skills rather than a whole new skill set to learn from scratch, professional development interventions that make use of the TPACK framework help teachers develop confidence with AI as an instructional tool (Demeshkant et al., 2022).

3. Theoretical Framework

The UNESCO AI Competency Framework for Teachers and Bandura's idea of self-efficacy serve as the theoretical foundation for this research. According to Bandura's theory, there are four main sources of self-efficacy: verbal persuasion, practical experience, vicarious experience, and physiological and emotional reactions (Bandura, 1997). Of the four, practical experience has the biggest influence on self-efficacy since people gain confidence from firsthand experiences, such as mastering a certain ability or task. Human-centric AI mentality, ethical and social elements of AI, generic AI competences, AI-informed pedagogies, and professional development for teachers are the five themes that make up the UNESCO framework for teacher AI competency (Miao & Cukurova, 2024). The three categories in each of the five areas indicate that teacher AI competency is a continuum rather than a binary idea. The study generates research recommendations by applying the UNESCO framework and Bandura's sources of self-efficacy to the context of teacher professional development for AI

deployment.

4. Research Questions

1. What is the link between teacher self-efficacy and AI-based teacher training?
2. What kinds of AI teacher training models are already used, based on current research?
3. What problems do Indian secondary schools face in giving AI training to teachers?
4. What ideas or steps can help design AI teacher training that builds real, lasting confidence?

5. Objectives of the Paper

1. To study the link between teacher self-efficacy and AI-based professional development.
2. To look at current models and practices used for AI teacher training.
3. To find the main problems facing AI teacher training in Indian secondary schools, especially in areas with fewer resources.
4. To suggest a self-efficacy based plan for building strong AI teacher training programmes.

6. Methodology

The methodology used in this research is a descriptive review of the corpus of existing academic literature on teacher self-efficacy and professional growth. When examining teacher professional development for emerging technologies like artificial intelligence (AI), which is a relatively new topic with little scholarly research, a thorough evaluation of empirical research is the recommended method. Additionally, rather than depending just on the experiences of a particular cohort of teachers, a literature review allows the paper to compile data and evidence-based approaches from various sources throughout international research. We searched databases like Google Scholar and ERIC, as well as publishers like Springer and Taylor & Francis, for pertinent peer-reviewed articles, research studies, and books on teacher self-efficacy and AI professional development. Among the search terms were teacher AI competency, TPACK with AI, AI professional development, and teacher AI self-efficacy. Articles published between 2020 and 2025 were given preference, with a greater focus on works published in 2024 and later due to the ongoing proliferation of research on AI in education. In addition to international research, the paper makes use of recent studies on digital infrastructure in Indian secondary schools as well as policy documents like the National Education Policy 2020 and associated guidelines on teacher training by the National Council of Educational Research and Training (NCERT, 2020) (Kour & Mirza, 2026). This approach enables the paper to provide a balanced analysis of teacher professional development for AI by considering both global trends and local (Indian) experiences. Only peer-reviewed articles and relevant studies were considered, eliminating subjective opinion pieces, and ensuring that the findings are based on objective research data.

The collated information was analyzed using established theoretical frameworks, including Ba ndura's theory of self-efficacy and the UNESCO AI Competency Framework for Teachers, to generate insights informing the paper's recommendations and discussion. The review methodology is ideal for addressing the research questions since

it pulls evidence from multiple studies identifying teacher self-efficacy, professional development, and training recommendations for adopting AI.

7. Emerging Models of AI-Integrated Professional Development

Professionally developing teachers to acquire AI competency follows similar patterns as those of other emerging technologies, with most existing approaches falling under the categories below.

- Brief workshops that provide teachers with a single introduction to a particular AI technology or application. The effectiveness of these seminars in professional development is typically restricted because they only teach theoretical knowledge of the technology and little possibilities for practice.
- A gradual, step-by-step introduction to AI, starting with the fundamentals and working your way up to real-world applications and classroom integration. This method is perhaps the most successful since it acknowledges that before teachers can properly incorporate technology into their teaching, they must have confidence with it.
- Creating forums for peer interaction where educators who use AI may exchange stories, offer criticism, and support one another. Given Bandura's (1997) claim regarding the importance of human interactions in confidence building, such encounters are crucial for professional development. Peer relationships also facilitate vicarious experiences, which are an additional source of self-efficacy.
- Programs for mentoring and coaching in which more seasoned peers or benefactor-teachers guide instructors with lower levels of AI skill and confidence. This method provides teachers with an additional way to get vicarious experiences while acknowledging the significance of individual diversity in professional growth.
- Teachers can view AI competency as an extension of their teaching knowledge and skills rather than a totally new set of competencies by using the TPACK framework to manage AI professional development, taking into account the pedagogical character of the technology.

8. Challenges in the Indian Secondary School Context

Implementing comparable professional development interventions in the Indian secondary school context may be difficult due to a number of characteristics found in the reviewed research.

- **Inadequate infrastructure:** The majority of government secondary schools lack sufficient technology resources and have poor internet connectivity. According to a recent study, only a tiny percentage of instructors in rural secondary schools in Jammu felt confident in their digital competencies, and the majority of institutions lacked adequate ICT resources (Kour & Mirza, 2026). As a result, teachers may find it very difficult to practice using AI tools after receiving initial training, which would impede the development of long-term competence and confidence. Furthermore, the majority of teachers already have to balance their teaching obligations, marking assignments, and other tasks, which limits their time for further training.

- **Insufficient time and workload:** The majority of teachers already struggle to balance their teaching obligations, marking assignments, and other responsibilities, which leaves them with little time for further training.
- **Varying levels of proficiency:** Most teachers begin AI training from different levels of competency. Therefore, a uniform approach to training might cause those who are relatively less confident to lag behind.
- **Diverse proficiency levels:** The majority of educators start their AI training with varying degrees of expertise. As a result, those who are comparatively less confident may fall behind if instruction is conducted uniformly.
- **Language and applicability to local context**: The majority of AI resources and materials are available in English and employ examples from around the world, which may not be totally applicable to the language and regional context of the nearby secondary schools in Odisha.
- **Lack of ongoing support systems:** Most teachers may view AI tools as an additional load in the absence of adequate ongoing support, much like the difficulties encountered with incorporating computers into the classroom. Institutions must provide sufficient peer support and mentoring programs and make sure that people continue to get help long after they are first exposed.

9. Recommendations

Based on the findings of the study, the following recommendations can be made:

- The foundation of teacher professional development for AI should be the idea of gradually introducing the technology through experience, first with individual use and then on to classroom practice.
- Teachers should be able to share their experiences and support one another through professional development initiatives, such as peer-to-peer mentoring.
- Instead of being one-size-fits-all, teacher professional development in AI should take into account the variations in teachers' levels of digital competency.
- Existing frameworks for teacher training and policy, such as the National Education Policy 2020 and associated standards on ongoing professional development, should be incorporated into AI teacher training.

10. Conclusion

Artificial intelligence is not a panacea that can revolutionize education on its own. The degree to which instructors can successfully adopt and modify it to fit their environment is a major factor in its effectiveness; this process calls for professional development interventions targeted at boosting their self-efficacy. This paper shows that such interventions should take a gradual, practice-informed approach to ensure that teachers can gain the necessary confidence in their ability to successfully implement the technology by reviewing the body of research on teacher professional development in AI. Such an approach is essential to ensuring that AI is successfully integrated into teaching and learning while supporting teachers' professional growth, especially for school systems like those in Odisha where limited resources will

determine the kind of professional development interventions that can be practically implemented.

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A STUDY OF THE IMPACT OF INCLUSIVE AND EQUITABLE EDUCATION THROUGH AI

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Abstract

Inclusive education necessitates learning environments that can effectively cater to the varied health and learning requirements of students, including those with disabilities, chronic health issues, and learning challenges. Conventional classroom environments frequently find it difficult to offer individualized support due to constraints in time, resources, and instructional adaptability. Smart classrooms, enhanced by artificial intelligence (AI), present new opportunities for developing adaptive, responsive, and Digital Learning Environments. This study investigates how AI-driven technologies, such as adaptive learning systems, assistive tools, learning analytics, and intelligent classroom management systems, can aid students with special educational needs. The researcher assesses the effects of AI-supported smart classrooms on student engagement, learning outcomes, accessibility, and teaching practices. The study was conducted on 60 High school students of Oxford Junior College, Ujjain. Descriptive statistics and t-test was employed. The study also addresses ethical and practical considerations, including data privacy, equitable access, and the necessity of human oversight in technology-enhanced education. The findings are intended to illustrate how smart classrooms can promote inclusion, enhance learning experiences, and facilitate personalized interventions. The researcher explores the use of Inclusive and Equitable Education through AI, while also pinpointing the need and offering recommendations for the responsible integration of AI in inclusive educational environments.

Keywords: *Artificial intelligence, Inclusive Education, Equitable Education, personalized learning, teaching and learning.*

Introduction

The incorporation of Artificial Intelligence (AI) into the educational sector has revolutionized teaching methodologies, enabling tailored learning experiences, adaptive evaluations, and insights driven by data. This document offers a comparative analysis of AI-driven teaching strategies in contrast to conventional methods, emphasizing their individual strengths, weaknesses, and relevance. While traditional education focuses on instructor-led teaching, direct interaction, and uniform curricula, AI-driven approaches encourage personalized learning journeys, immediate feedback, and engaging interactions. The research utilizes theoretical frameworks and recent empirical studies to evaluate how AI technologies,

including intelligent tutoring systems, machine learning algorithms, and virtual assistants, transform the educational process. The results indicate that AI improves flexibility, efficiency, and inclusivity, yet it also presents challenges concerning ethics, accessibility, and the relationships between teachers and students. Conversely, traditional methods continue to be essential for nurturing social, emotional, and critical thinking abilities through interpersonal engagement. To meet the needs of different learners and guarantee that everyone has access to high-quality education, this study investigates how AI solutions can be implemented in the classroom. (UNESCO, 2021). In low-resource settings, limited access to technology and infrastructure remains a significant barrier to leveraging AI for educational equity (Selwyn & Facer, 2021). The study highlights the necessity of a hybrid model that merges the personalization and scalability offered by AI with the empathy and contextual awareness of human educators. This integrated approach is posited as the most effective means of addressing the varied needs of learners, promoting comprehensive development, and equipping students for upcoming challenges. The comparative evaluation concludes that AI ought to be regarded as a supplement, not a substitute, for traditional teaching.

Literature Review

The various ways artificial intelligence can be used to enable individualized learning experiences in the context of inclusive education are explored in this review of the literature. Research highlights how AI is revolutionizing individualized learning experiences. By evaluating performance data and customizing educational materials, AI-powered learning systems may adjust to the demands of each learner, according to Baker and Siemens (2014). To fill in knowledge gaps and accommodate varying learning speeds, tools such as adaptive learning platforms give students personalized feedback and resources (Holmes et al., 2019). The review of recent studies sheds light on how AI-powered assistive technology can help build more inclusive learning environments (Brown & Jones, 2019; Chen et al., 2022).

It explores research showing how well AI algorithms can customize instructional materials and approaches to meet each student's particular needs (Smith et al., 2020; Johnson & Wang, 2021). This review looks at how technologies improve accessibility for students with impairments, with a focus on assistive solutions powered by AI. The function of intelligent tutoring systems (ITS) in promoting inclusive education is examined in depth in this review. Research reflects on the need for policy support and teacher training to ensure the effective use of AI in classrooms. (Mishra et al.,2021)

Significant study into artificial intelligence's (AI) potential to advance equity has been sparked by the increased interest in using AI in education. With an emphasis on tackling the digital gap, individualized learning, accessibility for students with impairments, and ethical issues in AI integration, this review synthesizes the body of extent research. (Muller et al., 2023; UNESCO, 2022). Students from marginalized or underperforming groups benefit most from these individualized approaches, which provide them with focused interventions to close achievement gaps.

Purpose of the study

The above research literature review highlights important obstacles and demonstrates the enormous promise of AI to advance Inclusive Education. To address infrastructure shortcomings and guarantee ethical AI integration, there are still significant gaps. These results highlight how using AI as a transformational tool for educational equity requires cooperation and ethical regulation.

Objectives of the Study

1. To find out the significant difference between the pre-test mean score of the control group and the pre-test mean score of the experimental groups.
2. To find out the significant difference between the control group's post-test mean score and the experimental group's post-test mean score.

Hypothesis

The following null hypotheses were framed for the study

1. There is no significant difference between the pre-test mean score of the control group and the pre-test mean score of the experimental group.
2. There is no significant difference between the post-test mean score of the control group and the post-test mean score of the experimental group.

Research Design

Methodology

A Parallel group experimental method was adopted in the study. The true experimental design: the pre-test-post-test design was used.

Population and Sample

The present study was confined to 60 students of High school in Oxford Junior College, Ujjain. 30 students were considered as a controlled group and another 30 students were considered as a tool for study. The control group was not allowed to get any exposure to the subject matter than the conventional method of teaching, but the experimental group students were taught with the Inclusive and Equitable teaching through AI.

Tools of the study

1. The investigators constructed and validated the assessment test for Inclusive and Equitable teaching.
2. The assessment test consisted of objective-type questions which carried one mark for each question and contained 20 marks.

Statistical Technique Employed

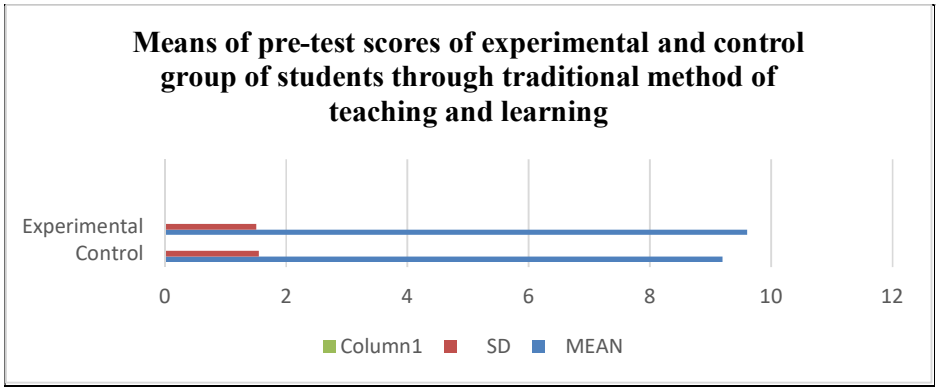
The data was collected and analyzed keeping the objectives in view and the design of the study. Descriptive statistics were worked out to describe the nature of the data. To find the perceived influence of Inclusive and Equitable Education through AI, a t-test was employed. The control group was taught through traditional method of teaching. But the experimental group was taught with the Inclusive and Equitable Education. Thus, the effectiveness of Inclusive and Equitable Education through AI was determined.

Pre-test score of students through traditional method of teaching and learning

Table No. 1 Comparison of the difference between the means of pre-test scores of experimental and control groups of students through Traditional method of teaching and learning

Groups	N	df	Mean	SD	Critical Ratio
Control	30	29	9.2	1.55	1.05
Experimental	30		9.6	1.51	

Graph 1

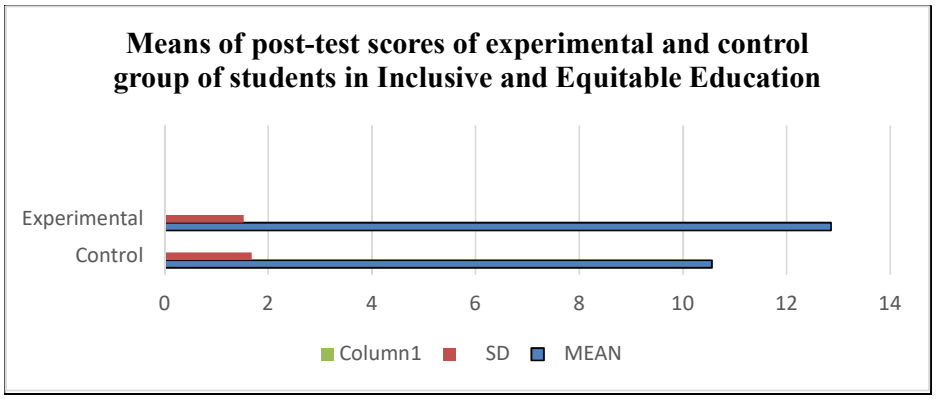


The post-test score of students in Inclusive and Equitable Education through AI

Table No. 2 Comparison of the difference between the means of post-test scores of experimental and control groups of students in Inclusive and Equitable Education through AI

Groups	N	df	Mean	SD	Critical Ratio
Control	30	29	10.56	1.68	5.75**
Experimental	30		12.86	1.53	

Graph 2



The students in the control group scored a mean of 10.56 on the achievement test that was administered with a standard deviation of 1.68. The mean scores of the students in the experimental group who were taught through Inclusive and Equitable Education was found to be 12.86 with a standard deviation of 1.53. The t-value was found to be significant at the table

value of significance at 0.05 level and 0.01 level. The null hypothesis is rejected. The post-test score of students in Inclusive and Equitable Education through AI was more than the pre-test score of students.

The Need for Inclusive and Equitable Education

An inclusive education strategy aims to ensure that all students have equal access to high-quality education, regardless of their background, race, socio-economic level, gender, disability, or learning skills. Together, inclusive education and equity education guarantee that every student has the tools, support, and opportunities that best suit their needs and enable them to achieve. However, there are still some domains to inclusive and equitable education which should be analyzed. Among these are the most important areas are discussed.

Learning Disabilities and Special Needs

Students with special needs or disabilities frequently have difficulties in conventional classroom environments, where the instructional strategies may not meet their demands.

Language and Cultural Barriers

Students from different linguistic and cultural backgrounds could find it difficult to understand the topic being taught or to get pertinent learning resources.

Economic Disparities

Students from lower-income households might not have as much access to technology and other educational resources that could improve their learning.

Teacher Training and Availability

Teachers may lack the resources or professional growth necessary to address the various needs of their pupils, particularly in big or underfunded classrooms.

Suggestions

- ✓ It is suggested that AI-driven technologies, including virtual assistants, intelligent tutoring systems, and algorithms, can offer personalized feedback, adaptable assessments, and tailored curricula that cater to the unique needs and preferences of each learner.
- ✓ Empirical research and theoretical frameworks provide evidence of the positive impact of AI on student motivation, encompassing factors such as autonomy, competence, and relatedness.
- ✓ Furthermore, it examines potential ethical concerns related to the use of AI to enhance student engagement, such as data privacy and algorithmic bias—both of which must be carefully considered to ensure that its integration into education is conducted responsibly and effectively.
- ✓ There is a need for further research and collaboration among educators, researchers, and developers utilizing AI technology to fully leverage its potential in fostering motivation among learners, thereby facilitating the successful achievement of specialist formation goals.

Conclusion

This study provides empirical insights into the comparative effectiveness of AI-based and traditional teaching methodologies, highlighting their respective strengths and limitations. Findings reflect the pedagogical strategies and support the development of hybrid instructional models that balance technological personalization with socio-emotional and ethical dimensions of learning. This article investigates how the attainment of specialised formation requires students to exhibit a high level of determination to engage actively in the learning process and the development of skills. This article explores the role of Artificial Intelligence (AI) in enhancing student commitment during their preparation for a specialized field.

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TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT

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Abstract

A modern era the teacher has very wide and multifaceted role to fulfil needs of students and changing society. To keep pace with this, they have to update and develop their proficiency, skills and knowledge. Professional development is important for any professional to keep their roots strong in the profession. For teacher, professional development is mandatory. Professional development of teacher includes all types of learning opportunities like academic degrees, conferences and non-formal learning opportunities. There are a number of ways to improve and update professional development, which includes teaching, sessions, and communities of practice, guidance, technical assistance, lesson study and supervision. Previously, 'professional development' of teachers means only 'staff development' or 'in-service training' which usually consisting of workshops or short-term courses that would offer teachers new information on a particular aspect of their work. In modern era the professional development of teachers has been considered a long-term process that includes regular opportunities and experiences planned systematically to promote growth and development in the profession. This paper deals with the continuous professional development (COD) of teachers in modern era including characteristics of professional development of teachers and also discuss about a framework for continuous professional development (COD).

Introduction

A ‘teacher’ is a person who carries out an academic programme, evaluates student participation in an academic programme and administers or provides consistent and substantial leadership to an academic programme. A nation’s progress depends upon the quality of its teachers and for this reason teaching is the noblest among all professions. As stated by NCTE (1998) in quality concerns in secondary teacher education the teacher is the most important element in any educational programme. The country has the need of well qualified and professionally trained teachers in larger numbers in the upcoming years, because of that there is a great need of qualitative teacher education to fulfill our nation’s demand.

Meaning of Teacher Education

Teacher Education is defined in many ways:

™ Teacher Education encompasses teaching skills, sound pedagogical theory and professional skills. (W.H. Kilpatrik).

Concept of Teacher Education

Teacher education refers to the policies and procedures designed to equip teachers with the knowledge, attitudes, behaviours and skills they require to perform their tasks effectively in the classroom, school and wider community. Teacher Education is a programme

that is related to the development of teacher proficiency and competence that would enable and empower the teachers to meet the requirements of the profession and face the challenges therein. NCTE has defined Teacher Education as, "A programme of education, research and training of persons to teach from pre-primary to higher education level". According to UNESCO (2005), teacher education "addresses environmental, social, and economic contexts to create locally relevant and culturally appropriate teacher education programmes for both pre-service and in- service teachers".

Teacher Training vs Teacher Education

In 1906-1956, the programme of teacher preparation was called teacher training. It only focuses on skill training. As by W.H. Kilpatric, ―Training is given to animals and circus performers, while education is to human beings. The term 'Teacher Training' has been used traditionally since a long time for all teacherpreparation programmes. Literally, training is a 'well- organized activity with the objective of imparting clearly et instructions or pre-decided activity to improve the receiver's performance or make them achieve a certain level of knowledge or specified skill'. Training is the continuous activity provided to individuals/groups to increase productivity and enhance performance of the people concerned. Training is learning of specialized skills to perform certain specified tasks. For example, software development is a specialized activity which requires trained skills to develop a software. Training mainly improves the performance of special skills.'Teacher Training' involves learning real life classroom situations while 'Teacher Education' is knowledge about modes of learning and instructions. Teacher Educationincludes 1. Teaching skills, 2. Sound pedagogical theory and 3. Professional skills. 'Teacher Training' involves learning real life classroom situations while 'Teacher Education' is knowledge about modes of learning and instructions. Teacher Education includes 1. Teaching skills, 2. Sound pedagogical theory and 3. Professional skills.

1. **Teaching Skills:**

While a teacher is teaching, he/she makes many tactics, approaches, strategies such as introducing the lesson, asking questions Concept, Types, and Scope of Teacher Education in between, using different teaching aids, giving reinforcements to gain students' attention. It is theduty of the teacher to internalize these skills which would help them to handle the teaching-learning process in a better way. It also includes effective classroom management skills, preparation and use of instructional materials and communication skills.

2. **Sound Pedagogical Theory:**

The sound base of various philosophical, psychological and sociological theories has a great impact in the teaching-learning process. A teacher should know the sociological theories behind teaching-learning, philosophical theories (for example, naturalism, idealism, pragmatism) various psychological theories like reinforcement theory, and theories of learning, moral development theories. Therefore, pedagogical theory is based on psychological, philosophical and sociological aspects that would help teachers to have a sound basis for using teaching skills in the classroom.

3. **Professional Skills:**

This includes strategies, techniques and approaches that will help teachers to improve and grow in their profession and at the same time, help the profession of teaching to grow. Soft skills, computer skills, counselling skills, management skills, and interpersonal skills are part of Teacher Education. Life-long learning skills are also important in Teacher Education because we have to cater the needs of new generation learners. The blending of teaching skills, sound pedagogical theory and professional skills would serve to create the right knowledge, attitude and skills in teachers, which promote Holistic Development which is the need of the hour.

Aims and Objectives of Teacher Education

Teacher education is a crucial process that prepares individuals to become effective teachers. The aims and objectives of teacher education are designed to ensure that teachers are well-equipped with the necessary knowledge, skills, attitudes, and values to facilitate learning and contribute to the development of students and society.

Aims of Teacher Education

1. **Preparation of Competent Teachers:** To prepare teachers who are professionally competent and capable of handling diverse classroom situations.
2. **Development of Teaching Skills:** To develop effective teaching skills and methodologies that enhance student learning.
3. **Promotion of Professionalism:** To instill a sense of professionalism and ethical responsibility in teachers.
4. **Facilitation of Continuous Learning:** To encourage teachers to engage in lifelong learning and professional development.
5. **Contribution to Educational Development:** To prepare teachers who can contribute to the overall development of the education system and society.

Objectives of Teacher Education

1. **Knowledge Acquisition:** To provide teachers with a strong foundation in subject matter knowledge and educational theories.
2. **Skill Development:** To develop skills in lesson planning, classroom management, evaluation, and use of educational technology.
3. **Attitude Formation:** To cultivate positive attitudes towards teaching, students, and the profession.
4. **Understanding Learners:** To help teachers understand the psychological, social, and cultural aspects of learners.
5. **Research Orientation:** To encourage teachers to engage in educational research and apply findings to improve teaching practices.
6. **Adaptability:** To prepare teachers to adapt to changing educational needs and innovations.

These aims and objectives collectively ensure that teacher education programs produce qualified, motivated, and effective teachers who can foster quality education and holistic

development of learners.

Importance of Continuous Professional Development

Continuous Professional Development (CPD) is essential for maintaining instructional quality in dynamic educational contexts. OECD (2019) findings reveal a strong correlation between sustained CPD participation and improved student performance. Teachers engaged in regular professional learning demonstrate enhanced classroom management, innovative pedagogy, and effective assessment strategies. In addition to improving student achievement, CPD positively influences teacher motivation and retention. Ingersoll and Strong (2011) report that teachers who receive continuous mentoring and professional support are less likely to leave the profession. This is particularly important given global concerns about teacher shortages. CPD also fosters collaboration and knowledge sharing. Wenger's (1998) theory of Communities of Practice suggests that professional learning is strengthened when teachers engage collectively in shared inquiry and problem-solving. Furthermore, CPD ensures alignment between teachers' competencies and evolving curriculum reforms, technological integration, and policy changes. In rapidly changing educational environments, CPD serves as a mechanism for adaptability and innovation.

Benefits of Teacher Training Programs

Teacher education programs yield many benefits that extend beyond individual educators, positively impacting students and the educational system as a whole. Given below are the most prominent benefits of the teacher training program:

- **Enhanced Pedagogical Skills:** Teachers gain diverse pedagogical skills, empowering them to apply varied teaching methods and adapt to different learning styles within their classrooms.
- **Improved Classroom Management:** Training programmes provide educators with effective classroom management strategies, creating an environment conducive to learning and minimizing disruptions.
- **Increased Student Engagement:** Educators trained in innovative teaching methods are better positioned to capture and maintain student interest, resulting in improved engagement and participation.
- **Boosted Confidence and Job Satisfaction:** Teacher training contributes to the professional development of educators, enhancing their confidence in the classroom and fostering job satisfaction.
- **Positive Impact on Student Outcomes:** Well-trained teachers directly impact student outcomes, contributing to improved academic performance and holistic development.

Need for Teacher Education

- Teacher education programmes depend on the constitutional framework and social requirements of the country. A country like India has developed teacher training programmes which meet the requirements at various levels, i.e., pre-primary to higher secondary.

- Curriculum and syllabus of teacher education programmes varies as per the need and requirement at these levels. The need for teacher education is felt due tothe following reasons.
- The core concern of teacher training programmes is to develop sound knowledge in subject areas at various levels. It is noticed that subject content of various subject differs from pre-primary to higher secondary. So as to develop subject knowledge,professional programmes are required. Internalizing subject knowledge helps to organize variety of learning experiences.
- ™ Students are the core component of classroom teaching. Students' cognitive, social, physical, and emotional developmental stages must be well understood to conduct meaningful teaching-learning process. Teacher training programmes provide the necessary knowledge in these areas. This helps in academic achievement of students.
- Classroom atmosphere is a place where we meet students from varied backgrounds like caste, creed, sex, colour, religion, and region. Teachers should develop the skill in handling diverse group of students. Each student is unique in learning. Various learning styles of the students should also be catered to meet the learning styles of the students of a particular class.
- ™ Teachers should develop the ability in designing instructional plans to meet the students' needs, curricular goals and models, subject matter, and community. Sound pedagogical knowledge should be developed to promote students learning, which help students in critical thinking, problem solving skills and reflection.
- ™ Classroom environment varies at various levels of education. To meet the necessary requirement of classroom, teachers should be prepared to tackle the

situations in the classroom.

- ™ Teachers should be able to promote among students qualities like social interaction, cooperation among others, study habits and self-motivation. Learning helps students in developing their personality, to be active member of the society and to meet challenges.
- Teacher education should be channelized to meet these requirements of the students.Transmission of culture of the country can happen through well-trained teachers.
- Teacher education should provide with the necessary skill to transmit the culture of the country. It should meet the educational as well as the national goal of the country. It should be done to develop proper professional attitudes and calibre among teaching community.

Challenges in Teacher Professional Development

Despite its recognized importance, teacher professional development faces several

challenges. One major constraint is limited time within teachers' workload to engage in meaningful professional learning (OECD, 2018). Additionally, insufficient institutional support and lack of funding hinder sustained PD initiatives, particularly in developing countries. Research by Avalos (2011) indicates that many PD programs fail due to their lack of contextual relevance. One-time workshops, often detached from classroom realities, have minimal long-term impact. Guskey (2002) emphasizes that professional development must be ongoing, practical, and connected to student learning outcomes to be effective. In developing countries, challenges include inadequate infrastructure, limited access to digital technologies, and policy inconsistencies. According to UNESCO (2016), many low-income nations struggle to provide continuous, structured professional learning opportunities. Furthermore, resistance to change, lack of motivation, and weak monitoring systems may impede the effectiveness of PD programs. Addressing these challenges requires systemic reform, including policy support, resource allocation, leadership commitment, and integration of school-based professional learning model

Conclusion

The literature consistently affirms that teacher education and professional development are central to improving educational quality. Grounded in theoretical perspectives such as reflective practice, constructivism, and transformative learning, effective teacher development programs promote continuous growth, collaboration, and instructional improvement. However, challenges related to implementation, sustainability, and contextual relevance must be addressed through comprehensive policy frameworks and institutional support. Strengthening teacher education systems is therefore essential for achieving long-term educational reform and National development goals.

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COGNITIVE APPRENTICESHIP MODEL- AN EXPERIENTIAL STRATEGY FOR DAVANGERE HIGH SCHOOL STUDENT ACHIEVEMENT IN MATHEMATICS

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Abstract

Education is a powerful instrument for individual and societal development, fostering the construction of new knowledge by integrating fresh experiences with prior understanding. Constructivism provides a theoretical framework for explaining how learners actively construct knowledge through interaction, experience, and collaboration, making it particularly relevant in the digital age where learning occurs within and across diverse networks. Cognitive apprenticeship extends these principles by enabling experts or teachers to model cognitive processes, provide scaffolding, and gradually transfer responsibility to learners, thereby helping them acquire both conceptual understanding and practical problem-solving skills. The present study employed an experimental approach using a pre-test–post-test non-equivalent group design to examine the effectiveness of the Cognitive Apprenticeship Model on students' achievement in Mathematics. The experimental group received instruction through the Cognitive Apprenticeship Model, while the control group was taught using the conventional activity-oriented method. The collected data were analyzed using the t-test, and the obtained t-value of 6.33 was found to be statistically significant. The findings indicate a significant improvement in the post-test achievement scores of students taught through the Cognitive Apprenticeship Model, demonstrating its effectiveness in enhancing Mathematics achievement among higher secondary school students.

Keywords: *Cognitive Apprenticeship Model, Experiential Strategy, Achievement in Mathematics*

1. Introduction:

Education is a transformative process that facilitates the holistic development of students by bringing about positive changes in their intellectual, emotional, social, and physical behaviour. Through education, teachers expose learners to relevant knowledge, concepts, values, and skills that enable them to understand the world and respond effectively to the challenges of everyday life.

2. Need and Significance of the Study:

The increasing complexity of the business and professional world demands that students acquire diverse knowledge, skills, and competencies through meaningful learning experiences. Traditional approaches to Mathematics instruction are often insufficient to provide learner-centred, activity-oriented, and contextually relevant educational experiences that foster higher-order thinking and problem-solving abilities. In this context, the cognitive apprenticeship approach has emerged as an effective instructional model for promoting deep understanding and authentic learning. Rooted in the principles of constructivism, cognitive

apprenticeship emphasizes learning through guided participation, observation, practice, and reflection in real-world contexts. Unlike the conventional teacher-centred approach, the learner-centred paradigm, championed by John Dewey in the early twentieth century, recognizes students as active participants in the construction of knowledge. Contemporary educational methods and instructional strategies have further strengthened this approach by making learning more engaging, experiential, and meaningful. Cognitive apprenticeship extends these principles by enabling experts or teachers to model cognitive processes, provide scaffolding, and gradually transfer responsibility to learners, thereby helping them acquire both conceptual understanding and practical problem-solving skills.

3. Cognitive apprenticeship model:

"Cognitive apprenticeship is a model of instruction that works to make the thinking visible". Cognitive apprenticeship model involves six components:

- Modeling:- Expert models the activity
- Coaching:- Encouraging the students as they try to complete tasks on their own
- Scaffolding:- Providing some materials to solve their difficulty
- Articulation:-Open the eyes of students to new way of thinking
- Reflection:-Enabling the students to compare their own problem solving process
- Exploration:-Pushing students in to a mode of problem solving on their own

A. Modeling:

Modeling is a fundamental process of learning that occurs continuously in everyday life. Individuals acquire many skills by observing and imitating the actions of others. Simple tasks, such as washing dishes, primarily involve physical actions and procedural skills, making them relatively easy to learn through direct observation and imitation. However, complex tasks that require higher-order cognitive processes are far more challenging to model because the underlying mental operations cannot be directly observed. For instance, when students watch a proficient mathematics learner solve a complex problem silently, they can observe only the written steps and final solution. They cannot see how the learner interprets the problem, selects appropriate strategies, applies mathematical principles, or evaluates alternative methods during the thinking process. Cognitive apprenticeship addresses this limitation by encouraging experts or teachers to make their thinking visible through techniques such as verbalizing their reasoning, demonstrating problem-solving strategies, and explaining the decision-making process. This enables learners to understand not only what to do but also why and how particular approaches are used, thereby promoting deeper conceptual understanding and effective problem-solving skills.

B. Coaching and scaffolding:

Coaching and scaffolding are essential components of the cognitive apprenticeship model that support learners in achieving instructional goals through guided assistance. Coaching is a comprehensive process in which the teacher or an expert facilitates learning by providing guidance, feedback, reminders, hints, encouragement, and continuous monitoring of learners' progress.

Scaffolding, considered a specific form of coaching, involves providing temporary support that enables learners to perform tasks beyond their current level of competence, with the support gradually withdrawn as they gain independence. This concept is grounded in Vygotsky's (1978) Zone of Proximal Development (ZPD), which emphasizes that learners achieve higher levels of understanding through guidance from teachers or more capable peers. Effective scaffolding includes shared learning goals, a whole-task approach, timely assistance, support aligned with learners' needs, an optimal level of guidance, and expert modeling.

c. Articulation and Reflection

Articulation and reflection are important elements of the cognitive apprenticeship model that promote deeper learning and metacognitive development. Articulation refers to the process by which learners express, explain, and demonstrate their knowledge, reasoning, and problem-solving strategies, making their thinking explicit through discussions, presentations, demonstrations, and written work. This enables teachers and peers to provide meaningful feedback and helps learners refine their understanding.

Reflection, on the other hand, involves critically examining one's learning experiences, performance, and outcomes to identify strengths, weaknesses, and areas for improvement. Through guided questioning, self-evaluation, and analysis of learning processes, learners develop greater self-awareness, critical thinking, and the ability to apply knowledge effectively in new situations. Together, articulation and reflection enhance conceptual understanding, foster independent learning, and strengthen higher-order cognitive skills.

D. Exploration:

Exploration is a key component of the cognitive apprenticeship model that promotes independent learning by gradually reducing teacher support and encouraging learners to apply their knowledge and skills autonomously. As coaching and scaffolding are faded, students actively investigate problems, formulate hypotheses, test strategies, and construct new knowledge through authentic learning experiences. Unlike passive learning, exploration involves guided inquiry in which teachers provide broad goals and appropriate guidance while allowing learners to identify problems, develop solutions, and make discoveries independently. This approach enables students to explore both real-world phenomena and problem-solving processes, thereby strengthening critical thinking, creativity, and decision-making skills. During exploration, teachers continue to provide support whenever necessary, encourage articulation and reflection, and gradually transfer responsibility to learners. Through activities such as projects, role-playing, simulations, and collaborative inquiry, students develop expert-like thinking, become self-directed learners, and gain the confidence to apply their knowledge in real-life situations.

4. Statement of the problem

In this study the researchers are trying to find out the effectiveness of cognitive apprenticeship model on achievement in Mathematics. Hence the study is entitled as "Cognitive Apprenticeship Model–An Experiential Strategy for Davangere High School students Achievement in Mathematics"

5. Objectives of the study:

Objective formulated for the present study includes:

1) To find out the effectiveness of Cognitive Apprenticeship model on achievement in Mathematics among High School Students.

2) To find out the effectiveness of Activity oriented method on achievement in Mathematics among High School Students.

3) To compare the extent of effectiveness of cognitive apprenticeship model with that of Traditional oriented method

4) To find out and compare the effectiveness of Cognitive Apprenticeship model and Traditional oriented method on Achievement in Mathematics with respect to the following domains

(i) Knowledge
(ii) Understanding
(iii)Application

6. Methodology:

The experimental method was found appropriate for the study

7. Population, Sample and Tool

The population consisted of High School Students of Davanagere city following the Karnataka state syllabus. Sample of the present study consists of 120 students of 9th standard in Bapuji nursery, higher primary and High School, Davangere. Tools used for the collection of data are the achievement test in Mathematics, lesson transcripts in Mathematics based on Cognitive Apprenticeship Model and Traditional Oriented Method

Statistical techniques used:

The following statistical techniques were uses

1) Arithmetic mean
2) Standard deviation
3) t-test
4) ANOVA

8. Analysis of data with respect to Achievement Test in Mathematics

In the present study the investigator compared the achievement of experimental and control group. For that the scores obtained in the Pre - test and Post-Test were analyzed:

1. Test of significance of difference between Mean Post-Test Scores of Experimental and Control Groups on Achievement in Mathematics

The investigator analyzed the data to examine the effectiveness of Cognitive Apprenticeship model on the achievement in Mathematics. The test of significance between the mean Post-Test scores of Experimental and Control Groups are given in Table 1.

Table 1: Test of significance of difference between Mean Post-Test Scores of Experimental and Control Groups on Achievement in Mathematics

Group	umber	Mean	tandard Deviation	-value	Level of Significance
Experimental	60	25.93	1.59	7.83	P <0.01
Control	60	22.33	3.23		

From the Table 1, it is evident that the t-test is 7.83 is significant at 0.01 level. Table value for t-test at 0.05 and 0.01 level are 1.96 and 2.58 respectively. This shows that the two groups differ significantly with respect to the Post-Test Achievement test score in Mathematics.

2. Comparison of Experimental and Control Groups on achievement in Mathematics as a whole based on Pre-Test and Post-Test scores:

The investigator compared the achievement in Mathematics of two groups on the basis of Pre - test and post-test scores. Here the experimental group was taught through Cognitive Apprenticeship model and Control Group taught using Traditional Oriented method of teaching. The scores obtained by administering the achievement test in Mathematics, before and after the experiment was subjected to test using one tailed test. The details of analysis are given in Table 2.

Table 2: Comparison of Experimental and Control Groups on achievement in Mathematics as a whole based on Pre-Test and Post-Test scores

Test	Group	Number	Mean	SD	T-value	Level of Significance
Pre-test	Experimental	60	19.03	3.60	1.79	P>0.05
	Control	60	17.63	3.59		
Post-Test	Experimental	60	25.93	1.59	6.33	P<0.01
	Control					

From Table 2, the t-test obtained for Pre - test is 1.79 which is not significant at 0.01 level. This shows that, there is not a significant difference in achievement in Mathematics of Experimental and Control Group. For Post-Test the t-test obtained is 6.33.This shows that there is significant difference between the experimental and control group with regard to their achievement in Mathematics for Post-Test. The mean Post-Test score of the Experimental group is significantly higher than that of the control group. So it is possible to say that after treatment, the experimental group achieved more than control group. Thus, it can be inferred that the Cognitive Apprenticeship Model helped the Experimental group to achieve better than the control group. So it can be concluded that Cognitive Apprenticeship is more effective than Traditional Oriented Method of Teaching.

3. Comparison of Achievement in Mathematics of Experimental and Control Group under three domains-knowledge, understanding and application:

The investigator attempted to compare the achievement in Mathematics of the Experimental Group and Control groups under different domains -knowledge, understanding and

application. Pre - test and Post-Test scores for the separate items are compared for Experimental and Control Groups to find the significance in the mean difference.

Table 3: Comparison of Achievement in Mathematics of Experimental and Control Groups on the Pre - test and Post-Test Scores under Knowledge Domain

Test	Group	Number	Mean	SD	**T-value**	of Significance
Pre - test	Experimental	60	2.45	0.93	1.25	p>0.05
	Control	60	2.2	0.88		
Post-Test	Experimental	60	5.5	1.18	2.39	P<0.01
	Control					

From Table 3 t-test obtained for Pre - test is 1.25 which is not significant at 0.05 level from this result we can understand that two groups differ in their academic ability of knowledge level in the Pre - test. The t-test of Post-Test obtained is 2.39 which is not significant at 0.05 level. From this result we can understand that two groups do not differ significantly in their academic ability at knowledge level in the Post-Test.

Table-4: Comparison of Achievement in Mathematics of Experimental and Control Groups on the Pre - test and Post-Test Scores under Understanding Domain

Test	**Group**	**Number**	**Mean**	**SD**	**T-VALUE**	**Level of Significance**
Pre - test	Experimental	60	10.15	2.06	3.22	p>0.05
	Control	60	8.7	1.89		
Post-Test	Experimental	60	15.35	2.87	3.36	P<0.01
	Control					

From Table -4, the t-test obtained for Pre - test is 3.22, which is significant at 0.05 level. From this result we can understand that two groups differ significantly in their academic ability at understanding level in the Pre - test. The t-test obtained for Post Test is 3.36, which is significant at 0.01 level and 0.05 level. From this result we can understand that two groups differ significantly in their academic ability at understanding level in the Post-Test

Since the mean score of Experimental group is greater than the Control Group for the Post-Test, The Experimental Group is superior to Control Group in Mathematics Achievement at understanding level. Hence it can be concluded that the performance of the Experimental Group taught through Cognitive Apprenticeship Model is better than that of Control Group taught through Traditional Oriented Method with regard to Achievement in Mathematics under the understanding domain.

Table 5: Comparison of Achievement in Mathematics of Experimental and Control Groups on the Pre - test and Post-Test Scores under Application Domain

Test	Group	Number	Mean	SD	CR	evel of Significance
Pre - test	Experimental	60	1.88	1.04		
	Control	60	1.5	0.72	1.9	p>0.05
Post-Test	Experimental	60	5.08	1.20		
	Control				2.48	p<0.01

From Table 5, the t-test obtained for Pre - test is 1.9, which is not significant at 0.05 level. From this result we can understand that two groups do not differ significantly in their academic ability at application level in the Pre - test. The t-test obtained for Post-Test is 2.48, which is significant at 0.05 level. From this result we can understand that two groups differ significantly in their academic ability at application level in the Post-Test.Since the mean score of Experimental Group is greater than the Control Group for the Post-Test, Experimental Group is superior to Control Group in Mathematics Achievement at application level. Hence it can be concluded that the performance of the Experimental Group taught through Cognitive Apprenticeship Model is better than that of control Group taught through Activity Oriented Method with regard to achievement in Mathematics under the application domain

9. Major finding

The comparison of t-test shown that there is a significant difference in achievement of students in Mathematics

10. Conclusion

As education is an unremitting process, the process of making educational practices is also vibrant. Educational practitioners are trying to refine the instructional system more effective and interesting. The achievement in Mathematics of Higher Secondary level students taught through Cognitive Apprenticeship is higher than the Activity Oriented Method with respect to the domains such as knowledge, understanding and application. Achievement in Mathematics of students at Higher Secondary Level taught through Cognitive Apprenticeship is more effective than Activity Oriented Method. Cognitive apprenticeship model provides the efficient way of imbibing knowledge in children. \

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ATTITUDES OF UNIVERSITY TEACHERS OF KARNATAKA TOWARDS EMERGING TECHNOLOGIES (AR/VR, IoT AND ROBOTICS) IN EDUCATION

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Abstract

Emerging technologies are increasingly reshaping the teaching and learning processes in higher education. Technologies such as Augmented Reality (AR), Virtual Reality (VR), the Internet of Things (IoT), and Robotics offer significant opportunities for immersive learning, real-time data collection, simulation, automation, personalized instruction, and experiential learning. However, the effective adoption and integration of these technologies largely depend on university teachers' attitudes, technological readiness, digital competence, and professional capabilities. In this context, the present study was undertaken to examine the attitudes of university teachers in Karnataka towards emerging technologies, with particular emphasis on AR/VR, IoT, and Robotics in education. A descriptive survey method was adopted, and a sample of 400 university teachers from selected universities and higher education institutions of Karnataka was proposed for the study. For data collection, the investigator developed an Attitude towards Emerging Technologies in Education Scale (AETES) based on a five-point Likert scale. The scale covered major dimensions such as perceived usefulness, ease of use, pedagogical value, and application of AR/VR, IoT and Robotics in education, technological readiness, perceived challenges, and future readiness. The collected data were analysed using Mean, Standard Deviation, independent-samples t-test, one-way ANOVA, and Pearson's product-moment correlation. The illustrative findings suggest that university teachers generally have a favourable attitude towards emerging technologies in education. Significant differences were observed across selected demographic variables, and technological readiness was found to have a positive relationship with favourable attitudes towards emerging technologies. The study emphasizes the need for systematic faculty development programmes, adequate technological infrastructure, institutional support, and appropriate policies to facilitate the effective, meaningful, and responsible integration of AR/VR, IoT, and Robotics into higher education.

Keywords: *Emerging Technologies, Augmented Reality, Virtual Reality, Internet of Things, Robotics,*

1. Introduction:

Technology has become an essential part of contemporary higher education, significantly influencing the processes of teaching, learning, research, and institutional management. The rapid advancement of digital technologies has transformed the ways in which knowledge is generated, shared, communicated, and accessed by teachers and learners. Universities are increasingly adopting innovative technological solutions to create interactive learning environments, improve educational experiences, and enhance institutional effectiveness. Among the emerging technologies gaining considerable attention in higher education are

Augmented Reality (AR), Virtual Reality (VR), the Internet of Things (IoT), and Robotics. These technologies offer new possibilities for immersive learning, experiential education, automation, personalized instruction, real-time data management, and the development of technology-enabled educational environments.

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The Internet of Things refers to interconnected physical devices equipped with sensors, software and communication capabilities that enable them to collect and exchange data. In higher education, IoT can support smart classrooms, attendance systems, environmental monitoring, laboratory management, campus security and real-time learning analytics.

Robotics is another emerging technology with significant educational potential. Educational robots can support programming, engineering, STEM education, problem-solving and collaborative learning. Robots may also be used for simulation, laboratory activities and specialized instructional applications.

Although these technologies offer substantial educational opportunities, their successful implementation cannot be achieved merely by providing technological infrastructure. Teachers are central to the process of technology integration. Their attitudes, beliefs, confidence, knowledge and willingness to experiment with new technologies strongly influence the extent to which emerging technologies are incorporated into classroom practices.

University teachers may perceive emerging technologies as opportunities for innovation, improved student engagement and personalized learning. At the same time, they may have concerns regarding cost, technical complexity, lack of training, infrastructure, privacy, cybersecurity, accessibility and potential disruption of established teaching practices.

Therefore, understanding university teachers' attitudes towards AR/VR, IoT and Robotics is important for developing effective technology integration strategies in higher education. The present study attempts to examine these attitudes among university teachers of Karnataka.

2. Need and Significance of the Study:

The study is significant because emerging technologies are becoming increasingly relevant to higher education. The findings may help universities understand the preparedness and attitudes of teachers towards technological innovations.

The study is important for the following reasons:

1) It provides information about university teachers' attitudes towards AR/VR, IoT and Robotics.
2) It helps identify the perceived educational usefulness of emerging technologies.
3) It identifies possible technological and institutional barriers.
4) It provides evidence for planning faculty development programmes.
5) It may assist universities in developing technology integration policies.
6) It highlights the need for infrastructure and technical support.
7) It may contribute to curriculum modernization in higher education.
8) It provides a basis for further research on emerging technologies in Indian higher education.

3. Statement of the Problem:

"ATTITUDES OF UNIVERSITY TEACHERS OF KARNATAKA TOWARDS EMERGING TECHNOLOGIES (AR/VR, IOT AND ROBOTICS) IN EDUCATION."

4. Objectives of the Study:

The study was undertaken with the following objectives:

1) To study the attitudes of university teachers of Karnataka towards emerging technologies in education.
2) To study university teachers' attitudes towards Augmented Reality and Virtual Reality in education.
3) To study university teachers' attitudes towards the use of IoT in education.
4) To study university teachers' attitudes towards Robotics in education.
5) To examine whether there is a significant difference in attitudes towards emerging technologies with respect to gender.
6) To examine whether there is a significant difference in attitudes towards emerging technologies with respect to teaching experience.
7) To examine whether there is a significant difference in attitudes towards emerging technologies with respect to academic discipline.
8) To study the relationship between technological readiness and attitudes towards emerging technologies.
9) To identify the major perceived challenges associated with the adoption of emerging technologies in higher education.

5. Hypotheses of the Study:

The following null hypotheses were formulated:

1) H01: There is no significant difference between male and female university teachers in their attitudes towards emerging technologies in education.

2) H02:There is no significant difference among university teachers with different levels of teaching experience in their attitudes towards emerging technologies.

3) H03:There is no significant difference among university teachers belonging to different academic disciplines in their attitudes towards emerging technologies.

4) H04:There is no significant relationship between technological readiness and attitudes towards emerging technologies.

6. Variables of the Study

Background Variables

1) Gender
2) Teaching Experience
3) Academic Discipline

Major Variable:

The emerging technologies considered in the present study are:

1) Augmented Reality (AR)
2) Virtual Reality (VR)
3) Internet of Things (IoT)
4) Robotics

7. Operational Definitions:

1) Emerging Technologies: Emerging technologies refer to developing or rapidly evolving digital technologies that have the potential to transform educational practices. In the present study, the term specifically refers to AR, VR, IoT and Robotics.

2) Augmented Reality: Augmented Reality refers to technology that overlays computer-generated information, images or objects onto the user's real-world environment.

3) **Virtual Reality:**Virtual Reality refers to a computer-generated immersive environment that enables users to interact with simulated objects and situations.

4) **Internet of Things**: IoT refers to interconnected physical devices equipped with sensors, software and communication capabilities that collect and exchange data.

5) **Robotics**:Robotics refers to the design, development and application of programmable machines or robots to perform educational, instructional or support functions.

6) **Attitude**:Attitude refers to the favourable or unfavourable feelings, beliefs and behavioural tendencies of university teachers towards the use of emerging technologies in education.

8. Methodology:

8.1 Research Method:

The descriptive survey method was adopted for the present investigation.

8.2 Research Design:

A normative survey research design was used to collect information regarding university teachers' attitudes towards AR/VR, IoT and Robotics.

8.3 Population:

The population comprised university teachers working in universities and higher education institutions located in Karnataka.

8.4 Sample:

A sample of 400 university teachers was proposed for the study. Sample Distribution is as follows:

Variable	Category	N
Gender	Male	230
	Female	170
Experience	Below 10 years	145
	10–20 years	155
	Above 20 years	100
Discipline	Science/Technology	140
	Social Sciences/Humanities	140
	Professional/Other Disciplines	120

The distribution is illustrative and should be replaced with the actual sample distribution.

8.5 Tool Used for Data Collection: For the present study, an Attitude towards Emerging Technologies in Education Scale (AETES) may be developed by the investigator to assess the attitudes of university teachers towards emerging technologies such as Augmented Reality/Virtual Reality (AR/VR), Internet of Things (IoT), and Robotics in education. The scale may include statements covering important dimensions such as awareness of emerging technologies, perceived usefulness, ease of use, application of AR/VR in teaching and learning, use of IoT in education, application of robotics in education, student engagement and learning, technological readiness, institutional support, perceived challenges, ethical and privacy concerns, and future readiness. A five-point Likert response format may be adopted, consisting of Strongly Agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1). Negatively worded statements may be scored in reverse order. Thus, a higher total score would indicate a more favourable attitude towards emerging technologies in education. Before final administration, the scale should be subjected to expert validation, pilot testing, item analysis, and reliability analysis to establish its suitability for data collection.

Standardization of the Tool: The Attitude towards Emerging Technologies in Education Scale (AETES) may be standardized systematically to ensure its validity, reliability, and suitability for assessing university teachers' attitudes. The standardization process may begin with an extensive review of literature and collection of relevant materials related to emerging technologies and their applications in education. Based on the review, the major dimensions of emerging technologies may be identified and an initial pool of statements may be prepared. The preliminary tool may then be submitted to subject experts for their suggestions regarding the relevance, clarity, appropriateness, and coverage of the statements. Necessary modifications may be made based on expert opinions, followed by pilot administration of the revised tool to a suitable sample. The responses obtained during the pilot study may be subjected to item analysis, and unsuitable, ambiguous, or weak items may be eliminated or modified. Subsequently, appropriate evidence of validity and reliability may be established through suitable statistical procedures. After incorporating the findings of the pilot study and item analysis, the final version of the AETES may be prepared along with appropriate scoring and interpretation procedures. For the final journal manuscript, the actual number of items, validity coefficients, reliability coefficient, item-analysis results, and pilot-study findings should be reported based on the empirical evidence obtained during the standardization

process.

8.6 Data Collection Procedure:

The researcher contacted selected university teachers from different higher education institutions in Karnataka. The purpose of the investigation was explained to the respondents. The AETES was administered personally and/or through an online survey platform. Respondents were requested to provide their responses honestly. The collected questionnaires were checked, coded and tabulated for statistical analysis.

8.7 Statistical Techniques Used:

The collected data were analysed using appropriate statistical techniques. Mean and Standard Deviation were used to describe the overall attitudes of university teachers. An independent-samples t-test was used to determine significant differences between two groups, particularly with respect to gender. One-way ANOVA was used to examine differences among three or more groups, such as teaching-experience or academic-discipline groups. Pearson's Product-Moment Correlation was used to determine the relationship between technological readiness and attitudes towards emerging technologies. The level of significance was fixed at **0.05**.

9. Analysis and Interpretation based on Hypotheses:

1) H01: There is no significant difference between male and female university teachers in their attitudes towards emerging technologies in education.

Table – 1: t-test of Attitudes towards Emerging Technologies by Gender

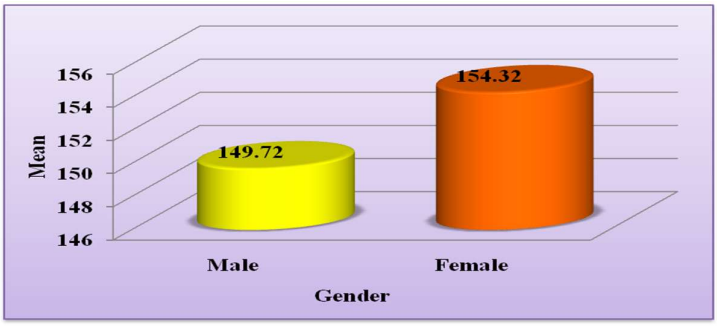
Gender	N	Mean	SD	t-value
Male	230	149.72	16.31	2.34*
Female	170	154.32	16.39	

***df = 398; Significant at 0.05 level**

Interpretation:

The obtained t-value of 2.34 is greater than the critical t-value of approximately 1.96 at the 0.05 level. Therefore, the null hypothesis is rejected. The result indicates a significant difference between male and female university teachers in their attitudes towards emerging technologies. In the illustrative data, female teachers obtained a higher mean attitude score.

Graph – 2: Comparison of Score of Attitudes towards Emerging Technologies by Gender



2) **H02: There is no significant difference among university teachers with different levels of teaching experience in their attitudes towards emerging technologies:**

Table – 3: One-Way ANOVA of Attitudes towards Emerging Technologies by Teaching Experience

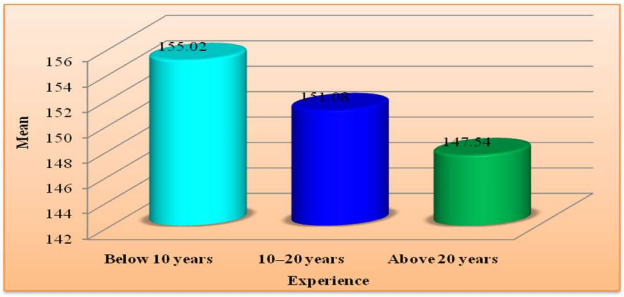
Experience	N	Mean	Source	SS	df	MS	F
Below 10 years	145	155.02	Between Groups	2,846.37	2	1,423.19	5.18*
10–20 years	155	151.08	Within Groups	109,089.63	397	274.72	
Above 20 years	100	147.54	Total	111,936.00	399		

***significant at 0.05 level**

Interpretation:

The obtained F-value of 5.18 is significant at the 0.05 level. Therefore, the null hypothesis is rejected. The result indicates that university teachers with different levels of teaching experience differ significantly in their attitudes towards emerging technologies.The highest mean attitude score was obtained by teachers with less than 10 years of experience. A post-hoc test should be applied to actual data to determine which specific groups differ significantly.

Graph – 3: Comparison of Scores of Attitudes towards Emerging Technologies by Teaching Experience



3) **H03: There is no significant difference among university teachers belonging to different academic disciplines in their attitudes towards emerging technologies.:**

Table – 4: One-Way ANOVA of Attitudes by Academic Discipline

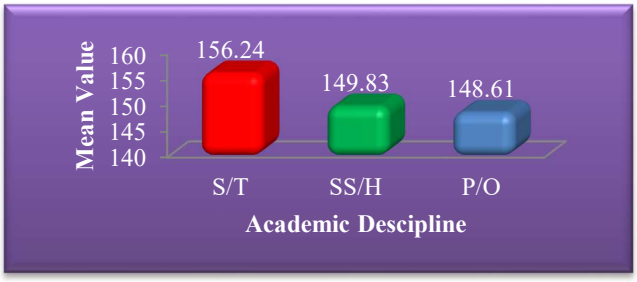
Academic Discipline	N	Mean	Source	SS	df	MS	F
Science/Technology	140	156.24	Between Groups	3,167.25	2	1,583.63	5.83*
Social Sciences/Humanities	140	149.83	Within Groups	107,768.75	397	271.45	
Professional/Other	120	148.61	Total	110,936.00	399		

***Significant at 0.05 level**

Interpretation:

The obtained F-value of 5.83 is significant at the 0.05 level. Therefore, a significant difference exists among university teachers belonging to different academic disciplines. Teachers from Science and Technology disciplines demonstrated comparatively more favourable attitudes towards emerging technologies.

Graph-4: Comparison of mean value of university teachers belonging to different academic disciplines



4) H04: There is no significant relationship between technological readiness and attitudes towards emerging technologies.:

Table – 5: Correlation between Technological Readiness and Attitudes

Variables	N	R-value	Significance
Technological Readiness and Attitude towards Emerging Technologies	400	0.64**	Significant

Interpretation:

The obtained correlation coefficient of r = 0.64 indicates a positive and significant relationship between technological readiness and attitude towards emerging technologies. This suggests that university teachers with greater technological readiness tend to demonstrate more favourable attitudes towards AR/VR, IoT and Robotics.

5) The overall attitudes towards emerging technologies:

Table – 6: Mean and Standard Deviation of Attitudes towards Emerging Technologies

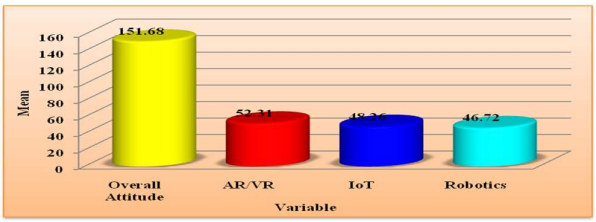
Variable	N	Mean	SD
Overall Attitude	400	151.68	16.42
AR/VR	400	52.31	6.84
IoT	400	48.26	6.12
Robotics	400	46.72	6.08

Interpretation:

The illustrative findings indicate that university teachers generally have a favourable attitude towards emerging technologies. Among the three technology areas, AR/VR obtained the highest mean score, followed by IoT and Robotics. This suggests that teachers may perceive immersive technologies such as AR and VR as particularly useful for improving student

engagement and experiential learning.

Graph – 3: Comparison of theMean and Standard Deviation of Attitudes towards Emerging Technologies



10. **Major Findings:** The major findings of the study are:

1) University teachers generally possess a favourable attitude towards emerging technologies in education.

2) AR/VR received a relatively favourable response among university teachers.

3) Teachers also showed positive attitudes towards IoT-based educational applications.

4) Robotics was perceived as a useful emerging technology, particularly for STEM and experiential learning.

5) A significant gender difference was observed in attitudes towards emerging technologies.

6) Significant differences were found among teachers with different levels of teaching experience.

7) Significant differences were observed among teachers from different academic disciplines.

8) Science and Technology teachers demonstrated relatively more favourable attitudes towards emerging technologies.

9) Technological readiness was positively and significantly related to attitudes towards emerging technologies.

10) The findings emphasize the importance of teacher preparedness for successful technology integration.

11. **Discussion:** The findings suggest that university teachers recognize the educational potential of emerging technologies. AR and VR can provide immersive and experiential learning opportunities that are difficult to achieve through conventional teaching methods. For example, students can explore virtual laboratories, historical environments, scientific models and professional simulations without requiring physical access to expensive facilities. IoT can contribute to smart educational environments through connected devices, sensors and real-time data. Universities may use IoT for smart classrooms, laboratory monitoring, campus management and learning analytics. Teachers' positive attitudes towards IoT can facilitate its integration into academic and administrative processes. Robotics has particular relevance to STEM education, engineering, computer science and skill-based learning. Robots can facilitate programming, experimentation, problem-solving and collaborative learning. The relationship between technological readiness and attitude suggests that confidence and competence with technology are important factors in successful adoption. Teachers who possess adequate knowledge, skills and institutional support may be more

willing to experiment with emerging technologies. However, technology adoption should not be viewed solely from a technical perspective. Ethical issues including privacy, cybersecurity, surveillance, accessibility, digital inequality and responsible data use must also be considered. Therefore, universities should promote responsible and human-centred technology integration.

12. **Educational Implications:** The findings have important implications for higher education.

1) Faculty Development: Universities should organize regular Faculty Development Programmes on:

- AR/VR applications
- IoT-enabled classrooms
- Educational Robotics
- Immersive learning
- Simulation-based teaching
- Digital assessment
- Emerging technology ethics

2) Infrastructure Development: Universities should provide appropriate infrastructure including:

- VR headsets
- AR-enabled devices
- Sensors
- IoT kits
- Educational robots
- High-speed internet
- Smart classrooms
- Simulation platforms

3) **Curriculum Development:** Emerging technologies should be integrated into university curricula wherever academically appropriate. Teacher education programmes should also prepare future teachers to use AR/VR, IoT and Robotics.

4) **Institutional Support:** Teachers require technical support, training, access to resources and sufficient time to experiment with new technologies.

5) Ethical Technology Use: Universities should develop policies concerning privacy, cybersecurity, accessibility, intellectual property and responsible use of emerging technologies.

13. Recommendations

Based on the findings, the following recommendations are made:

1) Universities should establish Emerging Technology Centres or Innovation Labs.

2) Regular training programmes should be organized for university teachers.

3) AR/VR laboratories should be developed in disciplines where immersive learning is useful.

4) IoT-based smart classroom and laboratory facilities should be promoted.
5) Robotics laboratories should be established, particularly in STEM-related disciplines.
6) Teachers should be encouraged to undertake action research on emerging technologies.
7) Universities should provide technical support for teachers.
8) Technology integration should be linked with pedagogical objectives rather than technology adoption alone.
9) Ethical guidelines should be developed for emerging technology use.
10) Further studies should examine students' attitudes towards AR/VR, IoT and Robotics.
11) Comparative studies may be conducted between government and private universities.
12) Future research may examine the relationship between technological competence, attitude and actual technology adoption.

14. Limitations of the Study:

The study has the following limitations:
1) The study is limited to university teachers in Karnataka.
2) The proposed sample consists of 400 teachers.
3) The study focuses specifically on AR/VR, IoT and Robotics.
4) Data are primarily based on self-reported responses.
5) Actual classroom implementation of emerging technologies was not directly observed.
6) Variables such as age, educational qualification, digital literacy, institutional type and access to infrastructure may also influence attitudes but were not considered in detail.

15. **Conclusion:** Emerging technologies such as Augmented Reality, Virtual Reality, Internet of Things and Robotics have considerable potential to transform higher education. They can facilitate immersive learning, experiential learning, real-time data collection, simulation, personalized instruction and innovative assessment. The present study indicates that university teachers of Karnataka generally demonstrate favourable attitudes towards emerging technologies. Differences according to gender, teaching experience and academic discipline suggest that technology adoption is influenced by individual and professional characteristics. The positive relationship between technological readiness and attitude further indicates that teachers need adequate knowledge, skills, confidence and institutional support to effectively integrate emerging technologies. The successful adoption of AR/VR, IoT and Robotics should therefore be approached as a combination of technology, pedagogy, professional development, infrastructure and ethical responsibility. Universities in Karnataka can play a significant role in preparing teachers and students for an increasingly technology-enabled educational environment.

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AI-ENABLED COGNITIVE SUPPORT TOOLS FOR MANAGING STRESS DURING THE SCHOOL-TO-COLLEGE TRANSITION: EXAMINING THE ROLE OF POSITIVE AND NEGATIVE THINKING PATTERNS

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Abstract

Transition from secondary to post-secondary studies can be called one of the most difficult periods in a student's life. Factors like new and unexpected academic demands, lack of supportive structures, and changes in social identity often trigger additional stress. Research based on Cognitive Behaviour Therapy shows that the intensity of stress experienced by students during this transition is not so much dependent on the transition itself but rather on its interpretation and response to it by the student in question. Those students who constantly have negative automatic thoughts, such as exaggeration of academic setbacks, or generalization of initial difficulties as a proof of total failure usually report higher levels of anxiety, avoidance behavior and lower engagement in learning process. On the other hand, students who have learned to think in more balanced and realistic way demonstrate better coping skills, resilience and adjustment to the situation. This paper examines how positive and negative thinking patterns affect stress during the school-to-college transition. It is based on two cognitive models: It takes from two well-known cognitive behavioral approaches developed by Aaron Beck and Albert Ellis. Moreover, the study will highlight the potential of AI technologies to assist students in their psychological adaptation. The necessity for this issue arises from the relatively small number of counselors against a large number of students in most colleges. In addition, the study will discuss three kinds of AI technologies. These include chatbots to assist in reframing the negative thinking of the students, applications to monitor the emotions and sentiment of the student, and predictive learning analytics systems to identify potential dropouts. Lastly, the ethical concerns encountered because of using these technologies are considered in the paper.

Keywords*: school-to-college transition, cognitive patterns, stress, artificial intelligence, student well-being, cognitive behaviour therapy.*

Introduction

Transitioning from high school to college may not be always an easy process for everyone. In most cases, this transition marks the end of a number of years of developing routines and identity, along with other factors that have been established through the years of studying. Freshmen have to cope with a number of changes all at once: greater academic pressure,

larger classrooms, new peers, and sometimes relocation to another city or living without their family. Stress is a natural part of this experience but if it is prolonged or not handled correctly, it may damage student's progress. An increasing number of studies in psychology indicate that the level of distress that occurs during this period has little to do with the actual difficulty of adapting to the new surroundings and much more to do with how the students perceive the process of change. Two different students who experience the same decline in their performance in the first semester could react completely differently: one will see it as an indicator of his own incompetence, whereas the other one will interpret it as a short-lived and easily correctable mistake. However, at the same time, there is also a structural drawback in terms of how universities are able to attend to the well-being of their students, because in most cases the number of counsellors per student is quite low, especially for universities from developing countries. It means that there is a mismatch between the level of psychological problems that students might have at certain stages of their studies, like the beginning of the first semester, and the ability of university to react to them individually. AI has started to become a possible way out of this situation, providing scalable, constant and reliable way of support. This paper will discuss the interaction between these two topics: thinking patterns and stress and use of AI in college.

Theoretical Framework

The present study is based on two theories of cognitive-behavioural perspectives to highlight the effect of thought process on stress. According to the cognitive perspective of Aaron Beck, those people who are facing psychological stress tend to think in an automatic negative way regarding themselves, their situation, and their future, which is known as the cognitive triad. In terms of a college setting, a freshman suffering from stress will think automatically that "I am not able to make it here." Another approach that can explain why some students become psychologically distressed is the Rational Emotive Behaviour Therapy by Albert Ellis, and his ABC approach: An Activating event (like getting low grades or not being able to make friends) goes through the filter of a Belief (which is the meaning a student gives to the event), resulting in a Consequence both emotionally and behaviorally. Ellis maintained that psychological problems are mainly caused by irrational and/or distorted beliefs and not by events per se. In combination, these theories give rise to a useful perspective on transition stress, which can be viewed not as an unavoidable consequence of going through a tough experience in life, but rather as an interpretation process, which, in theory, can be recognized and adjusted. This approach is significant since it makes the process of intervention possible, regardless of whether it is being carried out by a human counselor or even AI-based technology as proposed in this paper.

Positive and Negative Thinking Patterns During Transition

There are some kinds of cognitive distortions that occur during this transition time at an especially high rate. Table 1 describes the most common distortions along with the positive way of looking at these events, which Cognitive Behavioral Therapy strives to foster.

Cognitive Distortion	Typical Automatic Thought	Balanced Alternative Thought
All-or-nothing thinking	"I failed one test, so I am a failure."	"I did poorly this time; one result does not define me."
Overgeneralization	"I struggled in this subject, so I am bad at everything."	"I am finding this subject difficult; other areas may still be fine."
Catastrophizing	"A slow start means I will fail the whole year."	"A slow start is common; I can adjust my study plan."
Mind reading	"Everyone thinks I don't belong here."	"I don't actually know what others think; I can wait and observe."
Personalization	"My roommate is quiet because of something I did."	"There could be many reasons; it may not be about me."

Table 1. Common Cognitive Distortions during the School-to-College Transition

Students who are used to engaging in such distortions usually display avoidance behaviors in the form of absence from classes, withdrawal from social situations, or withdrawal from support systems for fear that it would prove their negative self-assessment. This avoidance serves to reinforce the initial distortion, creating a vicious circle.

Conversely, students with balanced thinking patterns see the same set-backs as particular, temporary, and manageable, which promotes problem solving behavior over avoidance. The balanced thinking pattern is not a form of irrational optimism since it does not disregard the reality of difficulties but looks at the difficulties in such a manner that will enable positive action. In any support system, whether human or technological, it is important for it to assist students in examining and restructuring their automatic thoughts causing them stress.

Role of Artificial Intelligence in Supporting Cognitive Adjustment

There are several types of tools based on AI that are useful for helping individuals think healthily while in the transition phase, each one catering to a certain part of the stress cycle discussed above. Table 2 below shows some examples of these categories, the role they play, and their application example.

AI Tool Category	Core Function	Illustrative Use Case
Chatbot-based cognitive reframing assistant	Guides the student through a simplified thought-record dialogue	An apprehensive student about taking an examination identifies the automatic thought, evaluates the evidence and makes an alternate judgment
Sentiment and mood-tracking application	Logs daily emotional check-ins and detects trends over time	A prolonged period of mood downturn following a certain class raises the need for an easy-going evaluation
Predictive learning-analytics system	Uses attendance and engagement data to flag disengagement risk	A student who fails to submit assignments is detected and reported before being withdrawn

Table 2. AI-Enabled Tools Supporting Cognitive Adjustment during Transition

These categorizations are not just theoretical. The Woebot program developed by Fitzpatrick et al. (2017) has been able to prove that a chatbot providing conversations like those seen during CBT can have significant success in lowering the levels of anxiety and depression experienced by young adults. This provides evidence of the feasibility of such a concept in regards to the reframing assistant mentioned earlier. This paper uses that reasoning but applies it to the cognitive issues related to transitioning from school to college.

If combined, however, these tools will not serve as substitutes for the intuition, empathy, and professional education of human counsellors. On the contrary, they allow the institution's efforts to permeate the continuous process experienced by students, influencing them at the point when the very processes of mental pattern creation mentioned above take place in an almost imperceptible way. It allows for the distribution of counselling resources to people who need them the most, instead of depending on students themselves to recognize their needs and reach out for assistance. The scalability also has an element of equity associated with it since students who have issues accessing counseling on account of various socio-economic barriers such as first-generation students, rural students, and those who are embarrassed about accessing mental health services might find the tool easier to access in terms of the initial step.

Ethical Considerations

Incorporating AI in the provision of mental health care among students presents some of the concerns that organizations need to consider in their implementation. The privacy of the data is of utmost importance since the data pertaining to moods, stress, and academic study data are highly private for the students, therefore, it is necessary that they be told how their private data would be gathered, used, viewed, and stored. Moreover, there is always a threat of over-reliance on the automated systems in the situations when some of the students might treat the software as an equivalent of professional counseling services, which might be dangerous especially if there are situations of severe distress. Algorithmic bias is another issue, which has to be addressed by any organization implementing AI, as the prediction models based on the inadequate amount of data might result in inappropriate identification of the distressed students who do not conform to behavioral patterns known to the system. That is why the implementation of the AI in the field of mental health has to be supplemented with human guidance and clear understanding of the limits of the system.

Discussion

From all of the evidence and theory presented above, it becomes apparent that the process of transition from school to college is better viewed as a process in which pre-existing and developing thinking patterns play an important role. The destinies of two students who experience the same problems during this process may diverge dramatically depending mainly on their interpretation of these problems. This conclusion has its practical meaning as well. Orientation courses, freshman seminars and programs of peer mentoring may include some elements of cognitive awareness, helping freshmen identify common patterns of distorted thinking such as catastrophizing and overgeneralization. Incorporating these approaches early on, before students have experienced their first big failure, might make it easier for them to use their awareness when they need to do so. AI-based technologies incorporated in these

approaches would be a good supplement, especially for the purpose of finding out the students that are struggling without anyone knowing about it, and will ask for help only when their situation worsens dramatically. It is obvious that with these technologies being able to monitor constantly and throughout all the students at once, they are able to pick up some signals that even a small counselling team would be unable to pick up on. It seems like the best approach is to combine technologies and human work together.

Conclusion

The move from high school to college requires much effort on the part of students, and it is not how these obstacles will be interpreted by students that mostly affects their stress levels. Two individuals may find themselves in almost the same situation but end up being totally different because of the interpretation of events that occurs. Using the cognitive-behavioural model described by Beck and Ellis, this paper discussed that negative automatic thoughts and cognitive distortion increase stress associated with this stage, whereas balanced and realistic thinking contribute to better adjustment. Artificial Intelligence provides an efficient solution to support the mentioned cognitive processes during the transition in terms of reframing using chatbots, tracking emotions through apps and predicting learning needs through analytical approaches. It should be noted that in spite of the shortage of counselling services which makes it impossible to reach all those students who require assistance, such solutions can help. Nonetheless, issues related to privacy, bias, and a reduction in professional judgment, associated with AI-powered psychological tests, need to be carefully considered prior to implementation. Thus, the best strategy to ensure mental well-being of students during this transition would be a combination of AI-powered early intervention and accessible human counselling.

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ARTIFICIAL INTELLIGENCE LITERACY AND STUDENT ENGAGEMENT AMONG COLLEGE STUDENTS

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Abstract

The present study aimed to examine the relationship between Artificial Intelligence Literacy and Student Engagement among college students. The study adopted the Descriptive Survey Method, with a sample of 304 college students selected from various colleges of education using the Simple Random Sampling Technique. Data were collected using the Artificial Intelligence Literacy Scale developed by Shuai Ma and Zhenzhen Chen (2024) and the University Student Engagement Scale developed by Savita Gupta and Renu Nagpal (2021). The collected data were analyzed using Mean, Standard Deviation, t-test, ANOVA, and Pearson's Product-Moment Correlation. The findings revealed a negligible positive relationship between Artificial Intelligence Literacy and Student Engagement ($r = 0.071$, $p = 0.217$). This indicates that students with higher levels of Artificial Intelligence Literacy tend to show a slight increase in Student Engagement. However, the observed relationship was not statistically significant at the 0.05 level. The findings suggest that Artificial Intelligence Literacy may be associated with a slight positive tendency in Student Engagement among college students, although the strength of the relationship is negligible.

Keywords: *Artificial Intelligence Literacy, Student Engagement, College Students, AI Literacy, Normative Survey Method, Pearson's Product-Moment Correlation.*

Introduction

Artificial Intelligence (AI) is increasingly being integrated into higher education, changing the ways students learn, access information, and complete academic activities. As AI technologies become more common, Artificial Intelligence Literacy has become important for students to understand, evaluate, and use AI tools effectively and responsibly. Student Engagement refers to students' active participation, interest, effort, and involvement in their learning activities. AI-based tools may support engagement by providing personalized learning, immediate feedback, and easy access to educational resources. Students with better AI literacy may therefore be more capable of using these technologies effectively in their learning. However, the relationship between AI literacy and student engagement may vary depending on several factors. Hence, the present study examines the relationship between Artificial Intelligence Literacy and Student Engagement among college students. The study also explores whether increased AI literacy is associated with changes in students'

engagement in learning.

Need and Significance of the Study

The rapid development of Artificial Intelligence (AI) has brought significant changes to higher education. Students are increasingly using AI-based tools for accessing information, understanding concepts, completing academic tasks, and supporting their learning. Therefore, developing Artificial Intelligence Literacy is essential for students to understand and use AI tools effectively, responsibly, and appropriately in their educational activities. Student Engagement is an important component of effective learning. Active participation, interest, effort, and involvement in academic activities can contribute to meaningful learning experiences. Since AI provides opportunities for personalized learning, immediate feedback, and easy access to educational resources, it is important to examine whether students' level of AI literacy is associated with their engagement in learning activities. The present study is significant for students, teachers, teacher educators, and educational institutions. The findings may help teachers understand the role of AI literacy in students' learning and participation and may support institutions in planning appropriate AI-literacy programmes. The study may also provide a useful foundation for researchers who wish to conduct further studies on AI literacy, student engagement, and technology-supported learning in higher education.

Review of Related Literature

1. **Kang and Park (2026)** developed an AI literacy scale for higher education students. The study identified AI knowledge, impact assessment, performance evaluation, and practical application as important dimensions of AI literacy.
2. **Casal-Otero et al. (2023)** examined AI literacy among university students and found differences in AI knowledge based on students' academic backgrounds and previous AI experience. The study emphasized the need to develop AI literacy among higher education students.
3. **Long et al. (2026)** reviewed studies on AI and student engagement in higher education. The findings indicated that AI-based technologies can improve students' cognitive, behavioral, and emotional engagement when appropriately integrated into teaching.
4. **Xu and Zhi (2026)** studied AI-assisted learning among university students and found that AI support, teacher support, and students' learning experiences influence student engagement.
5. **Xia et al. (2025)** examined the effects of generative AI on university students' motivation and engagement. The findings showed that appropriate use of generative AI can positively support students' motivation and engagement in learning.

Objectives

1. To study the Level of Artificial Intelligence Literacy among College Students.
2. To study the Level of Student Engagement among College Students.
3. To find out whether there is any significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Gender.

4. To find out whether there is any significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Locality.
5. To find out whether there is any significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Age.
6. To find out whether there is any significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Stream of Study.
7. To find out whether there is any significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Type of Institution.
8. To find out the relationship between Artificial Intelligence Literacy and Student Engagement among College Students.

Hypotheses

1. There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Gender.
2. There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Locality.
3. There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Age.
4. There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Stream of Study.
5. There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Type of Institution.
6. There is no significant relationship between Artificial Intelligence Literacy and Student Engagement among College Students.

METHODOLOGY

The present study adopted a Descriptive Survey Method. A sample of 304 college students was selected using a Simple Random Sampling Technique. Data were collected using two standardized instruments: the Artificial Intelligence Literacy Scale (AILS) developed by Shuai Ma and Zhenzhen Chen (2024) and the University Student Engagement Scale (USES) developed by Savita Gupta and Renu Nagpal (2021). In addition, a Personal Data Sheet constructed by the investigator was used to gather demographic details. The collected data were analyzed using descriptive and inferential statistical techniques such as mean, standard deviation, t-test, F-test and Pearson's Product-Moment Correlation.

TESTING OF OBJECTIVES

1. To study the Level of Artificial Intelligence Literacy among College Students:
   This section describes the level of artificial intelligence literacy among college students that obtained from the study.

Table 1 Level of Artificial Intelligence Literacy among College Students

Level of Artificial Intelligence Literacy	No of Students	Percentage %
Low	58	19.1
Moderate	177	58.2
High	69	22.7
Total	**304**	**100.0**

The above table reveals that 58 (19.1%) college students have a low level of Artificial Intelligence Literacy, 177 (58.2%) college students have a moderate level and 69 (22.7%) have a high level. It can be inferred that the majority of the college students possess a moderate level of Artificial Intelligence Literacy.

2. To study the Level of Student Engagement among College Students:

This section describes the level of student engagement among college students that obtained from the study.

Table 2 Level of Student Engagement among College Students

Level of Student Engagement	No of Students	Percentage %
Low	47	15.5
Moderate	181	59.5
High	76	25.0
Total	**304**	**100.0**

The above table shows that 47 (15.5%) college students have a low level of student engagement, 181 (59.5%) have a moderate level and 76 (25.0%) have a high level. Therefore, it is concluded that the majority of the college students exhibit a moderate level of student engagement.

TESTING OF HYPOTHESIS

Hypothesis 1

There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Gender.

Table 3 showing the significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Gender.

S.No	Variables	Gender	N	Mean	SD	't' Value	Significance
1	Artificial Intelligence Literacy	Male	100	106.21	9.818	0.997	Not Significant
		Female	204	107.40	9.618		
2	Student Engagement	Male	100	63.08	4.084	0.855	Not Significant
		Female	204	63.50	3.746		

Interpretation

The obtained *t*-values for both AI Literacy and Student Engagement are **not significant at the 0.05 level**. Therefore, there is no significant difference between male and female college

students in AI Literacy and Student Engagement. Therefore, the null hypothesis is **accepted**.

Hypothesis 2

There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Locality.

Table 4 showing the significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Locality.

S.No	Variables	Locality	N	Mean	SD	't' Value	Significance
1	Artificial Intelligence Literacy	Rural	89	102.90	9.327	4.940	0.01
		Urban	215	108.71	9.332		
2	Student Engagement	Rural	89	63.88	3.460	1.602	Not Significant
		Urban	215	63.14	4.000		

Interpretation

The obtained *t*-value shows a significant difference in AI Literacy between rural and urban college students at the **0.01 level.** Urban students had higher AI Literacy than rural students; hence, the null hypothesis is rejected.

For Student Engagement, the obtained *t*-value is **not significant at the 0.05 level.** Therefore, there is no significant difference between rural and urban students, and the null hypothesis is accepted.

Hypothesis 3

There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Age.

Table 5 showing the significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Age.

Sl. No.	Variables	Age	N	Mean	SD	'F' Value	Significance
1	Artificial Intelligence Literacy	18-20 years	21	114.10	4.482	16.916	0.01
		21-23 years	147	108.86	9.340		
		Above 24 years	136	103.90	9.586		
2	Student Engagement	18-20 years	21	62.90	4.110	0.492	Not Significant
		21-23 years	147	63.21	3.959		
		Above 24 years	136	63.59	3.723		

Interpretation

The F-ratio shows a significant difference in AI Literacy based on age. Students aged **18–20 years** had higher AI Literacy than those aged 21–23 years and above 24 years; hence, the null hypothesis is rejected. For Student Engagement, the obtained F-ratio is **not significant at the**

0.05 level. Therefore, there is no significant difference among the three age groups, and the null hypothesis is accepted.

Hypothesis 4

There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Stream of Study.

Table 6 showing the significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Stream of Study.

Sl. No.	Variables	Stream of Study	N	Mean	SD	'F' Value	Significance
1	Artificial Intelligence Literacy	Arts	69	107.26	9.626	9.917	0.01
		Science	123	109.54	9.321		
		Commerce	112	104.07	9.376		
2	Student Engagement	Arts	69	63.64	3.839	3.167	Not Significant
		Science	123	62.70	3.985		
		Commerce	112	63.91	3.650		

Interpretation

The F-ratio shows a significant difference in AI Literacy based on stream of study. Science students had higher AI Literacy than Arts and Commerce students; hence, the null hypothesis is rejected.

For Student Engagement, the obtained F-ratio is **not significant at the 0.05 level.** Therefore, there is no significant difference among Arts, Science and Commerce students, and the null hypothesis is accepted.

Hypothesis 5

There is no significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Type of Institution.

Table 7 showing the significant difference in Artificial Intelligence Literacy and Student Engagement among College Students with respect to Type of Institution.

Sl. No.	Variables	Type of Institution	N	Mean	SD	'F' Value	Significance
1	Artificial Intelligence Literacy	Government	89	102.09	9.955	98.449	0.01
		Government Aided	98	102.30	8.084		
		Private	117	114.69	4.274		
2	Student Engagement	Government	89	64.81	3.236	21.577	0.01
		Government Aided	98	64.05	3.047		
		Private	117	61.68	4.279		

Interpretation

The obtained *F*-value shows a significant difference in **AI Literacy** among college students based on the **type of institution at the 0.01 level**. Private college students had higher AI Literacy than government-aided and government college students; hence, the null hypothesis is rejected. For **Student Engagement,** the obtained *F*-value also shows a significant difference at the **0.01 level**. Government college students had higher Student Engagement than government-aided and private college students; hence, the null hypothesis is rejected.

Hypothesis 6

There is no significant relationship between Artificial Intelligence Literacy and Student Engagement among College Students.

Table 8 showing the significant relationship between Artificial Intelligence Literacy and Student Engagement among College Students.

Variables	Correlation Coefficient	P Value	Significance
Artificial Intelligence Literacy and Student Engagement	0.071	0.217	No Significant

Interpretation

From the above table, it is observed from the Pearson Correlation Coefficient Value that there is no significant relationship between Artificial Intelligence Literacy and Student Engagement. Hence the null hypothesis, there is no significant relationship between Artificial Intelligence and Student Engagement of college students is accepted.

Educational Implications of the Study

1. **Strengthening AI Literacy:** Colleges should provide structured AI literacy programmes, workshops and practical activities to improve students from moderate to higher levels of AI competency.
2. **Bridging the Rural–Urban Gap:** Special AI learning opportunities and technological support should be provided to rural students to reduce the difference in AI Literacy observed between rural and urban students.
3. **Discipline-Specific AI Education:** Since Science students demonstrated higher AI Literacy, colleges may provide additional AI-oriented learning activities for Arts and Commerce students to ensure more equitable development across streams.
4. **Institutional Support:** Government and government-aided institutions should strengthen access to AI-related learning resources and opportunities, particularly because institutional differences were found in AI Literacy.
5. **Separate Strategies for Engagement:** Since AI Literacy was not significantly related to Student Engagement, institutions should not assume that improving AI skills alone will increase engagement; dedicated teaching strategies and learner-centred activities are also needed to strengthen Student Engagement.

Conclusion

The present study concludes that college students possess a **moderate level of Artificial Intelligence Literacy and Student Engagement**. The findings show that AI Literacy varies significantly with respect to locality, age, stream of study, and type of institution, while gender does not produce a significant difference. Student Engagement also differs significantly according to type of institution, but not according to gender, locality, age, or stream of study. The most important finding is that **Artificial Intelligence Literacy and Student Engagement have a very weak positive but statistically non-significant relationship (r = 0.071, p = 0.217).** Thus, higher AI Literacy does not necessarily result in higher Student Engagement among the college students studied. Overall, the study highlights the importance of strengthening AI Literacy through appropriate educational programmes while simultaneously developing effective learner-centered strategies to enhance Student Engagement. The findings provide useful implications for students, teachers, teacher educators, and higher education institutions in promoting responsible and effective use of AI in education.

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STUDENTS' ENGAGEMENT AND WELL-BEING IN THE PRESENT SCENARIO OF ARTIFICIAL INTELLIGENCE: A HUMAN-CENTERED AI MODEL FOR SECONDARY SCHOOLS

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Abstract

Artificial Intelligence (AI) is rapidly changing the educational landscape and is becoming increasingly relevant to secondary school education. In the present scenario, AI-supported tools such as generative AI, adaptive learning systems, intelligent tutoring systems, educational chatbots, and learning analytics provide new opportunities to personalize learning and improve student engagement. At the same time, the well-being of secondary school students requires greater attention because excessive technology use, academic pressure, social isolation, misinformation, privacy concerns, and overdependence on AI may negatively influence learners. This article examines the relationship between AI, student engagement, and student well-being in secondary schools and proposes a simple ***Human-Centred AI Model****. The model places the student at the centre and connects AI support, teacher guidance, student engagement, well-being, critical thinking, and holistic development. The model emphasizes that AI should complement teachers and strengthen human interaction rather than replace it.*

Keywords: *Artificial Intelligence, Student Engagement, Student Well-Being, Secondary Schools, Human-Centred AI, Personalized Learning, AI Literacy*

1. Introduction

The present educational scenario is characterized by rapid technological development, changing learning needs, digital transformation, and increasing use of Artificial Intelligence. AI has moved from being an emerging technology to becoming an important component of contemporary educational practice. Students increasingly encounter AI through educational applications, search engines, recommendation systems, generative AI tools, language-learning platforms, and digital learning environments.

Secondary school education is particularly important because students at this stage develop academic abilities, social relationships, emotional maturity, critical thinking, and aspirations for higher education and careers. Their engagement in learning and overall well-being are therefore essential for successful educational development.

AI provides opportunities to make learning more personalized and interactive. It can provide immediate feedback, recommend learning resources, adapt activities to students' abilities, and support students who require additional assistance. Research on AI-supported school learning has identified personalized learning, learning gains, and student engagement

as important potential benefits (Niyazova et al., 2026). Similarly, research on AI in K–12 education highlights the growing use of AI for personalized learning, assessment, intelligent tutoring, and educational support (Ng et al., 2023). However, AI also creates new educational challenges. Students may become dependent on AI-generated answers, experience reduced independent thinking, encounter inaccurate information, or have concerns regarding privacy and data use. UNESCO emphasizes that AI in education should be developed and implemented through a human-centred approach that protects human agency, inclusion, equity, and ethical principles (UNESCO, 2023). Therefore, the present scenario requires an approach that combines the advantages of AI with the strengths of human interaction. This article proposes a **Human-Centred AI Model for Secondary Schools** to connect AI with student engagement and well-being.

2. AI in the Present Secondary School Scenario

AI is influencing secondary education in several ways. Students can use AI-supported applications to obtain explanations, practise concepts, receive feedback, translate content, generate examples, and explore topics beyond classroom instruction. Teachers can use AI to prepare learning materials, differentiate instruction, analyse student performance, and provide formative assessment. Generative AI has further expanded these possibilities. Students can interact with AI through natural language and receive responses to questions across different subjects. However, the availability of immediate answers also creates concerns regarding academic integrity and the development of independent learning skills.

The present scenario therefore requires students not merely to **use AI**, but to understand and evaluate it. AI literacy should become an important component of secondary education. Students need to know how AI works at a basic level, recognize its limitations, verify information, understand bias, protect personal data, and use AI ethically.

3. Student Engagement in Secondary Schools

Student engagement refers to the extent to which students participate actively and meaningfully in learning. It can be understood through three major dimensions.

Behavioural Engagement

Behavioural engagement includes attendance, participation, and completion of learning activities, persistence, and involvement in classroom tasks.

Emotional Engagement

Emotional engagement involves students' interest, motivation, confidence, enjoyment, sense of belonging, and positive attitudes towards school and learning.

Cognitive Engagement

Cognitive engagement involves critical thinking, problem-solving, reflection, creativity, analysis, and the willingness to make intellectual effort. AI can support all three dimensions when appropriately integrated. Interactive activities can encourage participation, personalized learning can improve motivation, and AI-supported problem-solving can provide opportunities for deeper learning. However, engagement should not be measured simply by the amount of time students spend using technology. Meaningful engagement involves active

thinking, participation, reflection, collaboration, and purposeful learning. In the present educational scenario, the concept of happy learning is increasingly relevant to the effective use of Artificial Intelligence (AI) in education. Happy learning extends beyond conventional classroom practices by promoting curiosity, creativity, enjoyment, and lifelong learning. When students experience engaging and meaningful learning activities, they are more likely to participate actively, develop positive attitudes toward learning, and achieve better academic outcomes (Bhavya R. & Dange, J. K., 2020). AI-supported educational tools can strengthen this process by providing personalized learning experiences, immediate feedback, interactive activities, and learning resources that respond to students' individual needs and abilities. Such technology-supported experiences can increase students' motivation and engagement while making learning more flexible and enjoyable. Furthermore, integrating happiness into the learning process can contribute to improved student engagement, motivation, and academic achievement (Bhavya R. & Dange, J. K., 2021). Therefore, the integration of AI and happy learning within a human-centred approach can create a supportive educational environment in which technology enhances learning while teachers continue to provide emotional support, guidance, empathy, and meaningful human interaction.

4. AI and Student Well-Being

Student well-being is an important foundation for effective learning. It includes emotional, psychological, social, and academic dimensions. A student who feels confident, supported, safe, and connected to others is more likely to participate actively in learning. AI can support academic well-being by helping students organize learning activities, identify areas of difficulty, receive immediate feedback, and access additional learning resources. Personalized learning may help students learn at an appropriate pace and reduce some forms of academic frustration. At the same time, excessive use of AI and digital technologies may create challenges. Students may experience screen fatigue, reduced face-to-face interaction, and dependence on technology, information overload, or anxiety about academic performance. Therefore, AI should be used to **support well-being rather than become the centre of students' educational lives**.

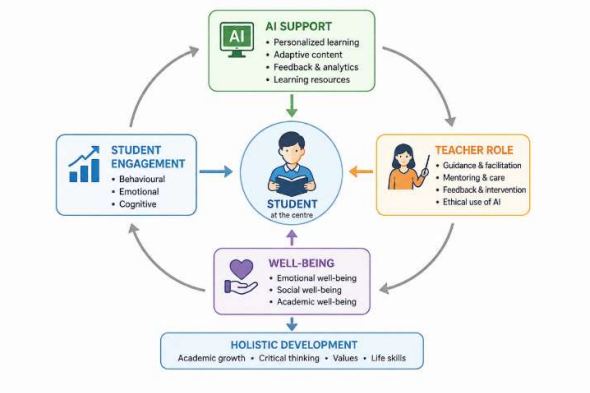
5. Need for a Human-Centred AI Approach

A human-centred approach places students' needs, dignity, agency, safety, and development at the centre of technology use. AI should serve educational purposes rather than determine them. Teachers are essential to this approach. AI can identify patterns in learning, but teachers understand students within their social, cultural, emotional, and educational contexts. AI can provide feedback, but teachers provide encouragement, empathy, mentoring, and professional judgment. UNESCO's guidance on generative AI in education emphasizes the importance of human agency, ethical considerations, data privacy, inclusion, and appropriate pedagogical use of AI (UNESCO, 2023). UNESCO's AI Competency Framework for Students also emphasizes human-centred thinking, ethics, AI knowledge, and responsible use (Miao, Shiohira, & Lao, 2024). Thus, the objective should not be **AI replacing teachers**, but **AI strengthening teachers' capacity to support students**.

6. Human-Centred AI Model for Secondary Schools

The proposed model is intentionally simple and focuses on the relationship among AI, teachers, students, engagement, and well-being.

Figure 1. Human-Centred AI Model for Enhancing Students' Engagement and Well-Being in Secondary Schools



Simple explanation of the model

The model begins with **Human-Centred AI**, which provides appropriate technological support for learning. AI provides personalized learning, feedback, accessibility, and learning analytics. This support is expected to contribute to **student engagement** through behavioural, emotional, and cognitive participation. Improved engagement can contribute to **student well-being**, particularly academic confidence, motivation, belongingness, and emotional support. The **teacher remains central** to the process by providing guidance, mentoring, feedback, empathy, and intervention. Teachers interpret AI-generated information and make professional decisions rather than allowing AI to independently determine students' needs. The interaction between AI, students, and teachers promotes **critical thinking and student agency**. Students learn to question, evaluate, verify, and responsibly use AI rather than simply accepting AI-generated information. The ultimate outcome is **holistic development**, including academic achievement, social development, emotional well-being, critical thinking, creativity, and responsible digital citizenship.

7. Major Elements of the Model

7.1 AI Support

AI provides personalized learning materials, adaptive activities, feedback, accessibility tools, and learning analytics. Its purpose is to enhance learning opportunities rather than replace classroom teaching.

7.2 Student Engagement

The model considers engagement as behavioural, emotional, and cognitive. AI should encourage students to participate, think, explore, collaborate, and reflect.

7.3 Student Well-Being

The model connects academic engagement with emotional, social, and academic well-

being. Students should experience confidence, belongingness, motivation, and appropriate academic support.

7.4 Teacher Support

Teachers provide the human dimension of education. They interpret students' needs, build relationships, provide emotional support, facilitate collaboration, and ensure responsible AI use.

7.5 Critical Thinking and Student Agency

Students should remain active decision-makers. They should question AI-generated information, verify evidence, identify errors and bias, and make independent judgements.

7.6 Holistic Development

The final goal is not simply improved test scores. The model aims at the development of academically competent, emotionally resilient, socially responsible, critically thinking, and digitally competent students.

8. Benefits of the Human-Centred AI Model

The model can provide several benefits to secondary schools.

First, AI can support **personalized learning** by adapting activities to students' needs. Second, immediate feedback can encourage students to identify and correct mistakes. Third, AI can support **inclusive education** through translation and accessibility tools. Fourth, learning analytics can help teachers identify students who may need additional academic support.

Most importantly, the model maintains the importance of human relationships. Students continue to interact with teachers and peers while using AI as a supplementary learning resource.

9. Challenges

The implementation of the model must consider several challenges.

AI dependency: Students may rely excessively on AI instead of developing independent learning skills.

Academic integrity: Generative AI can be used to produce assignments without genuine student participation.

Privacy: Student data must be protected from inappropriate collection or use.

Digital inequality: Students may have unequal access to devices, internet connectivity, and AI tools.

Misinformation: AI-generated information may be inaccurate or misleading.

Reduced human interaction: Excessive use of AI may reduce opportunities for communication and collaboration.

Teacher preparedness: Teachers require professional development to use AI effectively and ethically.

These challenges demonstrate why a human-centred approach is necessary.

10. Recommendations

Secondary schools should:

1. Develop clear policies for responsible AI use.

2. Provide AI literacy education to students.
3. Train teachers in AI-supported pedagogy.
4. Use AI for personalization and formative assessment.
5. Encourage independent thinking before using AI assistance.
6. Teach students to verify AI-generated information.
7. Protect students' personal data.
8. Maintain face-to-face teacher and peer interaction.
9. Monitor the effects of AI on students' engagement and well-being.
10. Ensure equitable access to AI-supported learning resources.

Conclusion

The present scenario of Artificial Intelligence offers significant opportunities for transforming secondary education. AI can support personalized learning, feedback, accessibility, engagement, and academic assistance. However, technology alone cannot guarantee student well-being or meaningful learning. The **Human-Centred AI Model** proposed in this article places the student at the centre of the educational process and connects AI support with student engagement, well-being, teacher guidance, critical thinking, and holistic development. The model emphasizes a partnership among **AI, teachers, and students**. The future of secondary education should therefore not be based on the question of whether AI will replace teachers. Instead, the focus should be on how AI can help teachers understand and support students more effectively while enabling students to become independent, critical, responsible, and confident learners. **AI should be a support system for human learning—not a substitute for human relationships.**

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PROFESSIONAL DEVELOPMENT OF PHYSICAL EDUCATION TEACHERS THROUGH DIGITAL TOOLS

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Abstract

Professional development is essential for Physical Education (PE) teachers to improve their teaching effectiveness, professional Wowledge, technological competency, and ability to meet the changing needs of learners. The rapid development of digital technology has created new opportunities for PE teachers to enhance their professional skills. Digital tools such as video analysis applications. online learning platforms. fitness trackers, virtual classrooms. mobile applications, artificial intelligence, and social media can support continuous professional learning. This paper discusses the impouance or digital tools in the professional development of Physical Education teachers, their applications, benefits. challenges, and strategies for effective implementation. It emphasizes that appropriate integration or' technology can make PE teaching more innovative, evidence-based, inclusive, and learner-centred.

Keywords: Physical Education, Professional Development, Digital Tools, Technology. Online Learning, AI, Teacher Education

1. Introduction

Physical Education plays an important role in developing students' physical fitness, motor skills, health awareness, teamwork, discipline, and lifelong physical activity habits. The role of the Physical Education teacher is changing rapidly because of technological developments in education and sports. Traditional professional development programs such as workshops, seminars. Conferences, and training courses remain valuable. However, digital technologies provide PE teachers with flexible and continuous opportunities of professional learning. Teachers can access online.

Courses, research articles, webinars, instructional videos, digital teaching resources, and professional communities from any location.

Therefore, digital tools can become an important component of continuous professional development for Physical Education teachers.

2. Objectives of the Study

The major objectives are:

1. To examine the role of digital tools in the professional development of Physical Education teachers.
2. To identify important digital tools useful for PE teachers.
3. To examine the benefits of technology-based professional development.
4. To identify challenges faced by PE teachers in using digital technologies.
5. To suggest strategies for effective use of digital tools in professional development.

3. Digital Tools for Professional Development:

3.1 Online Learning Platforms

Online learning platforms provide PE teachers with access to courses, lectures, demonstrations, assessments, and certification programs. Teachers can update their knowledge in areas such as sports science, fitness, pedagogy, yoga, nutrition, sports

psychology, and assessment.

3.2 Video Analysis Tools

Video analysis enables teachers to record and examine students' sporting movements and techniques. Teachers can study running, jumping, throwing, gymnastics, athletics, and various sports skills through slow-motion and frame-by-frame analysis.

This helps teachers identify technical errors and provide more effective feedback.

3.3 Mobile Applications

Mobile applications can support professional learning by providing access to fitness programs, exercise demonstrations, lesson resources, spots rules, assessment tools, and educational materials.

PE teachers can also use mobile applications to monitor physical activity and fitness-related information.

3.4 Wearable Technology

Smartwatches, fitness bands, heart-rate monitors, and activity trackers provide information about physical activity, heart rate, steps, sleep, and exercise intensity. Teachers can develop professional knowledge about fitness monitoring and use such technology to improve physical activity programs.

3.5 Artificial Intelligence

Artificial Intelligence (AI) is emerging as a useful technology for teachers. AI can assist PE teachers in generating lesson ideas, creating assessment questions, organizing teaching resources, Analysing performance data, and developing individualized learning activities.

However, teachers should use AI critically and verify its information before applying it in educational settings.

3.6 Webinars and Virtual Conferences

Webinars and virtual conferences allow PE teachers to learn from experts, researchers, coaches, and educators from different parts of the world. They reduce travel requirements and provide opportunities for interaction and knowledge sharing.

3.7 Digital Professional Communities

Online professional communities allow teachers to share lesson plans, research findings, teaching experiences, sports activities, and innovative practices. Such communities encourage collaboration and lifelong learning.

4. Benefits of Digital Tools

Digital tools can provide several benefits for the professional development ot PE teachers:

- Continuous access to professional learning.
- Development or digital literacy and technological skills.
- Access to current research and teaching practices.
- Improved lesson planning.
- Better demonstration and analysis of spout skills.
- Opportunities for collaboration with other teachers.
- Flexible and self-paced learning.
- Improved assessment and feedback.
- Exposure to national and international experts.
- Development of innovative and student-centred teaching approaches.

5. Role of the Physical Education Teacher

The PE teacher should not be only a user of technology but also a critical and responsible digital educator. Teachers should:

1. Select appropriate digital tools according to learning objectives.
2. Develop digital literacy and information-literacy skills.
3. Use technology to support—not replace—physical activity.
4. Protect students' privacy and personal data.
5. Evaluate the reliability of online information.
6. Use digital assessment and feedback appropriately.
7. Participate in online professional learning communities.
8. Continuously update their technological knowledge.

6. Challenges

Despite its advantages, the use of digital tools presents several challenges:

- Lack or digital skills among some teachers.
- Limited access to devices and reliable internet.
- Cost of advanced technology.
- Lack of technical support.
- Resistance to changing traditional teaching practices.
- Privacy and data-security concerns.
- Excessive dependence on technology.
- Lack of adequate training specific to Physical Education.

These challenges needto be addressed through institutional support and systematic teacher training.

7. Strategies for Effective Professional Development

Educational institutions can strengthen digital professional development by:

- Conducting regular technology-oriented workshops.
- Organizing webinars and online training programs.
- Providing access to digital learning resources.
- Creating PE teacher online communities.
- Providing technical suppor to teachers.
- Encouraging teachers to share successful digital practices.
- Integrating AI and digital literacy into teacher education.
- Providing suitable digital infrastructure.
- Encouraging action research using digital technologies.
- Developing institutional policies for safe and ethical technology use.

8. Conclusion

Digital technology has become an important component of professional development for Physical Education teachers. Online learning platforms, mobile applications, video analysis, wearable devices, virtual conferences, digital communities, and artificial intelligence provide new opportunities for teachers to develop their professional knowledge and skills. Effective professional development should combine technological competence with sound pedagogical knowledge and practical Physical Education experience. Technology should enhance physical activity, teaching quality, assessment, collaboration, and lifelong learning rather than replace the essential practical nature of Physical Education. The future PE teacher should therefore be physically active, pedagogically competent, digitally literate, innovative, and a lifelong learner. Proper institutional support and continuous training can help teachers use digital tools effectively and contribute to quality Physical Education.

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AI ETHICS LITERACY AMONG TEACHER EDUCATORS AND PRESERVICE TEACHERS: A COMPARATIVE SURVEY STUDY

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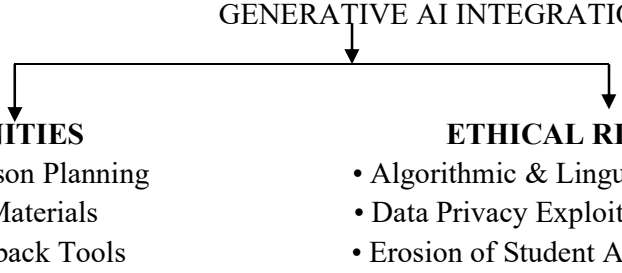
Abstract

Background: The fast growth of Generative Artificial Intelligence (GenAI) in education calls for a clear understanding of ethical AI literacy among teachers and those training to become teachers.
Purpose: This study compares how well teacher educators and preservice teachers understand areas of AI ethics. It looks at four areas: Algorithmic Bias & Fairness Data Privacy & Governance Pedagogical Integrity & Agency and Societal & Environmental Impact.
Methodology: A survey was used to collect data from 480 participants—135 teacher educators and 345 preservice teachers—from higher education institutions. The data collection followed a research approach and used a stratified two-stage cluster sampling method. The AI Ethics Literacy Scale was used, showing internal consistency ($\alpha = 0.89$). Statistical tools included statistics, independent t-tests and two-way ANOVA.
Findings: There is a difference in overall AI ethics literacy between teacher educators ($M=3.82$, $SD=0.45$) and preservice teachers ($M=3.24$, $SD=0.58$; $t(478)=10.56$, $p<.001$ $d=1.11$). Teacher educators rated higher on data privacy and pedagogical integrity. Preservice teachers had scores in algorithmic bias and long-term societal impact but were more familiar with using GenAI tools.
Implications: The study suggests that AI ethics should be included in teacher training programs and professional development. Schools and universities need to build ethical foundations around AI use.

Keywords: *AI Ethics Literacy, Teacher Education, Preservice Teachers, Generative AI, Comparative Survey, TPACK, Educational Governance.*

1.Introduction

The rise of Generative Artificial Intelligence (GenAI) including language models and image-generating tools is changing how teaching happens all over the world. These technologies can help create lessons give instant feedback and support lesson planning. They also bring serious concerns about fairness, student privacy and academic honesty. In teacher education these issues matter a lot. Teacher educators must not use AI in their own teaching and research but they also have to prepare future teachers to guide students in using AI responsibly.



Even though there is growing discussion about AI in schools few studies compare how well

teacher educators and preservice teachers understand AI ethics. Most frameworks focus on how easy it's to use technology rather than whether people can think critically about its risks. This study fills that gap by comparing AI ethics knowledge across both groups based on Saunders' Research Onion model.

1.1Objectives

1. To measure the level of AI ethics knowledge in teacher educators and preservice teachers across four key areas: algorithmic bias, data privacy, pedagogical integrity and societal impact.
2. To check if there is a difference in overall and specific area scores between the two groups.
3. To see if gender and prior training in technology affect AI ethics literacy for both groups.

1.2 Hypotheses

H1: There is a significant difference in total AI ethics literacy between teacher educators and preservice teachers.

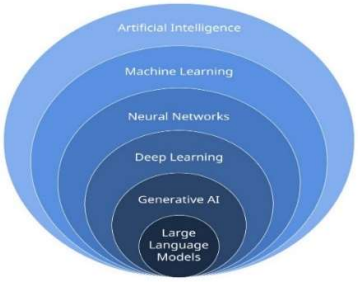
H2: Teacher educators score higher than preservice teachers in data privacy and pedagogical integrity.

H3: Prior formal training in educational technology improves AI ethics literacy in both groups.

2. Review of Literature and Conceptual Framework

2.1 A Curriculum for AI Ethics Literacy

Building on Long and Magerko's work on AI literacy and the UNESCO framework for teachers we define AI Ethics Literacy as knowing and being able to assess dangers linked to using AI in classrooms. It includes thinking recognizing problems and making smart choices.



Hierarchical scope of AI technologies informing ethical literacy

2.2 Core Dimensions of the Construct

Our framework breaks down AI ethics into four parts:

1. **Algorithmic. Fairness**: Seeing biases in datasets and AI results related to gender, culture or language.
2. **Data Privacy & Governance:** Understanding rules about data storage, who owns student information and legal issues like copyright when using public AI tools.
3. **Pedagogical. Agency**: Ensuring that AI supports learning without replacing thinking and avoiding practices that let students off the hook.
4. **Environmental Impact:** Recognizing differences in access to AI, environmental costs of running AI systems and risks of exploitation.

3. Methodology

3.1 Methodological Alignment (Research Onion)

- Research Philosophy: Pragmatism – focusing on outcomes and real-world relevance.
- Research Approach: Deductive – testing ideas based on existing theories.
- Methodological Choice: Quantitative single-method design.
- Research Strategy: Online surveys with validated psychological tools.
- Time Horizon: Cross-sectional – data collected during one term.

3.2 Sampling Strategy & Sample Size

A two-stage sampling process was used. First institutions offering teacher training were grouped by management type (private). Then participants were selected from two groups: teacher educators and preservice teachers.

The sample size was set using G*Power analysis for a samples t-test (alpha = 0.05, power = 0.80 effect size d = 0.50). This gave a minimum group size of 63.

TOTAL PARTICIPANTS (N = 480)

TEACHEREDUCATORS n = 135 (28.1%)

PRESERVICE TEACHERS n = 345 (71.9%)

3.3 Instrumentation:

Data was gathered using the AI Ethics Literacy Scale (AI-ELS) a 20-item tool on a 5-point Likert scale (1 = Disagree, 5 = Strongly Agree). The scale had reliability (α = 0.89).

Dimension	Sample Item	No. of Items	Cronbach's α
Algorithmic Bias	"I can identify cultural or gender biases present in AI-generated lesson plans."	5	0.84
Data Privacy	"I refrain from inputting identifiable student data or assessments into public GenAI tools."	5	0.88
Pedagogical Integrity	"I know how to design assessments that maintain integrity without relying on unreliable AI detectors."	5	0.82
Societal Impact	"I am aware of the environmental and socioeconomic disparities tied to commercial AI access."	5	0.81

4. Results & Findings

4.1 Comparative Analysis (Hypothesis Testing)

An independent t-test compared scores between the two groups.

Subgroup	N	Mean (M)	SD	*t*	df	*p*	Cohen's *d*
Teacher Educators	135	3.82	0.45	10.56	478	< .001	1.11
Preservice Teachers	345	3.24	0.58	—	—	—	—

Note. An independent-samples *t*-test was performed to determine whether a statistically significant difference existed in the scores of teacher educators and preservice teachers. The findings revealed that teacher educators (M = 3.82, SD = 0.45) reported significantly higher scores than preservice teachers (M = 3.24, SD = 0.58), $t(478) = 10.56$, $p < .001$. The magnitude of the observed difference was substantial, as indicated by a Cohen's d value of

1.11, representing a **large effect size**. These findings suggest that the two groups differed considerably in their scores on the variable under investigation.

H1 is supported: Teacher educators scored higher overall.

4.2 Breakdown Across Sub-Dimensions

Mean scores for each area show where strengths and weaknesses lie.

SUB-DIMENSION MEAN COMPARISON		
Sub-Dimension	**Educators**	**Preservice Teachers**
Algorithmic Bias & Fairness	3.64	2.91
Data Privacy & Governance	4.12	3.10
Pedagogical Integrity & Agency	4.05	3.55
Societal & Environmental Impact	3.47	3.40

- Data Privacy & Governance: Teacher educators (M=4.12) clearly knew more about privacy rules than preservice teachers (M=3.10). H2 holds.
- Algorithmic Bias: Preservice teachers scored lowest here (M=2.91) showing that even though they use tools like ChatGPT they rarely question bias in results.

4.3 Factor Analysis: Impact of Prior EdTech Training

A two-way ANOVA looked at role and past training.

- Main Effect of Role: $F(1,476)=78.42$, $p<.001$ $\eta p^2=.141$
- Effect of Prior Training: $F(1,476)=34.12$, $p<.001$, $\eta p^2=.067$
- Interaction Effect (Role × Training): $F(1,476)=2.15$, $p=.143$ (not significant)

H3 is confirmed: Both groups get a boost in ethics knowledge when they've taken formal EdTech courses. This effect does not depend on whether someone's a teacher educator or a student.

5. Discussion

The findings indicate a significant difference between teacher educators and preservice teachers in AI ethics-related understanding, suggesting an important **operational–ethical gap in teacher education**. Preservice teachers may demonstrate greater familiarity and confidence in using generative artificial intelligence (GenAI) tools, particularly in relation to prompting, content generation, and digital applications. However, operational proficiency does not necessarily imply adequate awareness of the ethical implications of AI use. Issues such as algorithmic bias, privacy and data protection, misinformation, intellectual property, academic integrity, and the reliability of AI-generated content require critical and ethical judgement beyond technical competence. Thus, the ability to use AI effectively should be distinguished from the ability to use it responsibly and ethically.

Teacher educators, on the other hand, are likely to possess stronger professional and institutional knowledge concerning educational policies, data protection, assessment practices, and principles of fairness and accountability. Nevertheless, the rapid emergence of generative and multimodal AI technologies may create challenges in translating these established principles into specific classroom practices. This suggests a complementary gap: preservice

teachers may possess greater operational familiarity with emerging AI tools, whereas teacher educators may have stronger conceptual and professional grounding but require continued exposure to evolving AI applications. Such a disparity is particularly significant because teacher educators are responsible for preparing future teachers who will influence the adoption and responsible use of AI in school contexts.

The findings further suggest that **AI ethics literacy should be treated as an integral component of teacher professional preparation rather than as an incidental outcome of technology use**. Familiarity with AI tools alone cannot ensure responsible decision-making. Teacher education programmes therefore need to integrate ethical considerations with technological and pedagogical competencies. Authentic educational dilemmas—such as the use of chatbots in student assignments, the use of AI-generated feedback for assessment, protection of student information in cloud-based applications, and the identification of bias or inaccurate AI-generated content—can provide meaningful contexts for developing ethical reasoning and professional judgement.

The significant effect associated with training provides further support for the importance of **structured and targeted curriculum-based interventions** in developing AI ethics literacy. AI ethics knowledge cannot be assumed to develop automatically through exposure to AI technologies or informal self-directed learning. Rather, it requires systematic instruction, critical reflection, and opportunities to apply ethical principles to authentic educational situations. Case studies, scenario-based learning, role-playing, reflective discussions, and collaborative activities involving teacher educators and preservice teachers could provide effective pedagogical approaches for strengthening ethical decision-making.

Overall, the findings emphasise that **AI competence in teacher education must extend beyond technological proficiency to include ethical awareness, critical evaluation, and professional responsibility**. Preparing teachers for AI-integrated classrooms therefore requires programmes that enable future educators not only to use AI tools, but also to critically question their outputs, recognise potential risks, evaluate their educational appropriateness, and guide learners towards responsible and ethical engagement with artificial intelligence.

6. 6. Conclusion

The present study demonstrates the importance of strengthening AI ethics literacy within teacher education. The findings indicate that technological proficiency in using generative AI does not necessarily translate into adequate ethical awareness or responsible decision-making. This highlights the need to develop AI competence as a multidimensional construct encompassing technological knowledge, critical evaluation, ethical reasoning, and professional judgement. AI ethics should therefore be positioned as a core component of teacher preparation rather than as an optional or supplementary area of study. Systematic exposure to ethical principles and authentic AI-related educational dilemmas can enable preservice teachers and teacher educators to make informed decisions regarding the responsible use of AI in teaching, learning, assessment, and educational research.

7. Recommendations

Based on the findings, the following recommendations are proposed:

- **Curricular integration:** B.Ed. and M.Ed. programmes should incorporate structured AI ethics and critical AI literacy content addressing algorithmic bias, data privacy, academic integrity, transparency, responsible prompting, and ethical decision-making.
- **Professional development:** Regular faculty development programmes should be organised to enhance teacher educators' knowledge of emerging AI technologies and their ethical and pedagogical implications.
- **Institutional governance:** Teacher education institutions should establish clear policies and guidelines specifying responsible and acceptable uses of AI in teaching, learning, assessment, and research.
- **Experiential learning:** Case studies, scenario-based activities, role-play, and reflective discussions should be incorporated to develop practical ethical reasoning and decision-making skills.
- **Continuous curriculum review:** AI ethics curricula and institutional guidelines should be periodically reviewed and updated in response to the rapid evolution of AI technologies and emerging ethical concerns.

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PEDAGOGICAL INNOVATIONS AND INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE IN THE ERA OF AI

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Abstract

Innovative teaching methods and strategies in science education play a vital role in boosting student involvement and achieving high academic standards. Recently, there has been a movement towards smart pedagogy, which incorporates features such as adaptability and self-directed learning to better fit the frameworks of smart education and smart classrooms (Uskov et al., 2018). Despite global advancements, certain areas, such as Somaliland, continue to depend on conventional didactic approaches, underscoring the necessity for contemporary teaching methods that promote lifelong learning (Yasin and Kabeta, 2023). Strategies that encourage innovation, such as teaching based on augmentation, have proven effective in enhancing teaching practices by encouraging discussion and critical thinking in science classes (Yılmaz et al., 2017). Educational models are being transformed by technology, particularly AI, which enables personalized and engaging learning experiences, as evidenced by tools such as ChatGPT (Bouriami et al., 2025). Moreover, the integration of flipped classrooms in mathematics education signifies a significant pedagogical shift, enhancing understanding and engagement in STEM fields (Egara et al., 2025). These innovations collectively contribute to a more flexible and dynamic educational environment, better preparing students for future challenges in the fields of science and technology.

Keywords: *Innovative strategies, teaching through augmentation, flipped classroom, educational innovation.*

Introduction

The incorporation of Artificial Intelligence (AI) into educational innovation is profoundly transforming teaching methods by promoting personalized, adaptive learning environments that focus on students in diverse educational settings.

AI technologies, including adaptive learning platforms, intelligent tutoring systems, and analytics tools powered by AI, offer immediate feedback and personalized learning paths, thereby improving the educational experience. AI-driven methods allow educators to customize teaching strategies to meet the distinct needs and preferences of each student, fostering a learner-focused approach that emphasizes engagement and learning efficiency (Mittal et al., 2024; Sumartono et al., 2025).

Supporting pre-service and in-service teacher education to enhance instructional preparation that incorporates ethical judgment and pedagogical reasoning based on AI use is crucial for pedagogical innovation. Teachers can creatively use AI tools while overcoming obstacles such

as content evaluation and school limits when AI-driven instructional activities are incorporated into teacher education. This fosters technological knowledge, pedagogical integration, and ethical awareness. According to these trends, to promote innovation readiness in the AI era, teacher preparation programs should prioritize experiential learning, real tasks, and reflective practices (Gulen & Kucuk, 2026; Wang et al., 2026).

Beyond teaching, AI integration in higher education includes curriculum design, material creation, assessment methods, and increased administrative efficiency. AI supports learning analytics, provides prompt feedback, and simplifies institutional procedures to support sustainable educational practices. Comprehensive use cases for the successful use of AI in higher education, however, are still a developing field that needs further research to guide governance and policy for long-term AI-driven educational models (Labib & Elsabry, 2024).

The impact of AI is especially noticeable in specialized domains such as engineering education, where it makes individualized curriculum design, virtual laboratories, and intelligent coaching possible. By improving accessibility and engagement, the combination of AI with technologies such as big data, cloud computing, and 5G spurs pedagogical innovation. However, to promote inclusiveness and efficacy in AI-based educational initiatives, obstacles pertaining to infrastructure, resistance to change, and equity issues require strategic solutions (Zhang et al., 2024).

In entrepreneurial education, AI serves as both an impetus and a tool for pedagogical innovation, although current student engagement with AI remains limited to a few tools. Theoretical models propose embedding AI more broadly to enhance entrepreneurial learning, underscoring the importance of identifying effective practices and overcoming adoption challenges to maximize AI's educational benefits of AI (Labyad et al., 2024).

Integrating AI with educational theories, such as multiple intelligences, is another advancement. This integration promotes individualized training that fosters creativity and problem-solving skills by using AI-enabled smart interaction technologies (such as speech and image recognition) to monitor and analyze students' abilities in real time. AI-assisted multi-intelligence frameworks offer new opportunities for pedagogical innovation by bridging the gaps between conventional teaching approaches and future workforce demands (Palarimath et al., 2024).

AI integration has also been beneficial for distance learning. In e-learning, blended learning, and mobile learning formats, AI-driven systems support accessibility, flexibility, and personalized learning. However, ongoing optimization is necessary to improve pedagogical efficacy and handle integration issues to fully realize AI's promise in distance learning (Morgado et al., 2005).

Finally, studies on education reveal that AI applications are expanding and changing quickly, with machine learning, learning analytics, and educational data mining being important hotspots. Emerging AI paradigms, explainable AI (XAI) and generative AI, are expanding educational frontiers and fostering ongoing pedagogical innovation by enhancing academic prediction, dropout avoidance, and performance evaluation (Qu & Yang, 2024). Personalized and adaptable learning environments, better teacher preparation, integration into specialized and higher education, improved distance learning modalities, and changing

research trends are all characteristics of AI-driven pedagogical innovation.

Science education has undergone substantial transformation owing to pedagogical innovations and instructional methodologies that embrace technological advances and adjust to the needs of contemporary learners. The use of Active Learning techniques, especially in the AI-driven era, is an important innovation that moves education from a knowledge-centered to a learner-centered paradigm (Bouriami et al., 2025). The incorporation of technologies such as ChatGPT is an example of how technology can encourage student autonomy and customize learning experiences, both of which have a beneficial impact on the quality of education. Pedagogical Link-Making is another fundamental strategy that emphasizes connecting scientific ideas during class discussions.

By identifying three types of link-making and related teaching techniques that enhance comprehension in science classrooms, this approach emphasizes the significance of sociocultural perspectives in science education (Scott et al., 2011). Innovative approaches, such as game-based learning and flipped classrooms, have been acknowledged in health professions education, such as in the teaching of dental materials science. In addition to increasing student participation, these tactics are linked to favorable opinions among students (Lin et al., 2023). Through inclusive leadership techniques, it has been demonstrated that the implementation of flipped classrooms and problem-based learning greatly enhances critical thinking and learning results. This method creates a dynamic and encouraging learning environment that promotes critical thinking and active engagement (Bhuttah et al. 2024). Furthermore, the application of artificial intelligence (AI) to STEM education is a rapidly developing topic that uses AI to support sophisticated analytics, instructional automation and personalized learning. By addressing several issues and enhancing both immediate and long-term learning outcomes, this integration seeks to improve STEM education (Triplett, 2023). Finally, encouraging curiosity has become a key pedagogical approach in science education. In addition to motivating students and improving memory encoding, curiosity fosters exploratory behavior, which increases engagement and improves learning outcomes. The creative use of instructional resources and broad language models, which greatly increase student involvement in science learning, are strategies for promoting curiosity (Hunaepi et al. 2024).

Need for the study

Because scientific education must be more effective, engaging, and inquiry-based, it is essential to study pedagogical innovations and instructional strategies. Traditional methods often fail to foster critical thinking, creativity, and practical problem-solving. Given the speed at which science and technology are developing, educators must use innovative teaching strategies that promote conceptual understanding and active learning in the classroom. Students' interest, excitement, and academic achievement can be enhanced by looking at modern teaching techniques, including project-based learning, flipped classrooms, and STEM integration. This study is essential for identifying best practices, improving learning outcomes, and preparing students to meet the expectations of a society that is becoming increasingly reliant on science.

Theoretical Framework

The study of Pedagogical Innovations and Instructional Strategies in Teaching Science is theoretically grounded in constructivist learning theory, which stresses active knowledge production through experience and interaction. Vygotsky's Social Development Theory, which highlights the significance of the social environment and scaffolding in learning, also informs this method. Additionally, Bruner's Spiral Curriculum and Piaget's Cognitive Development Theory enable age-appropriate inquiry-based education. When combined, these theories encourage innovative methods that foster increased understanding, critical thinking, and scientific literacy through hands-on experiments, collaborative projects, and technology integration. The study and evaluation of instructional techniques that promote the goals of science education in the twenty-first century are guided by this framework.

Review of literature

Nikolaieva, O., Nikolaiev, V., Yanchytska, K., Yuzkiv, H., and Ytvynenko, N. (2023). Modern pedagogical discourse is based on innovative approaches to teaching the humanities and social sciences. Multidisciplinary Science Journal, 5, Innovation in education is critical because it makes it possible to continuously improve the quality and value of educational content. The purpose of this article is to highlight the use of a "innovative environment" in higher education as an important component of instructional discourse. Investigating methods for integrating cutting-edge approaches into the teaching of social sciences and humanities in higher education is still relevant. The results of this study serve as a basis for pedagogical discourse in higher education by demonstrating the benefits of creative approaches in teaching humanities courses.

Manasia, L., and Ciolan, L. (2024). Imagining innovation in higher education: An innovative pedagogical photovoice research. In Higher Education, Active Learning In order to investigate new pedagogical practices in higher education, Ciolan and Manasia's study "Picturing innovation in higher education: A photovoice study of innovative pedagogies" uses photovoice as a participatory research approach. 43 students from a variety of fields participated in the study, which took place over three academic semesters. In order to identify four primary clusters of innovative pedagogies—"Hero Pedagogies," "Community and Solidarity Pedagogies," "Sustainable Green Pedagogies," and "Technology Enhanced Pedagogies"—this method combined photographs and self-authored narratives as data sources and analyzed them using Interpretative Phenomenological Analysis (IPA) and photovoice (Ciolan and Manasia, 2024).

Duschl (2019). Using knowledge with scientific practices, early childhood instructional pathways, teaching experiments in science and mathematics, upper/lower anchors for measuring progress, and concepts & practices are the five domains covered by the paper's introduction and framework for LP research, which also describes its historical development and future research directions. The conclusion discusses more general difficulties that planners, researchers, and teachers encounter with incorporating LP into STEM education.

Martin et al., 2024.The importance of effective pedagogical strategies is echoed in another study proposing the 3C Model to teach coding and computational skills in primary education. This model is crafted to align with students' developmental stages and encourage engagement

through physical computing and digital coding platforms, thereby enhancing CT skills beyond procedural and rote learning.

Kandemir and associates, 2020.Several important elements are highlighted in the literature on the pedagogy of teaching basic text-based programming via the perspective of computational thinking (CT). Kandemir, Kalelioğlu, and Gülbahar's study highlights how theory and practice are intertwined while teaching programming. They offer a pedagogical framework that incorporates programming paradigms, implementation strategies, instructional approaches, and methodologies based on CT ideas.

Yin and colleagues, 2024.Collaborative learning (CL) strategies, which are acknowledged as key approaches in CT education, also promote group work that boosts the effectiveness of CT interventions. Despite the fact that many studies lack detailed descriptions of group compositions, the utilization of diverse CL activities in classrooms emphasizes the significance of collaboration in instruction.

Mills and associates, 2024.Another study examines how coding and CT are incorporated into curricula in various nations, highlighting aspects of educational settings that effectively foster the development of these abilities. It suggests that CT abilities are essential for contemporary education and emphasizes the need for pedagogical frameworks that facilitate interdisciplinary learning in addition to addressing curricular limits.

Research Methodology

In order to investigate the concepts in current discussions of Science for Life: "Pedagogical Innovations and Instructional strategies in Teaching Science in the Era of AI" the methodology for this topic paper entails qualitative research and a systematic review of related literature. A thorough search of academic books, journals, and articles was part of the procedure, and a systematic review was carried out to compile, evaluate, and synthesize the body of knowledge already available on the subject.

Research Objectives

- To investigate how AI tools, such as ChatGPT and intelligent tutoring systems, can be integrated into science teaching to enhance personalized learning, improve student engagement, and optimize instructional methods by tailoring content to individual needs and fostering interactive learning environments (C Gurion et al., 2025; Mishra, 2024; Mustofa et al., 2025).
- To examine the effectiveness of AI-enabled pedagogical strategies in science education, particularly in STEM fields, by assessing their impact on students' cognitive, skill, and affective learning outcomes and flow experiences(Shi et al., 2024; Triplett, 2023).
- To analyze educators' readiness and identify professional development needs for the ethical and efficient implementation of AI-driven instructional tools in science classrooms, with emphasis on building AI literacy and ethical guidelines to balance technology use with maintaining teacher-student interaction and educational propriety (C Gurion et al., 2025; Siddiqui, 2025; Vorobyeva et al., 2025).
- To explore and propose innovative AI-based pedagogical models that support transformative learning, adaptive instruction, and collaborative environments in

science education that also address challenges like algorithmic bias, data privacy, and inclusivity (Siddiqui, 2025; Sumartono et al., 2025).

- To evaluate the technical and ethical challenges of integrating AI technologies in science teaching and learning, including issues of overreliance, content validity, infrastructure, and the need for critical human oversight, with recommendations to harmonize AI innovations with traditional teaching approaches for inclusive and effective science education (C Gurion et al., 2025; Mustofa et al., 2025; Vorobyeva et al., 2025).

Research Questions

1. To recognize and evaluate cutting-edge pedagogical strategies applied to scientific instruction at different educational levels.
2. To assess how well contemporary teaching methods such as inquiry-based learning, flipped classrooms, and project-based learning affect students' conceptual comprehension and interest in science.
3. To assess how scientific learning outcomes are affected by technology-integrated teaching strategies.
4. To investigate the attitudes, readiness, and perceptions of science instructors about the adoption of educational innovations.
5. To evaluate how inclusive teaching methods and customized instruction can help science classrooms accommodate a diverse student body.
6. To assess student accomplishment, motivation, and critical thinking by contrasting new instructional practices with conventional teaching approaches**.**

Discussion and Results

1. To recognize and evaluate cutting-edge pedagogical strategies applied to scientific instruction at different educational levels.

Adaptive learning technologies have significantly enhanced student engagement in science education by offering personalized learning experiences tailored to individual students' needs. These technologies utilize artificial intelligence (AI) and machine learning algorithms to adapt content and pace based on students' progress, learning styles, and interaction patterns, thereby fostering a more engaging and effective educational environment.

One of the primary ways in which adaptive learning technologies enhance student engagement is through personalized feedback and learning pathways. By leveraging AI-driven systems, students receive real-time feedback and are guided through personalized learning journeys that consider their unique strengths and weaknesses. This personalization enables students to engage more deeply with the material, as they are not constrained by the one-size-fits-all approach of traditional teaching methods (Yaseen et al., 2025 ; Zhao et al., 2024).

Moreover, adaptive learning platforms incorporate interactive elements and gamified experiences that further boost students' motivation and involvement. Features such as virtual labs and interactive assignments allow students to apply theoretical concepts in practical scenarios, enhancing both their engagement and understanding. For instance, educational platforms such as Coursera and Khan Academy have been highlighted for integrating such

adaptive technologies to improve accessibility and flexibility in learning, coupled with real-time analytics to provide personalized feedback (Isaeva et al., 2025).

Studies have shown that students exposed to adaptive learning technologies often demonstrate higher engagement levels than those in traditional educational settings. The ability of these systems to cater to individual learning preferences and paces leads to increased motivation and participation in the learning process. In the digital age, these personalized experiences are crucial for maintaining interest and ensuring that students remain invested in their learning journeys (Luo, 2023; Jiao, 2024).

Furthermore, adaptive technologies have been found to enhance educational outcomes by improving engagement and performance. By aligning with students' interests and abilities, these technologies encourage active participation and facilitate better academic achievement. For example, AI-driven systems such as Smart Sparrow and IBM Watson Education have reported higher course completion rates and improved student performance, confirming the powerful role of personalized adaptive learning tools in education (Sari et al., 2024).

In summary, adaptive learning technologies represent a transformative advancement in science education, enhancing student engagement through personalized learning experiences, real-time feedback, and interactive tools that facilitate active learning. These technologies not only bolster motivation and participation but also lead to improved educational outcomes, showcasing their pivotal role in modernizing education and meeting the diverse needs of learners in the digital era.

2. To assess how well contemporary teaching methods such as inquiry-based learning, flipped classrooms, and project-based learning affect students' conceptual comprehension and interest in science.

When integrating adaptive learning technologies into conventional classrooms, educators encounter a number of obstacles. The requirement for sufficient infrastructure to support these technologies is one of the main issues. The complete adoption of adaptive learning platforms is hampered by the unavailability of modern hardware and high-speed Internet in many educational institutions (Bușu, 2024; Denga & Denga, 2024). The need for professional development and teacher training programs is another major obstacle. To successfully include adaptive technologies into their teaching methods, educators must be proficient in their use. However, there are frequently insufficient resources and training programs to give educators the tools they need to effectively use these technologies (Santos et al., 22024; Isaeva et al., 2025).

Concerns about ethics and privacy present serious difficulties as well. In order to give students individualized learning experiences, adaptive learning technologies gather enormous volumes of student data. This brings up concerns about the security and privacy of student data. To protect student data, educators must make sure these systems adhere to ethical and legal requirements (Akavova et al., 2023). It is very difficult to guaranty fair access to this technology. The digital divide may get wider if students from different socioeconomic backgrounds have varying degrees of access to technology outside of the classroom. The learning outcomes anticipated from the deployment of adaptive learning technology in conventional classroom settings may be impacted by this inequality (Denga and Denga, 2024;

Santos et al., 22024).

Ultimately, even while adaptive learning technologies have a lot to offer in terms of enhancing student engagement and personalizing instruction, their effective incorporation in traditional classrooms depends on finding solutions to these problems. Educators and institutions must focus on infrastructure development, teacher training, privacy guaranties, and equitable access if they are to fully exploit the potential of adaptive learning technology in education.

In order to support adaptive learning technologies, schools can improve their technology infrastructure in a variety of important ways. In order to protect student privacy, schools must first ensure that their infrastructure is ready, which includes modernizing equipment, ensuring reliable Internet connectivity, and implementing robust security measures. The deployment of adaptive learning platforms may be hampered by technical limitations or security risks in the absence of these essential elements (Singh and Kaunert, 2024; Sari et al., 2224). Another essential element is the integration of cloud-based technology, such as Learning Management Systems (LMS) and AI-driven analytics, which enable customized learning experiences and provide teachers with insights on students' progress.

Real-time feedback and the scalable and adaptable deployment of instructional technologies are made possible by cloud integration (Venice et al., 2024). To guaranty that teachers are sufficiently prepared to employ adaptive learning technologies, schools should also prioritize teacher training and ongoing professional development. The potential benefits for pupils would be limited if teachers lacked the necessary training to incorporate these tools into their lesson plans (Isaeva et al., 2025). Ensuring that every student has an equal opportunity to benefit from these technologies is another crucial tactic for resolving equity and access challenges. This entails initiatives to close the digital divide, especially for disadvantaged students who might not have access to devices or internet connectivity (Mulenga and

By providing individualized educational content that suits each student's needs and learning preferences, investing in adaptive learning platforms that include AI and machine learning will further improve personalization and engagement. AI solutions can improve learning outcomes and engagement by automating administrative activities, provide real-time feedback, and producing thorough progress reports (Akavova et al., 22023; Yaseen et al., 2025). Lastly, institutions will be able to continuously maximize their usage of adaptive learning systems by implementing a strategic approach to managing these technologies, which includes continuous evaluation and iterative development. The likelihood of effective adoption and integration can be increased by involving stakeholders in the planning and implementation process, such as educators, students, and parents (Sajja et al., 22024; Singh and Kaunert, 2024).

3. To assess how scientific learning outcomes are affected by technology-integrated teaching strategies.

Schools can enhance their technology infrastructure in a number of important ways to support adaptive learning technologies. Schools must first make sure that their infrastructure is ready, which entails updating gear, guaranteeing dependable internet access, and putting strong security measures in place to safeguard student privacy. In the absence of these fundamental components, technical constraints or security threats could impede the implementation of

adaptive learning platforms (Singh and Kaunert, 2024; Sari et al., 2224). The integration of cloud-based solutions, such Learning Management Systems (LMS) and AI-driven analytics, which allow individualized learning experiences and give teachers insights into students' progress, is another crucial component.

Real-time feedback and the scalable and adaptable deployment of instructional technologies are made possible by cloud integration (Venice et al., 2024). In order to guaranty that teachers are adequately prepared to employ adaptive learning technologies, schools should also prioritize teacher training and ongoing professional development. Teachers may find it difficult to incorporate these tools into their lesson plans without the right training, which would restrict the potential advantages for students (Isaeva et al., 2025). Ensuring that every student has an equal opportunity to benefit from these technologies is another crucial way to address equity and access challenges. This includes initiatives to close the digital gap, especially for students from disadvantaged backgrounds who might not have access to the gadgets they need or internet connectivity (Mulenga and Shilongo, 2024; Dagunduro et al., 2024).

By providing individualized educational content that suits each student's needs and learning preferences, investing in adaptive learning platforms that include AI and machine learning will further improve personalization and engagement. AI solutions can improve learning outcomes and engagement by automating administrative activities, provide real-time feedback, and producing thorough progress reports (Akavova et al., 2022023; seen et al., 2025). Lastly, institutions will be able to continuously maximize their usage of adaptive learning systems by implementing a strategic approach to managing these technologies, which includes continuous evaluation and iterative development. The likelihood of effective adoption and integration can be increased by involving stakeholders in the planning and implementation process, such as parents, teachers, and students (Sajja et al., 2024; Singh and Kaunert, 2024).

4. To investigate the attitudes, readiness, and perceptions of science instructors about the adoption of educational.

Schools should emphasize updating its hardware infrastructure, concentrating on reliable devices, quick and dependable Internet connectivity, and interactive displays, in order to successfully adopt adaptive learning technology. In particular, investing in interactive whiteboards or projectors, providing high-speed internet with robust Wi-Fi coverage, and updating to tablets or laptops with touchscreens can greatly improve the learning experience and enable individualized learning.

1. **Devices**

• Tablets or laptops with touchscreens: Students can connect with adaptive learning platforms and content with ease thanks to these devices' portability and user-friendly interface. For some adaptive learning apps, like interactive activities and sketching, touchscreen capabilities is essential.

• Device Specifications: Verify that devices have enough memory, processing power, and storage to meet the needs of multimedia material and adaptive learning software. • Durability and Battery Life: To reduce interruptions during classes, select gadgets that can endure the rigors of regular classroom use and have a long battery life.

2. Access to the Internet:

• High-Speed Internet Access: To access adaptive learning platforms, watch instructional videos, and download educational materials, you need a fast and dependable Internet connection.

• Strong Wi-Fi Coverage: To enable several devices to connect at once, schools should make sure that all classrooms and common areas have strong Wi-Fi coverage.

• Examine Backup possibilities: In the event of a primary internet outage, look into backup internet connectivity possibilities.

3. Interactive Visuals:

• Interactive whiteboards or projectors: Teachers can use these tools to support collaborative learning activities and dynamically deliver adaptive learning information.

• Take Resolution and Brightness into Account: For good material visibility, especially in well-lit classrooms, make sure the display has high resolution and brightness.

• Touchscreen Functionality: Touchscreen-equipped interactive whiteboards increase student engagement and enable direct interaction with the course content.

4. Accessory Equipment:

• Headsets: Give students headsets for interactive sessions and audio-based learning exercises.

• Digital Pens: Digital pens can improve students' natural writing and drawing experiences whether they use tablets or interactive whiteboards.

• Printers: Make sure there are printers available so that worksheets, tests, and other educational resources may be printed.

5. Future-Proofing

• Scalability: Select hardware that can be readily expanded to handle future student enrollment increases or the introduction of new adaptive learning technologies.

• Accessibility: To help students with impairments, make sure hardware is compatible with assistive technology.

• Integration with Current Systems: Take into account how new hardware will work with the school's current learning management system and IT infrastructure.

Conclusion

In conclusion, pedagogical innovations and instructional techniques are critical to improving scientific education. In order to provide a more stimulating and productive learning environment, pedagogical innovations and instructional strategies in scientific education are varied and include the use of cutting-edge technologies, active learning techniques, and curiosity-driven approaches. Although these tactics differ in their particular applications and settings, they all aim to improve student involvement, learning procedures, and academic results. Teachers can foster students' critical thinking, increased comprehension, and active engagement by going beyond traditional methods.

Inquiry-based learning, using digital tools like AI, and group projects are creative ways to make science more relevant and approachable. Effective teaching strategies increase academic achievement while satisfying a range of learning needs. Adopting these innovations requires flexibility, continuous teacher training, and institutional support. Innovative education is

eventually necessary to produce future students who are scientifically literate and capable of problem-solving.

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ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN EDUCATION: REIMAGINING TEACHING, LEARNING, ASSESSMENT AND THE ROLE OF THE TEACHER

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Abstract

Artificial Intelligence (AI) has emerged as one of the most influential technological developments shaping contemporary education. Its evolution from intelligent tutoring systems, adaptive learning environments and automated assessment to generative artificial intelligence (GenAI), large language models and multimodal AI has created new possibilities for teaching and learning. At the same time, the rapid diffusion of AI has raised fundamental questions concerning pedagogy, teacher agency, learner autonomy, assessment validity, academic integrity, equity, privacy and the purpose of education. This review paper examines the changing relationship between artificial intelligence and pedagogical innovation, with particular attention to personalized learning, intelligent tutoring, AI-supported content creation, adaptive feedback, collaborative learning, inquiry-based learning, assessment and learning analytics. The paper adopts a conceptual narrative review approach and synthesizes findings from major scholarly reviews, recent empirical literature and international policy documents. The literature indicates that AI can facilitate differentiated instruction, provide immediate and personalized feedback, support learner engagement, assist teachers in instructional planning, and expand opportunities for flexible and individualized learning. Recent experimental evidence also suggests that appropriately designed ChatGPT-supported interventions can improve academic performance, affective-motivational outcomes and higher-order thinking propensities, although methodological limitations require cautious interpretation. At the same time, excessive dependence on AI may weaken learner agency, encourage superficial engagement and create new forms of academic misconduct. The paper argues that the educational value of AI does not reside primarily in the technology itself but in the quality of pedagogical design surrounding its use. A human-centred pedagogical framework is therefore proposed in which AI functions as an augmentation technology rather than a replacement for teachers. The paper concludes that the future of AI-enabled education should be guided by pedagogical purpose, human agency, ethical responsibility, inclusion, critical thinking and continuous teacher professional development.

Keywords: *Artificial Intelligence, Generative AI, Pedagogical Innovation, Personalized Learning, AI in Education, Intelligent Tutoring Systems, Teacher Role, Assessment, Higher Education, Human-Centred Education*

1. Introduction

Education has historically evolved in response to changes in society, knowledge, technology and the workplace. The emergence of Artificial Intelligence (AI) represents a particularly significant transformation because AI is not simply another medium for delivering educational content. Unlike conventional educational technologies, AI can analyse learner data, generate content, provide feedback, recognize patterns, adapt learning pathways and increasingly participate in natural-language interaction with teachers and students. Consequently, AI has the potential to influence not only the delivery of instruction but also the fundamental

pedagogical processes through which teaching and learning are designed.

Artificial Intelligence in Education (AIEd) is not a completely new phenomenon. Intelligent tutoring systems, adaptive learning environments, automated essay scoring, learner profiling, recommendation systems and predictive analytics have been investigated for several decades. A major systematic review by Zawacki-Richter et al. (2019), for example, identified four broad areas of AI application in higher education: profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems. However, the review also identified limited engagement with pedagogical theory and a relatively weak presence of educators in the research literature.

The arrival of generative AI has substantially changed this landscape. The public release of ChatGPT in late 2022 transformed AI from a relatively specialized educational technology into a widely accessible tool capable of generating text, explanations, questions, lesson ideas, summaries, examples, computer code and other forms of educational content. UNESCO observed that the rapid development of publicly available GenAI was occurring faster than the development of regulatory frameworks and institutional preparedness, thereby requiring a human-centred approach to its educational use.

The educational implications are profound. AI can potentially help teachers differentiate instruction, provide formative feedback, generate learning resources and analyse student performance. Students can use AI as a conversational tutor, writing assistant, brainstorming partner, language-support tool and source of alternative explanations. However, the same technology can produce inaccurate information, reinforce bias, compromise privacy, facilitate academic dishonesty and encourage students to outsource cognitive effort.

The central issue, therefore, is not whether AI should enter education. It has already entered educational systems. The more important question is how AI can be integrated into pedagogically meaningful, ethically responsible and human-centred educational practices. This review examines that question by analysing the emerging relationship between AI and pedagogical innovation.

2. Conceptualizing Artificial Intelligence in Education

Artificial Intelligence refers broadly to computational systems capable of performing tasks associated with human cognitive processes, including learning, reasoning, prediction, language processing, pattern recognition and decision-making. In educational settings, AI encompasses a diverse family of technologies rather than a single technological system.

AI in education can include machine-learning algorithms, intelligent tutoring systems, adaptive learning platforms, automated assessment, recommendation systems, learning analytics, natural-language processing, computer vision, speech recognition, generative AI and large language models.

The pedagogical significance of these technologies lies in their ability to alter relationships among the learner, teacher, content and learning environment. Traditional instructional systems tend to provide relatively standardized content and activities to groups of learners. AI-supported environments can potentially modify content, sequence, feedback and difficulty according to learner characteristics and performance.

Generative AI introduces another dimension because it can produce new educational artefacts

rather than merely classify or predict learner behaviour. Large language models can generate explanations, examples, questions, summaries and feedback in response to natural-language prompts. Kasneci et al. (2023) argued that large language models can support educational content creation, interaction, engagement and personalized learning, while simultaneously requiring new forms of AI literacy, critical thinking and fact-checking. Thus, AI should be understood not merely as an instructional tool but as a pedagogical infrastructure capable of influencing how educational experiences are designed.

3. Evolution from Educational Technology to AI-Enabled Pedagogy

The development of AI-enabled pedagogy can be understood as a progression through several stages. The first stage involved computer-assisted instruction, in which computers delivered predetermined instructional materials and exercises. The second stage introduced intelligent tutoring and adaptive systems capable of responding to learner performance. The third stage involved learning analytics and predictive systems that used educational data to identify patterns, predict performance and support institutional decision-making. The fourth and current stage is characterized by generative and conversational AI. Unlike earlier systems, generative AI allows learners and teachers to interact with AI using natural language and receive dynamically generated responses.

This transition represents a movement from technology-mediated instruction toward technology-supported pedagogical dialogue. Recent systematic reviews demonstrate the rapid expansion of research in this area. Yusuf et al. (2024) mapped 407 publications on generative AI in education and research and identified major themes including applications and impacts, ethical implications, perspectives and experiences, adoption, performance and intelligence. Their review also conceptualized GenAI as a tool for pedagogical enhancement, professional development, writing assistance, productivity and interdisciplinary learning. This rapid expansion indicates that AI is no longer being investigated exclusively as a technical innovation. Increasingly, researchers are examining how it can be integrated into pedagogical processes.

4. AI as a Catalyst for Pedagogical Innovation

Pedagogical innovation refers to meaningful changes in teaching and learning practices designed to improve educational processes and outcomes. AI can support pedagogical innovation by expanding teachers' capacity to design differentiated, interactive, adaptive and data-informed learning experiences.

However, technological adoption does not automatically constitute pedagogical innovation. Simply asking students to use ChatGPT for an assignment is not necessarily innovative pedagogy. Genuine innovation occurs when AI enables learning experiences that are more personalized, inquiry-oriented, collaborative, reflective, creative or authentic than conventional approaches. The literature suggests several major areas of pedagogical transformation.

4.1 Personalized and Adaptive Learning

One of the most established applications of AI in education is personalized learning. AI systems can analyse learner performance and recommend activities, resources or learning pathways based on individual needs.

Adaptive learning systems can modify the difficulty, sequence or type of instructional material in response to learner performance. This can potentially address one of the central limitations of mass education: the assumption that learners in the same classroom require identical instructional experiences.

A systematic review by Bayly-Castaneda et al. (2024), examining 78 studies published between 2019 and 2024, found that research on AI-mediated personalized learning was predominantly situated in higher education and that adaptive learning technologies remained prominent, while interest in generative language models was increasing.

Personalization may involve: adaptive content sequencing; individualized practice activities; personalized explanations; automated feedback; learning-resource recommendations; early identification of learning difficulties; and personalized learning pathways.

Nevertheless, personalization should not be equated with algorithmic individualization alone. Meaningful personalization requires consideration of learners' interests, cultural contexts, social relationships, motivations and developmental needs. Therefore, the appropriate pedagogical principle is personalization with human interpretation, rather than personalization through algorithmic automation alone.

5. AI-Supported Intelligent Tutoring

Intelligent Tutoring Systems (ITS) represent one of the earliest and most developed applications of AI in education. These systems attempt to reproduce selected functions of human tutoring by diagnosing learner performance, providing explanations, presenting tasks and adapting instructional sequences.

Traditional classroom instruction is constrained by teacher workload. A teacher may have limited time to provide individualized feedback to every learner. AI-based tutoring systems can potentially provide immediate assistance outside normal classroom hours.

Generative AI has expanded the possibilities of intelligent tutoring because students can interact conversationally rather than selecting from predetermined options. A learner can request an alternative explanation, ask for an example, identify a misconception or request progressively more difficult questions.

The pedagogical value of conversational tutoring, however, depends upon the quality of interaction. If AI simply provides answers, it may reduce cognitive effort. If it asks probing questions, offers scaffolding and encourages students to explain their reasoning, it can potentially promote deeper learning. Thus, the distinction between AI as answer provider and AI as cognitive scaffold is pedagogically important.

6. AI and Constructivist Learning

Constructivist theories emphasize active knowledge construction rather than passive reception. From this perspective, AI can support constructivist pedagogy when learners use it to investigate problems, compare explanations, test ideas and construct knowledge.

For example, instead of asking an AI system to write an essay, a teacher might ask students to:

1. formulate an initial argument;
2. generate an AI response;
3. identify factual weaknesses;
4. compare the AI response with scholarly sources;

5. revise their argument;
6. justify the revisions; and
7. reflect on the limitations of AI.

Such a design transforms AI from a substitute for student thinking into an object and instrument of critical inquiry. This approach is consistent with recommendations that AI integration should emphasize critical thinking and fact-checking rather than uncritical dependence on AI-generated responses. AI can therefore contribute to constructivist learning when it is embedded within activities involving questioning, verification, comparison, reflection and knowledge construction.

7. AI and Inquiry-Based Learning

Inquiry-based learning requires students to formulate questions, investigate evidence, develop explanations and communicate conclusions. Generative AI can function as a starting point for inquiry by helping students generate research questions, identify alternative perspectives or simulate different viewpoints. However, AI-generated information should itself become an object of investigation.

For example, students studying environmental education may ask an AI system to explain climate change. They can subsequently compare the response with scientific reports and peer-reviewed literature, identify omissions and inaccuracies, and construct a revised evidence-based explanation.

Such activities promote an important contemporary competence: AI-mediated information literacy. In the emerging educational environment, students must not only know how to obtain information but also evaluate how information is generated, verify its reliability and recognize the limitations of algorithmically produced content.

8. AI and Collaborative Learning

At first glance, AI may appear to encourage individual rather than collaborative learning. However, pedagogically designed AI activities can support collaboration.

Groups can use AI to generate competing solutions to a problem and then critically evaluate them. Students can assign different roles to members of a group, such as evidence verifier, argument evaluator, ethical critic and content developer.

AI can therefore become a collaborative intellectual resource rather than a replacement for peer interaction. The teacher's responsibility is to ensure that AI does not eliminate the social dimension of learning. Human dialogue, negotiation, empathy, communication and collective problem-solving remain essential educational outcomes.

9. AI and Differentiated Instruction

Differentiated instruction requires teachers to respond to differences in learners' readiness, interests and learning needs. AI can support differentiation by rapidly generating multiple versions of instructional materials.

A teacher can potentially request: a simplified explanation for learners requiring additional support; an advanced explanation for high-achieving learners; examples connected to local contexts; multilingual explanations; practice questions at different cognitive levels; and alternative representations of difficult concepts.

This may reduce some of the preparation burden associated with differentiated instruction.

Nevertheless, teachers must evaluate AI-generated resources before classroom use. AI-generated content can contain factual inaccuracies, cultural assumptions or inappropriate levels of complexity. Consequently, AI should be considered a teacher productivity and differentiation assistant, not an autonomous curriculum designer.

10. AI and Feedback

Feedback is a central component of formative assessment. Effective feedback helps learners understand where they are, where they need to go and how to improve. AI can provide rapid feedback on writing, problem-solving, language use and other forms of student work. This creates opportunities for iterative learning in which students revise their work multiple times.

However, automated feedback may be superficial if it focuses primarily on grammatical correctness or surface-level features. Educationally valuable feedback should address reasoning, conceptual understanding, argument quality and disciplinary standards.

A productive model is therefore:

Student work → AI-supported feedback → Student interpretation → Revision → Teacher feedback → Reflection

Rather than: Student work → AI correction → final answer

The first model preserves learner agency and encourages metacognition.

11. AI and Creativity

One of the most debated questions concerns whether generative AI enhances or undermines creativity.

AI can support divergent thinking by producing multiple possibilities, examples, analogies and alternative approaches. Students can use AI for brainstorming, scenario generation and design ideation. However, creativity requires more than producing many outputs. It involves originality, judgement, contextual relevance and purposeful transformation.

If students accept AI-generated ideas without modification, AI may produce homogenization rather than creativity. Therefore, teachers should require learners to explain: what the AI generated; which ideas they accepted; which ideas they rejected; why they modified particular suggestions; and what original contribution they made. The pedagogical objective should be creative augmentation, not creative substitution.

12. AI and Higher-Order Thinking

A major concern surrounding AI is its potential influence on higher-order cognitive skills. If students routinely use AI to generate answers, summarize readings or complete assignments, they may reduce opportunities for independent reasoning. On the other hand, carefully designed AI-mediated activities can require students to evaluate, critique, synthesize and improve AI-generated material.

Recent experimental evidence provides encouraging but qualified findings. Deng et al. (2024) conducted a systematic review and meta-analysis of 69 experimental studies and reported that ChatGPT interventions were associated with improvements in academic performance, affective-motivational states and higher-order thinking propensities. However, the authors also identified methodological limitations and called for stronger assessments, longitudinal research and objective measures of higher-order thinking.

This finding suggests that the educational impact of AI is not determined simply by whether

students use it. Rather, the design of the learning activity determines whether AI supports or replaces higher-order thinking.

13. AI and Assessment Innovation

Assessment is perhaps the area most significantly disrupted by generative AI. Traditional take-home essays and conventional written assignments can increasingly be completed with AI assistance. Consequently, educators must reconsider the relationship between assessment and learning.

AI creates an opportunity to shift from predominantly product-oriented assessment toward process-oriented and authentic assessment.

Potential assessment innovations include: oral examinations; project-based assessment; portfolios; demonstrations; reflective journals; viva voce examinations; classroom-based problem solving; iterative drafts; process documentation; AI-use disclosure statements; and evaluation of students' ability to critique AI-generated content.

The objective should not be to create an endless technological competition between AI generation and AI detection. Instead, assessment should focus on competencies that require meaningful learner participation.

A student's ability to explain, defend, apply, critique and transfer knowledge becomes increasingly important.

14. AI, Academic Integrity and Assessment Validity

Generative AI has created significant challenges for academic integrity. Students can potentially use AI to generate essays, answer questions or complete assignments without demonstrating the intended learning outcomes.

A recent systematic review of GenAI and academic integrity in higher education identified both educational opportunities and risks, particularly concerning academic dishonesty, while emphasizing the need for AI literacy, responsible use and institutional policies.

However, the problem should not be reduced to cheating.

The emergence of generative AI challenges educators to reconsider what constitutes authentic academic work. If an assessment can be completed successfully without the student possessing the intended knowledge or skill, the assessment itself may require redesign. Thus, AI creates not merely an integrity problem, but an assessment design problem.

15. Transformation of the Teacher's Role

One of the most important pedagogical implications of AI concerns the changing role of teachers. Early discussions sometimes presented AI as a potential replacement for teachers. Contemporary educational perspectives increasingly emphasize augmentation rather than replacement. UNESCO's guidance promotes a human-centred approach to GenAI, emphasizing human agency, ethical safeguards, privacy, inclusion and pedagogical validation.

The teacher's role is likely to evolve from primarily transmitting information toward: learning designer; facilitator; mentor; discussion leader; evaluator; ethical guide; learning diagnostician; AI-literacy educator; and curator of reliable knowledge.

AI may be capable of producing explanations, but teachers understand learners within social and cultural contexts. Teachers recognize emotional needs, classroom relationships, motivation, developmental differences and ethical considerations. Therefore, AI may automate

selected tasks, but it cannot simply automate the professional identity of the teacher.

16. AI and Teacher Professional Development

Successful AI integration requires substantial teacher professional development. Teachers need more than technical training. They require pedagogical AI literacy.

Such literacy should include understanding:

1. fundamental AI concepts;
2. capabilities and limitations of generative AI;
3. prompt design;
4. AI-supported instructional planning;
5. AI-supported assessment;
6. data privacy;
7. algorithmic bias;
8. academic integrity;
9. copyright and intellectual property;
10. responsible AI use; and
11. methods for evaluating AI-generated educational resources.

UNESCO has developed AI competency frameworks for both teachers and students, reflecting the growing recognition that AI literacy must become part of educational capacity-building. Professional development should therefore move beyond workshops on "how to use ChatGPT" toward sustained development of AI-informed pedagogical judgement.

17. AI, Inclusion and Equity

AI has significant potential for inclusive education. Speech recognition, text-to-speech, translation, adaptive interfaces, automated captioning and personalized content can support learners with diverse needs. AI may also help reduce language barriers by providing explanations and translations in multiple languages. However, AI can simultaneously reproduce or intensify educational inequalities. Students with better devices, connectivity, digital literacy and access to premium AI systems may gain advantages over students without those resources. Algorithmic bias is another concern. AI systems are trained on data that may inadequately represent particular linguistic, cultural or social groups.

Therefore, AI-enabled inclusion requires attention to: affordability; accessibility; multilingualism; culturally responsive content; assistive technologies; disability inclusion; digital infrastructure; and algorithmic fairness. UNESCO specifically identifies inclusion, equity, gender equality, linguistic and cultural diversity and human agency as issues that must be protected in the educational use of GenAI.

18. Major Findings from the Reviewed Literature

The review indicates several broad patterns.

1. AI has moved from specialized intelligent tutoring and adaptive systems toward mainstream generative and conversational applications.
2. Personalization remains one of the strongest educational applications of AI. However, effective personalization requires human interpretation and contextual sensitivity.
3. Recent evidence indicates potential positive effects of ChatGPT-supported interventions on academic performance, affective-motivational outcomes and higher-

order thinking, although methodological limitations mean that these findings should not be interpreted as proof that unrestricted AI use improves learning.

4. The literature increasingly recognizes that AI creates significant ethical, academic-integrity and equity challenges.
5. Systematic reviews continue to identify gaps in empirical evidence, particularly concerning long-term effects, school education, cultural contexts and theoretically grounded pedagogical applications. Yusuf et al. (2024), for example, identified limited K–12 research and limited experimental evidence in the GenAI literature.
6. Teacher preparation remains critical. Earlier AIEd research was dominated by technical disciplines and often insufficiently connected with pedagogical theory, suggesting that educational researchers and teacher educators must play a stronger role in shaping AI adoption.

19. Implications for Teachers

1. Teachers should not approach AI simply as a technological competency. They should develop the capacity to make pedagogical decisions about when, why and how AI should be used.
2. Teacher education programmes should include AI-supported lesson planning, AI literacy, assessment redesign, prompt literacy, verification of AI-generated content, academic integrity, data ethics and inclusive AI practices.
3. Teachers should also model responsible AI use. Rather than banning AI completely or allowing unrestricted use, educators can establish transparent classroom norms concerning acceptable and unacceptable uses.
4. Most importantly, teachers should retain professional judgement over curriculum, pedagogy, assessment and student welfare.

20. Implications for Teacher Education Institutions

Teacher education institutions have a particularly important role because today's student teachers will become tomorrow's mediators of AI-enabled learning.

Teacher education curricula should therefore incorporate AI across multiple areas rather than treating AI as an isolated elective.

For example:

Educational Psychology: AI, cognition and learner autonomy.

Educational Technology: AI tools and instructional design.

Assessment: AI-supported formative assessment and authentic assessment.

Inclusive Education: AI-supported accessibility.

Research Methodology: AI-assisted research alongside research ethics.

Professional Development: AI competency and lifelong learning.

Educational Management: AI governance and institutional policy.

This multidisciplinary integration can prepare future teachers for educational environments in which AI is increasingly embedded.

21. Implications for Educational Policy

Educational policy should establish a balance between innovation and protection.

Institutions require clear guidelines concerning privacy, academic integrity, intellectual

property, age-appropriate AI use, accessibility and responsible implementation.

However, excessive regulation may prevent beneficial experimentation. Policies should therefore be sufficiently flexible to accommodate technological change.

UNESCO recommends coherent policy frameworks based on human-centred principles, while the U.S. Department of Education similarly emphasizes human capacity and responsible integration in its discussion of AI and the future of teaching and learning.

For India, AI policy should additionally address multilingualism, regional diversity, infrastructure disparities and the professional development of teachers.

22. Research Gaps and Future Directions

The existing literature provides strong evidence of rapid research growth, but several important gaps remain.

1. More longitudinal studies are required. Many current studies examine short-term interventions, whereas the effects of sustained AI use on learning habits, motivation and cognitive development remain insufficiently understood.
2. More research is required at the school level. Recent systematic mapping indicates that K–12 research remains comparatively limited.
3. Future studies should investigate AI use across diverse cultural and linguistic contexts. Much of the current literature is concentrated in technologically developed settings.
4. Stronger experimental designs are needed. Future studies should include adequate sample sizes, control groups, validated instruments and objective learning outcomes.
5. Research should examine teacher-AI collaboration rather than focusing exclusively on student use.
6. Assessment research must explore new models capable of evaluating learning in an environment where generative AI is readily available.
7. Greater attention should be given to student well-being, cognitive dependence, digital fatigue and the psychological effects of continuous AI interaction.
8. Future research should move beyond the question of whether AI "works" toward the more meaningful question:

23. Conclusion

Artificial Intelligence is reshaping the educational landscape by introducing new possibilities for personalization, intelligent tutoring, feedback, content creation, assessment, learning analytics and collaborative inquiry. The emerging evidence indicates that AI can contribute positively to learning when it is deliberately integrated into well-designed pedagogical practices. However, AI should not be viewed as an autonomous solution to educational challenges. The quality of AI-enabled education ultimately depends upon curriculum design, teacher expertise, learner agency, institutional policy and ethical governance. The most significant pedagogical transformation is therefore not the replacement of teachers by AI but the emergence of a new form of human-AI educational partnership. Teachers may increasingly use AI to reduce routine workload, generate instructional alternatives, analyse learning data and provide differentiated support. Students may use AI as a tutor, brainstorming partner, feedback mechanism and inquiry resource. Yet human beings must continue to determine educational purposes, evaluate knowledge, exercise judgement and cultivate values. The

future of education should consequently not be framed as AI versus teachers. The more productive question is how teachers, learners and AI can work together to create richer, more inclusive, intellectually demanding and ethically responsible learning environments. A human-centred approach is particularly important because the ultimate purpose of education extends beyond information acquisition. Education develops judgement, creativity, empathy, critical thinking, social responsibility, ethical reasoning and the capacity to participate meaningfully in society. AI can support these purposes, but it cannot define them.

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A SYSTEMATIC REVIEW OF GENERATIVE ARTIFICIAL INTELLIGENCE TOOLS IN EDUCATION

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Abstract

Generative Artificial Intelligence (GenAI) has rapidly emerged as a significant technological development in education, particularly following the public release of ChatGPT in late 2022. Tools based on large language models and multimodal generative systems are increasingly being used for tutoring, content generation, feedback, assessment support, language learning, lesson planning, programming, research assistance, and personalized learning. This systematic review synthesizes recent research on the applications, educational benefits, limitations, ethical issues, and implementation requirements associated with generative artificial intelligence tools in education. The review draws particularly on systematic reviews and meta-analyses published since the emergence of contemporary GenAI tools, including research examining ChatGPT, broader GenAI applications, higher education, K–12 education, and student learning outcomes. Existing evidence indicates that GenAI can support academic performance, motivation, higher-order thinking, accessibility, feedback, and teaching productivity when integrated through appropriate pedagogical scaffolding. The review argues that educational value depends less on the mere availability of GenAI tools than on how they are pedagogically designed, supervised, evaluated, and embedded within curriculum and assessment. A human-centred approach involving AI literacy, transparent institutional policies, privacy protection, teacher professional development, assessment redesign, and continuous evaluation is therefore recommended.

Keywords: *ChatGPT; artificial intelligence in education; systematic review; AI literacy; personalized learning*

Introduction

Artificial Intelligence (AI) has progressively transformed educational technologies, but the emergence of generative artificial intelligence represents a particularly significant development. Unlike conventional educational AI systems that primarily classify, predict, recommend, or automate predefined processes, GenAI systems can generate new text, images, computer code, audio, video, and other forms of content in response to natural-language instructions. The release of ChatGPT in 2022 substantially lowered the technical barrier to interacting with large language models and accelerated the adoption of generative AI within educational contexts. Recent research consequently describes GenAI as a technology with potentially transformative implications for teaching, learning, assessment, and academic work.

Background of the study

Generative Artificial Intelligence in Education

GenAI refers to computational systems capable of producing novel content based on patterns learned from large datasets. In education, the most visible applications have involved large language models, but the broader GenAI ecosystem includes text, image, audio, video, code, and multimodal generation.

The educational significance of these technologies lies not simply in their ability to generate content but in their capacity to interact with learners and teachers through conversational interfaces. This creates opportunities for individualized explanations, iterative feedback, dialogue-based learning, and rapid content creation.

Major Categories of Educational GenAI Tools

The literature can broadly categorize GenAI tools according to their principal educational functions:

Category	Educational applications
Conversational/LLM tools	**Tutoring, explanations, brainstorming, question answering**
Writing-generation tools	**Drafting, editing, summarization, paraphrasing**
AI feedback tools	**Formative feedback, language correction, revision support**
Image-generation tools	**Visual learning materials, illustrations, design projects**
Code-generation tools	**Programming assistance, debugging, code explanation**
Presentation/content tools	**Lesson materials, slides, instructional resources**
Multimodal GenAI	**Text-image interaction, visual analysis, multimedia learning**
Research-oriented tools	**Literature discovery, summarization, research assistance**
Language-learning tools	**Conversation practice, translation, vocabulary and writing support**

Importantly, the educational effectiveness of these categories depends on instructional context. A tool used as an unsupervised replacement for student reasoning may have very different consequences from the same tool used as a scaffold followed by independent performance.

Objectives of the study:

- To synthesize the emerging evidence concerning generative artificial intelligence tools in education
- To identify the benefits and challenges of Generative artificial intelligence tools in learning outcomes.

Literature Review:

Deng et al. (2025) conducted a systematic review and meta-analysis of experimental studies examining whether ChatGPT improves student learning. The researchers identified **69 studies published between 2022 and 2024**. The studies were predominantly conducted at the university level and covered several subject areas, with language education receiving considerable attention. The findings showed that ChatGPT interventions generally improved **academic performance, affective-motivational outcomes, and higher-order-thinking propensities**. However, ChatGPT also reduced students' mental effort, while no significant effect was found on self-efficacy. The researchers emphasized the need for longer-term studies, objective measures of higher-order thinking, adequate sample sizes, and assessments that require students to demonstrate skills rather than simply produce answers. This study is highly relevant because it provides experimental evidence rather than relying solely on students' perceptions of GenAI.

Chen and Cheung (2025) conducted a systematic review and meta-analysis examining the effects of GenAI on university students' learning outcomes. Their findings indicate that GenAI

can positively influence **language skills, academic achievement, affective-motivational outcomes, and higher-order thinking**. However, the study found no significant overall effect on metacognition. The researcher also examined contextual factors influencing GenAI's effectiveness. The findings are significant to the present study because they demonstrate that GenAI may improve several learning outcomes while simultaneously raising questions about students' ability to regulate and monitor their own learning.

Jin and Sercu (2025) systematically reviewed **21 experimental studies** involving ChatGPT interventions in higher education. Their review found that research was concentrated particularly in **language and STEM disciplines**. Two broad intervention types were identified: **task assistance** and **general learning support**. ChatGPT was generally effective in supporting knowledge acquisition, but its effects on skills development were more variable. Interestingly, medium-term interventions produced more promising results, whereas short-term effects were limited and long-term outcomes were mixed. This study suggests that the duration and design of an AI-supported intervention may be important determinants of educational effectiveness.

Chen et al. (2025) conducted a systematic review and meta-analysis examined the effect of ChatGPT on student engagement. The researchers screened 766 articles and included 17 empirical studies involving 1,735 students. The findings indicated a medium overall effect of ChatGPT-based learning on student engagement. Positive effects were identified across behavioral, cognitive, and emotional engagement, with the strongest effect reported for cognitive engagement. The study identified personalized tutoring, programming and technical assistance, and content generation/collaboration as important mechanisms through which ChatGPT can support engagement. At the same time, the researchers noted the risk of disengagement associated with over-reliance on AI. This study supports the argument that GenAI may influence not only academic achievement but also students' participation and engagement in learning.

GenAI in Pedagogical Practices (2025) A systematic review of empirical studies published between 2022 and 2024 examined how GenAI is being incorporated into pedagogical practices. The review analyzed 28 empirical studies published in high-impact journals indexed in Web of Science. The study found that GenAI can improve instructional efficiency, personalized learning, feedback, learner engagement, motivation, idea generation, critical thinking, and problem-solving. At the same time, the review identified challenges associated with the responsible integration of GenAI into teaching and learning. This research is particularly relevant to the applications and benefits components of the proposed systematic review.

Research Methodology:

The study adopts a descriptive research design to explore the significance, benefits and challenges of generative artificial intelligence tools in education. The approach is qualitative, utilizing content analysis to review existing literature on the topic. Key aspects of the methodology include.

Data Collection: Secondary data were sourced from peer-reviewed journal articles, academic publications and reputable online databases, studies published in 2005were prioritized to

ensure relevance and recency.

Analysis Process: A content analysis framework was employed to identify recurring themes, insights, and trends in the reviewed literature. The data were categorized into thematic areas such as tools, benefits, challenges and pedagogical implications.

Scope of the study: The research focuses on generative artificial intelligence tools in education used in diverse contexts, including higher education. Both qualitative and quantitative aspects of previous studies were examined to provide a holistic understanding.

Limitations: As the study relies on secondary data, findings are interpretative and dependent on the quality of reviewed literature. The absence of primary data collection limits the scope for contextual insights.

Findings of the study: From the literature review it can be analyzed that:

Recent systematic reviews indicate that research on GenAI in education has expanded extremely rapidly since 2022. However, the evidence base is unevenly distributed. Higher education represents the dominant research setting. A 2025 systematic review of ChatGPT research reported that approximately 69.7% of the reviewed studies were conducted in higher education, whereas primary and secondary education represented substantially smaller proportions. This concentration is important because findings from university students cannot automatically be generalized to younger learners. K–12 education involves different developmental characteristics, curriculum structures, teacher responsibilities, parental considerations, privacy requirements, and safeguarding issues.

- GenAI can provide conversational explanations adapted to learners' questions and apparent needs. Students can request alternative explanations, examples, summaries, practice questions, or step-by-step guidance. This creates the possibility of individualized learning at a scale that conventional teacher-only models may find difficult to achieve.
- Writing support is one of the most frequently reported applications. GenAI can help students brainstorm ideas, identify grammatical problems, reorganize arguments, translate passages, and receive iterative feedback.
- GenAI can generate rapid formative feedback on drafts, responses, code, and other student work. Its scalability is particularly attractive in large classes.
- Teachers can use GenAI to create lesson outlines, examples, discussion questions, quizzes, rubrics, scenarios, and differentiated instructional materials. This may reduce preparation time and enable teachers to experiment with multiple instructional approaches.
- Code-generation tools can explain programming concepts, generate sample code, identify errors, and provide debugging suggestions. Such tools can function as interactive programming assistants.

Conclusions & Suggestions:

The findings indicate that GenAI represents neither an inherently beneficial nor inherently harmful educational technology. Its educational consequences are strongly mediated by instructional design, assessment practices, learner characteristics, teacher competence, institutional policies, and the characteristics of the AI system itself. One of the clearest patterns in the literature is the importance of pedagogical scaffolding. GenAI appears most

educationally valuable when it supports rather than replaces cognitive activity. The current evidence also reveals an imbalance between enthusiasm for technological capabilities and evidence concerning long-term educational effects. Recent systematic reviews consistently demonstrate that universities dominate the evidence base. Research involving younger learners is comparatively limited, despite the importance of developmental, safeguarding, and age-appropriate considerations. Generative artificial intelligence is rapidly changing the educational landscape. The literature reviewed in this study indicates substantial potential for GenAI to support personalized learning, tutoring, writing, language development, feedback, programming, instructional-material creation, and teacher productivity. Recent systematic reviews and meta-analyses provide evidence of positive effects on several learning-related outcomes, including academic performance, motivation, language skills, and higher-order-thinking propensities. Nevertheless, GenAI should not be treated as an automatic solution to educational challenges. Risks involving hallucinations, academic integrity, over-reliance, bias, privacy, inequitable access, and insufficient teacher preparation remain significant. Furthermore, current research is disproportionately concentrated in higher education and frequently relies on short-term interventions. The central conclusion of this review is therefore that **the educational value of GenAI depends primarily on the quality of its pedagogical integration rather than on the sophistication of the technology alone**. GenAI should augment human teaching and learning rather than replace human judgment. Effective implementation requires AI literacy, pedagogical scaffolding, assessment redesign, teacher development, ethical governance, privacy protection, and continuous evaluation.

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ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN EDUCATION: A SYSTEMATIC LITERATURE REVIEW AND SYNTHESIS OF RESEARCH EVIDENCE

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Abstract

Artificial Intelligence (AI) is becoming increasingly visible in education, influencing lesson planning, teaching, assessment and student support. The emergence of Generative Artificial Intelligence (GenAI) has accelerated this change because teachers and learners can now use AI to generate explanations, questions, examples, and feedback and learning resources. This systematic literature review examines how AI contributes to pedagogical innovation and what recent research reveals about its effects on teaching and learning. Literature published mainly between 2019 and 2026, including systematic reviews, meta-analyses and empirical studies, was examined. Particular attention was given to personalized learning, assessment, feedback, engagement, higher-order thinking and teacher roles. The evidence generally shows positive effects of AI-supported learning on academic achievement, motivation, engagement and higher-order thinking. However, these benefits are not automatic. Outcomes depend on pedagogical design, teacher involvement, learner characteristics, and type of AI application and duration of use. The review also identifies concerns related to accuracy, academic integrity, privacy, bias, overdependence and unequal access. The study concludes that AI is most valuable when it strengthens sound pedagogy rather than replaces it. Meaningful innovation depends on teachers using AI purposefully to create active, reflective, collaborative and personalized learning experiences.

Keywords: *Artificial Intelligence, Generative AI, pedagogical innovation, AI in education, personalized learning, higher-order thinking, and teacher education*

1. Introduction

Education has continually changed alongside technological developments. Artificial Intelligence is now becoming another significant influence on teaching and learning. Unlike earlier digital tools that mainly provided access to information, contemporary AI systems can interact with learners, generate content and respond to individual questions.Generative AI has made this change particularly visible. Teachers can use AI to prepare lesson ideas, questions, examples, activities and feedback, while students can use it to clarify concepts, brainstorm and explore alternative explanations. These possibilities are promising, but they also raise concerns about inaccurate information, student dependence, academic integrity and privacy.More importantly, using AI does not automatically mean that pedagogy has changed. A teacher who asks AI to produce a conventional worksheet is using new technology, but the learning process may remain traditional. Pedagogical innovation occurs when AI contributes

to meaningful changes in how learners think, collaborate, investigate, solve problems or reflect on their learning.This review therefore examines not only whether AI is effective, but how it is being used, what outcomes are associated with it and what conditions make its use educationally meaningful.

2. Need of the Study

Research on AI in education is expanding rapidly, but the evidence is spread across different educational levels, subjects, technologies and outcomes. This makes it difficult for teachers and institutions to understand the broader picture.The need for this review arises from four concerns. First, AI is developing faster than many educational systems can respond. Second, AI is being used for very different purposes, including tutoring, assessment, personalization and content generation. Third, technological adoption should not be confused with pedagogical innovation. Finally, teachers remain responsible for deciding how AI should be used and for ensuring that technology serves learning rather than replacing it.A systematic review can bring these strands together, identify common findings and highlight areas where evidence is still limited.

3. Review of Related Literature

3.1 AI in Education

AI has been used in education for several decades through intelligent tutoring systems, adaptive learning, automated assessment and learning analytics. Bond et al. (2024), reviewing 66 systematic reviews in higher education, identified personalization, adaptive systems, learner profiling and prediction as important research areas. Generative AI has expanded these possibilities by allowing more natural interaction between learners and AI.

3.2 Generative AI and Pedagogical Innovation

Generative AI can produce explanations, examples, questions and learning materials. Yusuf et al. (2024), in a systematic mapping review of 407 publications, identified pedagogical enhancement, adoption, performance and ethical concerns as major themes. The educational value of GenAI depends on the learning task. If students simply copy answers, learning may become passive. If they analyse and improve AI responses, the same technology can support deeper thinking.

3.3 AI and Personalized Learning

AI can provide different explanations, examples and levels of support according to learner needs. A student struggling with a concept may request a simpler explanation, while another may explore a more challenging application. However, meaningful personalization requires teacher judgement. AI can offer options, but teachers must decide what support is appropriate.

3.4 AI and Assessment

AI can help generate questions, suggest feedback and support formative assessment. At the same time, GenAI challenges conventional assignments because students can use it to produce essays and answers. This creates an opportunity to use more authentic assessment, including projects, oral explanations, portfolios, demonstrations and reflective tasks that reveal how students think and apply knowledge.

3.5 AI and Higher-Order Thinking

AI can either reduce or encourage higher-order thinking depending on how it is used. Asking

students to copy an AI response provides little opportunity for analysis. Asking them to identify errors, verify evidence, compare answers and improve an explanation creates richer cognitive engagement. Chen and Cheung (2025) found a positive effect of GenAI on higher-order thinking, although evidence for metacognition was less conclusive.

3.6 AI in K–12 Education

Liu and Zhong (2024), reviewing 45 empirical K–12 studies, highlighted experiential learning, group learning, authentic contexts, teacher involvement and scaffolding. Díaz and Nussbaum (2024), reviewing 183 papers, observed that many AI applications in K–12 education still rely on established pedagogical approaches. This shows that AI does not automatically create a new pedagogy.

3.7 AI in Science Education

Science education offers opportunities for AI-supported inquiry. Students can use AI to generate questions, compare explanations and explore possible solutions. Almasri (2024), reviewing 74 empirical studies, found applications involving learning environments, assessment, quiz generation and prediction. The value of AI depends on whether it supports inquiry and reasoning rather than simply supplying answers.

4. Objectives

The study aims to:

- examine recent research on AI and pedagogical innovation;
- identify major applications of AI in teaching and learning;
- examine its influence on student learning outcomes;
- identify pedagogical approaches associated with effective AI use;
- examine changing teacher roles; and
- Identify challenges, implications and research gaps.

5. Research Questions

- How is AI being used to support pedagogical innovation?
- What impact does AI have on student learning outcomes?
- Which pedagogical approaches work effectively with AI?
- How is AI changing the teacher's role?
- What challenges and research gaps remain?

6. Methodology

A **Systematic Literature Review (SLR)** was conducted using research published mainly between 2019 and 2026. Literature was identified through Scopus, Web of Science, ERIC, ScienceDirect, SpringerLink, Wiley Online Library and Google Scholar. Search terms included "Artificial Intelligence and education," "AI and pedagogy," "Generative AI and teaching," "ChatGPT and learning outcomes," "AI and personalized learning," and "AI and assessment."

Studies were included when they examined AI or GenAI in educational settings and addressed teaching, learning, assessment or pedagogy. Peer-reviewed empirical studies, systematic reviews and meta-analyses were prioritized. Technical studies without educational application and opinion pieces without an evidence base were excluded.

The selected studies were analysed according to educational level, AI application, and

pedagogical approach, learning outcome, teacher role and major findings. Existing meta-analytic effect sizes were compared descriptively rather than statistically combined because different reviews may contain overlapping primary studies.

7. Data Analysis and Interpretation

Recent quantitative reviews generally show positive effects, although the size of the effect varies.

Study	Evidence	Focus	Main Finding
Bond et al. (2024)	66 reviews	Higher education	Personalization and adaptive learning prominent
Yusuf et al. (2024)	407 publications	GenAI	Pedagogical and ethical issues prominent
Almasri (2024)	74 studies	Science education	AI supported learning and assessment
Liu & Zhong (2024)	45 studies	K–12	Experiential and collaborative learning important
Díaz & Nussbaum (2024)	183 papers	K–12 pedagogy	Established pedagogies remain common
Chen & Cheung (2025)	57 studies	GenAI	Positive effects including higher-order thinking
Liu et al. (2025)	49 studies	GenAI	Positive effects on achievement and motivation
Wu et al. (2026)	35 experiments	ChatGPT	Moderate positive overall effect
Mo et al. (2026)	66 studies	Undergraduate learning	Large positive overall effect

Liu et al. (2025) reported effects of about 0.857 for achievement and 0.803 for motivation. Chen and Cheung (2025) reported an overall effect of approximately $g = 0.804$. Wu et al. (2026) reported $g = 0.670$ in experimental studies involving ChatGPT.These findings are encouraging, but differences between studies show that AI does not have one fixed educational effect. Learners, subjects, intervention duration and instructional design all matter.The most consistent message is that pedagogy should guide technology. AI is more useful when connected to inquiry, collaboration, problem-solving, personalization, formative assessment and reflection.

8. Major Pedagogical Innovations

Several forms of innovation emerge from the literature:

- **Personalized learning:** differentiated explanations and support.
- **AI-supported inquiry:** question generation and exploration.
- **Collaborative learning:** critical discussion of AI responses.
- **Formative assessment:** question generation and feedback.
- **Reflective learning:** evaluation of AI interactions.
- **Authentic learning:** realistic scenarios and problems.

These approaches place AI within the learning process rather than making it the centre of the lesson.

9. Changing Role of the Teacher

AI is changing the teacher's role, but it does not eliminate the need for teachers.

The traditional model can be represented as:

Teacher → Information → Student

An AI-supported model can become:

Teacher → Learning Design → Student + AI → Critical Evaluation → Application

Teachers increasingly act as learning designers, facilitators, mentors, evaluators and ethical guides. AI can generate information, but teachers provide context and judgement. AI can suggest activities, but teachers decide whether they support the intended learning outcomes.

Teacher education therefore needs to develop AI-integrated pedagogical competence rather than only technical skills.

10. Challenges

Accuracy: AI may produce convincing but incorrect information.

Overdependence: Excessive reliance may reduce independent thinking.

Academic Integrity: Conventional assignments may become less reliable.

Privacy: Student and learning data require protection.

Bias: AI outputs may reflect biases in data or system design.

Inequality: Unequal access to devices, connectivity and advanced tools may widen educational gaps.

Teacher Preparedness: Teachers need practical training to use AI meaningfully.

11. Conclusion

The evidence suggests that AI has considerable potential to support pedagogical innovation. Recent research generally reports positive effects on achievement, motivation, engagement and higher-order thinking. However, AI itself does not create innovative education.The strongest benefits appear when teachers use AI to redesign learning experiences rather than simply automate existing practices. AI can support personalization, inquiry, collaboration, feedback and reflection, but these benefits depend on thoughtful instructional design.The teacher therefore remains central. AI can generate content, but teachers provide judgement, context, relationships and values. The future of education should not be framed as teachers versus AI. A more productive approach is teachers working intelligently with AI.

12. Implications

For Teachers

Professional development should include AI literacy, prompt design, lesson planning, differentiated instruction, assessment and verification of AI outputs.

For Teacher Education

Student teachers should experience AI through authentic teaching tasks and reflect on its pedagogical value.

For Curriculum

AI literacy should include evaluating AI responses, identifying inaccuracies, recognising bias and using AI ethically.

For Assessment

Greater emphasis should be placed on application, reasoning, creativity and reflection through

projects, portfolios, demonstrations and oral explanations.

For Institutions

Clear policies should address privacy, academic integrity, accessibility, assessment and responsible AI use.

For Policy

AI strategies should combine infrastructure, teacher capacity, pedagogy, assessment, ethics and equity.

13. Limitations

AI research is changing rapidly, so the evidence base is continually expanding. Existing studies also differ in educational level, subject, AI application, intervention length and methodology.Research is currently stronger in higher education than in primary and secondary education. Many studies are relatively short, so less is known about long-term effects on learner independence, critical thinking and classroom relationships.The present study also synthesizes existing meta-analyses rather than conducting a new statistical meta-analysis because of possible overlap among primary studies.

14. Recommendations for Future Research

Future research should examine:

- long-term AI-supported learning;
- AI use in primary and secondary education;
- teacher professional development;
- collaborative and inquiry-based learning;
- AI and metacognitive development;
- student AI literacy;
- authentic assessment;
- culturally responsive AI pedagogy;
- AI use in low-resource settings;
- student autonomy and AI dependence; and
- ethical and inclusive AI practices.

Researchers should examine not only test scores but also creativity, critical thinking, independence and classroom interaction.

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MULTIDISCIPLINARY INTEGRATION OF ARTIFICIAL INTELLIGENCE IN EDUCATION

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Abstract

Artificial Intelligence (AI) is nowadays so fast that it is radically changing the world of studies. Modern educational AI needs a multidisciplinary approach that integrates cognitive knowledge with science, data analysis, economics, sociology, and ethics, going beyond simple computational automation. To develop "Smart Facilitators "—teachers enabled with the technological aspects, pedagogical knowledge, and ethical and technical skills necessary to navigate and construct a smart future—this article examines how the multidisciplinary integration of AI can be understood and utilized. This study creates a framework for teacher professional development; acquire pedagogical paradigms, by examining how AI interacts with many academic areas. In the end, the article makes the case that an empathetic, An AI-powered collaborative and integrated ecosystem will enhance teacher educators' abilities rather than replace them.

1. Overview

In the 21st century Artificial Intelligence (AI), has evolved from an indepth area of computer science to a pervasive infrastructure giving impact to international economies, cultures, and fundamental institutions, is in the vanguard of this change. Education is the most important aspect of an institution for preparing humanity for a young automated future, but it is also the most vulnerable humanity for an automated future, yet it is also the most susceptible to disruption. In the past, instructional ideas of technology have been incorporated into traditional method (chalk-and-talk) methods as cumbersome supplemental aids. But paradigm shifts Generative AI, machine learning algorithms, and natural language processing (NLP) have brought about a drastic paradigm shift focuses on machine learning algorithms, generative AI, and natural language processing (NLP).AI is evolving tool to active teachers in the instructional strategic plans. The function of the felicitator must be thoroughly reevaluated in light of this systemic and effective change. It is no longer appropriate to say and view teachers as the gatekeepers of information. The idea of the "Smart Facilitator "—a highly adaptive professional who creates individualized learning experiences using cognitive computing, data-driven insights, , and multidisciplinary methodologies will replaces it.

AI concept in education cannot take place in a technical vacuum in order to study properly adapt this change. Now its necessitates a multidisciplinary framework that purposefully links computer science with sociology, ethical philosophy, cognitive psychology, and specific

subject-area pedagogies. This study explores the structural study of multidisciplinary integration give clear path for educate in interdisciplinary integration, providing a clear way for educating and enabling the knowledgeable educators who will create a knowledgeable future with AI

2. The Multidisciplinary Basis of AI in Education

AI must be evaluated using a multidisciplinary concept in order to comprehend how it changes education. The theoretical basis of educational AI systems is the new approach of technological innovation and humanistic idealistic research.

2.1 The Learning Sciences and Cognitive Science

Fundamental goal of both AI development and educational practice is to develop and improve learning strategies. Both machine learning models and traditional classroom teaching practices are informed by the theoretical models of human memory, attention, executive functioning, and metacognition provided by cognitive science. For instance, adaptive educational platforms mainly rely on cognitive load theory to control mental strain and pace lesson delivery, whereas artificial neural networks are loosely built after human biological brain architecture.

Teachers are better able to evaluate AI diagnostics of students learning speed, cognitive barriers, retention timing when they balance this connection. This helps them to combine human idealistic empathy with algorithmic, technical advice. Through the application of working memory and spaced repetition theories to automated metrics, astute educators can comprehend the rationale behind an algorithm's recommendation of a particular review module, transforming an in depth unprocessed technology output into a focused and empathetic learning intervention.

2.2 Cultural Adaptability and Education Sociology

The education is highly social interactive process of getting informed. The use of AI tools takes place in intricate sociocultural systems characterized by institutional, linguistic disparities, prejudices, and digital gap or barriers.

A sociological study of AI in education state said, that data’s are regularly checked for systemic bias. This helps us to prevent AI from repeating past socioeconomic injustices as AI datasets will disadvantage minority students if they only represent the favored group. This happens when study focuses solely on the majority’s thoughts patterns of behavior, cultural need and lag also with the references, and learning habits. To keep fairness and avoid inbuilt, existing inequalities, teacher must critically check AI outputs. They need to know how cultural ideological context shapes or built and judges student behavior.

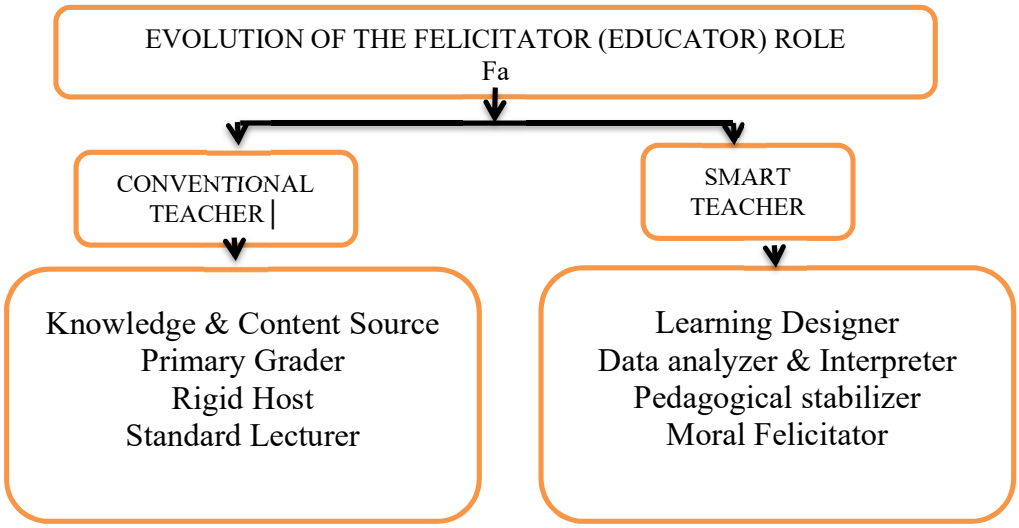
2.3 Data Sovereignty and Ethical Philosophy

Based on fundamental studies of laws of science and ethical philosophy is necessary for integrating AI into the classroom. Data handling, tracking, algorithmic decision-making, and also student privacy must all explicitly adhere to the principles of autonomy, fairness, beneficial, and the ethical obligation to do no harm. Teachers have to balance the moral and social conflicts between student self-identity and computerized continuous monitoring, tracking, or observation of a individual or group. This multidisciplinary integration task helps student data the power, independence and trusted to rule and make decisions without outside interference is maintained and that AI tools help to student’s dignity instead of treating

students like business and resourceful constraints

3. The "Smart Teacher" Concept: Functions and Skills

An emphatic change in the definition of a facilitator is necessary for the integration of AI. The "Smart teacher "or facilitator is an advanced expert working at the true nexus of tech and humans rather than a basic technician who without any proof complies with algorithmic advice.



3.1 The Instructor as the Architect of Learning

The smart teacher becomes a learning architect as adaptive AI platforms handle more and more of the material delivery. They provide inclusive learning environments where AI handles repetitive ideas, chores, including creating scoring simple tests, vocabulary lists, giving primary feedback on studies. This allows the human guide to focus on high-impact activities that computers cannot duplicate, such as directing group ideas, projects, encouraging critical thinking, awareness and conducting in-depth basic seminars. The digital spaces are arranged by the student learners so that automated assistance, evaluation with human contact work hand in hand.

3.2 The Instructor as a Data Interpreter

AI systems produce extremely large size volumes of data, which will show in highly detailed interphase dashboards. Advanced digital literacy study is one of the smart felicitator's basic strength. Teachers must be able to convert visualizations into useful teaching techniques. When an AI dashboard indicates student unable to hold with a particular topic, the instructor must decide whether the difficulty is due to a technical background ,language barrier, a foundational gap, or unclear software terminology in order to select the best human intervention in the study.

3.3 The Instructor as a Moral and Emotional Guide

As automation takes on more technical jobs human-specific talents are becoming more and more important. Intelligent felicitators act as the classroom's pillar. They teach students how to understand, navigate an AI-driven society in an correct and ethical manner while fostering resilience, empathy, open-mindedness, and teamwork. The key factor is that ,how to respect

original human ideas, challenge algorithmic presumptions, assumptions, avoid taking shortcuts in academic journey of study that circumvent critical thinking, and use creative ,critical ,generative AI steps..

4. Theoretical Case Evaluations: Practical AI Paradigms

This part evaluate how key factors of AI educational concepts change instructional workflows and teaching dynamics and strategies in order to anchor these multidisciplinary theories in active classroom practice.

4.1 Cognitive Micro-Scaffolding and Intelligent Tutoring Systems

ICT cognitive modeling is the basic foundation of Intelligent Tutoring Systems (ITS). These skills and methods evaluate each student's step-by-step problem-solving process rather than delivering a standard lecture to a bulk of students. When a student makes a mistake in the middle of a multi-step task, the system offers a customized tip that is intended to correct that particular misconception. And give promising statements.

- **Modification of Conceptual Workflow**

It is no longer necessary for the teacher to demonstrate difficult procedures on a whiteboard for the majority of a class period. Rather, the intelligent system serves hold as a co-teacher by offering technical, consistent, foundational and emotional l practice. The intelligent instructor keeps an eye on the dynamics of the classroom and intervenes when the system identifies a student who is having serious conceptual difficulties that automated solutions are unable to address. As a result, the classroom becomes a highly customized lab setting rather than a homogeneous, one-size-fits-all lecture.

4.2 Macro-Aesthetic Grading and Automated Feedback Assistants

Advanced language processing with grammatically automated feedback aides to use for evaluate student writing. Before students present final work to the teacher, these systems assess language formation, structure, grammar, consistency, and structural set to give them with quick, basic suggestions along with clarity.

- **Modification of Conceptual Workflow**

The traditional grading cycle is totally reversed by AI. The facilitator receives a document that has already been studied, polished by an automated AI system rather than spending hours to fix mechanical spelling, punctuation, and simple sentence patterns. This enables the teacher to concentrate their criticism on intricate, deep writing components, including the new thoughts, ideology, concepts, held uniqueness, emotional resonance, voice, and rhetorical complexity. The teacher becomes a high-level creative mentor, guide instead of a robotic proofreader.

5. Educational Structures for Harmonious Integration

Facilitator need strong basic conceptual frameworks ideas that link technology with tried-and-true teaching strategies and approaches in order to properly balance and integrate AI in the class room without sacrificing the human aspect and also carry human touch.

5.1 The Framework for TPACK-AI

The TPACK-AI framework must replace the conventional Technological Pedagogical Content Knowledge (TPACK) framework. This subject necessitates that educators and learners, comprehend not only their subject concept matter and how students teach the subjects

(pedagogy), but also how AI systems (technology) impact student comprehension and content studies.

A facilitator or guide using the TPACK-AI paradigm is aware of the advantages and cognitive constraints of technologies that used by AI. They ensure that AI supports learning strategies rather than find them by knowing exactly when an automated tool of AI will help to explain the concept when it can lead to passive learning.

5.2 Adaptive and Differentiated Learning Frameworks

AI technology makes individual possible on a never-before-seen ideas and scale. A single classroom may adopt numbers of different learning routes and ideas at once thanks to adaptive AI software. This environment is managed by the smart teacher, who uses automated AI technologies to give new, advanced tasks to pupils who are ahead of pace and support to those who are struggling. This paradigm ensures that no student is left behind by shifting teaching learning process from a fixed-time, variable-outcome model (where everyone spends two weeks on a topic regardless of competence) to a variable-time, mastery-based model.

6. Conceptual Difficulties and the Preservation of Humanity

There are several theoretical obstacles, hurdles as well as opportunities for integrating AI into schooling. These fundamental concerns, ideas, thoughts must be carefully and critically studied and examined in order to move toward a smart future without complaining.

6.1 Automated Standardization's Danger

The possibility AI uniformity is one of the main issues with the broad usage of AI in education. Machine learning methods favor consistent, predictable responses since they rely on past patterns. AI evaluation in grading and instructional ideas, systems increases potential of molding students to write, think, pick, design and solve problems in new ways if they are granted excessive authority. By promoting non-linear thinking, unorthodox creativity, and artistic expression with realization that help them to predict, astute educators must actively fight this trend.

6.2 Dependency on Technology and Cognitive Atrophy

As we all knew Generative AI tools are so easy to use, they present serious risks to students' mental thoughts. Following or believing heavily on AI for writing, programming, and basic problem-solving can cause cognitive decline. As a result, students may lose their critical ability to study independently, build logical arguments, and structure their thoughts with own opinions. When technology takes over all the intellectual labor, human cognitive skills naturally weaken.

To prevent this and build mental resilience, beliefs, for that educators need to create learning environments that feature "desirable difficulties"—intentional mental obstacles that force students to use their own brains to succeed .This is the task openly every stages one can detect it and solve it.

6.3 Preserving the Educational Bond

A machine cannot compute or duplicate the relationship between a teacher and a student, which is characterized by respect, growth, inspiration, and emotional and dedicated support. Human relationships are the foundation of education. Given technology runs the risk of creating a sterile, isolated digital environment in the learning process. In order to maintain

interest, communication, cooperative group projects, at the core of the educational process, educator makes sure that AI is always a helpful tool and it's a new bond like trust.

7. Institutional Policy and Teacher Preparation Strategic Framework

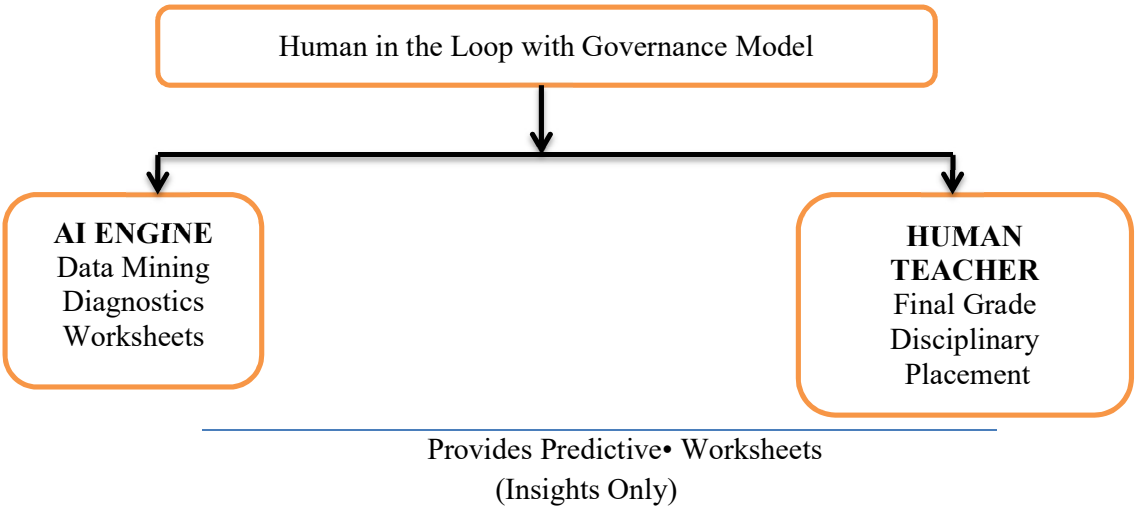
Systematic changes in professional teachers training, infrastructure, and legislation are necessary to create an AI-augmented educational ecosystem. This will help to build new thoughts and new era of structuring the new possibility which are in imagination.

7.1 Using an Interdisciplinary Perspective to Rethink Teacher Training

The current and basic pathways used by teacher training institutions (TTI's) need to be fundamentally reshaped. AI can no longer be treated as a stand-alone, elective seminar in professional and ethical development. Rather, core education programs should incorporate multidisciplinary studies that combine learning philosophies; data ethics, cognitive psychology, and evaluation are basic principles. This guarantees that new aspirants see AI as a professional, realistic, manageable tool.

7.2 Creating "Human-in-the-Loop" Governance Frameworks

This frameworks established by educational organizations. All high-stakes choices, including final courses, grades, disciplinary measures, evaluations and student placements, should ultimately be made by trained human facilitators, according to these laws, even though AI can help them with grading, diagnostics, administrative and assessment work and great impact in teaching learning strategies. Algorithms should never take the place of human expert judgments.



8. Conclusion

Now a Days AI is multidisciplinary incorporated in to education field which specifically signifies a fundamental, basic shift in the exchange of knowledge. Developing the "Smart Teacher" or facilitator is a crucial step towards making technology benefits to society as a whole. Smart teachers use AI from a mere automation tool into a catalyst for human potential by fusing technical aspects with psychology, sociology, and ethics. The need of education is to develop critical, sympathetic, and creative minds as we moving towards automated future. Understand AI needs to be focused and used for superior knowledge.

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TECHNOLOGY INTEGRATION IN SCHOOL EDUCATION: A SURVEY OF TEACHERS' ATTITUDES, PRACTICES AND CHALLENGES IN PRIVATE SCHOOLS OF NAGAMANGALA TALUK

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Abstract

The rapid development of digital technologies has significantly influenced teaching and learning practices in school education. The effective integration of technology depends not only on the availability of digital resources but also on teachers' attitudes, classroom practices and the challenges they encounter. The present study examined teachers' attitudes towards technology integration, identified the major challenges faced by teachers, and determined the relationship between teachers' attitudes and their technology integration practices in private schools of Nagamangala Taluk, Mandya District, Karnataka. A descriptive survey method was adopted. The population consisted of approximately 200 teachers working in private schools affiliated with CBSE, ICSE and State curriculum. A sample of 120 teachers was selected using stratified random sampling. Data were collected through a structured questionnaire consisting of items related to teachers' attitudes, technology integration practices and challenges. Descriptive statistics, including frequency, percentage, mean and standard deviation, were used to analyse the data, while Pearson's product-moment correlation was used to examine the relationship between teachers' attitudes and technology integration practices. The illustrative findings indicate that the majority of teachers had a positive attitude towards technology integration, although several challenges related to infrastructure, internet connectivity, technical support, training and time constraints were reported. A positive relationship was also observed between teachers' attitudes and their technology integration practices. The study suggests that sustained professional development, adequate infrastructure and institutional support are essential for effective technology integration in school education.

Keywords: *Technology Integration, Teachers' Attitudes, Digital Technology, School Education, Technology Practices, Challenges, Survey Method*

1. Introduction

Technology has become an integral component of contemporary education. The increasing availability of smart classrooms, digital learning resources, educational applications, online platforms, multimedia resources and artificial intelligence-based tools has created new possibilities for teaching and learning. Technology can support teachers in presenting complex concepts, accessing diverse learning resources, engaging students, facilitating collaboration and assessing learning outcomes. The role of teachers remains central to the successful integration of technology. The availability of technological infrastructure alone cannot ensure meaningful technology-enhanced teaching. Teachers need appropriate digital competence, positive attitudes, pedagogical knowledge and institutional support to integrate technology effectively into classroom practices. Teachers' attitudes towards technology influence their willingness to adopt and use digital tools. Teachers who perceive technology as useful,

accessible and beneficial to student learning may be more willing to integrate it into their teaching. Conversely, lack of confidence, inadequate training, technical difficulties and negative perceptions may limit technology use. Private schools have increasingly adopted digital technologies to enhance teaching and learning. Schools affiliated with different curricula, including CBSE, ICSE and State curriculum, may differ in terms of infrastructure, availability of digital resources, teacher training and institutional expectations. Therefore, studying teachers' technology integration practices across different school contexts can provide useful insights. Nagamangala Taluk of Mandya District has a number of private educational institutions serving students from different backgrounds. Understanding teachers' experiences with technology in these schools is important for strengthening digital pedagogical practices. The present study therefore focuses on three major aspects: teachers' attitudes towards technology integration, the challenges faced by teachers, and the relationship between attitudes and technology integration practices.

2. Need and Significance of the Study

The integration of technology into school education is important for developing 21st-century learning environments. Digital technologies can facilitate interactive learning, multimedia-based instruction, collaborative activities, online assessment and access to educational resources. However, technology integration is not merely a matter of providing computers, projectors or internet facilities. Teachers need to possess the confidence and competence to select and use appropriate technologies according to learning objectives.

A survey of teachers can provide information regarding the current status of technology integration at the school level. It can also help identify barriers that may prevent teachers from using technology effectively.

The study is significant for the following reasons:

1. It provides information about teachers' attitudes towards educational technology.
2. It identifies major barriers affecting technology integration.
3. It examines whether positive attitudes are associated with greater technology use.
4. It may help school administrators plan appropriate professional development programmes.
5. It may assist policymakers in strengthening digital infrastructure.
6. It can provide useful information for teacher educators developing digital pedagogical competencies.

3. Statement of the Problem

“Technology Integration in School Education: A Survey of Teachers’ Attitudes, Practices and Challenges in Private Schools of Nagamangala Taluk.”

4. Objectives of the Study

The study was conducted with the following objectives:

1. To study teachers' attitudes towards the integration of technology in school education.
2. To identify the major challenges faced by teachers in integrating technology.
3. To determine the relationship between teachers' attitudes and their technology integration practices.

5. Research Questions

1. What is the level of teachers' attitudes towards technology integration in school education?
2. What are the major challenges faced by teachers while integrating technology into teaching?
3. Is there a significant relationship between teachers' attitudes and their technology integration practices?

6. Hypothesis

The following null hypothesis was formulated:

H_0: There is no significant relationship between teachers' attitudes towards technology integration and their technology integration practices.

7. Methodology

7.1 Research Method

The study adopted a **descriptive survey method**. The method was considered appropriate because the purpose was to collect information regarding teachers' existing attitudes, practices and perceived challenges related to technology integration.

7.2 Area of the Study

The study was conducted in **private schools located in Nagamangala Taluk, Mandya District, and Karnataka**.

7.3 Population

The population consisted of approximately **200 teachers** working in private schools in Nagamangala Taluk. The schools included institutions following **CBSE, ICSE and State curriculum**.

7.4 Sample and Sampling Technique

A sample of **120 teachers** was selected from the population using **stratified random sampling**.

The teachers were divided into three strata according to school curriculum.

Table 1 Distribution of Population and Sample

School Curriculum	Approximate Population	Sample	Percentage
CBSE	70	42	35.0
ICSE	50	30	25.0
State Curriculum	80	48	40.0
Total	**200**	**120**	**100.0**

The sample was selected proportionately to ensure representation of the three strata.

8. Research Tool

A structured questionnaire titled **"Teacher Technology Integration Questionnaire (TTIQ)"** was used for collecting data.

The questionnaire consisted of four sections.

Section A: Personal Information

This section collected information regarding:

- Gender
- Age

- Teaching experience
- Educational qualification
- School curriculum
- Subject taught
- ICT training

Section B: Teachers' Attitudes towards Technology

This section contained **15 items** measuring teachers' attitudes towards technology integration.

The items covered:

- Perceived usefulness
- Perceived ease of use
- Confidence
- Motivation
- Perceived benefits to students
- Willingness to adopt new technologies

A five-point Likert scale was used:

Strongly Agree – Agree – Undecided – Disagree – Strongly Disagree

Section C: Technology Integration Practices

This section consisted of **10 items** measuring teachers' classroom technology practices.

The items covered:

- Multimedia presentations
- Smart boards
- Digital learning resources
- Online educational platforms
- Educational applications
- Online assessment
- Video-based learning
- Digital collaboration
- Online assignments
- AI-supported educational tools

Section D: Challenges

This section consisted of **10 items** related to challenges in technology integration.

Major areas included:

- Poor internet connectivity
- Lack of digital devices
- Technical problems
- Lack of training
- Lack of technical support
- Time constraints
- Large class size
- Lack of suitable digital resources
- Limited digital competence
- Institutional constraints

9. Validity and Reliability

The questionnaire was subjected to expert review by specialists in teacher education and educational technology to establish content validity. Based on their suggestions, ambiguous and repetitive items were modified.

For the purpose of this draft, the illustrative pilot analysis yielded an overall **Cronbach's alpha reliability coefficient of 0.89**, indicating satisfactory internal consistency.

Note: The value 0.89 is an approximate/illustrative value and must be replaced with the actual reliability coefficient obtained from your pilot study.

10. Data Collection Procedure

The researcher contacted selected private schools in Nagamangala Taluk and obtained the necessary permission for data collection. The purpose of the study was explained to the participating teachers.

The questionnaire was administered to 120 selected teachers. Participants were informed that their responses would be used only for academic purposes. After completion, the questionnaires were collected, coded and prepared for statistical analysis.

11. Statistical Techniques

The following statistical techniques were used:

1. Frequency
2. Percentage
3. Mean
4. Standard deviation
5. Ranking
6. Pearson's product-moment correlation coefficient

12. Data Analysis and Interpretation

Objective 1

To study teachers' attitudes towards the integration of technology in school education.

Table 2 Level of Teachers' Attitudes towards Technology Integration

Level of Attitude	Frequency	Percentage
Low	12	10.0
Moderate	38	31.7
High	70	58.3
Total	**120**	**100.0**

Interpretation

The illustrative findings indicate that **70 teachers (58.3%)** demonstrated a high level of positive attitude towards technology integration. **38 teachers (31.7%)** showed a moderate level of attitude, whereas **12 teachers (10.0%)** demonstrated a low level.

The findings suggest that the majority of teachers had a favorable perception of technology integration in school education. This indicates that teachers generally recognize the usefulness of technology in improving classroom teaching and learning.

Table 3 Teachers' Attitudes towards Different Dimensions of Technology

Dimension	Mean	SD	Level
Perceived usefulness	4.18	0.64	High
Ease of use	3.82	0.72	High
Confidence	3.74	0.79	Moderate
Student learning benefits	4.21	0.61	High
Willingness to adopt technology	4.05	0.67	High
Overall	**4.00**	**0.69**	**High**

Interpretation

Among the different dimensions, teachers reported the highest mean score for **perceived benefits of technology for student learning (M = 4.21)**. Perceived usefulness also obtained a high mean score of **4.18**.

Teachers' confidence in using technology had a comparatively lower mean score of **3.74**, suggesting that although teachers generally recognise the importance of technology, some may require additional training and support to use digital tools confidently.

13. Objective 2

To identify the major challenges faced by teachers in integrating technology.

Table 4 Major Challenges Faced by Teachers

Sl. No.	Challenge	Mean Score	Rank
1	Poor/unstable internet connectivity	4.12	I
2	Lack of adequate digital devices	3.96	II
3	Lack of technical support	3.87	III
4	Insufficient training opportunities	3.79	IV
5	Time required for technology-based preparation	3.72	V
6	Technical problems during classroom teaching	3.68	VI
7	Limited digital competence	3.54	VII
8	Difficulty in finding appropriate digital resources	3.42	VIII
9	Large class size	3.31	IX
10	Lack of institutional encouragement	3.18	X

Interpretation

The findings indicate that **poor or unstable internet connectivity** was the most significant challenge reported by teachers, with a mean score of **4.12**. This was followed by **lack of adequate digital devices (M = 3.96)** and **lack of technical support (M = 3.87)**.

Insufficient training opportunities also emerged as an important challenge. These findings suggest that teachers' willingness to use technology may not always translate into effective classroom practice because infrastructural and professional barriers continue to influence technology integration.

14. Objective 3

To determine the relationship between teachers' attitudes and their technology integration practices.

Table 5 Correlation between Teachers' Attitudes and Technology Integration Practices

Variables	N	r-value	p-value	Decision
Attitudes and Technology Integration Practices	120	0.58	<0.001	Significant

Interpretation

The illustrative analysis indicates a **positive and statistically significant relationship** between teachers' attitudes towards technology and their technology integration practices (**r = 0.58, p < 0.001**).

Therefore, the null hypothesis stating that there is no significant relationship between teachers' attitudes and technology integration practices is **rejected**.

The result suggests that teachers with more positive attitudes towards technology tend to report higher levels of technology integration in their classroom practices.

Note: The correlation value is illustrative and must be recalculated using your actual questionnaire data before publication.

15. Findings

Based on the illustrative analysis, the following findings were obtained:

1. A majority of teachers (**58.3%**) demonstrated a high level of positive attitude towards technology integration.
2. Approximately **31.7%** of teachers demonstrated a moderate level of attitude.
3. Teachers perceived technology as useful for improving student learning and classroom instruction.
4. Teachers' confidence in using technology was comparatively lower than their perceived usefulness of technology.
5. Poor internet connectivity emerged as the most significant challenge.
6. Lack of digital devices and technical support were other major challenges.
7. Lack of training was identified as an important professional barrier.
8. A positive and significant relationship was found between teachers' attitudes and their technology integration practices.
9. The findings indicate that positive attitudes may be associated with greater use of technology in classroom teaching.

16. Discussion

The findings suggest that teachers generally have favourable attitudes towards technology integration. The high level of perceived usefulness indicates that teachers recognise the potential of digital technologies to improve classroom teaching and student learning.

However, the findings also indicate a gap between positive attitudes and actual implementation. Teachers may be willing to use technology but face difficulties arising from inadequate infrastructure, internet connectivity and technical support.

The relatively lower score for teachers' confidence indicates the importance of continuous professional development. Training programmes should move beyond basic computer literacy and focus on **digital pedagogical competence**, including the selection of appropriate digital

resources, technology-supported assessment, collaborative learning and responsible use of emerging technologies.

The significant positive relationship between attitudes and technology integration practices indicates that teachers' perceptions may play an important role in technology adoption. Creating positive experiences through training, peer support and successful classroom implementation may therefore encourage teachers to use technology more frequently and effectively.

17. Educational Implications

The findings have several implications for school education.

17.1 Professional Development

Schools should organise regular workshops on digital pedagogy, educational applications, digital assessment and emerging technologies.

17.2 Infrastructure

Adequate computers, projectors, smart boards, digital devices and reliable internet connectivity should be provided.

17.3 Technical Support

Schools should provide timely technical assistance so that teachers do not discontinue technology-based teaching because of technical problems.

17.4 Teacher Confidence

Professional development should provide teachers with opportunities for hands-on practice and classroom experimentation.

17.5 Sharing of Best Practices

Teachers who effectively integrate technology should be encouraged to share their experiences and teaching strategies with colleagues.

17.6 Institutional Support

School management should create an environment that encourages teachers to experiment with appropriate technologies without excessive fear of technical failure.

18. Limitations

The study has the following limitations:

1. The study was limited to private schools in Nagamangala Taluk.
2. The sample consisted of approximately 120 teachers.
3. The study included CBSE, ICSE and State curriculum schools.
4. Data were collected through self-reported responses.
5. The study used a descriptive survey design and therefore does not establish a causal relationship.
6. The findings may not be generalized to all schools in Karnataka.

19. Suggestions for Further Research

Further studies may be undertaken to:

1. Compare technology integration among government and private school teachers.
2. Compare CBSE, ICSE and State curriculum schools.
3. Study teachers' digital pedagogical competence.
4. Examine students' perceptions of technology-supported learning.

5. Investigate the effectiveness of AI tools in school education.
6. Conduct an experimental study to determine the effectiveness of technology-based teaching.
7. Conduct qualitative interviews to understand teachers' experiences in greater depth.
8. Study the relationship between teachers' digital competence and student achievement.

20. Conclusion

Technology integration has become an important component of contemporary school education. The present survey study indicates that teachers generally possess positive attitudes towards the use of technology in teaching and learning. At the same time, several challenges, particularly inadequate internet connectivity, insufficient digital resources, limited technical support and training opportunities, may restrict effective implementation.

The positive relationship between teachers' attitudes and their technology integration practices highlights the importance of developing favourable perceptions and confidence among teachers. However, positive attitudes need to be supported by appropriate infrastructure, professional development and institutional assistance.

Therefore, effective technology integration should be viewed as a combination of **teacher readiness, digital pedagogical competence, infrastructure, technical support and institutional commitment**. Strengthening these areas can help private schools in Nagamangala Taluk create more effective, engaging and technology-supported learning environments?

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AN EMPIRICAL INVESTIGATION OF ARTIFICIAL INTELLIGENCE LITERACY AMONG PROSPECTIVE EDUCATORS: PERSPECTIVES FROM B.ED. TEACHER TRAINEES IN SOUTHERN KARNATAKA

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Abstract

Artificial Intelligence (AI) is quickly changing education by impacting research, teaching, learning, assessment, content creation, and educational administration. AI literacy has emerged as a critical skill for student teachers. The study evaluates the level of Artificial Intelligence Literacy among BEd teacher trainees. The current study looked at 344 B.Ed. teacher trainees from particular Karnataka teacher education institutions' levels of artificial intelligence literacy. AI Knowledge and Understanding (AIKU), AI Use and Apply (AIUA), AI Self-Efficacy (AISE), and AI Ethics (AIE) are the four main aspects of AI literacy that were the subject of the study. The collected data were analysed using descriptive and inferential statistics, including Mean, Standard Deviation, independent-samples t-test, and linear regression. The findings indicated that there was no significant difference in AI literacy between male and female B.Ed. students. Male students obtained a mean score of 130.81 (SD = 13.30), whereas female students obtained a mean score of 132.00 (SD = 15.30), with a t-value of 0.50, indicating a non-significant difference. Similarly, comparison between first-year and second-year B.Ed. students revealed no significant differences in AI Knowledge and Understanding, AI Use and Apply, and the combined dimensions of AI Self-Efficacy and AI Ethics. The results indicate that gender and academic year did not significantly influence the measured dimensions of AI literacy in the present study. The study recommends continuous professional development, practical AI training, curriculum integration, adequate digital infrastructure, and responsible-use guidelines to prepare B.Ed. students for AI-enabled educational environments

Keywords: *Artificial Intelligence Literacy, B.Ed. teacher trainees, Digital Pedagogy, TPACK.*

INTRODUCTION:

Artificial Intelligence has emerged as one of the most influential technologies of the digital era and is increasingly becoming part of educational practices. AI applications are being used for lesson planning, development of teaching-learning materials, assessment, personalised learning, feedback, research, language learning, and educational administration. AI is becoming a crucial component of digital-age education and is no longer futuristic (Alwyn Vwen Yen LEE, 2020).India's revolution in artificial intelligence literacy potential to transform education administration, instruction, and learning. Data-driven decision-making, enhanced access, and specially tailored education (Viji & Agarwal, 2024)AI in education aims to use computer intelligence to improve teaching and learning above traditional classroom instruction, not to replace human teachers with robotic ones (Mita Banerjee, Pandey, 2024). AI is boosting student engagement, increasing instructional effectiveness, and facilitating individualised learning. AI is also redefining administrative duties and evaluation techniques. (Krishna Kumari Chetry, 2024)

Teachers appreciated how Chat-GPT and other AI technologies could speed up lesson planning and enhance personalization. Despite their optimism, the poll found that many teachers needed more targeted support and training. Successful integration requires that AI technologies be in line with existing curricula and cultural norms (Filiz, Kaya, & Adiguze, 2025). AI is well-prepared or supported and can influence AI progress in the future (Gayed, 2025). Institutions and educators should be prepared to handle AI tools sensibly. Additionally, it is critical to prepare students for situations dominated by AI (Ayala-Pazmiño, 2023) The study encourages international discussion on the safe, efficient, and equitable application of AI. Finally, it promotes ongoing innovation using inclusive methods (Borhene Chakroun et al., UNESCO, 2019). teaching in the twenty-first century requires updated digital literacy. Teachers need to be prepared to use and instruct AI. (Davy Tsz Kit and others, 2023)ethical standards in regulating AI's role in education and stresses a fundamental understanding of AI as crucial for future digital citizens (Matthias Carl Laupichler, et al. 2022) AI might someday take over education, leaving educators to handle punishment (S. K. Khatik and Praful Patel, 2021). AI's human-like abilities, like speech and picture recognition, are emphasised. The study makes recommendations for enhancing AI for better learning (V.V. Subrahmanyam and K. Swathi 2018)

Pre-service teachers' usage of the Magic School AI tool for assessment; the findings show a global increase in interest but a lack of focus on professional teaching skills in AI contexts (Katarina Sperling et al., 2024).AI was found to improve time efficiency and facilitate the creation of questions and rubrics. (Erdem Gamze Coşgun, 2025) AI tools shouldn't be abused for academic dishonesty and that they can improve learning, but they must be utilised carefully and under ethical supervision (Souvik Paul, Dr. Biswajit Chatterjee, 2025).it foresees a time when innovative, non-digital assessments can take the place of conventional evaluation techniques (Chokri Kooli, 2024). AI can improve educational inclusion with the appropriate practices and regulations (Julien, 2024).study advise decision-makers to strike a balance between human-centered education and technical innovation (Al-Zahrani 2024).AI should support conventional teaching techniques rather than take their place (Goyal et al., 2025).There is still little proof, the results indicate that AI tools can improve learner engagement and lower anxiety (AlTwjiri & Alghizzi, 2025). AI technologies affect effective learning elements in English as a Foreign Language (EFL) classroom such as motivation, attitude, and anxiety. (Dennison et al., 2025) Teachers may make data-driven judgements and provide more individualised instruction thanks to AI. (Dipanwita Bit and others, 2024)According to interviews, 77% of students thought the technology was helpful for rules and engagement. (Rad Shafiee, 2025)

Human-AI Synergy Degree Model (HAI-SDM). "Synergy degree" ranged from low to moderate, indicating discrepancies in the way the human and AI systems collaborated across several subsystems, such as subject, process, or environment (Kong, Fang, et al., 2025)AI can adjust feedback, pace, and content to needy, increasing interest and results. Adaptive learning paths, automatic feedback, and simplified administrative procedures are among the advantages (Merino-Campos, 2025).governmental support and cooperation from public-private partnerships is required for In order to use AI in classroom settings, the study calls (Kumar,

A., & Singh, P. (2020).

AI offers customized learning routes and emphasis perceived advantages like productivity and student engagement. (Lazar Krstić et.al., 2022), research demonstrates that training teachers for a tech-centered future requires improving digital literacy (Lademann et al., 2024). foundational AI training, collaborative learning, and ongoing professional development emphasise mindset adjustments towards AI-assisted education and learner empowerment. (Akilu Ismail et al. (2024),Chat-GPT discovered advantages in efficiency, access, and personalised learning. Chat-GPT enabled innovative education (Fatih Karataş et al., 2024). AI the value of transparency, fairness, and the capacity for explanation in AI-based learning. According to Swagatika Devi emphasiseset al. (2023)AI literacy did not predict emotion control, but it did have a favourable impact on comprehension, ethics, and problem-solving (Bo Pei et al.,2024) It suggests creating AI literacy courses that emphasise understanding, development, and moral application (Musa Adekunle Ayanwale et al., In 2024. Digital Education Council's suggestion strategy for AI Literacy Framework. AI has been demonstrated to personalise learning and simplify administration. (Taylar Wenzel and Michelle Kelley, 2025 Artificial Intelligence is viewed as a tool not substitute for educators (Lucas Kohnke et al., 2025)

Teacher education should include ethics-based AI training. Although they encouraged responsible use, students had a good opinion of AI (Souvik Paul et al., 2025). Teachers and curriculum designers are advised by TPACK to develop frameworks for digital competency that ensure both national and international standards. In addition to diverse domains that support fundamental skills and evolutionary research, it promotes teacher education. TPACK offers extra benefits during teacher training since it may address lesson design, efficiently integrate technology, increase student engagement, and create opportunities for personalized learning through enhanced learning outcomes. First, it provides educators with a strong scientific foundation for collaborative learning and interdisciplinary mentoring. Inadequate technology infrastructure, a lack of training in digital pedagogy, and technological barriers to successful implementation of some of the restrictions noted are all present in educational institutions.

OBJECTIVES OF THE STUDY

Objective -1 To compare the levels of AI literacy among male and female B.Ed. teacher trainees.

Objectives-2: To find whether there is a significant difference in AIKU (AI Knowledge & Understanding), AIUA (AI Use & Apply), AISE (AI Self-Efficacy) and AIE (AI Ethics) among I year and II year B.Ed. teacher trainees.

HYPOTHESIS OF THE STUDY

Hypothesis -1: There is no significant difference in the levels of AI literacy between male and female B.Ed. teacher trainees.

Hypothesis -2: There is no significant difference in AIKU (AI Knowledge & Understanding), AIUA (AI Use & Apply), AISE (AI Self-Efficacy) and AIE (AI Ethics) among I year and II year B.Ed. teacher trainees.

METHODOLOGY FOR THE STUDY

Respondents Profile: The study consisted of 344 B.Ed. students enrolled in teacher education institutions located in five districts of Karnataka, namely Hassan, Shivamogga, Mysuru, Bengaluru, and Mandya. The inclusion of students from different districts was intended to provide representation from different teacher education contexts. The respondents included B.Ed. students from different academic years and demographic groups.

Sampling Technique: A simple random sampling technique was adopted for the selection of B.Ed. students. The sampling procedure considered relevant demographic and academic characteristics to obtain representation from the selected teacher education institutions.

Research Design: The study adopted a descriptive survey research design to examine the level of Artificial Intelligence literacy among B.Ed. students and to compare AI literacy across selected demographic and academic variables.

Instrument: Artificial Intelligence Literacy Assessment Scale (AILAS) - A self-constructed tool was developed by the researcher, drawing the inferences from review of related literature on AI literacy and digital pedagogy. The questionnaire consisted 21 items across three dimensions namely AIKU (AI knowledge & understanding), AIUA (AI use & apply) and AISE (AI self-efficacy) and AIE (AI ethics). The item was measured on a 5-point Likert scale. The instrument was assessing samples understanding, practical application, learning, ethical awareness, and problem-solving skills related to AI. Survey questions about responsive usage of AI in assignment writing were found in the second section of the questionnaire, whereas questions about the independent variable AI literacy were found in the final section.

Data Collection: Google form was used to gather data from English pedagogy B.Ed teacher trainees. Prior consent was acquired by the participants and participation was entirely voluntary. Throughout the process, the respondents' confidentiality and anonymity were preserved.

Data Analysis: SPSS was used to measure the data. Descriptive and inferential statistics were used in the study. To summarize the responses, Mean and Standard Deviation (SD) were used. The differences in AI literacy between background variables gender and locality was examined using independent t-test. Linear regression was used to predict the influence of components within AI literacy. The analytical approach of the study specified a comprehensive understanding of the AI literacy levels among B.Ed. teacher trainees across different demographic categories.

RESULTS AND DISCUSSION

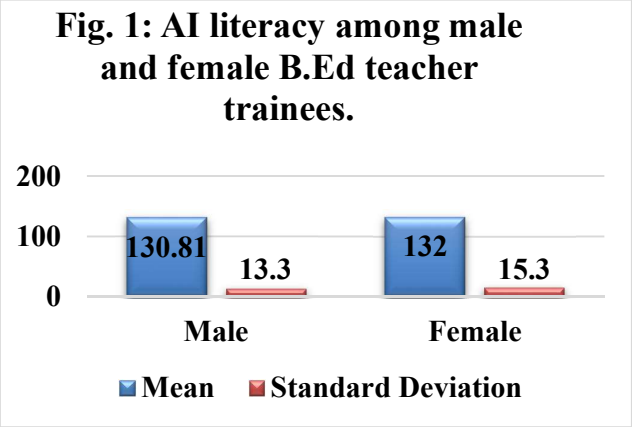
Objective -1 to compare the levels of AI literacy among male and female B.Ed. teacher trainees.

Hypothesis -1: There is no significant difference in the levels of AI literacy between male and female B.Ed. teacher trainees.

Table No.01: AI literacy among male and female B.Ed teacher trainees.

Gender	Mean	Standard Deviation	t-value	Significance
Male	130.81	13.30	0.50	NS
Female	132.00	15.30		

NS = Not Significant; $p > 0.05$.



The results indicate that the mean AI literacy score of male B.Ed. students was 130.81 (SD = 13.30), while the mean score of female B.Ed. students was 132.00 (SD = 15.30). The obtained *t*-value of 0.50 indicates that the difference between the two groups was not statistically significant at the 0.05 level. Therefore, the null hypothesis was accepted. The finding suggests that male and female B.Ed. students demonstrate broadly similar levels of AI literacy. Thus, gender does not appear to be a significant factor influencing AI literacy among the respondents in the present study.

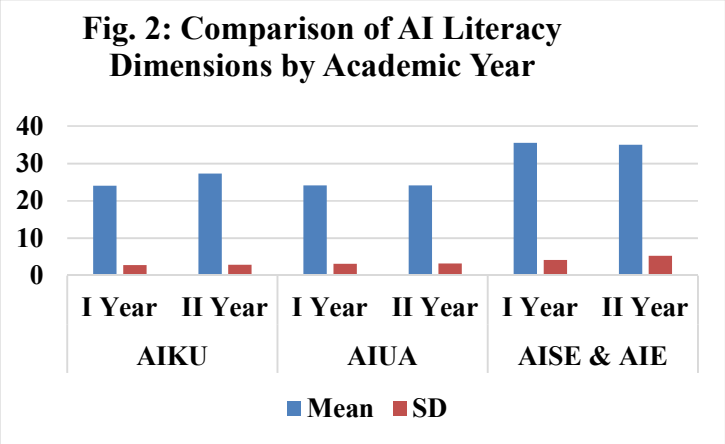
Objective 2:To find whether there is a significant difference in AI Knowledge and Understanding (AIKU), AI Use and Apply (AIUA), AI Self-Efficacy (AISE), and AI Ethics (AIE) among first-year and second-year B.Ed. students.

Hypothesis 2: There is no significant difference in AI Knowledge and Understanding (AIKU), AI Use and Apply (AIUA), AI Self-Efficacy (AISE), and AI Ethics (AIE) among first-year and second-year B.Ed. students.

Table 2: Comparison of AI Literacy Dimensions by Academic Year

Dimension	Year	Mean	SD	t-value	p-value	Result
AIKU	I Year	24.03	2.82	0.67	0.50	NS
	II Year	27.27	2.85			
AIUA	I Year	24.05	3.13	0.01	0.98	NS
	II Year	24.04	3.24			
AISE & AIE	I Year	35.54	4.14	0.85	0.39	NS
	II Year	35.04	5.19			

Note: NS = Not Significant; $p > 0.05$.



The results indicate that second-year B.Ed. students obtained a higher mean score in AI Knowledge and Understanding (27.27) compared with first-year students (24.03). However, the difference was not statistically significant ($t = 0.67$, $p = 0.50$). For AI Use and Apply, the mean scores of first-year and second-year students were almost identical, at 24.05 and 24.04 respectively. The obtained t-value of 0.01 and p-value of 0.98 indicate that there was no significant difference. For AI Self-Efficacy and AI Ethics, first-year students obtained a mean score of 35.54, while second-year students obtained 35.04. The difference was not statistically significant ($t = 0.85$, $p = 0.39$).

Therefore, the null hypothesis is accepted. The findings indicate that first-year and second-year B.Ed. students do not differ significantly in AI Knowledge and Understanding, AI Use and Apply, AI Self-Efficacy, and AI Ethics.

CONCLUSION

The study examined AI literacy through four major dimensions: AI Knowledge and Understanding, AI Use and Apply, AI Self-Efficacy, and AI Ethics. The findings indicate that there is no significant difference in AI literacy between male and female B.Ed. students. The mean scores of male and female students were relatively similar, and the obtained t-value was not statistically significant. Therefore, gender was not found to be a significant factor influencing AI literacy among the respondents. Similarly, the comparison between first-year and second-year B.Ed. teacher trainees revealed no significant difference in AI Knowledge and Understanding, AI Use and Apply, AI Self-Efficacy, and AI Ethics. Although second-year students demonstrated a higher mean in AI Knowledge and Understanding, the difference did not reach statistical significance. AI Use and Apply scores were almost identical between the two groups, while the difference in AI Self-Efficacy and AI Ethics was also statistically non-significant. The findings therefore suggest that AI literacy does not necessarily develop automatically through gender, academic year, or progression within the B.Ed. programme. Instead, meaningful development of AI literacy requires planned educational interventions, practical exposure, curriculum integration, institutional support, and continuous professional development.

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ANALYTICAL STUDY OF AI LITERACY AND TEACHER READINESS AMONG PRE-SERVICE EDUCATORS IN KARNATAKA

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Abstract

The rapid growth of AI-literacy and being capable of integrating intelligent technologies into teaching-learning processes in a meaningful and ethical manner are desperately needed due to the integration of Artificial Intelligence in education. The present study examines the level of AI literacy among pre-service teachers enrolled in B.Ed. programmes in Karnataka and analyses differences based on selected demographic variables. A descriptive survey research method was adopted for the study. The sample consisted of 321 B.Ed. students selected from teacher education institutions representing different districts of Karnataka through a simple random sampling technique. Descriptive statistics such as mean and standard deviation and inferential statistics such as the independent samples t-test were employed for data analysis. The findings indicate that pre-service teachers possess a developing level of AI literacy and that AI has considerable potential to support lesson planning, assessment, personalized learning, instructional design, and educational decision-making. The study emphasizes the need for systematic AI literacy programmes, practical training, ethical awareness, and integration of AI-related competencies into teacher education curricula. Strengthening AI literacy among B.Ed. students can contribute to developing professionally competent, technologically confident, and ethically responsible teachers capable of responding effectively to the emerging demands of AI-enabled education.

Keywords: *Artificial Intelligence, AI Literacy, Pre-Service Teachers, B.Ed. Students, Teacher Readiness, AI Self-Efficacy, AI Ethics, Teacher Education*

INTRODUCTION:

Artificial intelligence in education is a About leveraging computer intelligence to make the teaching and learning more effective and better than traditional classroom learning, not about replacing human teachers with robotic ones. By serving as a mediator, peer supported collaborative learning (PSCL) (Mita Banerjee,2024) This study explosive AI literacy in teacher education through a professional partnership model. Using the Digital Education Council's AI literacy framework, they restructured their teaching approach to include AI-driven methods (Michelle Kelley and Taylar Wenzel, 2025) The study investigates pre-service teachers' use of the magic school AI tools for assessment . It found AI increased time efficiency and supported question generation rubrics (Gamze Erdem, 2025)

AI systems automatically evaluate and assist in addressing the various demands and difficulties of the learners (Lazar Krstic, et.al.,2022)AI is present in many aspect of our daily lives, including Google, Siri smartphones and smart home gadgets. (BurgSteiner et.al.,2016). AI in education has increased. Establishing AI competency requirements in the Humanity and

STEM field promotes Interdisciplinary learning and prepares students for careers driven by AI (Barrerra Castro et.al.,2024).

AI awareness campaign and curricular integration are examples of practical strategies. To prepare future teachers foundation literacy must be strengthened.(Shi Ruisi,2024) The Technological Pedagogical and Content Knowledge (TPACK). TPACK framework was introduced by Mishra and Koehler in 2006. TPACK is a comprehensive model that expresses the ways and means of integration of technology with pedagogy and subject content in the present educational environment. Technology like automated grading, intelligent tutoring and natural language processing. The teacher may use AI to make the data driven judgment and provide more individual instruction (Dipanwita Bit and et.al.,2024)

TPACK offers more benefits during teacher training because it improves lesson designing, effective integration of technology, increases student involvement, opportunities for personalized learning through enhanced learning outcomes. TPACK offers a suggestion to educationalist, curriculum designers to frame the curriculum that ensures national (NEP 2020) and global (UNESCO) frameworks on digital competency In AI based education, justice, transparency and capacity for explanation or emphasis. AI just serves as a support system and won't take the place of teachers (Swagatika Devi, et.al.,2023) Practical experience was connected with ethical awareness and confidence in employing AI tools. Collaborative learning and hands-on training are advised (Bo Pei,2024) AI literacy did not predict emotion control, but it did have a favourable impact on comprehension, ethics and problems solving. It suggests creating a literacy program that emphasizes understanding, development and moral application (Musa, et.al.,2024)AI literacy is conceptualized in a teacher education literature. The results reveal a global rise in interest but limited focus on professional teaching knowledge in AI context (Katarina,et.al.,2024)

AI's human-like abilities, like speech and picture recognition are emphasized. The study provide recommendation for enhancing AI for better learning (V V Subrahmanyam and K Swathi 2018) the study promotes the use of new assessment instruction and the incorporation of literacy into educational policies (Hasan and etl.al.,2024) AI has a capacity to completely transform education, learning and teaching data driven decision making, enhanced access and specially toiler education (Viji Agarwal., 2024) increases students' engagement with AI tools and their views of academic quality. It recommended incorporating PSCL and AI tools into curriculum in order to maximize the learning setting (Genimon,et.al.,2024) The paper calls for worldwide conservation above the failure and secure application of AI. It promotes on going innovation and inclusive approaches (Borhene Chakroun2019)

AI became a core component of digital age teaching and is no longer considered futuristic (Alwyn Vwen et.al.,2020) AI is being used not just in corporate sector but also in education, administration and campus management (Shivangi Dhawan, Gopal Batra 2021) AI should be used as a support system to manage its integration, appropriate policy frame and awareness campaign required. (Harry and Sayudin,2023) To exam and improve the cooperation the research created the human AI Synergy degree model (HAI-SDM) (Kong,Fang, et.al.,2025)

AI should be used as a support system to manage its integration, appropriate policy

frame and awareness campaign required. (Harry and Sayudin,2023) To exam and improve the 6degree model (HAI-SDM) (Kong,Fang, et.al.,2025) AI is described as a two-edged sword that needs to be strategically integrated(Ajani,Ankintolu,2024) AI promotes an adaptable learning environment and allows for personalized training. Performance, satisfaction and learning outcomes have all improved with the use of AI(Ajani and Maphalala,2025)AI increases significance, research on its effects on education still need to be done (Francisco 2019) To exam and improve the cooperation the research created the human AI Synergy degree model (HAI-SDM) (Kong,Fang, et.al.,2025)

AI became a core component of digital age teaching and is no longer considered futuristic (Alwyn Vwen et.al.,2020) AI AI should be used as a support system to manage its integration, appropriate policy frame and awareness campaign required. (Harry and Sayudin,2023 The strategy was informed by the AI literacy framework of the digital education council. Being demonstrator to personalized learning and expedite administration (Taylar Wenzel,2025) Students may use AII technology efficiently and critically awareness lessens overconfidence(Senad Becirovic et.al 2025) Lack of adequate training for the educators to use AI effectively is a significant problem. It emphasizes how difficult it is to implement AI. (Azzam and Charles,2024)

OBJECTIVES OF THE STUDY

Objective 1: To compare the level of AI literacy among male and female B.Ed. students.

Objective 2: To compare the level of AI literacy among B.Ed. students belonging to urban and rural localities.

HYPOTHESIS OF THE STUDY

H_o1: There is no significant difference in the level of AI literacy among male and female B.Ed. students.

H_o2: There is no significant difference in the level of AI literacy among B.Ed. students belonging to urban and rural localities.

RESULTS AND DISCUSSION

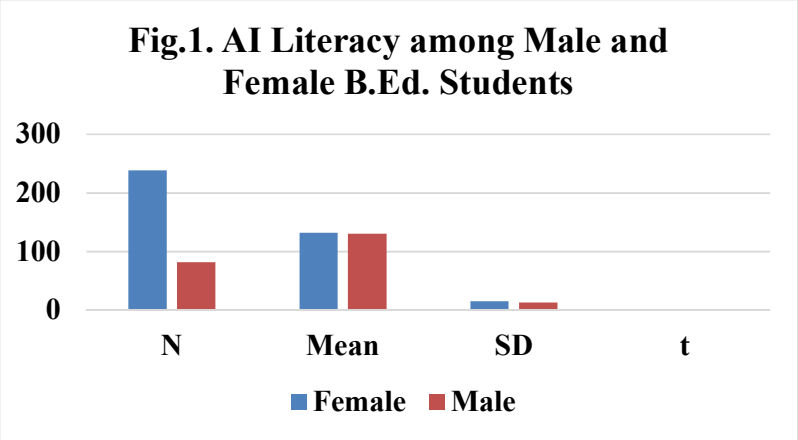
Objective 1: To compare the level of AI literacy among male and female B.Ed. students.

Hypothesis 1: There is no significant difference in the level of AI literacy among male and female B.Ed. students.

Table 1. AI Literacy among Male and Female B.Ed. Students

Gender	N	Mean	SD	*t*	Significance
Female	239	132.00	15.30	0.50	Not Significant
Male	82	130.81	13.30		

Note: NS = Not Significant; $p > 0.05$.



The results presented in Table 2 indicate that female B.Ed. students obtained a mean AI literacy score of **132.00** with a standard deviation of **15.30**, whereas male B.Ed. students obtained a mean score of **130.81** with a standard deviation of **13.30**. The calculated *t*-value of **0.50** is not statistically significant at the 0.05 level. Therefore, the null hypothesis is accepted. The findings indicate that there is **no significant difference in AI literacy between male and female B.Ed. students**.

Although female students obtained a slightly higher mean score than male students, the difference is statistically insignificant. This suggests that gender does not appear to be a major factor influencing overall AI literacy within the present sample.

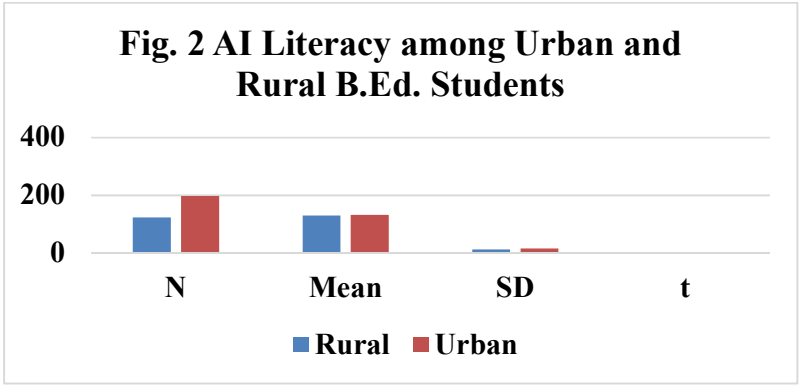
Objective 2: To compare the level of AI literacy among B.Ed. students belonging to urban and rural localities.

Hypothesis 2: There is no significant difference in the level of AI literacy among B.Ed. students belonging to urban and rural localities.

Table 2. AI Literacy among Urban and Rural B.Ed. Students

Locality	N	Mean	SD	*t*	Significance
Rural	123	130.69	13.29	0.81	Not Significant
Urban	198	132.34	15.60		

Note: NS = Not Significant; $p > 0.05$.



The results presented in Table 3 indicate that urban B.Ed. students obtained a mean AI literacy score of **132.34** with a standard deviation of **15.60**, while rural B.Ed. students obtained a mean score of **130.69** with a standard deviation of **13.29**.

The calculated *t*-value of **0.81** is not statistically significant at the 0.05 level. Therefore, the null hypothesis is **accepted**. The findings indicate that there is no significant difference in AI literacy between urban and rural B.Ed. students. Although urban students recorded a slightly higher mean score than rural students, the difference is not statistically significant. This suggests that locality does not have a substantial influence on AI literacy among the respondents included in the study.

LIMITATIONS OF THE STUDY

1. The study was limited to B.Ed. students in selected teacher education institutions in Karnataka.
2. The sample consisted of 321 respondents; therefore, the findings may not be generalized to all pre-service teachers without further investigation.
3. The study relied primarily on self-reported responses.

CONCLUSION

Artificial Intelligence is rapidly becoming an important component of contemporary education, creating both opportunities and challenges for teachers and teacher educators. The present study examined AI literacy among 321 B.Ed. students in Karnataka using four major dimensions: AI knowledge and understanding, AI use and application, AI self-efficacy, and AI ethics. The findings indicate that there is no statistically significant difference in AI literacy based on gender or locality among the respondents. This suggests that AI literacy development is not necessarily determined by demographic characteristics and that systematic educational opportunities can support the development of AI competencies among diverse groups of pre-service teachers. The study emphasizes that future teachers require more than technical familiarity with AI tools. They need conceptual understanding, practical competence, confidence, critical thinking, and ethical awareness. Therefore, teacher education institutions should move towards a structured model of AI competency development that combines theoretical knowledge, hands-on experience, pedagogical integration, critical evaluation, and ethical responsibility.

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ARTIFICIAL INTELLIGENCE FOR PROFESSIONAL DEVELOPMENT OF CHEMISTRY TEACHERS: OPPORTUNITIES, CHALLENGES AND FUTURE DIRECTIONS

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Abstract

Artificial Intelligence (AI) is drastically transforming education by offering new opportunities for indivisalised learning, content creation, intelligent assessment, data analysis, and professional development. Chemistry teachers, in specifically, can take benefits from AI-supported professional development since chemistry education demands the integration of theoretical understanding, mathematical reasoning,laboratory skills, problem-solving, visualization and powerful pedagogical strategies. These thematic articles explore the potential of Artificial Intelligence(AI) for the professional development of chemistry teachers and examine how Artificial Intelligence(AI) can assist continuous learning, lesson planning, reflective practice,assessment, classroom innovation and collaborative learning. Artificial Intelligence(AI)tools can help teachers in developing teaching resources, identifying misconceptions, generating differentiated learning activities, simulating laboratory experiences, creating formative assessments and exploring complex chemical concepts through visual and interactive representations. Simultaneously, the use of Artificial Intelligence(AI) raises important concerns related to academic integrity, accuracy, teacher autonomy, bias, data privacy, digital inequality, and the possibility of excessive dependence on automated systems. The article contends that Artificial Intelligence(AI)should not substitute the professional knowledge and judgment of chemistry teachers but should function as anassistive partner in their continuing professional development (CPD). Effective Artificial Intelligence(AI)integration requires suitable digital competencies, ethical guidelines, institutional support, subject-specific training and opportunities for teachers to essentially evaluate Artificial Intelligence(AI)-generated content. A framework for Artificial Intelligence(AI)-supported professional development is intended based on five interconnected dimensions: Artificial Intelligence(AI) literacy, pedagogical integration, reflective practice, chemistry-specific application and ethical responsibility. The article concludes that accountable and intentional integration of Artificial Intelligence(AI) can reinforce chemistry teachers' professional learning and eventually contribute to more inclusive, engaging and effective chemistry education.

Keywords: *Artificial Intelligence, Professional Development, Chemistry Teachers, Artificial Intelligence(AI)Literacy, Teacher Education, Chemistry Education, Digital Technology, Generative Artificial Intelligence(AI).*

1. Introduction

Professional development is avital component of effective teaching. Teachers need continuous prospect to update their pedagogical practices, subject knowledge, technological competencies, assessment strategies and understanding of learners. In science education, professional development is eventually important because technologies,scientific knowledge, laboratory practices, and techniques to teaching and learning continue to progress. Chemistry

teachers face the extra challenge of explaining abstract concepts such as chemical bonding, atomic structure, molecular interactions, thermodynamics,equilibrium, kinetics, and electrochemistry while also supporting learners connect these ideas to noticeable phenomena and real-world applications. The advent of Artificial Intelligence (AI) has generated new potentialities for teacher professional development. Artificial Intelligence (AI) representswildly to computational systems capable of performing tasks that conventionally require aspects of human intelligence, such as language processing, pattern recognition, content generation, prediction and decision support. Recent advances in Generative Artificial Intelligence(AI) have made these technologies approachable to teachers through conversational interfaces that can generate lesson plans, explanations,questions,simulations, examples, summaries and other educational resources. For chemistry teachers, Artificial Intelligence(AI) has particular potential because chemistry involves extensive use of symbolic language, representations, quantitative calculations, experimentation, visualization and problem-solving. Artificial Intelligence(AI) canhelp teachers in moving between microscopic, macroscopic and symbolic levels of chemical understanding. It can also help teachers design learning activities that address different abilities and learning needs. However, Artificial Intelligence(AI) should not be understood simply as one more digital tool. Its ability to generate apparently authoritative information introduces new professional responsibilities. Artificial Intelligence(AI) -generated explanations, chemical equations, laboratory procedures, numerical solutions and references may contain errors. Teachers therefore need sufficient Artificial Intelligence(AI) literacy and chemistry expertise to evaluate and adapt Artificial Intelligence(AI) -generated material. The purpose of this thematic article is to examine how AI can contribute to the professional development of chemistry teachers, identify major opportunities and challenges, and propose principles for responsible implementation.

2. Professional Development of Chemistry Teachers

Teacher professional development refers to systematic and continuous activities through which teachers enhance their professional knowledge, skills, beliefs and practices. Effective professional development is not restricted to attending occasional conference, workshops etc., It is a continuous process involving experimentation, reflection, collaboration, feedback, and application in authentic teaching contexts.

For chemistry teachers, professional development can involve many areas:

- Chemistry knowledge updating and recent scientific developments.
- Increasing pedagogical content knowledge (PCK).
- Evolving effective laboratory and inquiry-based teaching techniques.
- Learning recent approaches to assessment.
- Managing students' alternative conceptions and misconceptions.
- Integration of educational technologies into chemistry instruction.
- Developing inclusive and differentiated teaching practices.
- Reflecting systematically on classroom experiences.
- Collaborating with other chemistry teachers and professional communities.

3. AI as a Tool for Continuous Professional Learning

One of the major advantages of Artificial Intelligence (AI) is its potential to support teachers

whenever professional learning needs arise. Instead of waiting for a scheduled training programme, teachers can use Artificial Intelligence (AI) systems to explore a concept, obtain examples, generate questions, or seek alternative explanations.

For example, a chemistry teacher preparing a lesson on chemical equilibrium could ask an Artificial Intelligence (AI) system to provide: A simple description suitable for beginners, a description using particle-level reasoning, a Common student misconception, Higher-order questions, Formative assessment items, Real-world applications of equilibrium.

The teacher can then crucially evaluate these outputs and incorporate suitable ideas into the lesson. Artificial Intelligence (AI) can therefore facilitate just-in-time professional development, where learning occurs in replay to an immediate teaching requirement. This strategy may be particularly useful for teachers working in schools with limited access to subject-specific professional development programmes.

4. Artificial Intelligence (AI) Literacy as a New Dimension of Teacher Competence

The growing use of Artificial Intelligence (AI) means that chemistry teachers need more than general digital literacy. They require Artificial Intelligence (AI) literacy—the ability to understand how Artificial Intelligence (AI) systems work at a practical level, recognize their abilities and limitations, formulate productive prompts, evaluate generated information, and use Artificial Intelligence (AI) ethically.

Artificial Intelligence (AI) literacy for chemistry teachers should include:

- Understanding Artificial Intelligence (AI) Capabilities
- Evaluating Accuracy
- Prompt Design
- Ethical Use

5. Artificial Intelligence (AI) for Lesson Planning and Instructional Design

Lesson planning is a major area in which Artificial Intelligence (AI) can support chemistry teachers. Teachers can use Artificial Intelligence (AI) to brainstorm learning objectives, teaching strategies, examples, activities, assessment questions, and differentiated tasks.

The teacher remains responsible for opting and modifying the suggestions. Artificial Intelligence (AI) can lower the time required to generate initial ideas while allowing the teacher to focus on pedagogical selections. Artificial Intelligence (AI) can also assist teachers differentiate instruction. One single chemistry concept can be represented through multiple levels of complexity. Teachers can ask Artificial Intelligence (AI) to generate beginner, intermediate, and advanced questions or to provide explanations using everyday examples, diagrams, mathematical reasoning, or laboratory contexts. This can help inclusive classrooms where students have different levels of previous knowledge and learning needs.

6. Artificial Intelligence (AI) for Understanding and Addressing Chemistry Misconceptions

Chemistry is attributed by numerous persistent misconceptions. Students may misunderstand concepts such as conservation of mass, oxidation-reduction, chemical bonding, equilibrium, acids and bases, and the particulate nature of matter.

Artificial Intelligence (AI) can support teachers identify possible misconceptions by generating lists of common incorrect ideas and suggesting diagnostic questions. Teachers can

use these questions to determine students' conceptual understanding before and during instruction. Artificial Intelligence (AI) may also generate multiple explanations of a difficult concept. This can support teachers compare different pedagogical approaches and select the explanation most appropriate for their students.

However, teachers must verify Artificial Intelligence (AI) generated descriptions because an Artificial Intelligence (AI) system can itself reproduce misconceptions or oversimplifications.

7. Artificial Intelligence (AI) -Supported Assessment and Feedback

Assessment is another very important area for professional development. Artificial Intelligence (AI) can help teachers develop formative and summative assessment materials, including multiple-choice questions, numerical problems, short-answer questions, conceptual questions, and higher-order thinking tasks. Artificial Intelligence (AI) can also assist in generating feedback. For example, teachers can provide anonymized learner responses and ask an Artificial Intelligence (AI) system to identify patterns of errors or suggest feedback techniques. The teacher should review the suggestions before providing feedback to students.

The professional value of Artificial Intelligence (AI) in assessment therefore extends beyond saving time. It can support teachers reflect on the quality, validity, balance and cognitive demand of their assessments.

8. Artificial Intelligence (AI) and Chemistry Laboratory Education

Laboratory work is essential to chemistry education. Teachers must plan meaningful, safe and educationally effective experiments. Artificial Intelligence (AI) can support laboratory preparation by helping teachers predict observations, generate experimental questions, prepare pre-laboratory questions, develop post-laboratory activities, and identify possible sources of experimental error. Artificial Intelligence (AI) can also assist in designing virtual or simulated laboratory experiences. Such resources may be useful when laboratory facilities are limited, when an experiment is too expensive or hazardous for routine classroom use, or when students need opportunities to rehearse procedures before entering the laboratory. Artificial Intelligence (AI) should complement—not replace—hands-on laboratory experiences wherever practical and safe.

9. Artificial Intelligence (AI) for Collaborative Professional Learning

Professional learning is often more effective when teachers collaborate. AI can support professional learning communities by helping teachers develop discussion questions, compare lesson approaches, analyze teaching scenarios, and generate collaborative tasks.

A group of chemistry teachers could use AI to examine a common instructional challenge, such as students' difficulty understanding mole calculations. Teachers might independently develop strategies and then use AI to generate alternative approaches. The group can compare these ideas, evaluate them using their classroom experience, and develop a shared intervention. This model positions AI as a **discussion partner** rather than an authority. The expertise remains within the professional community, while AI expands the range of possibilities considered.

10. Artificial Intelligence (AI) for Reflective Practice

Reflective practice is central to professional growth. Teachers improve when they systematically examine what happened during a lesson, why it happened, and how future

teaching could be improved. However, reflective practice should remain teacher-driven. Artificial Intelligence (AI) should not determine whether a teacher's lesson was successful without contextual understanding.

11. Personalized Professional Development Pathways

Artificial Intelligence (AI) can potentially help individualized professional development. Teachers have different levels of experience, technological confidence, subject expertise and professional goals. An experienced chemistry teacher may want to explore advanced assessment practices, while an early-career teacher may need support with lesson planning, classroom management or fundamental pedagogical techniques.

Artificial Intelligence (AI) can support teachers identify learning goals and generate individualized sequences of professional learning activities.

12. Challenges and Risks of Artificial Intelligence (AI) in Teacher Professional Development

Despite its potential, Artificial Intelligence (AI) presents significant challenges.

- Perfection and Hallucination
- Overdependence
- Academic Integrity
- Data Privacy
- Bias
- Digital Inequality
- Loss of Human Interaction

13. Recommendations for Institutions and Teacher Educators

Schools, universities, and educational organizations should consider the following measures when introducing Artificial Intelligence (AI) into chemistry teacher professional development:

- Develop Artificial Intelligence (AI) literacy programmes specifically designed for teachers.
- Include chemistry-specific examples rather than relying only on generic Artificial Intelligence (AI) training.
- Provide opportunities for hands-on experimentation with Artificial Intelligence (AI) tools.
- Emphasize verification of Artificial Intelligence (AI) -generated scientific information.
- Develop institutional guidelines for responsible AI use.
- Protect teacher and student data.
- Encourage professional learning communities and peer collaboration.
- Provide mentoring for teachers who are less confident with technology.
- Evaluate the impact of Artificial Intelligence (AI) -supported professional development on classroom practice.
- Maintain opportunities for human-led workshops, mentoring, laboratory training, and professional dialogue.

Professional development should focus not simply on learning how to operate Artificial

Intelligence (AI) tools but on understanding when, why, and how Artificial Intelligence (AI) should be used.

14. Conclusion

Artificial Intelligence (AI) offers significant opportunities for the professional development of chemistry teachers. It can help continuous learning, lesson planning, differentiation, assessment, misconception analysis, collaboration, laboratory preparation and reflective practice. By providing rapid access to ideas and resources, Artificial Intelligence (AI) can make professional learning more flexible and personalized. However, Artificial Intelligence (AI) is not a substitute for chemistry expertise, professional judgement, pedagogical knowledge or human relationships. Its outputs may contain biases, inaccuracies or inappropriate recommendations. Responsible use therefore requires teachers to develop strong Artificial Intelligence (AI) literacy and maintain a critical approach to generated content. The effective integration of Artificial Intelligence (AI) into chemistry teacher professional development should be based on partnership rather than replacement. Teachers should remain the decision-makers, while Artificial Intelligence (AI) functions as a tool for exploration, creativity, reflection and efficiency. Professional development programmes should combine Artificial Intelligence (AI) literacy with chemistry-specific pedagogy, collaborative learning, ethical awareness and reflective practice. Ultimately, the importance of Artificial Intelligence (AI) in chemistry education will depend not on how much technology teachers use, but on how purposefully and critically they use it. When supported by suitable training, professional communities, institutional policies and ethical principles, Artificial Intelligence (AI) can become a powerful component of continuous lifelong professional development and contribute to a more inclusive, innovative and effective chemistry education system.

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THE DIGITAL DIVIDE AND THE ETHICS OF AI IN GLOBAL EDUCATION: ENSURING EQUITABLE ACCESS IN DEVELOPING CONTEXTS OF INDIA

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Abstract

The rapid introduction of Artificial Intelligence (AI) in education promises personalized learning and lower administrative burdens. However, in developing nations like India, these technological advances run directly into deep social and economic inequalities. This thematic paper looks at the intersection of the digital divide and the ethical concerns regarding AI integration in Indian education. Drawing on empirical data, national sample surveys, institutional studies, and doctoral research studies (e.g., ASER Centre, 2023; MoSPI, 2022; Azim Premji Foundation, 2021; Sharma, 2021; Wakude, 2022), this paper outlines how structural gaps like unstable internet connectivity, gender disparities in phone ownership, and a lack of regional language content turn AI in to a source of inequality. This paper offers practical policy suggestions grounded in India's National Education Policy (NEP 2020) and the IndiaAI Mission to help build an ethical, inclusive, and decentralized AI learning model.

Keywords: *Digital Divide, AI Ethics, Digital Equity, NEP 2020*

1. Introduction

Artificial Intelligence is moving from experimental lab settings to the mainstream classrooms. Intelligent Tutoring Systems (ITS), automated grading programs, and adaptive learning apps are often pitched as the ultimate fix for long-standing issues in global education especially in large class sizes, shortages of trained teachers, and unequal access to quality learning materials (UNESCO, 2023). In developing countries, this use of AI sounds convincing (NITI Aayog, 2021). India, for instance, faces a huge gap in educational infrastructure, particularly across its rural settings. Yet, bringing AI into a deeply unequal society comes with significant compromises. Technology does not operate in a vacuum but it takes on the biases and inequalities of the environment where it is deployed (Rani, 2020). If a student lacks a stable internet connection or a smartphone, advanced AI learning tools remain completely out of reach. When AI is rolled out without fixing these structural gaps, it risks widening the divide between privileged urban students and marginalized rural learners (Oxfam India, 2020; Sharma, 2021). The traditional mindsets of teachers, parents and other stakeholders at certain extend expands the digital divide in the use of smartphones in classes and before a certain age group. Hence, this paper explores the realities of the digital divide in India, examines the ethical risks of using AI in under-resourced schools, and suggests ways to ensure technological progress does not leave vulnerable communities behind.

2. The Digital Divide in India

The Digital Divide refers to the gap between individuals, households, socioeconomic groups, or geographic areas that have full access to modern information and communication technology (ICT) and those who do not have access to that (Lythreatis et al., 2022). Hence, to

understand whether AI can realistically improve Indian education, we first need to look at the physical and socio-economic infrastructure already on the ground. The digital divide in India is not just about having or not having a computer; it involves distinct layers: connectivity, hardware ownership, digital literacy, and gender-based access (Athreya & Simha, 2025; Wakude, 2022) to technologies and gadgets. This widens the gap and the digital divide. Three Core Dimensions of the Gap are,

-Access Gap (First-Level Divide) : Lack of physical infrastructure, high-speed broadband, or affordable devices (laptops, smartphones).

-Use Gap (Digital Literacy- Second-Level Divide)): Possessing hardware but lacking the skills, training, or confidence to navigate software, search effectively, or utilize digital platforms (Lythreatis et al., 2022).

-Quality Gap (Third-Level Divide): Differences in connection stability, speed, and device processing power (e.g., dial-up/low 3G speed vs. high-speed fiber internet) (Lythreatis et al., 2022).

The major reasons for these divide are Socioeconomic status, geographic location, and age and Education

2.1 Rural-Urban and Socio-Economic Gaps

While India has over 600 million internet users, internet penetration is spread very unevenly. A thorough study of Government and empirical research studies show a persistent gap between cities and villages (Kaur & Singh, 2016; Wakude, 2022):

- **Broadband Penetration:** Rural broadband penetration sits at around 29%, compared to a national average of 51% (PIB, 2026)
- **Household Device Access:** A landmark study by the Azim Premji Foundation (2021) revealed that almost 60% of school children in India could not access online learning opportunities during remote schooling shifts. Data from the Annual Status of Education Report (ASER Centre, 2023) shows that while smartphone ownership at home grew to over 67% in recent years, less than 20% of young children in primary grades had dedicated access to a device when they actually needed it for studying. Research on rural school infrastructure similarly highlights that shared family devices rarely translate to effective study access for children (Sharma, 2021). This creates inefficiency in the globalisation of education through technology.
- **Economic Cost Burden:** Data charges in India are relatively cheap per gigabyte, but for households earning less, buying routine data packages consumes roughly 3% of their monthly income compared to just 0.2% for middle-class households (Oxfam India, 2020). High-speed internet required for running complex generative AI applications remains an expensive luxury for poorer families especially in the rural and tribal areas.

2.2 The Gender and Digital Literacy Divide

The gap gets even wider when we factor in gender and functional literacy:

- **Gender Disparity:** According to joint studies by ICRIER and LIRNEasia (2021) and doctoral findings from different research studies on gendered technology adoption (Rani, 2020), Indian women are 15% less likely to own a mobile phone and 33% less

likely to use mobile internet than men. In rural homes with only one shared mobile phone, male children are almost always given priority for online classes and study tools (Kaur & Singh, 2016).

- **Functional Digital Literacy:** National Sample Survey data from the Ministry of Statistics and Programme Implementation (MoSPI, 2022) indicates that while around 20% of the overall population aged 5 and above possesses basic digital literacy, only 40% of youth aged 15–29 can operate a computer or use the internet in computers effectively. Basic digital literacy is an absolute requirement before anyone can meaningfully use AI-driven educational software (Wakude, 2022).

3. Ethical Dimensions of AI in Developing Educational Contexts

When AI tools are layered onto these structural inequalities, several ethical problems emerge.

3.1 Algorithmic Bias and Linguistic Exclusion

Most Large Language Models (LLMs) and educational AI algorithms are trained on datasets sourced heavily from Western, English-speaking contexts (UNESCO, 2023).

- **Linguistic Isolation:** India has 22 officially recognized languages and hundreds of dialects. AI models trained primarily on English fail to grasp regional context, local syntax, and cultural nuances. A student learning in Hindi, Marathi, or Tamil often gets less accurate output from AI tools compared to a student querying in English (Athreya & Simha, 2025; Wakude, 2022). Recent studies show lesser gap in this regard.
- **Reinforcing Social Hierarchies:** Automated scoring systems and predictive performance tools learn from historical data. If historical school data contains bias against lower-caste, tribal, or low-income students, the AI can end up grading their work more harshly or falsely flagging them as "high-risk dropouts" (NITI Aayog, 2021; Sharma, 2021).

3.2 Surveillance, Data Privacy, and Consent

To deliver personalized learning, EdTech applications collect huge amounts of personal data, including real-time facial expressions, reaction times, location details, and test performance.

- **Lack of Informed Consent:** In rural and under-resourced Indian schools, both parents and teachers often lack the digital literacy to understand complex privacy disclosures (ICRIER & LIRNEasia, 2021). Student data is routinely collected without meaningful informed consent.
- **Biometric Risks:** The expansion of facial recognition for tracking attendance creates serious privacy concerns. Without strict compliance with India's Digital Personal Data Protection (DPDP) framework, young students face the risk of having their personal data leaked or commercialized (Oxfam India, 2020; Rani, 2020).

3.3 Commercial Dominance and the "Corporate EdTech" Model

During periods of sudden digital migration, private EdTech platforms expanded rapidly across India.

- **EdTech Exploitation:** Studies on aggressive marketing tactics by commercial EdTech companies highlight how low-income families are pushed into expensive subscription models under the promise of "AI-driven success" (Azim Premji Foundation, 2021; Wakude, 2022). Illiterate or less qualified parents, for the better future of their wards,

unwittingly fell into the traps of such Advertisement. Relying heavily on private AI apps shifts the core responsibility of teaching away from state-funded public schools into the hands of profit-driven corporations. This creates a two-tiered system: wealthy students enjoy human-led teaching alongside advanced AI tools, while poorer students are left with low-cost, automated digital software with little to no human guidance (UNESCO, 2023). In bargain of searching for cheaper or economical ways , they end-up in inefficient tools or EdTechs.

4. Government Policies and Institutional Initiatives

The Indian government has recognized some of these gaps and introduced national initiatives aimed at balancing innovation with access:

Initiative	Key Objectives	Equity & Ethical Impact
National Education Policy (NEP) 2020	Promotes technology integration while warning against the digital divide; calls for multilingual content.	Sets up the National Educational Technology Forum (NETF) to guide decisions on tech adoption. MHRD (2020)
DIKSHA & e-PG Pathshala	Open-source national platforms offering free curriculum content across multiple Indian languages.	Reduces reliance on private subscriptions; archived across Shodhganga as key public IR tools. MHRD (2020); Wakude (2022)
IndiaAI Mission (2024–2026)	Multi-crore funding to build computing infrastructure, support AI startups, and develop public AI tools.	Focuses on creating open-source Datasets and localized LLMs tailored to Indian regional languages. PIB (2026)
PM Gati Shakti & BharatNet	Infrastructure push to lay fiber optic networks across all Gram Panchayats (village councils).	Aims to solve the baseline problem: getting stable internet to remote schools. PIB (2026)

Frameworks for Ethical Governance: The UNESCO 5C Model

To mitigate the vulnerabilities, international regulatory have evolved from abstract principles to actionable competencies. UNESCO's normative suite anchored by the *Recommendation on the Ethics of Artificial Intelligence* and complemented by the *AI Competency Frameworks for Teachers and Learners* establishes a human-centered approach to digital transformation.

Core Pillar	Strategic Operational Focus
1. Coordination	Sovereign policy alignment, ethical oversight bodies
2. Content	Culturally relevant, multi-lingual open-source models
3. Capacity	Pedagogical AI literacy for teachers and students
4. Connectivity	Public investments in rural grid & internet access
5. Cost	Sustainable funding models to prevent long-term debt

Under this framework, it does not replace teachers but teachers are recontextualized as ethical mediators who guide students through algorithmic outputs, identifying bias, and protecting

critical inquiry.

5. Recommendations for Equitable and Ethical AI Integration

To ensure AI works as a bridge rather than a wall in Indian education, policy makers, schools, and developers should focus on these practical priorities:

1. **Invest in Infrastructure:** AI software is useless without physical access. Priority funding must go toward completing the BharatNet rural broadband push and supplying public schools with solar-powered devices and reliable electricity (PIB, 2026; Sharma, 2021).

- **Build Local Language Datasets, Open-Source, Multilingual AI Models:** AI tools should be built using open-source architectures trained on localized datasets. Initiatives like Bhashini (India's AI-based language translation mission) need to be integrated directly into educational apps so students can learn comfortably in their native language (NITI Aayog, 2021; Wakude, 2022). Allocate public research grants toward digitizing, curating, and open-sourcing high-quality educational text and audio corpora in regional and indigenous languages.
- **Shift Focus from Technical Literacy to Critical AI Literacy:** Teacher training programs must move beyond operational instruction (how to type a prompt) to focus on critical evaluation. Teaching educators how to interrogate model assumptions, identify hallucinations, and protect student privacy.

2. **Prioritize Offline-First AI Architectures:** Tech developers should build lightweight, edge-computed AI models that can run on simple devices without requiring constant high-speed internet (Athreya & Simha, 2025).
3. **Mandate Algorithmic Audits and Data Protection:** Educational AI software used in schools should undergo mandatory bias and privacy checks. Automated systems must never be used as the sole decision-maker for grading, scholarship selection, or admissions (UNESCO, 2023; Rani, 2020).
4. **Teacher Empowerment Over Replacement:** AI should serve as an assistant to the teacher, not a substitute. Teacher training programs must include digital ethics and practical skills on how to use AI tools effectively alongside regular classroom teaching (MHRD, 2020; Sharma, 2021).
5. **Implement Strict Data Sovereignty Laws:** Establish legal protections that forbid multinational EdTech vendors from exporting student usage data outside national borders or leveraging non-consensual learner data to train commercial models.

6. Conclusion

AI offers real potential to broaden learning opportunities, but using it ethically in a country as diverse as India requires careful planning. If we ignore existing structural issues like poor connectivity, limited device access, and language barriers, AI will surely replicate and speed up existing social inequalities. Bridging the digital divide is not just a technical task; it is an ethical duty. By prioritizing public digital infrastructure, open-source localized software, strong privacy safeguards, and teacher training, India can build an educational model where AI serves every student, regardless of their locality or socio-economic background.

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AI-ENHANCED FORMATIVE ASSESSMENT AND EXPLAINABLE LEARNING ANALYTICS IN SECONDARY MATHEMATICS: A TEACHER-DRIVEN SMART-AI FRAMEWORK FOR ACHIEVEMENT, CRITICAL THINKING AND SOCIAL SKILLS

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Abstract

Artificial intelligence (AI) is increasingly transforming educational assessment through automated feedback, prediction, learner modelling, and learning analytics. However, its educational value depends not only on data analysis but also on teachers' ability to interpret evidence and translate it into appropriate pedagogical action. This conceptual paper presents the SMART-AI Mathematics Framework as a novel teacher-driven model integrating AI-enhanced formative assessment, explainable learning analytics, teacher professional judgement, and social constructivist mathematics pedagogy. The framework addresses the gap between assessment evidence and instructional action through a seven-stage Smart Teacher Assessment Cycle: Assess, Analyze, Diagnose, Adapt, Scaffold, Collaborate, and Reassess. AI-supported analytics identifies learning patterns, gaps, and potential misconceptions, while explainable analytics provides interpretable evidence to support teacher decision-making. Teachers then adapt instruction through collaborative problem solving, peer explanation, mathematical dialogue, scaffolding, and argumentation. The framework focuses on three key student outcomes: mathematics achievement, critical thinking, and social skills. It positions AI as an evidence-support mechanism rather than an autonomous teacher and conceptualizes the smart teacher as AI-literate, assessment-literate, data-informed, and ethically responsible. The paper concludes by proposing empirical validation through quasi-experimental and mixed-methods research.

Keywords: *Artificial intelligence, formative assessment, learning analytics, mathematics education, critical thinking, social skills, teacher professional judgement, social Constructivism.*

1. Introduction

Artificial intelligence (AI) is increasingly transforming educational assessment, feedback, learning analytics and instructional decision-making. Its educational value, however, depends not only on technological capability but also on teachers' ability to interpret AI-generated evidence and make ethical, informed pedagogical decisions (Miao & Cukurova, 2024).

Formative assessment is particularly important in mathematics education, where understanding involves conceptual knowledge, procedural skills, reasoning, problem-solving and communication. AI-enhanced assessment can identify learning patterns, errors and misconceptions, while learning analytics can organize this evidence to support timely instructional decisions (Maskos et al., 2025; Paulsen & Lindsay, 2024). However, predictions and analytics become meaningful only when teachers critically interpret them and connect

them with classroom evidence. A human-centred approach therefore positions AI as a support mechanism rather than a replacement for teacher judgement. In mathematics classrooms, AI-supported evidence can help teachers identify students' needs and provide differentiated scaffolding, collaborative problem-solving opportunities, and mathematical discussion and peer learning. Against this background, the present conceptual paper proposes the **SMART-AI Mathematics Framework**, which integrates **AI-enhanced formative assessment, explainable learning analytics, teacher professional judgement, and social constructivist mathematics pedagogy**. It introduces a seven-stage **Smart Teacher Assessment Cycle: Assess, Analyze, Diagnose, Adapt, Scaffold, Collaborate and Reassess**. The framework aims to connect AI-supported evidence with teacher-driven instructional action to enhance **mathematics achievement, critical thinking and social skills** among secondary school students. Accordingly, the purpose of this conceptual paper is **to propose and theoretically articulate a teacher-driven framework for integrating AI-enhanced formative assessment and explainable learning analytics with social constructivist mathematics pedagogy to support mathematics achievement, critical thinking and social skills among secondary school students**.

2. Conceptual and Theoretical Foundations

The **SMART-AI Mathematics Framework** is based on four key foundations: **human-centred AI, formative assessment, explainable learning analytics, and social constructivism**. AI can support prediction, assessment, feedback and pattern recognition, but it should enhance rather than replace teachers. UNESCO emphasises human agency, ethics and professional judgement in AI-supported education. Formative assessment provides evidence of students' learning and guides subsequent instruction (Black & Wiliam, 2009). AI and learning analytics can strengthen this process by identifying performance patterns, misconceptions and learning gaps. **Explainable learning analytics** makes AI-generated evidence understandable, enabling teachers to critically evaluate and use recommendations. The framework also draws on **Vygotsky's (1978) social constructivism**, emphasising collaboration, scaffolding, peer learning, discussion and mathematical reasoning. The theoretical process is:

AI identifies evidence → Teacher interprets evidence → Social constructivist pedagogy addresses learning needs.

Thus, the **Smart Teacher** requires five competencies: **assessment literacy, AI literacy, learning analytics literacy, pedagogical judgement and ethical AI literacy**.

3. Research Gap and Rationale

Existing research on **formative assessment, AI, learning analytics, explainability and social constructivist mathematics pedagogy** is largely fragmented. Limited attention has been given to integrating these components into a unified, teacher-driven process. In particular, the link between **explainable AI evidence and teachers' formative instructional decisions** remains underdeveloped. Ethical issues such as privacy and responsible use of student data also require attention. Therefore, the paper addresses an **integration gap** by connecting:

AI-enhanced formative assessment + Explainable learning analytics + Teacher judgement + Social constructivist mathematics pedagogy.

4. Originality and Conceptual Contribution

The originality of the paper lies in integrating previously fragmented elements into a teacher-driven framework for secondary mathematics education**. The proposed framework connects AI-supported learning evidence, explainable analytics, teacher professional judgement, and social learning to support** mathematics achievement, critical thinking, and social skills**. It introduces two conceptual elements: the** SMART-AI Mathematics Framework**, comprising** Student Learning Evidence, Machine/AI Analytics, Actionable Explain ability, Responsive Teacher Decision-Making, and Transformative Social Learning**, and the** Smart Teacher Assessment Cycle**, comprising** Assess, Analyze, Diagnose, Adapt, Scaffold, Collaborate, and Reassess**. Together, these elements position AI as a support mechanism for evidence-based teaching rather than as a replacement for teachers. These propositions are developed through synthesis of existing literature and require empirical validation in secondary mathematics classrooms.**

5. SMART-AI Mathematics Framework

The **SMART-AI Mathematics Framework** presents a continuous process linking formative assessment, AI analytics, teacher judgement and social learning. **Student Learning Evidence** is collected through mathematical responses, errors, reasoning and learning progress. **Machine/AI Analytics** identifies patterns, misconceptions and learning gaps. **Actionable Explain ability** provides understandable evidence behind AI-generated insights.

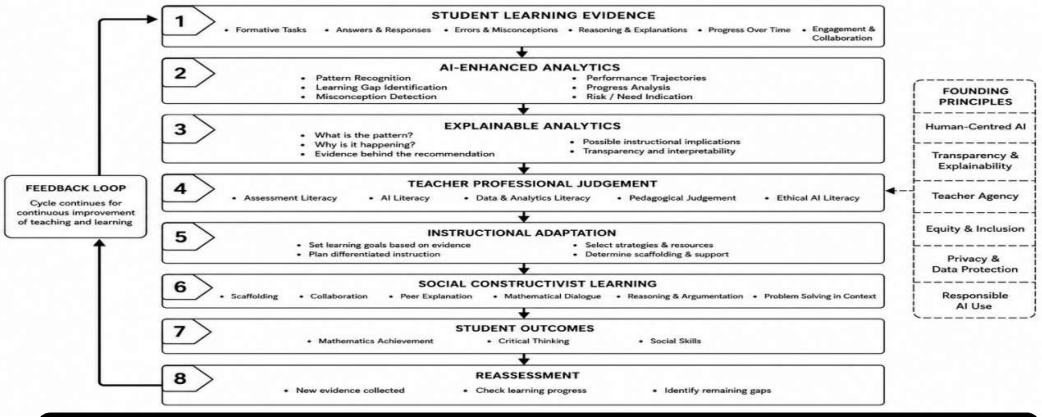
Teachers then use **Responsive Teacher Decision-Making** to interpret the evidence and adapt instruction. Students participate in **Transformative Social Learning** through collaboration, discussion, peer explanation, scaffolding and problem-solving.

The framework operates through the cycle:

Assess → Analyse → Diagnose → Adapt → Scaffold → Collaborate → Reassess → Repeat

Thus, SMART-AI positions **AI as an evidence-support tool, the teacher as the central decision-maker, and students as active participants in mathematical learning**.

SMART-AI Mathematics Framework



The SMART-AI Mathematics Framework integrates **AI-enhanced formative assessment, explainable learning analytics, teacher professional judgement, and social constructivist pedagogy in a continuous cycle to enhance**

6. Contribution to Assessment, Evaluation and Learning Analytics

The framework has direct relevance to the conference sub-theme.

Component	Function
Assessment	Generates evidence of current learning
Analytics	Identifies patterns and possible learning gaps
Explain ability	Makes analytical evidence interpretable
Evaluation	Teacher evaluates evidence and instructional response
Adaptation	Instruction is modified
Social learning	Students engage collaboratively
Reassessment	New evidence evaluates progress

The integrated process is:

Assessment → Evidence → Analytics → Explanation → Teacher Judgement → Action → Evaluation → Reassessment

This represents a conceptual shift from **assessment of learning** towards **assessment for responsive learning**.

7. Ethical and Responsible AI

The use of AI-supported assessment with school students requires **ethical, responsible, and human-centred practices**. Student data should be collected only for legitimate educational purposes and protected to ensure privacy and security. AI recommendations should be **transparent, explainable, and monitored for bias and inequity**, while following the principle of data minimization. **Human agency** must remain central, with teachers critically evaluating AI-generated information rather than relying on it blindly. Students should not be permanently labelled as "weak," "low ability," or "at risk" based solely on algorithmic predictions. Since AI systems may produce inaccurate, incomplete, or biased outputs, teachers must maintain **human oversight, professional judgement, and ethical responsibility** (Kasneci et al., 2023; Farrokhnia et al., 2024).

8. Implications for Teacher Education

The proposed framework has important implications for **B.Ed. and teacher-education programmes**, requiring a shift from basic digital competence towards **Pedagogical-AI Assessment Knowledge (PAAK)**, conceptualised as **Pedagogical Knowledge + Assessment Literacy + AI Literacy + Data Literacy + Ethical Reasoning**. Teacher education should therefore prepare student teachers in AI fundamentals, formative assessment, learning analytics, data interpretation, explainable AI, AI-output evaluation, ethics, privacy, differentiated instruction, collaborative learning and mathematical reasoning. A **Smart Teacher** should critically evaluate AI-generated evidence, question the basis of recommendations, consider alternative explanations, relate AI findings to classroom observations, and select appropriate instructional responses without labelling students. Thus, AI should function as a **decision-support tool** while teachers retain professional autonomy, ethical responsibility and pedagogical judgement.

9. Limitations

This paper has several **limitations**. First, the **SMART-AI Mathematics Framework** is conceptual and has not yet been empirically validated; therefore, its proposed relationships

cannot be considered causal. Second, its effectiveness may depend on the **quality of assessment data, AI accuracy, teacher AI competence, technological infrastructure, and classroom context**. Third, explain ability may improve transparency but does not guarantee appropriate teacher decisions, which depend on teachers' assessment and pedagogical expertise. Fourth, learning analytics raises concerns regarding **student privacy, algorithmic bias, and equity**. Finally, both the **PAAK construct and SMART-AI framework require systematic empirical validation** across diverse educational contexts before being established as robust theoretical and practical models.

10. Future Empirical Validation

The proposed framework can be empirically examined in secondary mathematics education using a **quasi-experimental pretest–posttest non-equivalent control-group design**. The experimental group may receive AI-enhanced formative assessment with explainable learning analytics, teacher-led instructional adaptation, and social constructivist pedagogy, while the comparison group follows conventional instruction. Key outcomes may include **mathematics achievement, critical thinking, and social skills**, along with teacher instructional adaptation, AI literacy, student engagement, and learning progression. Data may be analysed using **ANCOVA/MANCOVA, effect-size, regression, and mediation analyses**. Future research should examine whether learning gains result directly from AI or from **teachers' improved pedagogical decisions based on interpretable AI evidence**. The framework emphasises the latter, positioning AI as a support mechanism that strengthens **teacher professional judgement and instructional decision-making**.

11. Conclusion

Artificial Intelligence has significant potential to strengthen assessment and learning analytics in secondary mathematics education, but technology alone cannot guarantee improved learning. The **SMART-AI Mathematics Framework** integrates **AI-enhanced formative assessment, explainable learning analytics, teacher professional judgement, social constructivist pedagogy, and reassessment** through the cycle: **Assess → Analyse → Diagnose → Adapt → Scaffold → Collaborate → Reassess**. Its central contribution is to position **AI as an evidence-support tool rather than an autonomous teacher**, with teachers retaining responsibility for interpretation, ethical decision-making and instructional adaptation. Through collaboration, scaffolding, mathematical dialogue and reasoning, the framework aims to support **mathematics achievement, critical thinking and social skills**. Thus, the SMART-AI framework provides a conceptual foundation for future empirical research and contributes to the field of **Assessment, Evaluation and Learning Analytics**.

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GENERATIVE ARTIFICIAL INTELLIGENCE IN COMMERCE EDUCATION: TRANSFORMING TEACHING AND LEARNING FOR THE FUTURE

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Abstract

The advent of Generative Artificial Intelligence (GenAI) has fundamentally reshaped the landscape of higher education, particularly in specialized academic domains such as commerce education. This paper seeks to explore the pedagogical potential of leveraging emerging AI tools, including ChatGPT, Google Gemini, and Microsoft Copilot, to transform teaching/learning practices in commerce education, with a focus on accounting, finance, business economics, taxation, and management studies. By undertaking a conceptual and pedagogical inquiry, this paper aims to contribute an understanding of how best GenAI can be integrated into commerce education while simultaneously navigating the accompanying opportunities, challenges, and risks. Ultimately, this paper provides a set of recommendations for achieving responsible integration of GenAI into commerce education.

Keywords: *Generative artificial intelligence, Commerce education, Teaching and learning, Higher education, Academic integrity, Pedagogical innovation*

1. INTRODUCTION

The emergence of Generative Artificial Intelligence (GenAI) represents one of the most significant developments in higher education in the post-internet era. With the proliferation of AI tools capable of performing diverse functions ranging from text generation to mathematical computations, simulations, and even the creation of case studies with a high degree of accuracy, there is growing interest in the potential of these technologies to disrupt traditional areas of higher education, with commerce education being among the most affected. Commerce education typically encompasses disciplines such as accounting, finance, banking, taxation, business law, marketing, and economics, all of which have relied on a set of established principles and procedural frameworks. As such, the application of GenAI in this field warrants a careful and nuanced consideration. With the increasing adoption of automation and digital technologies in the workplace, students pursuing careers in commerce-related fields can expect to encounter a professional environment in which AI-driven technologies are pervasive. In this context, it is important that educational institutions embrace GenAI as a pedagogical tool to prepare students for the realities of the modern workplace. While the potential of GenAI to enhance the quality of education is undeniably compelling, there are also concerns about its potential to facilitate academic dishonesty and undermine the integrity of the learning process. This paper aims to elucidate upon the pedagogical potential of GenAI while also considering the limitations, challenges, and risks that it presents.

1.1. OBJECTIVES OF THE STUDY

This paper aims to achieve the following objectives:

- Examine the role of GenAI tools in enhancing teaching and learning in commerce education.
- Explore the pedagogical opportunities and innovations enabled by GenAI.
- Discuss the challenges and risks associated with GenAI in commerce education.
- Propose recommendations for responsible GenAI integration into commerce education.

1.2. SIGNIFICANCE OF THE STUDY

This paper contributes to the growing literature on the role of artificial intelligence in higher education, with a specific focus on Generative AI and commerce education. While there is a wealth of research on the applications and implications of AI in higher education, few studies have focused on the unique applications and opportunities that GenAI presents in commerce education, which this paper aims to address.

1. LITERATURE REVIEW

Zawacki-Richter, Marín, Bond & Gouverneur (2019) This systematic review found that pre-ChatGPT AI research in higher education focused mainly on predicting student performance, adaptive learning, and automated grading, with little attention to pedagogy or ethics.

Kasneci et al. (2023) The study highlighted ChatGPT-like tools' ability to personalize explanations and generate content, while warning of risks like inaccurate outputs, bias, and overreliance that could weaken independent thinking.

Chan & Hu (2023) Surveying university students, this study found generally positive attitudes toward generative AI as a learning aid, alongside concerns about fairness, overdependence, and unclear institutional policies.

Dwivedi et al. (2023) Drawing on multidisciplinary expert views, this synthesis concluded that conversational AI offers real value but poses risks to integrity, employment, and data governance, calling for discipline-specific adoption.

Rasul et al. (2023) Focused on higher education, this review identified benefits such as round-the-clock tutoring and reduced faculty workload, but cautioned against erosion of student judgment and urged further empirical research.

3. DISCIPLINE WISE APPLICATIONS OF GENAI IN COMMERCE EDUCATION

3.1 Accounting and Auditing

GenAI can Explaining Ind AS/US GAAP, generating journal entry/reconciliation practice questions, audit report simulations.

Recommended AI Tools: Microsoft Copilot (Excel), ChatGPT, Claude, CCH iKnowConnect.

Copilot works natively in Excel for journal entries/reconciliations; ChatGPT and Claude are strong for explaining standards in depth and generating varied practice scenarios; CCH iKnowConnect is purpose-built for accounting/audit research and reduces hallucination on technical standards.

3.2 Finance and Financial Modelling

GenAI can potentially be used to Spotting spreadsheet errors, explaining CAPM/DCF, ESG analysis, fraud detection, sentiment analysis.

Recommended AI Tools: Microsoft Copilot (Excel), ChatGPT, Google Gemini, Bloomberg GPT. Copilot audits formulas directly in the model; ChatGPT/Gemini handle conceptual walkthroughs and sentiment-analysis exercises well; Bloomberg GPT is trained specifically on financial data, useful for exposing students to industry-grade tools.

3.3 Marketing and Management

GenAI can be used to generate case studies, client overviews, and even AI-powered negotiation simulations to help students develop their skills in these areas. The rise of artificial intelligence has also prompted the emergence of a "feeling economy", wherein human skills such as managing, negotiating, and communicating have become increasingly important. Interestingly, there is potential to leverage GenAI to support students in developing these "human skills".Recommended AI Tools: Google Gemini, ChatGPT (voice/roleplay mode), Claude, Character.AI Gemini and ChatGPT support extended conversational roleplay for negotiation practice; Claude is strong for nuanced, longer case-study writing; Character.AI allows more customizable persona-based simulations for client interactions

3.4 Business Economics

GenAI can be used to generate graph-based questions in business economics, as well as explain economic concepts using metaphors and analogies to aid comprehension. Additionally, students can use GenAI to gain a deeper understanding of economic news and reports. Recommended AI Tools: ChatGPT (GPT-4-class), Google Gemini, Wolfram Alpha (for graphing/computation), Perplexity AI (for real-time economic news analysis)

ChatGPT and Gemini generate graphs and analogies well; Wolfram Alpha adds precise mathematical/graphical rigor; Perplexity is useful for grounding economic news discussion in current, cited sources rather than the model's static training data

3.5 Business Law and Taxation

GenAI can be used to explain legal/tax concepts, frequent amendments to statutes and regulations, sensitivity to outdated statutes.

Recommended AI Tools: ChatGPT, Google Gemini, CoCounsel (Thomson Reuters), Harvey AI (legal-specific)

General tools are useful as first-draft generators; CoCounsel and Harvey AI are purpose-built for legal research with tighter sourcing to current statutes, better suited to the paper's specific concern about regulatory obsolescence — though even these still require cross-verification against official government sources.

2. OPPORTUNITIES FOR TEACHING AND LEARNING OFFERED BY GENERATIVE ARTIFICIAL INTELLIGENCE

- **Personalised and Adaptive Learning Experiences:** Gen AI can be utilized to offer students with individualized learning experiences depending on their particular needs. For instance, if a student is struggling with a particular topic, such as cost accounting, the teacher can use Gen AI to help explain the subject matter in greater depth, generate practice questions and even produce revision notes based on the student's needs.
- **Case Study and Simulation-Based Learning:** Most disciplines within commerce education involve a significant emphasis on case studies as a tool for facilitating experiential learning and encouraging students to think critically. Gen AI can be leveraged to generate

business cases based on real-world scenarios, which can then be utilized to facilitate class discussions and encourage students to apply their knowledge to solve practical problems.

- **Research Support and Writing Assistance:** Students often have to conduct research, write essays or even complete dissertations as part of their coursework, which can be a challenging undertaking. In this context, Gen AI can be utilized to help students conduct literature reviews, organize their thoughts, develop outline proposals for their research, as well as write their essays and reports, thus saving them a significant amount of time and effort, as well as helping them improve their writing skills.
- **Automated Formative Assessments:** Educators can utilize Gen AI to develop quizzes, assessments, grading rubrics, and comment banks to help grade students' work, thus saving them time and effort while also enabling them to provide students with timely and constructive feedback. Additionally, automated assessments can help ensure consistency in grading practices, particularly in large classes.
- **Financial Modeling and Data Analysis Support:** When combined with spreadsheet processors such as Excel, Gen AI can help students conduct data analysis and generate financial forecasts, thus preparing them for careers in finance, as well as business analytics.
- **Language and Communication Support:** For non-native English speakers, writing assignments can often be a daunting task, given the need to adhere to specific conventions and standards. In this context, Gen AI can be utilized to offer language assistance, ranging from editing and proofreading to helping students generate more formal and professional-sounding prose.

3. OPPORTUNITIES AND CHALLENGES OF USING GENERATIVE AI IN COMMERCE EDUCATION

OPPORTUNITIES:

- **Enhanced Student Engagement:** Gen AI tools can be utilized to increase student engagement, particularly in disciplines such as taxation, law, and auditing, which often involve a significant emphasis on procedural knowledge. By utilizing chat-based interfaces, Gen AI can help make complex subjects more accessible and engaging, thus encouraging deeper learning.
- **Development of AI Literacy as an Employability Skill:** With the increasing adoption of AI in businesses worldwide, proficiency in utilizing these tools has become a valuable skill, with employers seeking individuals who are comfortable interacting with AI systems. As such, familiarity with AI tools can be leveraged as a means of enhancing employability, especially among students, who can utilize these tools to gain a competitive advantage in the job market. By encouraging students to develop AI literacy, educators can help equip them with skills that extend beyond their specialisation and facilitate their success in the modern workplace.
- **Adoption of Flipped and Blended Classrooms:** Many educators have adopted flipped and blended classrooms, wherein students engage with new material outside of class, usually in the form of videos or readings, and then apply their knowledge through activities and discussions during class time. This approach can be supplemented by the use of Gen AI tools, wherein students can interact with the material outside of class and then engage in more

interactive and discussion-based sessions during class, thus promoting deeper learning and critical thinking.

- **Addressing Differentiated Learning Needs:** Students have diverse learning needs and preferences, and some may find it more challenging to grasp certain concepts than others. Additionally, some students, particularly those whose first language is not English, may struggle with language barriers. Gen AI can be utilized to address these differentiated needs by providing additional support, such as explaining concepts in greater detail, providing language assistance, or breaking down complex subjects into more manageable components, thus facilitating equitable learning opportunities for all students.
- **Reduced Administrative Workloads for Educators:** Many educators have reported that administrative duties can often be time-consuming and detract from their ability to focus on teaching and research. By utilizing Gen AI tools to automate certain tasks, such as grading multiple-choice assessments or generating question banks, educators can save time and effort, thereby allowing them to dedicate more time and energy to their teaching and research activities.

CHALLENGES

- **Academic Integrity Concerns:** Gen AI tools have the potential to facilitate academic dishonesty, particularly in disciplines that place a strong emphasis on research and essay writing, such as commerce education. By simply inputting prompts, students can generate essays, case analyses, and even research reports, which they can then submit as their own work, thus undermining the integrity of the assessment process. As such, it is crucial for educators to implement measures to prevent and detect academic misconduct, such as plagiarism detection tools and strict honour codes.
- **Erosion of Core Analytical and Judgement Skills:** In disciplines such as accounting, financial analysis, and auditing, analytical and judgement skills are integral to professional practice. However, the reliance on Gen AI tools to generate responses and solutions may hinder the development of these skills, as students may become overly reliant on the tools rather than engaging in critical thinking and independent analysis. This presents a significant concern, particularly in fields that require strong analytical and judgement skills.
- **Accuracy and Reliability Concerns:** One of the main limitations of Gen AI tools is their potential to provide inaccurate information, particularly in subjects such as business law and taxation, where statutes and regulations are subject to frequent amendments. This can result in students receiving incorrect information, which can compromise their learning and decision-making. As such, it is important for educators to emphasize the importance of verifying the information provided by these tools and encouraging students to consult reliable sources.
- **Data Privacy and Ethical Considerations:** The widespread use of Gen AI tools raises important data privacy and ethical concerns, particularly in relation to the collection and use of student data. By utilizing these tools, students and educators may inadvertently share sensitive information with third parties, which can raise privacy and security concerns. Additionally, ethical considerations should be taken into account when utilizing Gen AI tools,

such as ensuring that these tools are used responsibly and ethically, and that students are aware of the potential limitations and risks associated with these tools.

- **Digital and Economic Divide:** Access to Gen AI tools may be limited among certain students, particularly those from low-income households or institutions that lack the necessary resources to adopt these technologies. This can create a digital and economic divide, wherein students from disadvantaged backgrounds may be unable to access the same educational opportunities as their peers, thus exacerbating existing inequalities in education.
- **Faculty Readiness and Training:** Many faculty members who teach commerce-related disciplines may lack the necessary skills and confidence to effectively integrate Gen AI tools into their teaching practices. This may discourage them from adopting these tools or using them inappropriately, thus undermining their potential benefits. As such, it is important for institutions to invest in faculty training and professional development to ensure that educators are equipped with the necessary skills to leverage these tools in their teaching practices.

4. PROPOSED FRAMEWORK FOR RESPONSIBLE ADOPTION OF GEN AI IN COMMERCE EDUCATION

Based on the opportunities and challenges presented by Gen AI in commerce education, this paper proposes the following framework for responsible adoption of these tools:

- **Curriculum redesign:** To fully integrate Gen AI into commerce education, it will be necessary to revise the curriculum to reflect the latest developments in this field. One way of achieving this objective is by incorporating 'AI literacy' into the curriculum or offering modules that encourage students to critically evaluate the information provided by these tools. This is important, given the potential for these tools to provide inaccurate information, particularly in subjects such as business law and taxation.
- **Assessment redesign:** Institutions should consider redesigning their assessment strategies to promote authentic assessment while also deterring the use of Gen AI tools for academic dishonesty. For instance, educators could consider adopting alternative assessment methods such as presentations and oral examinations to supplement written assessments. Additionally, assessments should be designed to encourage higher-order cognitive skills such as judgement and reasoning, thus ensuring that students are not solely reliant on AI tools to complete their assignments.

- **Faculty development:** Faculty members need to be trained on the effective use of Gen AI tools in education. By offering workshops and training sessions, institutions can empower educators to confidently utilise these tools in their teaching practices while also addressing their concerns and misconceptions about these technologies.
- **Ethical guidelines:** Institutions should develop ethical guidelines in relation to the use of Gen AI in education, and these guidelines should be disseminated to all stakeholders, including students and faculty members. These guidelines should provide practical recommendations on the ethical use of these tools while also addressing concerns related to data privacy and security.

5. RECOMMENDATIONS

Based on the preceding analysis, it is therefore important for educators to adopt a balanced perspective in relation to these tools, whereby they encourage their judicious use while also being aware of their limitations. In this context, this paper offers the following recommendations for achieving responsible adoption of Gen AI in commerce education.

First, educators should consider using these tools to support students' knowledge and procedural recall, while reserving higher-order skills for human judgement and instruction. As noted throughout this paper, Gen AI can be used to support various aspects of commerce education, ranging from providing explanations of concepts to generating practice questions and even completing assignments. Given that most disciplines within commerce education place a strong emphasis on judgement and analytical skills, it is important that these skills are cultivated through human instruction, rather than relying on Gen AI tools. For instance, in accounting, financial analysis, auditing, and tax planning, judgement plays a critical role in practice, and students need to develop these skills through human instruction, rather than relying on these tools to do it for them. This is not to suggest that these tools should not be used in these disciplines, but rather that they should be used judiciously to support knowledge and procedural recall, rather than supplanting the need for human judgement. Second, it will be important for institutions to invest in faculty development to ensure that they have the requisite skills and confidence to adopt these tools in a responsible manner. As noted in this paper, many faculty members who teach commerce-related disciplines are not familiar with AI tools, and this lack of familiarity may deter them from using these tools or using them irresponsibly. Finally, faculty members need to encourage students to utilise these tools in a responsible manner by educating them on their potential benefits and limitations. This includes encouraging students to use these tools to support their learning while also emphasizing the importance of verifying the accuracy of the information provided by these tools, particularly in disciplines such as business law and taxation, where accuracy is paramount.

8. CONCLUSION

Generative artificial intelligence represents a disruptive innovation that has the potential to revolutionize commerce education. While there are concerns about the potential of these tools to compromise academic integrity, judicious use of these tools can enhance the learning experiences of students while also preparing them for the modern workplace. By redesigning the curriculum and assessments while also providing faculty with the necessary support, educators can harness the potential of these tools to enhance commerce education.

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AI AND ENGLISH: SHAPING FUTURE-READY TEACHERS

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Abstract

Artificial Intelligence (AI) is rapidly transforming the landscape of education, particularly the teaching and learning of languages. English, as a widely used global language, offers significant opportunities for AI-assisted learning through intelligent tutoring systems, generative AI, speech recognition, automated feedback, adaptive learning platforms and conversational tools. These technologies can support learners in developing the four language skills—Listening, Speaking, Reading and Writing (LSRW)—while providing personalised learning experiences and immediate feedback. At the same time, AI is redefining the role of the English teacher. The teacher of the future is not merely a transmitter of linguistic knowledge but a facilitator, mentor, designer of learning experiences and critical user of AI. This thematic paper explores the potential of AI to enhance English Language Proficiency (ELP), its applications in English Language Learning (ELL), and the competencies teachers need to integrate AI meaningfully into pedagogy. It also examines challenges related to accuracy, academic integrity, privacy, bias, digital inequality and overdependence on technology. The paper argues that AI should augment, rather than replace, the human teacher. A future-ready English teacher is therefore one who combines linguistic expertise, pedagogical knowledge, digital competence, AI literacy and human values to create meaningful and inclusive languagelearning experiences.

Keywords: *Artificial Intelligence, English Language Learning, English Language Proficiency, Future-Ready Teachers, AI Literacy, LSRW Skills, Language Education*

INTRODUCTION:

The emergence of Artificial Intelligence has brought a significant transformation in the way knowledge is created, accessed, communicated and evaluated. Education is increasingly moving from conventional teacher-centred approaches towards technology-supported, personalised and learner-centred environments. Among the various educational domains influenced by AI, English Language Teaching and Learning has enormous potential for transformation. English learners traditionally depend on teachers, textbooks, language laboratories and peer interaction to develop proficiency. AI now offers additional possibilities: learners can converse with AI systems, receive instant writing feedback, practise pronunciation, generate reading materials at their level, expand their vocabulary, and obtain explanations of grammatical concepts. However, the increasing availability of AI does not diminish the importance of teachers. Rather, it changes their responsibilities. The future English teacher needs to know not only how to teach English but also how to use AI critically, creatively, ethically and pedagogically.

Thus, the central question is no longer:
"Can AI teach English?" but rather:
"How can English teachers harness AI to make language learning more meaningful, personalised, inclusive and effective?"

✞ ***AI in English Language Education***

Artificial Intelligence broadly refers to computational systems capable of performing tasks associated with human Intelligence, such as understanding language, generating content, recognising speech, identifying patterns, and providing recommendations.
In English education, AI can function as:

- a learning assistant
- a conversation partner
- a writing coach
- a pronunciation facilitator
- a vocabulary tutor
- a grammar support system
- an assessment assistant
- a content-generation tool
- a personalised learning companion

Generative AI has further expanded these possibilities by enabling teachers and learners to interact with AI through natural language.
The educational value of AI, however, does not lie simply in using sophisticated technology. Its real value emerges when it is purposefully integrated with sound language pedagogy.

✞ ***AI and English Language Proficiency***

English Language Proficiency involves the ability to use English effectively and appropriately in different contexts. AI can support the development of proficiency across the major language skills.

Role of AI in Developing English Language Skills

Language Skill	AI-Supported Activities	Potential Benefits to Learners	Role of the Teacher / Key Consideration
Listening	• Audio materials at different proficiency levels • Conversations with varied accents • Transcripts and captions • Comprehension questions • Repeated listening • Explanations of unfamiliar expressions	• Develops listening comprehension • Provides exposure to diverse accents • Enables self-paced and repeated practice • Extends learning beyond classroom time	The teacher selects appropriate materials and verifies their accuracy. AI can provide additional practice but should complement classroom interaction.

Speaking	• Simulated conversations Everyday communication practice • Interview rehearsal	• Builds speaking confidence • Provides lowpressure practice • Improves fluency and pronunciation • Encourages repeated	Teacher facilitates authentic human communication. AI should **supplement, not replace, human interaction**, which develops empathy, spontaneity, body language and social skills.
Language Skill	**AI-Supported Activities**	**Potential Benefits to Learners**	**Role of the Teacher / Key Consideration**
	• Role-play activities • Pronunciation practice • Feedback on language use	communication practice	
Reading	• Level-appropriate texts • Vocabulary explanations • Summaries • Comprehension questions • Contextual definitions • Text simplification • Personalised reading materials	• Supports different proficiency levels • Enhances vocabulary development • Improves comprehension • Enables personalised and differentiated learning	Teacher can use AI to create different versions of texts while maintaining common learning objectives and should evaluate the quality of AI-generated content.
Writing	• Grammar checking • Vocabulary suggestions • Sentence-level feedback • Coherence and structure support • Spelling and punctuation correction • Drafting and revision assistance	• Improves accuracy and organisation • Encourages selfediting and revision • Provides immediate feedback • Develops independent writing skills	Teacher should encourage **revision rather than direct AIgenerated answers**. AI should function as a **writing mentor, not a writing substitute**.

Source: *Author's synthesis based on the reviewed literature on Artificial Intelligence in English Language Learning.*

AI for Vocabulary and Grammar Learning

Vocabulary acquisition requires repeated exposure, contextual use and active retrieval. AI can generate personalised vocabulary exercises based on learners' needs.

For example, AI can create:

- contextual sentences
- synonyms and antonyms
- word-association activities

- vocabulary quizzes
- cloze exercises
- flashcard material
- situation-based dialogues

Similarly, grammar learning can move beyond mechanical exercises. Teachers can ask AI to generate contextual examples of grammatical structures and create differentiated practice activities.

Instead of merely teaching:

→ "The Present Perfect Tense"

→ a teacher can design an AI-supported communicative task such as:

→ "Ask the learner five questions about experiences they have had in their life and encourage them to respond using the present perfect."

→ Thus, AI can help shift grammar instruction from rule memorisation to meaningful language use.

→ AI and LSRW Skills: A New Possibility

→ The four language skills can be strengthened through an integrated AI-supported approach.

AI Support for English Language Skills

English Language Skill	**Possible AI Support**
Listening	Audio generation, transcripts, comprehension activities
Speaking	AI conversations, role-play, pronunciation practice
Reading	Adaptive texts, summaries, vocabulary support
Writing	Feedback, editing, drafting and revision support

Possible AI Support for English Language Skills

English Language Skill	**Possible AI Support**
Listening	Audio generation, transcripts, comprehension activities
Speaking	AI conversations, role-play, pronunciation practice
English Language Skill	**Possible AI Support**
Reading	Adaptive texts, summaries, vocabulary support
Writing	Feedback, editing, drafting and revision support

The teacher's role is to connect these technologies to authentic communicative situations.

For instance, students may:

Listen → Discuss → Read → Write around a common theme.

AI can support each stage while the teacher remains responsible for designing the learning experience and evaluating meaningful learning.

✞ ***From Teacher to AI-Augmented Teacher***

AI does not necessarily make teachers less important. Instead, it can make certain traditional teacher roles less dominant while creating new responsibilities.

Traditional teacher

Teacher → Content → Student

AI-augmented teacher

Teacher + AI → Learning Experience → Student

The future-ready teacher may function as:

- Facilitator – guiding learners rather than simply delivering information.
- Learning Designer – creating meaningful AI-supported activities.
- Language Mentor – supporting communication and language development.
- AI Curator – selecting appropriate AI tools and resources.
- Critical Evaluator – checking AI-generated information and language.
- Ethical Guide – teaching responsible use of AI.
- Human Connector – preserving empathy, collaboration and authentic communication.

Therefore, AI should not be viewed as a competitor to teachers but as a pedagogical partner.

❖ ***Essential Competencies of a Future-Ready English Teacher***

The English teacher of the future requires a combination of competencies.

Linguistic Competence

- Pedagogical Competence
- AI Literacy
- Digital Competence
- Critical Thinking
- Ethical Competence

✞ ***AI as a Tool for Personalised English Learning***

- One of the greatest possibilities of AI is personalisation.
- A classroom may contain learners with very different levels of English proficiency. A single textbook and identical activity may not meet everyone's needs.
- AI can help teachers create differentiated materials for:
- beginners
- intermediate learners
- advanced learners
- learners requiring additional support
- For example, the same topic— "Environmental Pollution"—could be presented as:
- a simple paragraph for beginners,
- a newspaper-style article for intermediate learners,
- an argumentative text for advanced learners.

Thus, AI can help teachers move towards "one classroom, multiple learning pathways."

✞ ***AI and Assessment of English***

AI can assist teachers in formative assessment by providing rapid feedback on student work.

Possible applications include:

- grammar analysis
- vocabulary assessment
- writing feedback
- reading comprehension
- pronunciation support
- personalised practice questions

However, AI-based assessment should not be treated as automatically reliable.

The teacher must remain the final educational decision-maker, particularly when assessment

involves complex abilities such as creativity, critical thinking, communication and contextual language use.

✞ ***AI and Inclusive English Education***

AI also has the potential to make English learning more accessible.

Learners can potentially benefit from:

- text-to-speech tools
- speech-to-text systems
- translation support
- simplified texts
- multimodal resources
- personalised explanations
- repeated practice without embarrassment

This may be particularly useful in multilingual educational contexts such as India, where learners enter English classrooms with diverse linguistic backgrounds and varying levels of proficiency.

AI can therefore contribute to a more flexible and learner-responsive English classroom—provided access to technology is equitable.

CHALLENGES AND CONCERNS

The integration of AI into English education also presents significant challenges.

- Accuracy
- Overdependence
- Academic Integrity
- Bias
- Privacy
- Digital Inequality
- Human Interaction

THE INDIAN CONTEXT

India presents a particularly interesting context for AI-supported English education. English is an important language in higher education, employment, science, technology, and global communication.

At the same time, Indian classrooms are linguistically diverse. Learners may have different mother tongues and varying degrees of exposure to English.

AI can support this context through:

- multilingual explanations
- personalised English practice
- conversational English activities
- pronunciation practice
- differentiated learning materials
- teacher-assisted content creation

However, technology should be implemented with attention to accessibility, affordability, linguistic diversity and digital literacy.

The objective should not be to replace India's rich multilingual ecosystem with English-only

technology. Instead, AI can be used to create bridges between learners' existing linguistic resources and English proficiency.

✞ **A *Suggested* Framework: SMART English Teacher**

A useful conceptual framework for the future-ready English teacher can be represented through the word SMART:

S – Subject and Language Expertise

Strong knowledge of English and language pedagogy.

M – Meaningful AI Integration

Using AI where it genuinely improves learning.

A – AI and Digital Literacy

Understanding AI tools, capabilities and limitations.

R – Reflective and Responsible Practice

Evaluating AI critically and ethically.

T – Teacher–Learner Connection

Preserving empathy, communication, collaboration and human relationships.

Thus:

SMART Teacher = Language Expertise + Pedagogy + AI Literacy + Ethics + Human Connection

Towards a Human-Centred AI Classroom

The goal of AI integration should not be to create a classroom dominated by machines. The goal should be to create a classroom in which technology enhances human potential.

A human-centred AI English classroom may follow this principle:

AI generates → Teacher evaluates → Learner explores → Learner creates → Teacher guides → Learner reflects

This cycle places the learner and teacher—not the technology—at the centre of education.

The most valuable outcome of AI-supported English education is therefore not simply faster completion of assignments. It is the development of learners who can:

- communicate confidently,
- think critically,
- use English effectively,
- evaluate information,
- collaborate with others,
- Moreover, use AI responsibly.

IMPLICATIONS FOR TEACHER EDUCATION

→ Teacher education institutions have an important responsibility in preparing futureready English teachers.

→ Teacher education programmes should provide opportunities for prospective teachers to:

→ Explore AI tools relevant to English education.

→ Design AI-supported English lessons.

→ Develop effective prompting skills.

→ Evaluate AI-generated language materials.

→ Understand AI ethics and academic integrity.

→ Develop AI-assisted assessment strategies.
→ Practise differentiated instruction using AI.
→ Reflect critically on the limitations of AI.
→ Learn to balance AI interaction with human interaction.
→ Develop lifelong learning habits in a rapidly changing technological environment.
→ AI literacy should therefore become an integral component of contemporary teacher professional development.

CONCLUSION:

- Artificial Intelligence is not simply another educational technology. It is transforming the nature of teaching, learning and knowledge itself. In English education, AI can provide unprecedented opportunities for personalised learning, continuous practice, instant feedback and multimodal language development.
- However, technology alone cannot produce proficient English users. Pedagogy, human interaction, motivation, empathy and meaningful communication remain essential.
- The future-ready English teacher will therefore not be the one who knows the most AI tools. Rather, it will be the teacher who knows which tool to use, when to use it, why to use it, how to evaluate its output and when not to use it.
- AI should augment the teacher, not replace the teacher; empower the learner, not replace the learner's thinking.
- The future of English language education lies not in choosing between AI and teachers, but in creating a meaningful partnership between Artificial Intelligence and human Intelligence.

Ultimately:

Smart AI + Smart Teachers + Smart Pedagogy = Future-Ready English Learners

Moreover, the real measure of success will not be how intelligent our machines become, but how intelligently teachers use them to help learners communicate, think and learn better in English.

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AI-ENABLED TEACHER EDUCATION: TRANSFORMING PRE-SERVICE TEACHERS INTO SMART AND FUTURE-READY EDUCATORS

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Abstract

Artificial Intelligence (AI) is rapidly transforming education by influencing teaching, learning, assessment, curriculum design, educational administration, and professional development. This transformation has significant implications for teacher education because pre-service teachers are the future mediators between technology, learners, knowledge, and society. The purpose of this conceptual paper is to examine how AI-enabled teacher education can transform pre-service teachers into smart and future-ready educators. The paper explores the changing role of teachers in an AI-mediated educational environment, the competencies required by pre-service teachers, pedagogical applications of AI, opportunities for personalized and inclusive learning, assessment and feedback, professional development, and the ethical challenges associated with AI use. The discussion is informed by contemporary international frameworks, particularly UNESCO's AI Competency Framework for Teachers, which emphasizes a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. Recent research also indicates that scholarship on AI in pre-service teacher education is expanding rapidly, with increasing attention moving from technological efficiency toward the development of AI-literate and pedagogically competent teachers. The paper argues that AI should not be viewed as a replacement for teachers but as a powerful partner that can augment teachers' professional capacities. Teacher education institutions therefore need to move beyond basic digital literacy and develop AI literacy, critical thinking, ethical reasoning, prompt and information literacy, data literacy, pedagogical decision-making, and reflective professional practice. The paper proposes a human-centred, competency-based and practice-oriented approach to AI-enabled teacher education. Such an approach can prepare pre-service teachers to use AI responsibly, creatively, inclusively and critically while preserving the human purposes of education.

Keywords: *Artificial Intelligence, AI-enabled teacher education, pre-service teachers, AI literacy, smart teachers, future-ready educators, teacher competencies, generative AI, digital pedagogy, ethical AI*

Introduction

Artificial Intelligence has moved from being a specialised technological innovation to becoming an increasingly influential component of contemporary educational ecosystems. AI-supported applications are now being used for content generation, lesson planning, tutoring, assessment, feedback, learning analytics, language support, adaptive learning and professional development. The growing accessibility of generative AI has further accelerated this transformation. Consequently, education systems are being required to reconsider not only how students learn but also what teachers need to know, do and value.

The emergence of AI creates a particularly important challenge for teacher education. Pre-service teachers are being prepared for classrooms in which learners may have access to AI

tools before they fully understand their benefits, limitations and risks. Therefore, teacher education cannot remain focused exclusively on conventional pedagogical knowledge and general digital skills. It must prepare teachers to critically understand and pedagogically integrate AI. UNESCO's AI Competency Framework for Teachers (2024) recognizes that AI is changing the traditional teacher-student relationship into a teacher-AI-student relationship and identifies 15 competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. The framework proposes progressive levels of competence—Acquire, Deepen and Create. Recent research specifically examining pre-service teacher education also indicates that AI research has expanded substantially, particularly following the emergence of generative AI. A 2026 systematic review of 229 publications identified three major research hotspots: core AI technologies, pedagogically oriented AI applications for competency development, and generative AI integration. Importantly, the research emphasis is increasingly shifting from merely improving teaching efficiency toward developing AI-literate educators. Thus, the central question is no longer whether AI will influence teacher education, but how teacher education institutions can prepare teachers to use AI intelligently, ethically and pedagogically.

AI and the Changing Role of the Teacher

The traditional image of the teacher as the primary source and transmitter of knowledge is being challenged by the availability of AI-powered information and learning resources. However, this does not imply that teachers are becoming less important. Instead, their professional role is becoming more complex.

In an AI-enabled classroom, teachers may increasingly function as:

1. **Learning designers** who create meaningful learning experiences.
2. **AI curators** who select appropriate and trustworthy AI tools.
3. **Learning facilitators** who guide students in using AI critically.
4. **Ethical decision-makers** who protect privacy, dignity, equity and academic integrity.
5. **Mentors and human supporters** who address emotional, social and developmental needs.
6. **Assessors** who evaluate learning beyond AI-generated outputs.
7. **Reflective practitioners** who examine the consequences of AI-supported teaching.
8. **Lifelong learners** who continuously update their AI-related knowledge and competencies.

The OECD argues that rapidly evolving AI and robotics require education systems to reassess the knowledge, skills and attitudes needed for future life and work. Similarly, the OECD Teaching Compass emphasizes teachers as agents of curriculum change, adaptive experts and co-designers of learning rather than passive implementers of externally determined innovations. Therefore, the future-ready teacher should not compete with AI in areas where machines are efficient. Instead, teachers should develop distinctly human capabilities such as empathy, judgement, creativity, ethical reasoning, communication, collaboration and contextual decision-making.

Why AI-Enabled Teacher Education is Necessary

Teacher education institutions traditionally develop pedagogical knowledge, subject

knowledge, classroom management skills and professional attitudes. In the AI era, these remain essential but need to be complemented by AI-related competencies.

AI-enabled teacher education is necessary for several reasons.

- **Preparing teachers for AI-mediated classrooms:** Pre-service teachers will enter classrooms where AI-based technologies are increasingly available. They therefore need opportunities to understand how AI works, what it can and cannot do, and how it can influence learners.
- **Developing AI literacy:** AI literacy involves more than knowing how to operate an AI application. Teachers should understand basic AI concepts, data, algorithms, generative systems, limitations, bias, reliability and responsible use.
- **Strengthening pedagogical decision-making:** The availability of an AI tool does not automatically make its use educationally appropriate. Pre-service teachers should learn to ask: *What is the learning objective? Why should AI be used? What value does it add? What risks does it create? What human interaction should remain central?*
- **Promoting lifelong professional learning:** AI is developing rapidly. Consequently, teachers cannot depend on one-time training. Teacher education should cultivate a culture of continuous experimentation, reflection, professional collaboration and lifelong learning.

A recent scoping review of 55 studies on AI for pre-service teacher development found a diverse range of AI applications and highlighted the growing significance of AI in teacher professional development.

Core AI Competencies for Pre-Service Teachers

An effective AI-enabled teacher education programme should develop a multidimensional competency framework.

- **Human-centred mind-set:** AI should serve educational and human purposes rather than determine them. Pre-service teachers need to understand human agency, dignity, social responsibility and the developmental needs of learners.
- **AI foundations and applications:** Teachers need foundational knowledge about AI systems, machine learning, generative AI, natural language processing, recommendation systems and learning analytics. They do not necessarily need to become programmers, but they should possess sufficient conceptual knowledge to make informed professional decisions.
- **AI pedagogical competence:** AI literacy becomes meaningful only when connected to pedagogy. Pre-service teachers should learn how AI can support inquiry-based learning, project-based learning, collaborative learning, differentiated instruction, creativity and problem-solving.

  UNESCO specifically identifies AI-enhanced pedagogical innovation as a competency involving critical assessment of AI's impact on teaching, learning and assessment and the design of AI-supported learning scenarios.
- **Ethical and responsible AI competence:** Teachers must understand issues such as privacy, data protection, algorithmic bias, misinformation, intellectual property, copyright, academic integrity and unequal access.

- **AI-supported professional learning:** AI can assist teachers in preparing lesson plans, generating examples, developing classroom activities, analysing feedback, creating differentiated resources and reflecting on teaching practices. However, professional judgement must remain with the teacher.
- **Critical AI literacy:** Perhaps the most important competency is the ability to question AI-generated information. Pre-service teachers should learn to verify claims, identify hallucinations, compare sources, detect bias and distinguish plausible information from reliable evidence.

AI-Enabled Pedagogical Applications in Teacher Education

Teacher education programmes can integrate AI through authentic pedagogical experiences rather than treating AI as a separate theoretical subject.

- **AI-assisted lesson planning:** Pre-service teachers can use AI to generate alternative lesson structures, learning activities, examples and differentiation strategies. Teacher educators can then require student teachers to critique and improve the AI-generated lesson rather than simply accept it.
- **Microteaching and simulation:** AI-supported simulations can expose pre-service teachers to diverse classroom situations. They can practise questioning, classroom management, differentiated instruction and feedback before entering real classrooms.
- **Personalized learning:** AI can support the creation of learning resources at different levels of complexity. This can help teachers address learner diversity, although personalization must not become automated labelling or profiling of students.
- **Assessment and feedback:** AI can assist in generating rubrics, formative questions and preliminary feedback. However, final assessment decisions should involve professional teacher judgement, particularly when evaluating creativity, reasoning, values and socio-emotional development.
- **Inclusive education:** AI can support translation, speech-to-text, text-to-speech, accessible learning materials and differentiated content. Such applications can potentially reduce barriers for learners with diverse linguistic and learning needs.
- **Reflective practice:** Pre-service teachers can use AI as a reflective dialogue partner by asking it to identify alternative interpretations of a classroom situation. The teacher trainee can then compare these suggestions with observation, evidence and professional knowledge.

Generative AI and the Development of Smart Teachers

Generative AI has introduced a new dimension to teacher education because it can produce text, images, questions, explanations, lesson plans and other educational materials. However, generating an output is not equivalent to producing educational value.

The OECD's Digital Education Outlook 2026 emphasizes that generative AI can support learning when guided by clear pedagogical principles, while unguided use can improve task performance without necessarily producing genuine learning gains.

Therefore, pre-service teachers should learn a **"critique–adapt–apply–reflect"** cycle:

- **Critique:** Examine the accuracy, relevance, bias and limitations of AI output.

- **Adapt:** Modify the output according to curriculum, learner characteristics and educational objectives.
- **Apply:** Use the adapted material in an appropriate pedagogical context.
- **Reflect:** Evaluate whether AI actually improved learning and what should be changed next time.

This approach transforms pre-service teachers from passive consumers of AI-generated content into thoughtful educational designers.

Ethical Challenges

AI-enabled teacher education also presents serious ethical challenges.

- **Academic integrity:** Students may submit AI-generated assignments as their own work. Teacher educators therefore need assessment strategies that emphasize process, oral defence, reflection, classroom performance and authentic tasks.
- **Privacy and data protection:** Educational AI systems may process learner information. Pre-service teachers must understand the importance of protecting personal and sensitive data.
- **Bias and discrimination:** AI systems can reproduce biases present in training data. Teachers must therefore avoid treating AI recommendations as neutral or objective.
- **Digital inequality:** Not every student or institution has equal access to devices, connectivity or premium AI tools. AI-enabled teacher education must therefore address the digital divide rather than deepen it.
- **Overdependence on technology:** Excessive dependence on AI can weaken independent thinking, creativity and professional judgement. AI should augment human intelligence, not replace it.

  UNESCO's approach is explicitly human-centred and emphasizes human agency, accountability, ethics and sustainability.

A Proposed Model for AI-Enabled Teacher Education

A practical model can be organised around five interconnected stages:

Stage 1 – Awareness: Introduce AI concepts, opportunities, limitations and social implications.

Stage 2 – Acquisition: Develop foundational AI literacy, digital skills, prompt literacy, information literacy and ethical awareness.

Stage 3 – Pedagogical Integration: Enable pre-service teachers to apply AI to lesson planning, teaching, assessment, inclusion and classroom problem-solving.

Stage 4 – Critical Reflection: Require teachers to evaluate AI outputs, identify risks, compare alternatives and justify their professional decisions.

Stage 5 – Innovation and Leadership: Prepare teachers to design new AI-supported learning experiences, collaborate with colleagues and contribute to institutional AI policies.

This progression is compatible with UNESCO's Acquire–Deepen–Create approach to teacher AI competencies.

Implications for Teacher Education Institutions

Teacher education institutions need systemic rather than superficial changes. First, AI literacy should be embedded across the curriculum rather than confined to one isolated technology

course. Second, teacher educators themselves require continuous professional development because they are responsible for modelling responsible AI practice. Third, institutions should develop clear policies regarding academic integrity, privacy, assessment and acceptable AI use.

Teaching practice should also become a laboratory for responsible AI experimentation. Pre-service teachers can document how they use AI during lesson planning, implement AI-supported activities during internships and critically evaluate the outcomes.

Institutions should also promote collaborative learning communities in which teacher educators and pre-service teachers share successful practices, failures and ethical dilemmas.

10. Conclusion

Artificial Intelligence is not simply another educational technology; it is a transformative force that is redefining what teachers need to know and how they perform their professional roles. Teacher education therefore stands at a critical point of transition. Preparing pre-service teachers for an AI-enabled future requires more than teaching them how to operate AI tools. It requires the development of AI literacy, pedagogical competence, critical thinking, ethical reasoning, data awareness, creativity and professional judgement.

The future-ready teacher should be neither an opponent of AI nor an unquestioning user of it. The teacher should be a critical, ethical and creative human professional who knows when, why and how AI should be used.

AI can automate certain tasks, generate resources, analyse information and provide rapid feedback, but it cannot replace the relational, moral and contextual dimensions of teaching. The ultimate objective of AI-enabled teacher education should therefore be to strengthen—not diminish—human agency.

Teacher education institutions must consequently move from technology adoption to competency development, from tool training to pedagogical integration, and from AI dependence to responsible human-AI collaboration. Such a transformation can produce smart teachers who are technologically capable, pedagogically innovative, ethically responsible and prepared to lead learning in an uncertain and rapidly changing future.

In this sense, the smart teacher of the future is not the teacher who knows the most AI tools. The smart teacher is the teacher who can combine artificial intelligence with human intelligence, professional wisdom and ethical responsibility to create meaningful learning.

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ARTIFICIAL INTELLIGENCE FOR ENHANCING STUDENT ENGAGEMENT AND WELLBEING: EMPOWERING TEACHERS FOR A SMART FUTURE

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Abstract

Artificial Intelligence (AI) is emerging as one of the most influential technologies transforming the educational landscape. Its applications in teaching and learning extend beyond automated assessment and personalized instruction to areas such as student engagement, motivation, emotional support, learning analytics, and wellbeing. In traditional classrooms, teachers often face difficulties in identifying individual learning needs, monitoring student participation, providing timely feedback, and responding to the diverse emotional and academic needs of students. Artificial Intelligence can assist teachers by analysing learning patterns, identifying students who may be disengaged, providing personalized learning experiences, and supporting timely interventions. At the same time, the use of AI in education raises important concerns relating to privacy, bias, digital inequality, overdependence on technology, academic integrity, and the possibility of reducing meaningful human interaction. Therefore, AI should not be viewed as a replacement for teachers but as a supportive technology that can strengthen teachers' capacity to understand and respond to students. UNESCO's AI Competency Framework for Teachers emphasizes that AI should be integrated through a human-centred approach, with teachers retaining responsibility for meaningful interaction and human flourishing in education. This paper explores the role of AI in enhancing student engagement and wellbeing, examines opportunities and challenges, discusses the changing role of teachers, and proposes strategies for responsible and inclusive AI integration. The paper argues that the future of education should not be merely technology-driven but human-centred, where smart technologies and smart teachers work together to create engaging, supportive, inclusive, and emotionally healthy learning environments.

Keywords: *Artificial Intelligence, Student Engagement, Student Wellbeing, Smart Teachers, Personalized Learning, Learning Analytics, Educational Technology, Human-Centred AI*

Introduction

Education is undergoing a significant transformation due to rapid developments in digital technologies and Artificial Intelligence. The traditional classroom, in which the teacher is the primary source of knowledge and students are largely passive recipients, is gradually changing into a more interactive, personalized, and technology-supported learning environment. Artificial Intelligence has become an important component of this transformation because it can process large amounts of information, recognize patterns, generate content, provide feedback, and support decision-making. In education, these capabilities create new possibilities for understanding students and designing learning experiences according to their

individual needs. The purpose of education, however, is not limited to academic achievement. Education also aims to develop confidence, curiosity, creativity, social skills, emotional resilience, critical thinking, and a sense of belonging. Therefore, student engagement and wellbeing are central to the educational process. A student who is academically capable but emotionally distressed, socially isolated, or disconnected from the classroom may not be able to achieve his or her full potential. Similarly, a student who is engaged only because of external pressure may not develop genuine interest in learning. Recent research indicates that student engagement has meaningful associations with both academic achievement and subjective wellbeing, demonstrating that these dimensions of student development are closely interconnected.

Artificial Intelligence can contribute to this area by enabling teachers to obtain richer information about students' learning behaviour. AI-powered learning platforms can analyse participation, assignment completion, assessment performance, interaction patterns, and learning progress. Such information may help teachers identify students who require additional academic support. AI can also provide personalized resources, adaptive activities, immediate feedback, and conversational assistance, potentially making learning more accessible and interactive.

At the same time, the introduction of AI into education must be approached carefully. Student data are sensitive, and educational institutions must ensure that information collected through AI systems is protected. UNESCO's guidance on generative AI in education emphasizes the importance of privacy protection, ethical safeguards, age-appropriate use, equity, and a human-centred approach.

Thus, the central issue is not whether AI should enter education, but how it should be used responsibly. The concept of the "smart teacher" should not mean a teacher who simply uses more technology. Rather, a smart teacher is one who combines professional knowledge, emotional intelligence, pedagogical expertise, ethical judgement, and appropriate use of AI to create better learning experiences for students.

Understanding Artificial Intelligence in Education

Artificial Intelligence refers broadly to computational systems capable of performing tasks that normally require aspects of human intelligence, such as learning from data, recognizing patterns, generating language, making predictions, and assisting decisionmaking. In education, AI can take several forms, including intelligent tutoring systems, adaptive learning platforms, automated feedback systems, educational chatbots, learning analytics, recommendation systems, speech and language technologies, and generative AI tools. The emergence of generative AI has further expanded the possibilities of educational technology. Generative AI can produce explanations, examples, questions, summaries, lesson materials, simulations, and other forms of educational content. When appropriately guided by teachers, such tools can provide students with additional opportunities for exploration and practice. They may also support teachers in preparing instructional materials and designing differentiated learning activities. However, AI-generated information is not automatically accurate, unbiased, or pedagogically appropriate. AI systems can produce incorrect information, reproduce biases present in training data, and provide responses that appear convincing despite being

inaccurate. Consequently, students must develop the ability to question, verify, analyse, and critically evaluate AI-generated information. Teachers therefore have an important role in teaching students not merely how to use AI but how to use it responsibly.

UNESCO's AI Competency Framework for Teachers describes AI competency as involving knowledge, skills, and values required for teachers to use AI appropriately. It places emphasis on a human-centred mindset, ethics, AI foundations and applications, AI pedagogy, and professional learning.

Concept of Student Engagement

Student engagement refers to the extent to which students actively participate in and connect with the learning process. It is a multidimensional concept that includes behavioural, emotional, and cognitive dimensions. Behavioural engagement involves participation, attendance, effort, and completion of learning activities. Emotional engagement relates to students' interest, enjoyment, belonging, and positive feelings toward learning. Cognitive engagement involves investment in understanding, critical thinking, problem-solving, and meaningful learning. Student engagement is essential because students learn more effectively when they are actively involved in the educational process. A disengaged student may attend a class physically but remain mentally disconnected from the learning activity. Therefore, engagement cannot be measured only by attendance or examination performance. AI can potentially help teachers understand different dimensions of engagement. For example, an AI-enabled learning platform may indicate that a student has stopped participating in online activities, is repeatedly submitting incomplete work, or is experiencing difficulty with particular concepts. Such information does not automatically prove that the student is disengaged, but it can provide an early signal for teacher attention.

The important point is that AI-generated indicators should support, rather than replace, teacher judgement. A student may fail to participate online because of poor internet connectivity, family responsibilities, illness, lack of confidence, or other circumstances. Therefore, the teacher must interpret the data within the broader social and educational context.

AI and Personalized Learning

One of the most significant contributions of AI to student engagement is personalized learning. Traditional classrooms often require teachers to teach a group of students who have different levels of knowledge, learning speeds, interests, and abilities. Providing individualized attention to every learner can be difficult, particularly in large classrooms.

AI-powered adaptive learning systems can modify learning content according to student performance. A student who has mastered a concept may receive more advanced activities, while a student experiencing difficulty may receive additional explanations and practice. This can reduce frustration and help students learn at an appropriate pace.

Personalization can also increase engagement because students may feel that learning activities are more relevant to their individual needs. When learners receive appropriate challenges rather than activities that are either too easy or too difficult, they may be more likely to participate actively.

However, personalization should not result in excessive automation. Students also need

opportunities to collaborate, communicate, debate, create, and learn from peers. Education is a social process, and technology should enhance rather than eliminate human interaction.

AI as a Tool for Increasing Classroom Engagement

AI can support teachers in designing interactive learning experiences. Teachers can use AI-assisted tools to develop quizzes, case studies, simulations, discussion questions, problem-solving activities, role-play scenarios, and differentiated assignments. These resources can make lessons more varied and can provide students with multiple ways of interacting with a subject. For example, a teacher teaching history may use AI to create different perspectives on a historical event and ask students to critically compare them. A science teacher may use AI to generate hypothetical situations for students to investigate. A language teacher may use conversational AI to provide additional opportunities for language practice. A commerce or management teacher may use AI-generated business cases to encourage decision-making and problem-solving.

Such applications can move students from passive reception of information toward active participation. The teacher's role becomes that of a facilitator who designs meaningful learning experiences and encourages students to question and analyse the information provided by AI.

AI and Immediate Feedback

Feedback is an essential component of effective learning. Students need to know what they have understood, where they have made mistakes, and how they can improve. In conventional classrooms, teachers may struggle to provide immediate individualized feedback to every student because of time and workload constraints.

AI systems can provide immediate feedback on certain types of learning activities. For example, language-learning platforms can identify grammatical errors, mathematical systems can identify incorrect steps, and adaptive platforms can recommend additional practice based on performance.

Immediate feedback can help students correct mistakes before they become persistent misconceptions. It can also encourage self-directed learning because students do not always need to wait for the next class to understand whether they are progressing.

Nevertheless, automated feedback should not replace teacher feedback in complex areas such as creativity, reasoning, values, communication, and personal development. Teacher feedback can provide context, encouragement, empathy, and professional judgement that automated systems cannot fully replicate.

Artificial Intelligence and Student Wellbeing

Student wellbeing refers to the physical, psychological, emotional, social, and educational conditions that enable students to function effectively and develop positively. Wellbeing is closely related to learning because students who experience excessive stress, anxiety, isolation, bullying, or lack of belonging may find it difficult to concentrate and participate effectively.

AI can potentially support student wellbeing by helping educators identify patterns that require attention. Learning analytics may indicate changes in attendance, participation, assignment completion, or academic performance. When combined with teacher observation and appropriate support systems, such information may help identify students who could

benefit from a conversation or additional assistance.

AI-based conversational systems may also provide students with basic informational or educational support outside regular classroom hours. For example, a student may use a learning assistant to clarify a concept, organize study activities, or receive guidance on available educational resources.

However, AI should not be considered a substitute for counsellors, teachers, parents, psychologists, or trusted adults. Emotional wellbeing requires human relationships, empathy, understanding, and professional intervention when necessary. UNESCO's human-centred approach is particularly important here because technology should support human flourishing rather than replace meaningful human interaction.

AI for Early Identification of Disengagement

One promising application of AI is the identification of students who may be at risk of disengagement. AI systems can examine patterns such as declining participation, repeated academic difficulties, irregular attendance, reduced interaction, or changes in learning activity.

Early identification can allow teachers to intervene before a problem becomes more serious. For example, if a student who previously participated actively begins submitting fewer assignments and performing poorly, the teacher may investigate the reasons. The appropriate response might be academic support, counselling, peer support, parental communication, or simply a personal conversation.

However, the use of predictive analytics raises serious ethical concerns. A prediction that a student is "at risk" should never become a permanent label. AI predictions can be wrong and may reflect biases in the data. Therefore, AI should be used as an early-warning support mechanism rather than as a system for making final judgements about students.

AI and Inclusion

AI has the potential to promote greater inclusion in education. Students with different learning needs can benefit from technologies such as speech recognition, text-to-speech systems, translation tools, adaptive learning applications, and personalized educational resources.

Students who have difficulty expressing themselves in traditional classroom settings may find alternative forms of interaction through digital tools. Language technologies can also support students who are learning in a language different from their home language.

AI can therefore contribute to educational accessibility when it is designed and implemented inclusively. However, digital inequality remains a major concern. Students from economically disadvantaged backgrounds may have limited access to devices, reliable internet connections, or high-quality digital resources. Consequently, AI integration should be accompanied by efforts to reduce the digital divide.

The Changing Role of the Teacher

The introduction of AI does not eliminate the importance of teachers. Instead, it changes the nature of teaching. UNESCO's AI Competency Framework explicitly emphasizes that teachers should remain central to meaningful interactions and human flourishing in education.

In an AI-supported classroom, teachers may increasingly function as learning designers, facilitators, mentors, ethical guides, evaluators, and relationship builders. They must decide

when AI is appropriate, which tools are reliable, how students should use them, and how learning outcomes should be assessed.

A smart teacher is therefore not simply a technologically skilled teacher. A smart teacher is one who understands both the possibilities and limitations of technology. Such a teacher knows when to use AI and, equally importantly, when not to use it.

Teachers also need to develop AI literacy. They should understand basic AI concepts, data privacy, algorithmic bias, responsible use, prompt design, verification of AI outputs, and the pedagogical implications of AI-assisted learning. Continuous professional development will be essential for this transition.

AI and Teacher Wellbeing

An important but sometimes overlooked aspect of AI in education is teacher wellbeing. Teachers frequently face heavy workloads related to lesson planning, assessment, documentation, administrative tasks, and individualized student support. AI may assist teachers with some routine activities, thereby allowing them to spend more time on meaningful interactions with students.

For example, AI can help generate initial lesson ideas, create question banks, organize information, provide draft feedback, or assist with administrative documentation. These applications may reduce repetitive work when used responsibly.

Reduced administrative workload can potentially allow teachers to focus more on mentoring, classroom interaction, creativity, and student wellbeing. However, AI can also create additional pressure if teachers are expected to adopt multiple technologies without sufficient training or institutional support. Therefore, technology should be introduced with professional development, adequate infrastructure, and realistic expectations.

AI and Emotional Engagement

Emotional engagement is an important part of learning. Students learn more effectively when they experience curiosity, interest, confidence, belonging, and a sense of achievement. AI can help teachers design learning experiences that are more relevant and interactive, but emotional engagement ultimately depends on human relationships.

Teachers play an irreplaceable role in encouraging students, recognizing their efforts, understanding their circumstances, and creating a supportive classroom climate. A sophisticated AI system may identify that a student's performance has declined, but the teacher is better positioned to ask the human question: "What is happening in this student's life?"

This distinction is crucial. AI can provide information about students, but teachers provide relationships with students. The future of education should therefore combine datainformed decision-making with empathy-informed teaching.

Challenges of Using AI for Student Engagement and Wellbeing

Despite its potential benefits, AI presents several challenges.

The first major concern is privacy. Educational AI systems may process sensitive student information, including academic records, behavioural data, and interaction patterns. Institutions must therefore establish clear policies regarding data collection, storage, access, and use.

The second concern is algorithmic bias. AI systems learn from data, and if the data

contain social or educational biases, AI recommendations may reproduce or reinforce those biases. This can have serious consequences for students from marginalized or disadvantaged backgrounds.

The third concern is overdependence. Excessive reliance on AI may reduce students' opportunities to think independently, solve problems, communicate with peers, and develop perseverance. If students use AI to complete every difficult task, they may obtain answers without developing the underlying knowledge and skills.

The fourth concern is the weakening of human interaction. Education is not merely the transmission of information. It involves relationships, values, social development, emotional support, and shared experiences. Excessive automation could weaken these dimensions.

The fifth concern is academic integrity. Generative AI can make it easier for students to produce assignments without genuinely engaging in the learning process. Therefore, teachers may need to redesign assessments to emphasize critical thinking, application, oral discussion, project work, reflection, and authentic performance.

Ethical Use of AI in Education

Responsible AI use requires clear ethical principles. Students should know when and how AI can be used for academic work. Teachers should verify AI-generated information before using it in teaching. Institutions should establish policies regarding privacy, academic integrity, accessibility, and responsible use.

Transparency is also important. Students should understand when AI is being used to support their learning and what types of information may be processed. AI should not make high-stakes decisions about students without meaningful human oversight.UNESCO's guidance emphasizes the need for safe, equitable, ethical, and meaningful use of generative AI in education, including attention to data privacy and appropriate governance.

The ethical principle can therefore be summarized as follows:

AI should assist educational decisions, not replace human responsibility for those decisions.

Building AI Literacy Among Students

If AI is becoming part of education, students need to learn how to use it responsibly. AI literacy should include understanding how AI systems work at a basic level, recognizing their limitations, evaluating the reliability of outputs, protecting personal information, identifying bias, and understanding ethical implications.

Students should be encouraged to use AI as a learning partner rather than as a shortcut. For example, instead of asking AI to write an entire assignment, a student could use AI to generate questions for discussion, receive alternative explanations, identify gaps in understanding, or obtain feedback on a draft.

Teachers should encourage students to ask questions such as: Is this information accurate? What evidence supports it? Could the AI be biased? What did I learn by using this tool? What part of this work reflects my own thinking?

Such practices can transform AI from a tool for answer generation into a tool for critical learning.

Strategies for Teachers to Use AI Effectively

Teachers should begin with educational objectives rather than technology. The first question should not be "Which AI tool should I use?" but "What learning problem am I trying to solve?" Once the objective is clear, the teacher can determine whether AI adds genuine value.

Teachers should also verify AI-generated content. Information generated by AI should be treated as a draft or resource requiring professional judgement rather than automatically accepted as fact.

Another important strategy is to maintain human interaction. AI can provide individualized practice, but classroom discussion, group activities, mentoring, and personal conversations should remain central. Teachers should also establish clear classroom rules for AI use. Students should know what forms of AI assistance are permitted, when disclosure is required, and which activities must be completed independently. Finally, teachers should continuously develop their AI competencies. UNESCO's framework highlights AI pedagogy and professional learning as important dimensions of teacher competency in the AI era.

Proposed Framework: Smart AI-Supported Education

A useful framework for enhancing student engagement and wellbeing through AI can be described through five interconnected components.

First, Understand: Teachers use AI-supported information to understand students' learning patterns, participation, interests, and areas of difficulty.

Second, Personalize: Learning activities are adapted according to individual needs, abilities, interests, and learning pace.

Third, Engage: AI is used to create interactive, collaborative, creative, and problembased learning experiences.

Fourth, Support: Students who demonstrate academic or behavioural difficulties receive timely human intervention and appropriate support.

Fifth, Humanize: Teachers ensure that technology strengthens relationships, empathy, inclusion, ethical development, and student wellbeing.

This framework emphasizes that the ultimate goal is not an "AI classroom" but a humancentred smart classroom.

Implications for Higher Education

The implications of AI are particularly significant in higher education. University students increasingly use AI for research, writing, coding, information gathering, language assistance, and academic support. Rather than relying solely on prohibition, higher education institutions need to develop responsible AI-use policies.

Assessment methods may need to change from assignments that can easily be generated by AI toward tasks requiring personal reflection, practical application, presentations, collaborative projects, research activities, and oral defence.

AI can also support university students through personalized academic advising, learning analytics, virtual assistants, and additional learning resources. Nevertheless, institutions should ensure that AI complements rather than replaces academic mentoring and student support services.

Implications for Indian Education

In the Indian context, AI presents both significant opportunities and challenges. India's education system serves students from highly diverse socio-economic, linguistic, cultural, and geographical backgrounds. AI could potentially support multilingual education, personalized learning, digital accessibility, teacher assistance, and large-scale educational resource development.

At the same time, differences in digital infrastructure and access must be considered. AI-based education cannot become an additional source of inequality. Rural and economically disadvantaged students should have equitable opportunities to access AIsupported learning.

Indian teachers therefore need appropriate professional development that combines technological skills with pedagogy and ethical awareness. AI should be introduced in ways that complement the country's educational objectives and preserve the importance of teachers, community, culture, and human values.

Major Findings

The discussion indicates that AI has considerable potential to enhance student engagement by providing personalized learning, immediate feedback, interactive content, adaptive activities, and learning support. AI can also assist teachers in identifying patterns that may indicate disengagement and can provide information that supports timely intervention.

The paper further indicates that AI can contribute to student wellbeing indirectly by reducing learning frustration, providing accessible support, enabling personalized learning, and helping teachers identify students who may need attention. However, AI should not be regarded as a replacement for professional counselling, teacher support, or meaningful interpersonal relationships.

Another major finding is that the effectiveness of AI depends substantially on teacher competence. Technology alone cannot create engagement or wellbeing. The teacher's ability to interpret information, build relationships, design meaningful learning experiences, and make ethical decisions remains fundamental.

Finally, the paper emphasizes that AI integration must be human-centred. Privacy, equity, transparency, bias, academic integrity, and student agency must be addressed if AI is to contribute positively to education.

Suggestions

Educational institutions should develop clear and practical policies for the responsible use of AI. These policies should address student privacy, academic integrity, ethical use, transparency, and acceptable applications of AI.

Teacher education and professional development programmes should include AI literacy and AI pedagogy. Teachers need opportunities to experiment with AI tools, understand their limitations, evaluate their educational value, and share successful practices. Institutions should also strengthen digital infrastructure and ensure that disadvantaged students are not excluded from AI-supported learning. Accessibility should be considered from the beginning rather than added later.

Assessment systems should be redesigned to encourage original thinking, creativity, critical analysis, reflection, collaboration, and practical application. AI should be integrated into

assessment literacy rather than treated solely as a threat to academic integrity.

Finally, schools and colleges should maintain strong counselling and student-support systems. AI can provide useful signals and resources, but human professionals should remain responsible for sensitive wellbeing issues.

Conclusion

Artificial Intelligence is reshaping education by changing the way teachers teach, students learn, and institutions understand educational processes. Its potential to enhance student engagement and wellbeing is significant because AI can support personalization, immediate feedback, adaptive learning, accessibility, learning analytics, and timely academic intervention. However, technology alone cannot create meaningful education. Student engagement depends on curiosity, motivation, belonging, interaction, and purposeful learning. Student wellbeing depends on emotional security, relationships, support, inclusion, and respect. These are fundamentally human dimensions of education. Therefore, the future should not be understood as a competition between teachers and artificial intelligence. The more meaningful vision is one in which teachers and AI complement each other. AI can process information, identify patterns, generate resources, and provide personalized assistance. Teachers can interpret those insights, understand students as individuals, provide empathy, inspire curiosity, develop values, and make responsible educational decisions. The smart teacher of the future, therefore, will not be the teacher who uses the greatest number of AI tools. The smart teacher will be the teacher who knows when to use AI, how to use it, when to question it, and when human interaction must take priority. In this sense, the future of education should be described not simply as Artificial Intelligence in Education, but as Human Intelligence working with Artificial Intelligence for better education. The ultimate objective should be to create learning environments where technology supports—not replaces—human connection, student agency, teacher professionalism, inclusion, and wellbeing. As UNESCO's teacher competency framework emphasizes, AI adoption should remain human-centred, with meaningful teacher-student interaction and human flourishing at the heart of education.

Thus, AI can become a powerful instrument for shaping smart teachers and smart learning environments, provided that innovation is guided by ethics, empathy, equity, and educational purpose.

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ARTIFICIAL INTELLIGENCE IN EDUCATION: RETHINKING STUDENT ENGAGEMENT AND WELL-BEING IN SMART LEARNING ENVIRONMENTS

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Abstract

Artificial Intelligence (AI) is rapidly transforming educational practices by creating smart learning environments that offer new possibilities for personalized, adaptive, and interactive learning. The integration of AI-powered tools in education has the potential to reshape how students participate in learning, interact with educational content, receive feedback, and manage their learning experiences. However, increasing dependence on AI also raises important questions regarding students' emotional, social, psychological, and digital well-being. Against this background, the present thematic paper explores the changing dimensions of student engagement and well-being in AI-enabled smart learning environments. The paper is based on a review and synthesis of secondary sources, including research studies, scholarly literature, policy documents, and reports related to Artificial Intelligence in Education, student engagement, personalized learning, and learner well-being. The paper examines how AI can enhance student engagement through personalized learning pathways, intelligent feedback, interactive learning experiences, adaptive content, learning analytics, and greater accessibility. It further explores the potential contribution of AI to student well-being by supporting flexible learning, reducing certain academic barriers, and facilitating timely academic assistance. At the same time, the analysis highlights emerging concerns such as excessive screen exposure, technology dependence, reduced human interaction, academic pressure, privacy and data protection, algorithmic bias, misinformation, and the potential impact of AI on students' autonomy and emotional well-being. The paper emphasizes that technological advancement alone cannot ensure meaningful engagement or holistic well-being. The role of teachers remains crucial in providing emotional support, meaningful human interaction, ethical guidance, and pedagogical mediation. The paper argues for a human-centred approach to AI integration in education, where Artificial Intelligence complements rather than replaces teachers and human relationships. It concludes that smart learning environments should aim not merely to produce technologically capable learners but to foster engaged, emotionally healthy, autonomous, responsible, and future-ready learners.

Keywords: *Artificial Intelligence, Student Engagement, Student Well-being, Smart Learning Environments, Personalized Learning, Human-Centred Education, AI in Education*

1. Introduction

1.1 Background of the Study

Education is undergoing a significant transformation as digital technologies become increasingly integrated into teaching, learning, assessment and educational management. Among these technologies, Artificial Intelligence (AI) has emerged as one of the most influential developments because of its capacity to analyse information, recognize patterns, generate content, support decision-making and interact with users through natural language. The rapid development of generative AI has further expanded the educational possibilities of AI, enabling students and teachers to use conversational systems for explanations, idea generation, feedback, translation, content creation and learning support. Consequently, AI is

no longer viewed only as a specialized technological application; it is increasingly becoming part of the everyday learning environment. The emergence of AI in education has created the possibility of moving beyond static digital learning towards more adaptive and responsive learning environments. AI-supported systems can analyse learners' interactions and performance and may recommend resources, modify learning pathways, provide feedback or support individualized learning. Reviews of research in Artificial Intelligence in Education have identified personalized learning, assessment, prediction, profiling, modelling and support for teachers and learners among important areas of development (Mustafa et al., 2024). These developments have contributed to the idea of the smart learning environment, in which technology is expected to respond intelligently to learner needs. However, the educational significance of AI cannot be determined simply by its technological capabilities. Education is fundamentally a human and social process. Learning involves motivation, attention, emotions, relationships, identity, communication, collaboration and a sense of belonging. Therefore, the introduction of AI raises a central question: can intelligent technologies make learning smarter without making education less human? This question becomes particularly important when considering student engagement and well-being. An AI system may provide rapid answers, but educational value depends on whether students are thinking, questioning, participating, collaborating and developing confidence in their own learning. UNESCO's guidance on generative AI in education emphasizes that AI should be introduced through a human-centred approach that considers inclusion, equity, privacy, safety, ethical validation and meaningful educational purposes (UNESCO, 2023). This perspective shifts the discussion from 'how much AI can be used' to 'how AI can be used responsibly to improve learning and human development.' The present thematic paper adopts this human-centred perspective.

1.2 Artificial Intelligence in the Changing Educational Landscape

AI has gradually moved from rule-based and specialized educational applications towards more flexible systems capable of interacting with learners and teachers. Earlier intelligent tutoring systems focused on providing individualized instruction and feedback. Contemporary AI-enabled systems include adaptive learning platforms, learning analytics, recommender systems, automated feedback tools, speech and language technologies, intelligent tutoring systems and generative AI. The increasing availability of generative AI has made interaction with AI more accessible because users can communicate with systems through ordinary language. This development is transforming the traditional relationship among teacher, learner and technology. UNESCO's AI Competency Framework for Teachers describes this emerging relationship as a teacher–AI–student dynamic and identifies 15 competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning (Miao & Cukurova, 2024). The framework indicates that teachers require more than technical knowledge; they need the capacity to make pedagogical and ethical decisions about AI. Similarly, UNESCO's AI Competency Framework for Students emphasizes the importance of preparing learners to become responsible and creative users and co-creators of AI. It highlights the need for students to engage with AI safely and meaningfully rather than becoming passive consumers of AI-generated information (UNESCO, 2024). Thus, the future of AI-enabled education requires both smart teachers and

AI-literate students.

1.3 From Smart Technology to Smart Learning

The concept of a smart learning environment refers to a learning context in which technology supports responsiveness, adaptability, interaction and personalization. AI can contribute to such environments by identifying learning patterns, adapting content, recommending resources and providing timely support. Yet, a technologically sophisticated environment is not automatically a smart educational environment. A genuinely smart learning environment should be pedagogically purposeful, inclusive, ethical and responsive to the whole learner. This distinction is particularly important for student engagement. Engagement is not simply the amount of time a learner spends interacting with a digital system. It includes behavioral participation, emotional involvement and cognitive investment in learning. A student may spend considerable time using an AI tool while engaging very little in independent thinking. Conversely, an AI-supported activity that requires students to evaluate information, compare perspectives and construct their own responses may promote deeper engagement. Recent evidence illustrates this complexity. Lo, Hew, and Jong (2024) synthesized 72 empirical studies examining Chat GPT and student engagement and found both engagement and disengagement. Behavioural engagement was prominent, but academic dishonesty was also identified as a form of disengagement. Emotional outcomes were mixed, while evidence concerning cognitive engagement was broader but weaker and included both increased understanding and concerns about reduced critical thinking and overreliance. A 2025 systematic review and meta-analysis likewise reported positive effects of Chat GPT-based learning on behavioral, cognitive and emotional engagement while noting risks such as over-reliance. These findings demonstrate that AI should not be treated as an automatic solution for improving engagement. The quality of the learning task, the student's AI literacy, teacher guidance and the institutional context all influence whether AI promotes meaningful engagement.

1.4 Student Engagement as a Central Educational Outcome

Student engagement is a central indicator of the quality of learning because it reflects how learners participate in and connect with educational experiences. It is commonly discussed through behavioural, emotional and cognitive dimensions. Behavioural engagement includes participation, effort, persistence and task involvement. Emotional engagement includes interest, enjoyment, belonging and attitudes towards learning. Cognitive engagement refers to mental effort, self-regulation, strategic learning, critical thinking and deeper processing. AI can potentially influence all three dimensions. In behavioural terms, AI may increase participation by providing immediate assistance, adaptive practice and interactive dialogue. In emotional terms, personalized support may make learning more relevant and less frustrating. In cognitive terms, AI can provide explanations, examples and prompts that scaffold complex learning. However, the same technology can reduce engagement if students use it to avoid effort, outsource thinking or complete assignments without understanding. The distinction between interaction and engagement is therefore essential. A student who repeatedly prompts an AI system may appear highly active, but activity alone does not establish meaningful learning. Educationally valuable engagement requires learners to remain intellectually

responsible for their decisions, interpretations and final products. This reinforces the importance of AI literacy and teacher mediation.

1.5 Student Well-being in the AI-Enabled Learning Environment

Student well-being is a broader concept than academic success. It includes emotional, psychological, social, academic and digital dimensions. AI may contribute to well-being by providing timely learning support, reducing some barriers to access, supporting self-paced learning and helping students obtain additional explanations. Accessibility technologies such as speech recognition, translation and text-to-speech may also improve participation for learners with diverse needs. At the same time, AI creates new concerns. Students may experience anxiety about inaccurate AI responses, uncertainty about acceptable AI use, pressure to use emerging technologies or concern about privacy. Excessive dependence on AI may affect students' autonomy and confidence in their own abilities. AI-supported surveillance and extensive collection of learner data may also raise concerns about privacy and dignity. These issues demonstrate that well-being must be considered when evaluating the success of smart learning environments. A human-centred approach is therefore essential. AI should support educational relationships rather than replace them. Teachers, peers, counsellors and other human professionals remain important sources of empathy, encouragement, social connection and contextual judgment. AI can assist learning, but it should not be treated as a substitute for the human support systems that contribute to student well-being.

1.6 Theoretical Background

The conceptual foundation of this thematic paper draws particularly on the multidimensional view of student engagement and on human-centred approaches to AI. The three-dimensional engagement perspective distinguishes behavioural, emotional and cognitive engagement and provides a useful lens for examining how AI influences different aspects of students' participation in learning. This framework is especially relevant because AI may have different effects across dimensions; for example, it may increase behavioural activity while simultaneously creating risks to cognitive independence. The paper also draws on principles associated with self-determination and learner autonomy. From this perspective, students are more likely to experience positive learning conditions when they have meaningful opportunities for autonomy, competence and relatedness. AI can support autonomy by enabling self-paced exploration and can support competence through scaffolding and feedback. However, excessive automation may weaken autonomy, while reduced teacher and peer interaction may undermine relatedness. Thus, AI needs to be designed and mediated in ways that preserve these human motivational needs.

1.7 Conceptual Perspective of the Present Paper

The conceptual position adopted in this paper is that AI capabilities do not directly determine student engagement and well-being. Instead, their effects are shaped by the quality of the smart learning environment and by mediating conditions. AI capabilities include personalization, adaptive learning, feedback, generative interaction, learning analytics and accessibility support. These capabilities can create opportunities for meaningful learning, but they can also create risks such as overreliance, privacy concerns, misinformation and reduced human interaction.

Teacher facilitation is positioned as a central mediator. Teachers determine how AI is integrated into learning activities, verify AI-generated information, establish ethical boundaries and maintain human interaction. Learner AI literacy is another mediator because students need to understand what AI can and cannot do and must be able to evaluate its outputs critically. Ethical governance and equitable access provide institutional conditions that influence whether AI benefits are distributed fairly.

Within this conceptual perspective, student engagement and well-being are interconnected outcomes. Meaningful engagement can contribute to students' sense of competence and academic well-being, while positive well-being can create conditions for sustained participation. Conversely, disengagement, anxiety, overdependence or lack of belonging may negatively influence both learning and well-being.

1.8 Objectives of the Study

The present thematic paper is guided by the following objectives:

- To examine the role of Artificial Intelligence in the development of smart learning environments.
- To analyse the potential influence of AI on behavioural, cognitive, emotional and social dimensions of student engagement.
- To examine the potential contribution of AI-enabled learning environments to different dimensions of student well-being.
- To identify the major opportunities and challenges associated with AI-supported student engagement and well-being.
- To examine the changing role and competencies of teachers in human-centred AI-enabled education.
- To propose a conceptual framework linking AI capabilities, smart learning environments, teacher mediation, student engagement and well-being.

2. Method Adopted

The present paper adopted a qualitative thematic literature review approach based entirely on secondary data. The method was selected because the purpose of the paper is to synthesize existing knowledge and develop a coherent conceptual understanding of the relationship between Artificial Intelligence (AI), student engagement and student well-being in smart learning environments.

The analysis considered both convergent and divergent findings. Positive possibilities such as personalization, timely feedback, accessibility and interactive learning were examined alongside concerns relating to overdependence, academic integrity, misinformation, privacy, bias, digital inequality and reduced human interaction. This balanced approach was adopted because the educational impact of AI is context-dependent and is influenced by the quality of pedagogy, teacher mediation, learner AI literacy and institutional governance. The study is limited to secondary literature concerning AI in educational and learning contexts, with particular emphasis on student engagement and well-being.

3. Artificial Intelligence in Smart Learning Environments

Artificial Intelligence in Education (AIED) is moving education from relatively fixed digital environments towards increasingly adaptive, interactive and data-informed learning

environments. AI applications now include intelligent tutoring systems, adaptive learning, learning analytics, recommender systems, automated feedback, conversational agents and generative AI. Recent reviews indicate that personalized learning, assessment, prediction and support for teachers and learners are among the most frequently discussed educational applications of AI (Mustafa et al., 2024).

A smart learning environment should not, however, be defined merely by the presence of sophisticated technology. It is better understood as an educational environment in which digital systems respond to learner needs while remaining connected to pedagogical goals, teacher judgement and human values. UNESCO (2023) emphasizes that generative AI should be introduced through a human-centred approach that protects privacy, promotes equity and ensures meaningful educational use. In this sense, the 'smartness' of an educational environment depends not only on what AI can do, but also on how intelligently and responsibly educators use it.

The development of AI-enabled environments creates an important link with the present conference theme. Smart teachers are required to interpret AI outputs, select appropriate tools, design meaningful learning activities and safeguard students' learning and well-being. UNESCO's AI Competency Framework for Teachers identifies five broad competency dimensions—human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning—showing that teacher competence is central to effective AI integration (Miao & Cukurova, 2024).

4. AI and Student Engagement

Student engagement is a multidimensional construct involving students' participation, effort, attention, emotional involvement and cognitive investment in learning. In an AI-enabled environment, engagement may be influenced through personalization, immediate feedback, conversational interaction, adaptive challenge, content generation and opportunities for learner choice. A systematic review of 72 empirical studies examining ChatGPT and student engagement found comparatively strong evidence concerning behavioural engagement with the technology itself, but also evidence of disengagement, including academic dishonesty. The review also identified mixed emotional outcomes and highlighted the need for stronger objective measures and longer-term research (Lo et al., 2024).

AI can support behavioural engagement by making learning activities more interactive and responsive. Conversational systems may enable students to ask questions repeatedly without waiting for teacher availability. Adaptive platforms may provide tasks at different levels of difficulty, while AI-generated practice questions can offer additional opportunities for participation. Such features may be especially valuable for learners who hesitate to ask questions publicly or who require repeated practice.

Cognitive engagement concerns the extent to which learners invest mental effort, use strategies and engage in deeper thinking. AI may support cognitive engagement when it is used to compare explanations, challenge assumptions, generate alternative perspectives or provide scaffolding. However, cognitive engagement may be weakened when learners simply accept generated answers. Therefore, the educational value of AI depends on whether students are positioned as active evaluators and creators rather than passive recipients.

Emotional engagement refers to learners' interest, enjoyment, sense of belonging and emotional connection with learning. AI-supported personalization may make learning experiences more relevant, while conversational tools may create a perception of responsive support. At the same time, excessive technology use, inaccurate responses, anxiety about AI, or reduced human interaction may negatively affect emotional engagement. The mixed findings reported by Lo et al. (2024) reinforce the need to consider both sides.

Social engagement is also important. Learning is not only an individual cognitive process; interaction with teachers and peers contributes to belonging and collaborative meaning-making. AI should therefore be designed to complement—not replace—human interaction. A smart learning environment that maximizes individual AI interaction while reducing peer discussion and teacher contact may be technologically advanced but educationally impoverished.

Table 1. Dimensions of Student Engagement and Potential AI Contributions

Dimension	Possible AI contribution	Potential concern
Behavioural	Interactive tasks, adaptive practice, reminders, conversational support	Surface-level interaction or excessive dependence
Cognitive	Scaffolding, explanations, alternative examples, questioning prompts	Reduced independent thinking if answers are accepted uncritically
Emotional	Personalized support, accessible assistance, confidence-building feedback	Anxiety, frustration, emotional overdependence or reduced human connection
Social	Collaborative AI-supported activities, language/communication support	Reduced peer interaction if AI replaces collaborative learning

5. AI and Student Well-being

Student well-being extends beyond academic achievement and includes emotional, psychological, social, academic and digital dimensions. AI can influence these dimensions positively or negatively. For example, personalized support may reduce frustration associated with learning difficulties, while accessibility technologies may increase participation. Conversely, surveillance, privacy concerns, excessive screen exposure, dependence on AI, inaccurate feedback and social isolation may create new pressures. AI may support academic well-being by helping students understand difficult concepts, receive immediate formative feedback and access learning resources. When used as a supplementary learning assistant, generative AI may reduce some barriers to independent study. However, academic well-being is not simply the reduction of effort. Meaningful learning requires productive struggle, reflection and the development of confidence in one's own capabilities. If students become dependent on AI for routine intellectual work, their sense of competence and autonomy may be affected. Emotional and psychological well-being requires particular attention. Students may use AI systems for explanations, encouragement or guidance, but educational institutions should avoid presenting AI as a substitute for human counselling, pastoral care or professional support. AI systems can misinterpret context and may produce unreliable or inappropriate responses. Human adults remain essential for situations requiring empathy, safeguarding and professional judgement. Digital well-being is another emerging consideration. Smart learning

environments may increase the amount of time students spend interacting with screens and digital systems. A human-centred design should therefore consider purposeful technology use, opportunities for offline learning, face-to-face interaction and healthy boundaries. Recent research on responsible AI governance in education identifies student well-being alongside privacy, fairness, transparency and human oversight as a major ethical area (Zhu et al., 2025).

Table 2. Student Well-being Dimensions in AI-Enabled Learning

Dimension	Possible benefit	Possible risk
Academic well-being	Timely support, feedback, personalized learning	Overdependence, reduced productive struggle
Emotional well-being	Accessible assistance and personalized encouragement	Anxiety, frustration, inappropriate AI responses
Psychological well-being	Support for confidence and self-paced learning	Loss of autonomy or excessive reliance
Social well-being	Communication and inclusive participation	Reduced human/peer interaction
Digital well-being	Efficient access to learning resources	Screen fatigue, constant connectivity, surveillance concerns

6. Opportunities

The literature suggests several opportunities for AI to strengthen educational experiences when its use is pedagogically purposeful. The first is personalization. AI can process patterns in learning activity and support adaptive content, resources and feedback. Reviews of AIED consistently identify personalization as a major potential benefit (Mustafa et al., 2024).

A second opportunity is timely feedback. AI can help students obtain immediate formative responses and can assist teachers in identifying common errors or misconceptions. A third opportunity is accessibility. Translation, speech recognition, text-to-speech and other AI-enabled tools may reduce barriers for learners with different linguistic or accessibility needs. UNESCO (2023) recognizes inclusive access as an important consideration in the use of generative AI. A fourth opportunity is learner autonomy. Students can use AI to explore questions, generate examples, compare perspectives and receive additional explanations at their own pace. This may be particularly valuable when AI use is embedded in tasks that require students to evaluate and transform AI outputs rather than copy them.

A fifth opportunity is teacher support. AI may reduce time spent on selected routine tasks, allowing teachers to devote more attention to instructional design, individual support, discussion and relationships. This should be viewed as augmentation rather than replacement. UNESCO's teacher competency framework explicitly emphasizes human agency and the need for teachers to determine how and when AI should be used (Miao & Cukurova, 2024).

Table 3. Opportunities Created by AI in Education

Opportunity	Educational value	Condition for meaningful use
Personalization	Responds to learner differences	Accurate data and teacher oversight
Immediate feedback	Supports formative learning	Feedback must be interpreted and acted upon
Accessibility	Reduces barriers to participation	Inclusive design and equitable access
Learner autonomy	Supports self-paced	AI literacy and critical

	exploration	evaluation
Teacher support	Assists routine and information-intensive work	Teacher remains responsible for pedagogical decisions
Engagement	Interactive and responsive learning experiences	Activities must require active thinking
Early support	May identify patterns associated with learning difficulty	Human verification before intervention

7. Challenges and Risks

The benefits of AI are accompanied by substantial challenges. Privacy and data protection are major concerns because AI-enabled learning environments may collect extensive information about learner behaviour, performance and interaction. Responsible governance therefore requires clarity about what data are collected, why they are collected, who can access them and how long they are retained. UNESCO (2023) places data privacy among the key conditions for responsible use of generative AI in education.

Algorithmic bias is another concern. AI systems may reproduce or amplify biases present in training data, design assumptions or evaluation processes. This can affect recommendations, language generation, assessment and access. Transparency is also challenging because users may not understand why a system produced a particular recommendation or output. Recent systematic reviews identify bias, privacy and transparency as recurring ethical concerns in AI-enabled education (Zhu et al., 2025).

Academic integrity is particularly relevant to student engagement. When students use generative AI to complete assignments without meaningful intellectual participation, visible task completion may increase while genuine engagement decreases. Lo et al. (2024) found academic dishonesty to be a significant form of disengagement in the emerging ChatGPT literature. This suggests that institutions should move beyond simple prohibition and develop assessment practices that value process, reflection, oral explanation, collaboration and responsible AI disclosure.

Overreliance is another risk. Students may accept AI-generated information because it is fluent and confident, even when it is inaccurate. This creates a need for AI literacy, source evaluation and critical thinking. Similarly, teachers may overtrust AI-generated recommendations or assessment outputs. Human oversight is therefore not an optional add-on; it is a core safeguard.

Table 4. Major Risks and Possible Safeguards

Risk	Possible consequence	Suggested safeguard
Privacy/data misuse	Exposure or inappropriate use of learner data	Data minimization, privacy policies and informed governance
Bias and unfairness	Unequal or inaccurate recommendations	Bias testing, diverse data and human review
Misinformation	Students learn inaccurate content	Source verification and teacher checking
Academic dishonesty	Reduced authentic engagement	Process-based assessment and AI-use disclosure
Overdependence	Reduced autonomy and critical thinking	Tasks requiring independent reasoning and reflection

Digital inequality	Unequal access to benefits	Institutional access and inclusive design
Reduced human interaction	Weaker belonging and relationships	Protected teacher and peer interaction
Digital fatigue	Reduced well-being	Purposeful use and healthy technology boundaries

8. Role of Teachers

The teacher's role becomes more—not less—important in AI-enabled education. AI can process information rapidly, but teachers understand learners within social, cultural and emotional contexts. UNESCO's 2024 AI Competency Framework for Teachers describes the emerging teacher–AI–student dynamic and identifies 15 competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy and AI for professional learning (Miao & Cukurova, 2024). Teachers act first as learning designers. They decide whether AI adds educational value to a particular task and design activities that promote inquiry, collaboration and reflection. Second, teachers act as critical evaluators by checking AI outputs for accuracy, relevance, bias and appropriateness. Third, teachers act as ethical guides by helping students understand responsible AI use, privacy, attribution and academic integrity. Teachers also provide the human relationship that AI cannot adequately reproduce. Encouragement, empathy, classroom belonging, conflict resolution and contextual judgement remain central to education. The teacher therefore becomes a mediator between technological possibility and educational purpose. Teacher professional development should consequently include not only tool-specific skills but also AI pedagogy, ethics, critical evaluation and well-being-oriented design.

9. Human-Centred AI

Human-centred AI provides the central normative principle of this paper. It means that AI should serve human learning, agency, dignity and well-being rather than allowing technological efficiency to become the primary educational goal. UNESCO (2024) places human agency, ethics, inclusion and accountability at the centre of teacher AI competencies, while its student framework emphasizes preparing learners to engage with AI safely and meaningfully. A human-centred approach requires five balances: technology and human interaction; personalization and learner autonomy; automation and teacher judgement; innovation and ethical safeguards; and efficiency and well-being. These balances are especially important because AI systems can optimize measurable indicators without necessarily improving the quality of educational experience. AI should therefore be treated as an educational partner or support system, not as a replacement for teachers or learners' own intellectual activity. The objective is not to create classrooms with maximum AI use, but learning environments where AI is used selectively when it improves learning, engagement, inclusion or well-being.

10. Proposed Conceptual Framework

The framework proposes that a human-centred smart learning environment can strengthen behavioural, cognitive, emotional and social engagement while supporting academic, emotional, psychological, social and digital well-being. At the same time, risks such as dependence, privacy concerns, bias and reduced human interaction can weaken these

outcomes. The teacher therefore functions as a central mediator and ethical safeguard.

Figure1. Proposed Conceptual Framework for AI, Student Engagement and Well-being

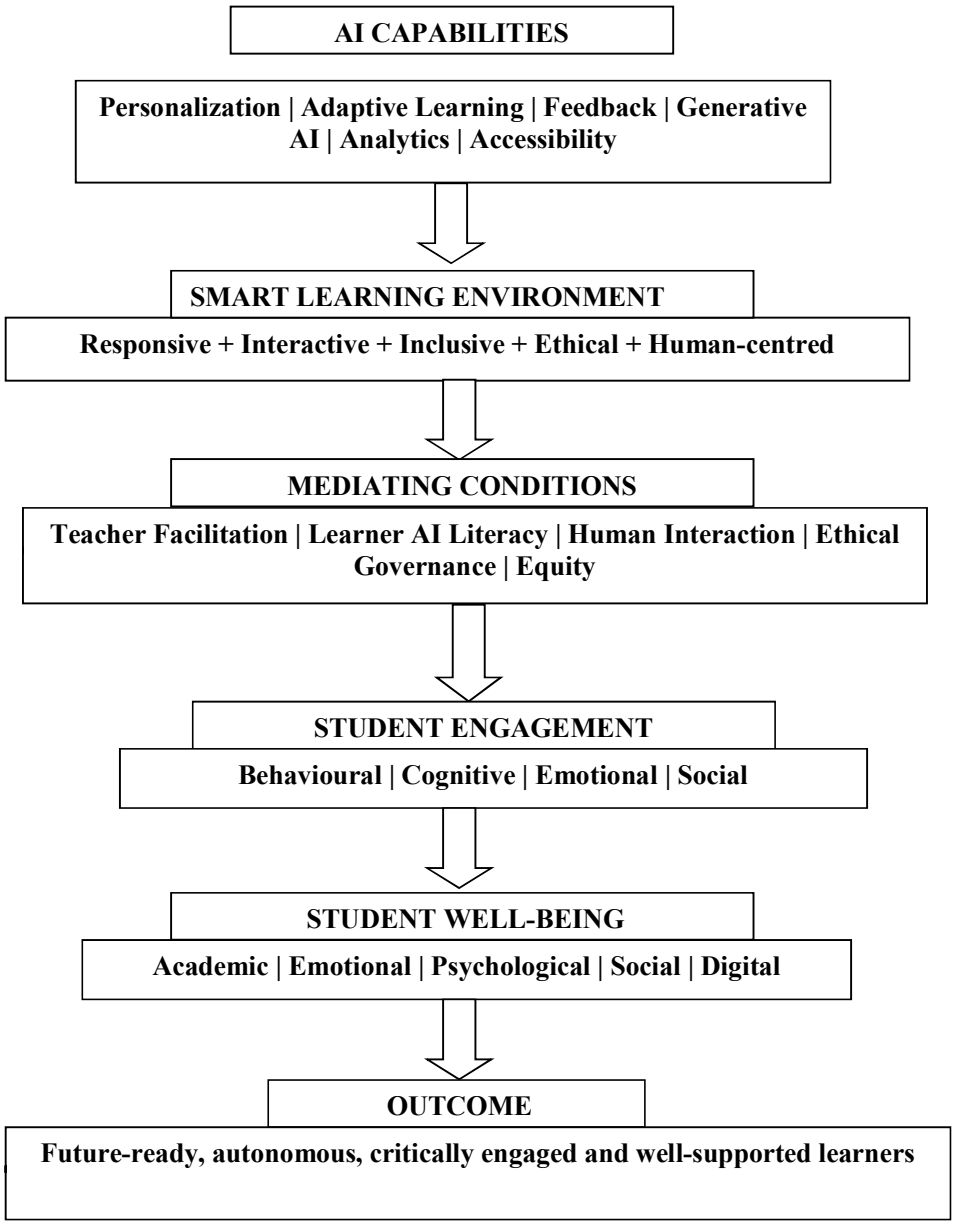

Table 5. Components of the Proposed Conceptual Framework

Component	Key elements	Expected role
AI capabilities	Personalization, adaptation, feedback, generation, analytics, accessibility	Create responsive learning opportunities
Smart environment	Interactive, inclusive, adaptive, ethical	Provide the context in which AI operates
Mediators	Teacher facilitation, AI literacy, human interaction, governance	Determine quality and direction of AI use
Engagement	Behavioural, cognitive, emotional, social	Immediate learner-level outcome
Well-being	Academic, emotional, psychological, social, digital	Holistic learner outcome
Longer-term outcome	Autonomy, critical thinking, responsible AI use	Future-ready learner development

11. Implications

For teachers, the findings imply a shift from being users of digital tools to becoming designers and evaluators of AI-supported learning. Teachers need opportunities to develop AI literacy, prompt and interaction skills, output verification, ethical judgement and AI pedagogy. For teacher education institutions, AI should be integrated across coursework and practicum rather than treated as a one-time technology workshop.

For schools and colleges, AI adoption should be accompanied by clear policies on privacy, academic integrity, assessment and responsible use. Institutions should also ensure equitable access so that AI does not increase existing digital inequalities. For curriculum developers, AI literacy should include not only how AI works, but also how to question outputs, recognize bias, protect data and use AI responsibly.

For policymakers, the central implication is that AI policy should measure educational and human outcomes, not simply technology adoption. UNESCO's frameworks provide a useful reference for building national and institutional approaches around human agency, ethics, AI foundations, pedagogy and professional learning (Miao & Cukurova, 2024).

12. Recommendations

1. Develop AI literacy programmes for both teachers and students, with emphasis on critical evaluation and responsible use.
2. Integrate AI pedagogy into teacher education and continuous professional development.
3. Adopt clear institutional guidelines for privacy, data protection, academic integrity and disclosure of AI use.
4. Use AI primarily where it adds clear pedagogical value rather than adopting tools for technological novelty.
5. Design assessments that emphasize reasoning, reflection, application, oral explanation and learning processes.
6. Maintain meaningful teacher–student and peer interaction in AI-enabled environments.
7. Provide equitable access to devices, connectivity, appropriate AI tools and support.
8. Establish human oversight for high-stakes decisions such as assessment, progression and

student support.

9. Promote digital well-being through purposeful technology use and balanced online/offline learning.

13. Research Gaps and Future Directions

The literature reveals important gaps. First, many studies examine short-term perceptions or immediate learning experiences, whereas the long-term effects of AI on engagement, autonomy, critical thinking and well-being remain less clear. Second, research should use stronger objective measures of engagement rather than relying primarily on self-report. Lo et al. (2024) specifically called for extended studies and objective measures.

Third, more research is required across different educational levels, disciplines, languages and cultural contexts. AI systems may behave differently across linguistic and cultural environments, and evidence concentrated in particular countries cannot automatically be generalized. Fourth, more research is needed on teacher mediation: which forms of teacher guidance produce beneficial engagement and which patterns of AI use increase dependency?

Fifth, student well-being requires more direct and multidimensional measurement. Future research should examine emotional, psychological, social and digital well-being alongside academic outcomes. Sixth, longitudinal and mixed-method studies could help explain how students' AI literacy develops and how sustained AI use changes learning habits.

Finally, research should investigate governance and ethical safeguards in real educational settings. Recent reviews identify privacy, bias, transparency, well-being and human oversight as interconnected governance issues (Zhu et al., 2025). Future research should therefore move from identifying ethical risks to testing practical institutional and classroom-level solutions.

Table 6. Priority Areas for Future Research

Research gap	Suggested direction
Long-term effects	Longitudinal studies of engagement, autonomy and well-being
Measurement	Objective and validated measures of multidimensional engagement
Context diversity	Studies across school, higher education, vocational and teacher education contexts
Cultural/linguistic diversity	Research across languages, regions and cultural settings
Teacher mediation	Examine how teacher guidance changes AI outcomes
Well-being	Multidimensional assessment of emotional, psychological, social and digital well-being
Ethical governance	Evaluate privacy, bias, transparency and human-oversight mechanisms
Assessment	Develop assessment models that preserve authentic learning in the presence of generative AI

14. Conclusion

Artificial Intelligence has the potential to reshape educational environments by making learning more adaptive, interactive, personalized and accessible. However, the central

question is not whether AI should enter education, but how it should be integrated so that technological capability contributes to meaningful learning. The literature indicates that AI can support student engagement through personalization, feedback, interaction and accessibility, but it can also create disengagement through academic dishonesty, overreliance and passive use (Lo et al., 2024).

Student well-being must therefore remain a central criterion for evaluating smart learning environments. AI-enabled education should protect privacy, support autonomy, preserve human relationships, promote inclusion and avoid unnecessary digital burden. The teacher remains indispensable as a learning designer, critical evaluator, ethical guide and source of human support. UNESCO's AI competency framework reinforces this position by placing human-centred mindset, ethics, AI pedagogy and professional learning at the core of teacher competence (Miao & Cukurova, 2024).

The proposed conceptual framework positions AI capabilities, smart learning environments, teacher mediation and ethical governance as interconnected conditions influencing student engagement and well-being. The future of smart education should therefore not be measured by the amount of AI used, but by the quality of learning and human development it enables. Smart teachers, supported by responsible AI, can help create smart learning environments in which technology enhances rather than diminishes human agency, critical thinking, relationships and well-being.

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ARTIFICIAL INTELLIGENCE FOR TEACHER EDUCATOR

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Abstract

By improving teaching, learning, evaluation, research, and professional development, artificial intelligence (AI) is revolutionizing teacher education. Teacher educators may create individualized learning experiences, automate routine duties, give prompt feedback, and enhance instrumental preparation with AI powered technologies. Future educators are more equipped to teach in highly technological classrooms thanks to the implementation of AI into teacher education. The idea to artificial intelligence (AI) for teacher educators is examined in this study along with its uses in lesson planning, evaluation, classroom simulations, content production, and educational research. Additionally, it emphasizes the advantages of AI, such as increased productivity, individualized education, increased student involvement, and assistance with data driven decision-making. The study also deals with important issues such as algorithmic bias, data privacy, ethical issues, digital inequality, and requirements for ongoing professional growth. The study comes to the conclusion that rather than taking on the role of teacher educators, AI should be seen as helpful tool. Responsible use, moral behaviour, and teacher educators' active participation in advocating critical thinking, creativity, and human centred learning are all necessary for its successful implementation. Institutions can produce talented, creative, and future-ready teachers who can meet the demands pf 21st century education by carefully incorporating AI into teacher education.

Introduction: Artificial Intelligence (AI) is revolutionizing teacher education by enriching instruction, learning, evaluation, and professional improvement. Teacher educators leverage AI to equip future teachers with contemporary skills, boost teaching effectiveness, and deliver customized learning experiences. AI functions as a supportive resource that supplements, rather than acts as a replacement for, the expertise and skills of teacher educators.

Meaning: AI for teacher educators incorporates applying intelligent computer system and AI-driven tools to assist in preparing teacher, planning instruction, performing appraisals, performing research, and supporting professional progress.

Goals:

- Elevate the standard of teacher training.
- Tailor the learning experience for each student teacher
- Strengthen both digital skills and teaching abilities.
- Facilitate evaluation and productive feedback.
- Encourage new approaches in teaching and learning.

Uses of AI for Teaching Educators:

1. Lesson Planning : AI helps design lesson plans, instructional content, and classroom exercises.
2. Assessment and Evaluation : AI creates quizzes, grades assignments, and offers real-time feedback.
3. Personalized Learning : AI suggests learning resources customized for student teachers.

4. Research Support : AI helps with literature reviews, data analysis, summarization, and research writing.
5. Professional Development : AI recommends training courses and supports educators in refining their teaching skills.
6. Classroom Simulation : AI-driven virtual classrooms give student teachers the chance to practice teaching in realistic settings.
7. Content Creation : AI produces presentations, worksheets, exam papers, and teaching aids.

Advantages

- Reduces time spent on repetitive tasks.
- Elevates the standard of teaching.
- Enables evidence-based choices.
- Encourages innovative methods for teaching.
- Supplies prompt and customized feedback.
- Reinforces the digital abilities of future teachers.

Challenges

- Educational data must remain confidential and safe that's a real concern.
- Depending too heavily on AI introduces its own threats.
- AI could produce information that's inaccurate or biased.
- Teacher educators need ongoing training that's a must.
- Not everyone has equal access to AI tools this creates a gap.

Ethical Considerations

- Keep student data safe and respect their privacy.
- Ensure equipment treatment for all. Watch out for hidden biases in system.
- Ensure equitable treatment for all. Watch out for hidden biases in system.
- Be open about how AI helps with decisions.
- Use AI the right way. Don't let it become a tool for cheating or copying.
- Always double-check anything AI produces before you bring it into your teaching.

Role of Teacher Educators

- Being AI into teacher training programs.
- Demonstrate to prospective educators how to apply AI in a responsible and ethical way.

- Support pre-service teachers in cultivating critical thinking skills and digital know – how.
  - Push for AI as a useful aid – not a replacement that steals over a teacher's job.
  - Lead by example when using AI during classroom lessons.

Conclusion: Artificial Intelligence is now a key tool in educating teachers. It assists in teaching, learning, checking student work, and promoting teachers' career advancement. Simultaneously, it gets future teachers ready for classrooms that have a lot of digital tools. For AI to succeed, teachers need to follow honest practices and continue acquiring new skills. Teacher educators also need to guide their students in using AI (so it leads to real and useful learning).

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PLANNING AND DEVELOPMENT OF SECONDARY EDUCATION THROUGH DIFFERENT EDUCATIONAL POLICIES

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Abstract

Secondary education occupies a pivotal position in the architecture of a nation's schooling system, functioning as the bridge between elementary schooling and higher education or the world of work. This article traces the planning and development of secondary education in India through a chronological review of the principal national commissions and policies that have shaped it since independence, namely the University Education Commission (1948-49), the Secondary Education Commission (1952-53), the Education Commission (1964-66), the National Policy on Education (1968 and 1986/92), the Right of Children to Free and Compulsory Education Act (2009), the Rashtriya Madhyamik Shiksha Abhiyan, the Samagra Shiksha Abhiyan, and the National Education Policy (2020). Drawing on official policy documents and nationally compiled education statistics, the article shows that successive policies have progressively expanded the scope of secondary education planning, from an early emphasis on curricular diversification to a contemporary emphasis on equity, flexibility, competency-based assessment and rural-urban parity. the article concludes that while policy articulation has been consistent in its broad aims across seven decades, translating these aims into adequate rural secondary school provision continues to depend on the strength of state- and district-level planning mechanisms.

Keywords: *Secondary Education, Educational Planning, Educational Policy, Kothari Commission, National Education Policy 2020, Rural Education*

1. Introduction:

Education is widely regarded as the most powerful instrument available to a nation for achieving social, economic, and cultural transformation, a view articulated explicitly by India's Education Commission of 1964-66, which held that the destiny of a country is shaped in its classrooms (Kothari Commission, 1966, ch.1, para-1.02). Within the broader architecture of schooling, secondary education, comprising the classes that follow elementary schooling and precede higher education, occupies a strategic position because it is the stage at which foundational learning is consolidated, adolescent aptitudes are identified, and pathways towards higher study or skilled employment are effectively determined. The manner in which secondary education is planned, therefore, has consequences that extend well beyond the individual classroom into the labor market and the wider society. India's approach to secondary education planning has evolved considerably since independence, shaped by a succession of national commissions and policy statements, each responding to the perceived limitations of its predecessor and to the changing developmental priorities of the country. This article undertakes a chronological review of these successive policies, examining how each

has contributed to the planning and development of secondary education, with particular attention to issues of access, equity, curriculum, and rural-urban parity. the article is organized as follows: Section 2 reviews the principal educational policies and commissions relevant to secondary education planning and development, Section 3 discusses the cumulative significance of this policy trajectory for the present state of secondary education; and Section 4 concludes with observations on the continuing relevance of systematic, evidence-based planning at the state and district level.

2. Educational Policies Related to Planning and Development of Secondary Education:

2.1 University Education Commission (1948-49)

The University Education Commission, chaired by Dry S. Radhakrishnan, was constituted primarily to examine higher education, but its report drew explicit attention to the inadequacy of the secondary education then feeding into the university system, thereby placing the reform of secondary schooling on the national policy agenda even before a dedicated commission had been established to examine it (University Education Commission, 1950). The Commission's observations on the weak preparatory value of prevailing secondary schooling were an important early impetus for the more focused review that followed within a few years. Although the Radhakrishnan Commission did not itself issue detailed recommendations for the reform of secondary schooling, its diagnosis that university entrants frequently arrived without adequate command of language, basic science or independent study skills implied, by logical extension, that the school stage immediately preceding higher education required dedicated policy attention in its own right. This diagnostic contribution is significant for the present review because it establishes that concern with the planning and quality of secondary education in independent India predates, and in part motivated, the appointment of a commission focused on secondary education specifically, illustrating the interconnected and cumulative character of India's post-independence education policy process from its earliest years.

2.2 Secondary Education Commission (1952-53)

The Secondary Education Commission, generally known as the Mudaliar Commission after its chairman Dr A. Lakshmanaswami Mudaliar, was the first commission in independent India devoted exclusively to secondary education. Its report recommended the diversification of courses beyond a narrowly academic curriculum, the introduction of a multipurpose school structure combining academic and vocational streams within a single institution, the establishment of guidance and counselling services to assist adolescent learners in identifying suitable educational and occupational pathways, and reform of the examination system to reduce excessive reliance on rote memorization (Secondary Education Commission, 1953). These recommendations established secondary education as a distinct field of national policy concern, separate from both elementary and university education, a distinction retained in every subsequent policy statement. Among the Mudaliar Commission's most consequential planning-related recommendations was its proposal that secondary education be treated as a distinct seven-year stage following four years of primary education, with the secondary stage itself subdivided into a lower stage oriented towards general education and a higher stage offering diversified academic and vocational streams, including technical, commercial,

agricultural, and fine arts options alongside the conventional humanities and science streams. The Commission also recommended the strengthening of state-level Boards of Secondary Education to standardize curricula and examinations, and it drew explicit attention to the need for improved teacher training specific to the secondary stage, recognizing that the diversification of curriculum it proposed could not be realized without a correspondingly diversified and adequately trained teaching workforce, a planning concern that recurs, in updated form, in every subsequent national policy on secondary education, including the National Education Policy of 2020.

2.3 Education Commission / Kothari Commission (1964-66)

The Education Commission of 1964-66, popularly known as the Kothari Commission after its chairman Dr D. S. Kothari, undertook the most comprehensive review of Indian education conducted in the post-independence period. Its report, titled Education and National Development, recommended a common national structure of ten years of general schooling followed by two years of higher-secondary and three years of undergraduate study, widely known as the ten-plus-two-plus-three pattern, together with a three-language formula, free and compulsory education up to the age of fourteen, and the systematic integration of work experience and vocational education into the secondary curriculum (Kothari Commission, 1966, ch. 4). The Commission identified four broad aims that education at every stage ought to serve: increasing productivity by relating schooling to economic needs; promoting social and national integration through a common school system; accelerating modernization through the cultivation of a scientific temper; and nurturing social, moral, and spiritual values (Kothari Commission, 1966, ch. 1, paras 1.20-1.24). These recommendations formed the substantive basis of India's first comprehensive National Policy on Education. With specific regard to planning, the Kothari Commission was notable for recommending that a defined proportion of national income, subsequently popularized as a target of six per cent of Gross National Product, be allocated to education, and for recommending the establishment of stronger state-level planning and evaluation machinery to translate national educational goals into state-specific targets and budgets (Kothari Commission, 1966, ch. 1, para 1.24). The Commission additionally recommended the adoption of a common school system of public education, open to children of all social and economic backgrounds, as a means of avoiding the emergence of a socially segregated, two-tier schooling system in which the quality of secondary education available to a child would depend on family income rather than on national planning priorities, a concern that anticipates, in substantial part, the equity-focused provisions of much later policy documents.

2.4 National Policy on Education, (1968)

The National Policy on Education, 1968 was India's first comprehensive national statement of educational policy and drew substantially on the recommendations of the Kothari Commission. It endorsed the aim of relating education to the life, needs, and aspirations of the people as the most urgent reform required of the Indian education system, and it recommended the adoption of a broadly uniform national structure of school and higher education across the states, together with greater emphasis on science education and the training of teachers (Government of India, 1968). From a planning perspective, the National Policy on Education,

1968 is significant chiefly for having established, for the first time, a formally endorsed national framework against which state governments could calibrate their own secondary education plans, replacing what had previously been a more fragmented, state-by-state approach to school structure and curriculum. the Policy's call for a substantial increase in public investment in education, together with its emphasis on equalizing educational opportunity and on making science and mathematics an integral part of the school curriculum at every stage, provided the broad planning parameters within which state education departments, including that of the then-unified Mysore State, subsequently reorganized their secondary school systems during the 1970s.

2.5 National Policy on Education, (1986) and Programme of Action (1992)

The National Policy on Education of 1986, together with its associated Programme of Action of 1992, reiterated and elaborated the goals of universal access, qualitative improvement, and the vocationalisation of secondary education first articulated by the Kothari Commission, while placing renewed emphasis on the education of girls, Scheduled Castes, Scheduled Tribes, and other historically disadvantaged groups. A significant development associated with this policy phase was the establishment and expansion of Jawahar Navodaya Vidyalayas, residential schools intended to provide high-quality secondary education to talented rural children irrespective of family income, thereby directly addressing the rural-urban quality gap in secondary schooling (Government of India, 1986; Government of India, 1992). The 1986 Policy and its 1992 Programme of Action are also notable for introducing the concept of minimum levels of learning, an early precursor to the outcome-based and competency-based approaches to curriculum and assessment that would later be more fully developed in the National Curriculum Framework and, subsequently, in the National Education Policy of 2020. At the planning level, this policy phase strengthened the role of District Institutes of Education and Training and of state-level planning bodies in operationalizing national goals, and it introduced Operation Blackboard as a scheme aimed specifically at improving minimum physical facilities in schools, an intervention that, although initially targeted at the primary stage, established an important precedent for subsequent infrastructure-focused planning interventions at the secondary stage.

2.6 Right of Children to Free and Compulsory Education Act, 2009

The Right of Children to Free and Compulsory Education Act, 2009 guarantees free and compulsory education to every child between the ages of six and fourteen in a neighborhood school, and prescribes minimum norms relating to pupil-teacher ratios, building safety, and teacher qualification, together with a requirement that private unaided schools reserve at least twenty-five per cent of entry-level seats for children from disadvantaged and economically weaker sections (Government of India, 2009). Although the statutory guarantee of the Act does not extend to the secondary stage, its neighborhood-school principle and minimum infrastructure norms have influenced subsequent secondary-stage planning guidelines and represent an important legal landmark in the broader trajectory of Indian education policy. The planning significance of the Right of Children to Free and Compulsory Education Act, 2009 for the secondary stage is chiefly indirect but nonetheless considerable. By establishing an enforceable, justiciable right to elementary education, the Act generated,

for the first time, a large and rapidly growing cohort of elementary-school completers whose continued participation in the education system could only be sustained through a corresponding expansion of secondary school capacity. This so-called demographic pressure effect is widely regarded, in the subsequent policy literature, as one of the principal drivers behind the launch of the Rashtriya Madhyamik Shiksha Abhiyan within roughly the same period, since the near-universalization of elementary enrolment achieved under the Act would otherwise have produced a bottleneck at the transition to secondary schooling in the absence of a matching secondary-stage access initiative.

2.7 Rashtriya Madhyamik Shiksha Abhiyan and Samagra Shiksha Abhiyan

The Rashtriya Madhyamik Shiksha Abhiyan was launched with the explicit objective of universalizing access to secondary education and improving its quality across the country, through the opening of new government secondary schools, the strengthening of science and mathematics laboratories, and the provision of transport and residential facilities for students in underserved areas. This scheme was subsequently consolidated, along with schemes for pre-school, elementary, and teacher education, under the umbrella of the Samagra Shiksha Abhiyan, bringing planning and financing for all stages of school education under a single integrated administrative framework intended to improve coordination across stages that had previously been planned and funded separately.

A central planning innovation associated with the Rashtriya Madhyamik Shiksha Abhiyan was its use of norm-based criteria, rather than purely discretionary allocation, to determine which localities qualified for a new secondary school, generally expressed in terms of a maximum permissible distance between a habitation and the nearest existing secondary school. This norm-based approach represented a significant methodological advance over the more ad hoc pattern of secondary school establishment that had characterized earlier decades, and it directly informs the kind of distance- and demand-based planning analysis that district education offices are expected to undertake when identifying candidate locations for new or upgraded secondary schools. The subsequent integration of this scheme within the Samagra Shiksha Abhiyan was intended to extend comparable norm-based planning logic across all stages of school education in a mutually consistent manner, rather than allowing pre-school, elementary, and secondary planning to proceed according to separate and potentially inconsistent norms.

2.8 National Education Policy (2020)

The National Education Policy, (2020) represents the most recent and, in several respects, the most far-reaching policy intervention affecting secondary education planning. It restructures school education into a five-plus-three-plus-three-plus-four curricular framework, under which the Secondary Stage comprises classes nine to twelve, organized into two phases, and envisaged as a stage of multidisciplinary learning and increased flexibility of subject choice, replacing the earlier rigid streaming into arts, science, and commerce (Government of India, 2020, p. 11). The Policy documents a marked decline in Gross Enrolment Ratio through the secondary stage, from 90.9 per cent at the upper-primary stage to 79.3 per cent for classes nine and ten and 56.5 per cent for classes eleven and twelve, and sets an explicit target of achieving a Gross Enrolment Ratio of one hundred per cent from pre-school to secondary

level by 2030 (Government of India, 2020, p. 10). It further commits to a substantial reform of board examinations to reduce dependence on rote preparation and private coaching, to the establishment of a National Assessment Centre known as PARAKH to standardize learning-outcome assessment, and to a range of equity-focused measures, including a Gender-Inclusion Fund, incentives for teachers willing to serve in rural and remote postings, and the reorganization of small, scattered schools into school complexes for shared resourcing (Government of India, 2020, pp. 18-21, 27-29). Complementing this policy architecture, the Unified District Information System for Education Plus continues to provide the empirical basis for monitoring the rural-urban and government-private gaps in infrastructure and staffing that these policy measures are intended to close (UDISE+, 2024, p. 8).

2.9 State-Level Implementation: The Case of Karnataka

National policies of the kind reviewed above are, under India's concurrent constitutional arrangement for education, implemented substantially through state-specific rules, schemes, and administrative machinery. Karnataka has, over successive decades, operationalized the national policy framework through its own state education department and through the district- and taluk-level offices responsible for translating state norms into local school-siting, staffing, and infrastructure decisions. The state has additionally experimented with cluster-based governance models broadly consistent with the school-complex approach subsequently endorsed at the national level, under which a designated senior secondary or high school functions as a resource and coordination hub for a group of smaller, often single-teacher, primary and upper-primary schools situated in its vicinity, with the stated aim of enabling the pooling of subject teachers, laboratory facilities, and library resources that no single small rural school could economically sustain in isolation (Government of India, 2020, pp. 28-29). The extent to which such state-level planning innovations succeed in closing the documented rural-urban gap in secondary school access and quality remains an important and, at present, comparatively under-researched empirical question, one that would benefit from focused district-level study of the kind this review recommends in its concluding section.

2.10 National Curriculum Framework for School Education (2023)

Following the release of the National Education Policy, 2020, the National Council of Educational Research and Training was tasked with developing a National Curriculum Framework for School Education to translate the Policy's broad vision into stage-specific curricular and pedagogical guidance for teachers, textbook writers and state curriculum bodies. The resulting framework, published in 2023, elaborates in considerable detail the subject-wise learning standards, credit-based structure, and multidisciplinary course combinations envisaged for the Secondary Stage, and is intended to serve as the principal instrument through which state education boards, including that of Karnataka, revise their own secondary-stage syllabi and textbooks (NCERT, 2023). From a planning perspective, the Framework is significant because it operates as the crucial intermediate link between broad national policy aspiration and the day-to-day curricular reality experienced by secondary school teachers and students, and its effective, resource-adequate implementation in rural schools constitutes a further, curriculum-specific dimension of the planning challenge examined throughout this review.

3. Conclusion:

This article has traced the planning and development of secondary education in India through the principal national commissions and policies enacted since independence, from the University Education Commission of 1948-49 to the National Education Policy of 2020. The review demonstrates a clear historical continuity in the broad aims of secondary education policy, namely expanding access, improving quality, and promoting equity, alongside a marked evolution in the specificity and data-orientation of the planning instruments employed to pursue these aims. The persistence of documented rural-urban disparities in secondary school enrolment and infrastructure indicates that the effective development of secondary education in India continues to depend substantially on the strength of state- and district-level planning processes through which national policy is translated into local provision. Future research and policy attention would benefit from a closer, district-level examination of how these successive national policies are actually implemented, monitored, and experienced in specific rural contexts, in order to identify the gap, where one exists, between policy intention and local educational reality.

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A THEMATIC OVERVIEW OF EMERGING OPPORTUNITIES IN ENABLING AI EQUITABLE AND INCLUSIVE EDUCATION

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Abstract

Artificial Intelligence (AI) is becoming an important part of education. It is being used in many ways, such as personalized learning, AI-based tutoring, automated feedback, learning analytics, language translation, accessibility tools, and the creation of learning materials. These technologies can help teachers and students by making learning more flexible and responsive to individual needs. At the same time, the growing use of AI in education raises an important concern. While AI has the potential to make education more inclusive and accessible, it may also create new forms of inequality. Students who do not have reliable internet access, digital devices, or the skills needed to use AI may not receive the same benefits as others. There are also concerns related to language, disability, gender, social background, privacy, bias, and the unequal availability of technology.The paper synthesizes evidence and policy perspectives from international organizations and peer-reviewed research, with particular attention to UNESCO's (2024) guidance on generative AI, AI competency frameworks, the Global Education Monitoring Report (2023), UNICEF's (2025) child-centred AI guidance, OECD research on students with special educational needs, and contemporary systematic reviews of AI in education. The analysis identifies seven interrelated themes: AI as an Instrument for Equitable Access, personalized and adaptive learning, AI Accessibility and Learners with Disabilities, linguistic and cultural inclusion, AI literacy and learner agency, Algorithmic Bias and the Reproduction of Inequality. The review argues that AI should not be conceptualized as a substitute for teachers or as an autonomous solution to educational inequality. Instead, AI should function as an equity-enabling educational infrastructure embedded within inclusive pedagogy, qualified teacher judgement, universal design, ethical governance and meaningful human participation. The paper concludes that AI can contribute to Sustainable Development Goal 4 in order to enhance quality education only when there is availability of access, capability, participation, and safety education are addressed simultaneously.

Keywords: *Artificial Intelligence, Inclusive Education, Personalized Learning, Algorithmic Bias, Inequality*

Introduction

Education is fundamentally concerned with expanding human capabilities and ensuring that learners, regardless of socioeconomic background, disability, language, gender, geography or other circumstances, have meaningful opportunities to learn and participate. Sustainable Development Goal 4 (SDG 4) therefore places inclusive and equitable quality education at the centre of the global education agenda (United Nations, 2015). The emergence of Artificial

Intelligence (AI) introduces both significant opportunities and unprecedented challenges for achieving inclusive and equitable education. (UNESCO, 2021)

AI is increasingly embedded in educational technologies through adaptive learning platforms, automated assessment, intelligent tutoring systems, speech recognition, machine translation, predictive analytics and generative AI (Zawacki-Richter et al., 2019). AI can explain topics, prepare learning materials, give feedback, translate content, and support different ways of learning (Lin et al., 2023). However, its benefits depend on access to devices, internet, electricity, digital skills, and trained teachers (UNESCO, 2023). Students with better resources may gain more from AI, while disadvantaged learners may continue to face educational inequalities (UNESCO, 2023). UNESCO's AI competency frameworks further emphasize that students and teachers require knowledge, skills and values for responsible participation in AI-mediated educational environments (Miao et al., 2024). UNESCO's 2023 Global Education Monitoring Report warns that digital technology can help disadvantaged learners but can also reproduce or increase inequalities when access, governance and teacher capacity are inadequate (UNESCO, 2023). AI can make learning easier by giving students quick explanations, practice activities, feedback, and support in different languages (Lin et al., 2023). However, not all students have the same opportunities to use these tools. Lack of internet, devices, electricity, digital knowledge, or teacher support can limit their benefits. Therefore, AI should be used in a fair and inclusive way. (UNESCO, 2023)

Inclusive and Equitable Education in the AI Era

Inclusive education extends beyond physical access to schools. It involves removing barriers to participation, learning and achievement. Equity differs from simple equality because learners may require different resources and forms of support to achieve meaningful educational opportunities.

Within an AI-enabled education system, three dimensions of equity are particularly important:

Equity of access

Learners should have meaningful access to appropriate devices, connectivity, electricity, AI-enabled resources and technical support.

Equity of participation

Learners should possess the digital, AI and critical-literacy capabilities necessary to participate effectively rather than merely consume AI-generated content.

Equity of outcomes

AI systems should be designed and evaluated according to whether they actually improve learning opportunities and outcomes for disadvantaged groups rather than simply increasing technological adoption.

This distinction is essential because educational inequality can occur at several stages: access, use, quality of interaction, representation, decision-making and outcomes.UNICEF's recent child-centred AI guidance similarly emphasizes non-discrimination, inclusion, privacy, transparency, accountability, safety and meaningful participation of children in AI systems.

Objectives

1. To overview the potential of AI in promoting inclusive and equitable educational opportunities.

2. To identify major educational applications of AI that can support inclusive and equitable education.
3. To analyse the central paradox : AI Can Reduce and Reproduce Inequality
4. To review the potentiality of AI in enhancing equality in education.

Methodology

This paper adopts a thematic literature review. It does not include original experimental data. Instead, it examines and brings together information from research studies, review papers, policy documents, and educational reports. Relevant literature was searched through sources such as ERIC, Scopus, Web of Science, ScienceDirect, IEEE Xplore, UNESCO, UNICEF, OECD, OpenAlex, ResearchGate, and Google Scholar.

Findings

The reviewed studies were grouped according to common themes related to inclusion and equality. From the literature, the following main themes were identified:

Theme 1: AI as an Instrument for Equitable Access

AI can help students who have limited access to good educational resources (Miao et al., 2021). It can give explanations, feedback, practice activities, learning support, translations, text-to-speech and speech-to-text services. It can also create or change learning materials and provide help beyond normal classroom hours. (Miao et al., 2021; Lin et al., 2023) These benefits are useful in places facing teacher shortages, remote locations, or limited resources. However, AI alone cannot remove the digital divide. Proper infrastructure, internet access, devices, digital skills, language support, and trained teachers are necessary. (UNESCO, 2023) Therefore, schools must focus on accessibility, not only availability. AI should be viewed as an educational resource that benefits all learners, not only those with better resources. (Miao et al., 2021; UNESCO, 2023) However, AI cannot automatically overcome the digital divide. UNESCO's evidence emphasizes that educational technology requires appropriate infrastructure, governance and teacher preparation. The benefits of technology can remain concentrated among learners who already possess greater socioeconomic and technological advantages. (UNESCO, 2023) Therefore, an equity-oriented AI strategy must distinguish between AI availability and AI accessibility. (Miao et al., 2021; UNESCO, 2023)

Theme 2: Personalized and Adaptive Learning

Personalized learning is an important use of AI in education. AI tools can study students' answers and learning progress and suggest suitable lessons, activities, and feedback. (Miao et al., 2021; Lin et al., 2023) In a normal classroom, one teacher may have to teach many students who learn at different speeds and have different needs. It can be difficult to give each student individual attention. AI can provide extra support by finding areas where a learner is struggling and suggesting suitable learning materials or practice. (Lin et al., 2023) Research on AI in education highlights personalized learning, intelligent tutoring systems, and adaptive learning as useful ways to support students and respond to their individual learning needs. (Lin et al., 2023) Systematic reviews demonstrate that AI is being used across instructional, assessment and administrative functions. (Zawacki-Richter et al., 2019) However, personalization should not be confused with replacing the teacher. UNESCO's technology-in-education evidence stresses that technology should support human interaction rather than seek

to substitute it. (UNESCO, 2023) An AI system may recognize that a student repeatedly answers a mathematical problem incorrectly, but a teacher may understand that the underlying difficulty is anxiety, language comprehension, a misconception or a family circumstance.

Theme 3: AI Accessibility and Learners with Disabilities

AI has considerable potential to support inclusive education for learners with disabilities. Examples include: speech recognition for learners with motor difficulties, text-to-speech for learners with visual or reading difficulties, automatic captioning, image description, language simplification, adaptive interfaces, predictive text, personalized instructional materials, assistive communication technologies. (Linsenmayer, 2025; UNICEF, 2025) Recent OECD research specifically examines how AI can support students with special educational needs while emphasizing ethical design, research, monitoring, data protection, security and accountability. (Linsenmayer, 2025) UNICEF likewise identifies improved accessibility for children with disabilities as one potential benefit of AI. (UNICEF, 2025)

This aligns strongly with principles associated with Universal Design for Learning (UDL), where multiple means of engagement, representation and action/expression are used to reduce barriers to learning. (CAST, 2018; Loreman, 2017) Nevertheless, AI-generated accessibility features must themselves be accessible. Poor speech recognition for certain accents, inaccurate image descriptions or systems that do not understand assistive technologies can create new barriers.Therefore, accessibility must be evaluated by the learners who actually depend on these technologies. (Linsenmayer, 2025)

Theme 4: Linguistic and Cultural Inclusion

Language represents one of the most important dimensions of educational equity. AI-based translation, speech recognition and language-generation technologies can potentially expand access to educational content across languages. (Miao & Holmes, 2023) This is particularly significant in multilingual societies such as India. (UNESCO, 2023) AI can support: translation of educational resources, bilingual explanations, vocabulary development, language practice, speech-based learning, localized educational content, multilingual teacher support. (Miao & Holmes, 2023) However, linguistic AI can also reproduce language hierarchies. Major languages often receive substantially greater digital representation than minority, indigenous or regional languages. (UNESCO, 2023)

AI tools may work better in widely used languages because they have access to more training information. In contrast, they may give weaker or less suitable results in languages that have fewer digital resources. (Paul et al., 2025) This can create inequality among learners. (UNESCO, 2023) Therefore, simply translating educational content is not enough. (Miao & Holmes, 2023) Fair AI systems should also respect local languages, knowledge, traditions, cultural backgrounds, and different ways of expressing ideas. (UNESCO, 2023) Educational AI should be designed to understand the needs of diverse communities and represent their experiences properly. (Miao & Holmes, 2023) This approach can help learners feel included and ensure that technology supports different languages and cultures in education equally. (UNESCO, 2023)

Theme 6: AI Literacy and Learner Agency

AI literacy is becoming an important part of modern education. (Miao et al., 2024) UNESCO's AI Competency Framework for Students includes 12 competencies under four areas: human-centred thinking, AI ethics, AI techniques and applications, and AI system design. These skills develop through understanding, using, and creating with AI. Students should not only learn to use AI tools but also use them carefully and responsibly. (Miao et al., 2024) AI literacy means knowing basic AI ideas, understanding its limits, checking false or misleading information, evaluating sources, identifying bias, protecting personal data, and using AI ethically. Students should also report when AI is used, question AI decisions, and understand its effects on society and people. (Miao et al., 2024) This is particularly important for equity because learners from privileged backgrounds may receive AI literacy informally through families, private institutions and technology-rich environments. Schools therefore have an important responsibility to democratize AI literacy. (Miao et al., 2024; UNESCO, 2023)

Theme 7: Algorithmic Bias and the Reproduction of Inequality

AI systems learn from data. If historical data contain social inequalities, the resulting algorithms can reproduce them. In education, algorithmic bias may affect: student performance prediction, admission, dropout prediction, automated grading, recommendation systems, learner profiling, behavioral prediction, resource allocation. (Baker & Hawn, 2022; Idowu, 2024) A systematic review of education algorithms highlights fairness concerns across applications such as dropout prediction, performance prediction, classification and recommended systems. (Idowu, 2024) The problem is particularly serious when AI decisions are treated as objective simply because they are computational. An algorithm is not automatically neutral. Data-driven does not necessarily mean bias-free. AI systems should therefore undergo regular audits for: demographic bias, linguistic bias, disability-related bias, socioeconomic bias, gender bias, cultural bias, differential accuracy. (Baker & Hawn, 2022; Idowu, 2024) Students and teachers should also have mechanisms for questioning AI-supported decisions. (Idowu, 2024; OECD, 2023)

The Central Paradox: AI Can Reduce and Reproduce Inequality

AI can reduce inequality when it:

- Expands access to quality learning resources
- Supports learners with disabilities
- Enables personalized learning
- Supports multilingual education
- Provides additional feedback
- Assists teachers
- Makes educational content more accessible.

AI can reproduce inequality when it:

- Requires expensive devices
- Depends on high-speed connectivity
- Performs poorly for minority languages
- Contains biased training data

- Profiles disadvantaged learners inaccurately
- Collects excessive personal data
- Excludes communities from AI design
- Replaces human interaction
- Assumes that all learners possess equal AI literacy.

Special Significance for India

The issue has particular relevance for India because of its linguistic diversity, large student population, socioeconomic variation, rural-urban differences and expanding digital education ecosystem. India's National Education Policy 2020 has explicitly recognized the relevance of emerging technologies, including AI, and government implementation materials document AI-related learning initiatives at school level. However, equitable AI implementation in India requires attention to rural connectivity, affordability of devices, electricity availability, regional languages, teacher digital competence, disability accessibility, gender-related digital disparities, socioeconomic differences, data protection, culturally relevant educational content.

The Indian context therefore offers an important opportunity to develop low-cost, multilingual, accessible and community-responsive AI models for education rather than simply importing technology developed for high-resource environments. AI-enabled education in India should consequently be aligned with constitutional values, educational inclusion, multilingualism, social justice and the broader objectives of NEP 2020.

Discussion

The central finding of this thematic review is that AI is neither inherently equitable nor inherently inequitable. Its educational consequences depend upon the conditions surrounding its implementation. The same technology may produce very different outcomes for different learners. A generative AI tutor may provide valuable individualized assistance to one learner while providing inaccurate or culturally inappropriate information to another. An automated assessment system may identify students requiring additional support but may also reproduce historical bias if its training data are unrepresentative.

Consequently, technological innovation must be accompanied by educational judgement. This finding is consistent with the broader evidence base. UNESCO states that technology in education should serve learners and educational goals, rather than being adopted simply because it is new. Research also shows that AI can improve access, but it needs careful planning, ethical use, safety, strong research, and accountability. AI should adjust to learners' different needs, languages, abilities, and backgrounds instead of expecting learners to adjust to the technology. Thus, the future of inclusive AI in education should be guided by a simple principle: Technology should adapt to educational diversity, not force educational diversity to adapt to technology.

Conclusion

AI is changing education by supporting personalized learning, quick feedback, accessibility, translation, teachers, and wider access to learning resources. However, it can also increase inequality because of unequal access, biased systems, language barriers, privacy concerns, and limited teacher preparation. AI should support, not replace, teachers and learners. To achieve SDG 4, education systems must use AI fairly and responsibly so every learner can learn,

participate, succeed, and make choices. The success of AI should not be measured only by its advanced technology, but by how well it improves learning opportunities for students who have often been left behind.

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ARTIFICIAL INTELLIGENCE: RETHINKING TRANSFORMATIVE TEACHING AND LEARNING FOR SUSTAINABLE EDUCATION

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Abstract

Artificial Intelligence brings a paradigm shift and personalized learning support through education, and personalised learning support. Sustainable development education has the capacity to realise the learners and respond based on social complex economic, and environmental challenges. Integrating AI with sustainable education offers an opportunity to reconsider how teaching learning can support and enhance quality education for sustainable development, of AI and ESD, therefore, offers an opportunity to reconsider how teaching and learning can support sustainable development. This thematic paper reflected recent literature to examine the potential of AI in advancing transformative and sustainability-oriented education. The reviewed information explores six important themes, such as: quality and personalised education; inclusion and equity; sustainability competencies; transformative pedagogy; teacher -AI literacy and professional competence; and the ethical, social and environmental challenges of AI. The reviewed reports indicated that AI can enhance learner support, accessibility, inquiry, critical engagement and problem-solving when embedded within appropriate pedagogical and institutional contexts. However, unequal digital access, algorithmic bias, privacy concerns, academic integrity concerns, limited teacher preparedness, and AI's environmental footprint may limit the usage of AI in the field of the teaching-learning process. The paper consequently advances the idea of AI-sustainable education, in which technological innovation is aligned with human agency, educational equity, transformative pedagogy, sustainability competencies and responsible governance to support meaningful and responsible educational transformation.

Keywords: *Artificial Intelligence, AI Literacy, Transformative Pedagogy, Sustainable Education*

1. Introduction

AI, along with specialised technological innovation, increases only influence on everyday teaching and learning practices. Adaptive learning systems, intelligent tutoring, learning analytics, automated feedback and generative AI are changing how students access information and interact with learning materials. These developments have created opportunities for more individualised and responsive educational experiences, while also raising fundamental questions about the changing roles of teachers and learners (Alkhawaja et al., 2025; Kim, 2025; Lin et al., 2023). Recent reviews similarly show that personalisation, sustainable learning, and AI literacy have become prominent areas in contemporary AI-in-education research (Abulibdeh, 2025; Bagherimajd & Khajedad, 2025). The educational significance of AI is especially evident when considered alongside the Sustainable Development Goals (SDGs). Education plays a central role in sustainable development because it fosters the knowledge, values, and competencies that enable individuals to understand and respond to complex societal challenges.

Integrating AI in the teaching learning process will enhance sustainable development however, there may be some challenges faced by the teachers and students in their pedagogical context the challenges such as: unequal digital access, algorithmic bias, privacy concerns, academic integrity concerns, limited teacher preparedness, and AI's environmental footprint will hinder the teaching and learning process. Within education, this distinction is especially important. AI can provide a student with an answer, but sustainable education requires the learner to understand a problem, question assumptions, consider alternatives and make responsible decisions(Mensah, 2019). According to (Alkhawaja et al., 2025; Osman & Bashir, 2026) researcher revealed that AI-supported sustainability education further explained the importance of pedagogical design, AI literacy and meaningful student engagement in the teaching-learning process. The present thematic paper, therefore, examines the intersection of Artificial Intelligence, transformative teaching and learning, and sustainable development, rather than treating AI as an end in itself, the paper considers how it can be integrated into educational processes that develop sustainability competencies while preserving human agency and addressing ethical and social concerns.

2. Review of Literature

Artificial Intelligence has increasingly become part of educational practice through adaptive learning, intelligent tutoring systems, learning analytics, automated feedback and generative AI. Its educational applications have largely been associated with personalisation, learner support, assessment and improved access to educational resources. (Feng & Carolus, 2026; Lin et al., 2023)In their systematic review of intelligent tutoring systems, they demonstrate how AI-supported systems can address individual learning needs and foster more flexible learning environments. Similar possibilities have been identified in recent reviews of AI and sustainable education, particularly regarding personalised learning, accessibility, and AI-supported educational decision-making. (Toha, 2026). The connection between AI and sustainable development has also received increasing attention. Research on higher education indicates that AI may contribute to SDG 4 through personalised learning, adaptive instruction and improved learner support, while its applications may also help reduce educational inequalities (Apata et al., 2026a; Leal Filho et al., 2024). Students' perceptions similarly suggest that AI can assist with self-directed learning, problem-solving, and digital literacy, although concerns regarding dependence, accuracy, and ethical use remain. (Alkhawaja et al., 2025). Another important strand of literature concerns AI literacy and sustainability competencies. (Alamäki et al., 2024) demonstrate that students' understanding of AI and sustainable development needs to develop together if AI is to be used meaningfully for sustainability. Research on AI-supported sustainability learning further indicates that interactive simulations, personalised instruction and inquiry-oriented activities can help learners engage with complex sustainability issues. At the same time, researchers have highlighted the limitations and risks associated with AI. Unequal technological access can reproduce educational inequalities, while concerns about privacy, algorithmic bias, academic integrity, and inadequate teacher preparation complicate its implementation. (Apata et al., 2026a). Broader sustainability research also highlights the energy and resource requirements of AI systems. (Kar et al., 2022; Nishant et al., 2020).

Taken together, the literature shows considerable interest in AI as a contributor to sustainable education, but the relationship remains fragmented across technological, pedagogical, competency-based and ethical perspectives. The present paper brings these strands together by examining how AI can support transformative teaching and learning for sustainable development, while also considering the conditions under which such integration can remain equitable and responsible.

3. Conceptual Framework

The conceptual framework of the present paper is built around the relationship between AI capabilities, pedagogical transformation, sustainability competencies and sustainable educational outcomes. The framework begins from the premise that technological capability by itself does not produce sustainable development. Rather, AI needs to be translated into meaningful educational experiences through appropriate pedagogy. The first component of the framework is AI capability, which includes adaptive learning, intelligent tutoring, learning analytics, generative AI and assistive technologies. These capabilities create possibilities for personalisation, accessibility, feedback and inquiry for learners. The second component is transformative pedagogical integration, through which AI is incorporated into inquiry-based, problem-based, project-based, collaborative and experiential learning for teachers. The third component concerns sustainability competencies, including critical thinking, system thinking, problem-solving, collaboration, future-oriented thinking and ethical decision-making for educational stakeholders. These competencies can contribute to educational outcomes associated with quality, inclusion, equity and learner agency and, ultimately, to wider education sustainable development. Importantly, the above framework is not linear or automatic. Its effectiveness is conditioned by teacher AI competence, student AI literacy, infrastructure, equitable access, ethical governance, data protection and human agency. According to (Toha, 2026) integrating AI with higher education emphasises the potential of the learners in getting sustainable education.

4. Theoretical Framework

The paper draws primarily on Transformative Learning Theory and Sustainability Education Theory, while also incorporating ideas from constructivist approaches to learning. Transformative Learning Theory is relevant because sustainable development requires learners to examine established assumptions and develop new ways of understanding complex social and environmental problems. AI can contribute to this process when used to facilitate inquiry, scenario analysis, reflection, and problem-solving rather than simply supplying ready-made answers in pedagogical contexts. Sustainability Education Theory provides the framework for a broader educational purpose. It views education as a means of developing the knowledge, values, and competencies necessary to respond to sustainability challenges. (Apata et al., 2026a; Tarrant & Thiele, 2016) Similarly, use sustainability education theory to examine how AI can support critical thinking, agency, systems-level awareness and sustainability-related educational outcomes. The constructivist perspective complements these theories by viewing learners as active participants in knowledge construction. (Toha, 2026) argues that AI can serve as a cognitive scaffold for personalised, inquiry-driven, and reflective learning. Thus, AI becomes educationally transformative when learners actively use it to question, investigate,

interpret, and construct knowledge.

5. Objectives

1. To examine the contribution of AI-supported for sustainable education.
2. To identify the opportunities that AI can facilitate transformative teaching and learning.
3. To explore the major pedagogical, ethical, social and environmental challenges associated with AI-enabled sustainable education.

6. Methodology

The paper follows a thematic literature review approach. The analysis draws primarily on the scholarly articles provided for the study. It focuses particularly on literature addressing AI in education, sustainable education, Education for Sustainable Development, sustainability competencies and higher education.

The literature was examined by identifying recurring concepts and relationships across the selected studies. Particular attention was given to research on the educational applications of AI and its literacy, pedagogical and learning outcomes, accessibility, sustainability competencies, teacher preparedness, and ethical concerns. The relevant literature for the present study was collected from scholarly databases, including Scopus, Taylor & Francis, Eric, Web of Science and Google Scholar.

7. Findings: Major Themes

7.1 AI for Quality and Personalised Education

The literature consistently identifies personalised learning as one of the most important educational possibilities associated with AI. Adaptive systems and intelligent tutoring can respond to differences in learners' pace, performance and support requirements (AlSagri & Sohail, 2024). AI-based analytics may also help institutions to identify students' experiences regarding academic difficulties and facilitate earlier interventions in their personalised learning process. The significance of personalisation extends beyond convenience. When students receive learning experiences that respond more closely to their needs, educational support can become more flexible and learner-centred. However, personalisation should not result in excessive dependence on automated systems. Meaningful learning still requires teacher judgement, student participation and opportunities for independent reasoning.

7.2 AI for Inclusion and Educational Equity

The second theme concerns the potential of AI to widen participation in education. Multilingual tools, speech-to-text systems, adaptive interfaces and other assistive technologies may help learners who encounter linguistic or accessibility barriers. AI-supported distance learning can also extend educational opportunities to geographically underserved students. (AlSagri & Sohail, 2024; Osman & Bashir, 2026) At the same time, unequal access to digital infrastructure creates a significant contradiction. Learners without reliable connectivity, appropriate devices, or sufficient AI literacy may benefit less from AI-enabled education. Thus, AI may become a mechanism for reducing inequality only when questions of access and affordability are addressed.

7.3 AI and Sustainability Competencies

The third theme focuses on competencies needed for sustainable development. AI-supported

learning environments can provide opportunities for learners to investigate complex problems, compare alternatives and examine possible future outcomes. However, the literature also warns against replacing students' thinking with automated responses (Alkhawaja et al., 2025; Su et al., 2026). Concerns that excessive reliance on AI may negatively affect problem-solving, while other studies suggest that AI can support self-directed learning and digital literacy to enhance sustainability competencies among teachers and students. The value of AI, therefore, depends upon whether learners use it as a resource for thinking or as a substitute.

7.4 AI and Transformative Pedagogy

The fourth theme concerns the pedagogical use of AI. AI has greater transformative potential when it is embedded in inquiry-based, problem-based, project-based and experiential learning. In such learning environments, students can investigate authentic sustainability problems, analyse information, compare possible solutions and reflect on their implications.

(Niri et al., 2026; Osman & Bashir, 2026) Provide an example of this orientation through their proposed AI-supported model, which incorporates project-based learning, cross-cultural collaboration, scenario-based learning, and SDG awareness. Thus, it is suggested that AI can facilitate learning experience and make the teacher and student rethink transformative pedagogy that moves beyond information acquisition towards collaboration, reflection and responsible participation.

7.5 Teacher AI Literacy and Professional Competence

The fifth theme highlights the importance of teachers. AI adoption cannot be sustained simply by providing access to technology. Teachers need to understand the capabilities and limitations of AI, evaluate its outputs and determine when its use is appropriate for education (Deshen et al., 2026). Teacher competence, therefore, includes technical knowledge, pedagogical judgement, critical evaluation and ethical awareness in their pedagogical context. Recent research(AlSagri & Sohail, 2024; Kar et al., 2022; Ng et al., 2021) Recommended comprehensive educator training that covers the pedagogical, technical, and ethical dimensions of AI.

7.6 Ethical, Social and Environmental Challenges

The final theme concerns the conditions that may limit AI's contribution to sustainability. Privacy, algorithmic bias and academic integrity remain major issues and concerns. AI-generated information may also be inaccurate, while dependence on automated systems can affect students' independent thinking.

Infrastructure and implementation costs represent another challenge. The literature noted that (Nishant et al., 2020) computational resources, software and institutional investment may remain inaccessible in resource-constrained settings. Finally, AI's own environmental resource requirements raise a broader sustainability question: education cannot claim to use AI sustainably without considering the technology's ecological consequences(AlSagri & Sohail, 2024; Apata et al., 2026b).

8. Educational Implications

The findings suggest that AI integration requires a shift in the role of the teacher from information provider towards learning designer, facilitator and critical mediator. For students, AI literacy should involve more than learning how to operate technological tools. Learners

need to evaluate AI outputs, recognise potential bias, verify information, and understand the consequences of irresponsible usage of AI. Integrating AI literacy within sustainability-oriented curricula can help students develop responsible digital citizenship. Educational institutions also need clear policies concerning privacy, academic integrity, accessibility and responsible AI use. Infrastructure investment must be accompanied by teacher preparation so that the availability of technology translates into meaningful educational practice. These priorities are also reflected in recent literature here cite emphasising institutional investment, educator training and responsible governance.

9. Discussion

AI does not automatically make education sustainable, its contribution depends upon how technological capabilities are translated into educational experiences with the help of teacher and student. The first important insight is that AI can improve personalisation, accessibility, and learner support, but these benefits are meaningful only when they strengthen, rather than replace, human learning. The second is that AI presents a dual possibility for equity. It can reduce barriers through accessibility and personalised support, yet an infrastructural divide can create another layer of educational disadvantage. The third insight concerns pedagogy. AI has limited transformative value when used solely to generate content or answers. Its stronger contribution emerges when embedded in learning processes that require inquiry, critical reflection, collaboration, and problem-solving. This makes pedagogy the bridge between AI capability and sustainable education.The fourth insight is the continuing importance of teachers, AI increases the need of educators who can make informed pedagogical and ethical decisions. On this basis, the paper proposes AI-sustainable education. This goes beyond the idea of AI-enabled education by asking whether technological integration supports educational quality, equity, human agency, sustainability competencies, ethical responsibility and long-term social and environmental well-being.

10. Conclusion

AI is creating new possibilities for educational personalisation, accessibility, learner support and rethinking for transformative learning. Its potential contribution to sustainable development is particularly significant when it is connected with sustainability competencies and learner-centred pedagogies. However, these possibilities are connected with issues regarding inequality, privacy, bias, academic integrity, teacher preparedness and the environmental implications of AI. The paper therefore conclude that AI-sustainable approach places technological innovation within the broader purposes of education in developing learners capabilities, critical thinking, ethical awareness and socially responsible to face the sustainability challenges. Thus, AI should remain rethinking educational transformation in promoting sustainable development in education.

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ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT IN EDUCATION: A LITERATURE REVIEW

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Abstract

Artificial Intelligence (AI) has emerged as an important technological development with the potential to transform education and contribute to sustainable development. The integration of AI into education can support personalized learning, improve accessibility, assist teachers, enhance educational administration, identify students at risk of dropping out, and facilitate data-informed decision-making. These possibilities are particularly relevant to Sustainable Development Goal 4 (SDG 4), which calls for inclusive and equitable quality education and lifelong learning opportunities for all. At the same time, AI creates significant challenges related to digital inequality, data privacy, algorithmic bias, academic integrity, teacher preparedness, environmental costs and the changing nature of teaching and learning. This literature review examines the role of artificial intelligence in promoting sustainable development in education, with particular attention to educational quality, equity, inclusion, teacher development, resource efficiency and lifelong learning. Recent systematic reviews indicate that AI research in education is expanding rapidly, while research specifically connecting AI with sustainability remains comparatively developing. The review argues that AI can contribute meaningfully to sustainable education only when its implementation is human-centred, ethical, inclusive and pedagogically appropriate. The paper concludes that educational institutions should develop AI literacy among teachers and students, establish responsible AI policies, strengthen digital infrastructure, protect learner data and ensure that technological innovation supports rather than replaces human educational relationships.

Keywords: *Artificial Intelligence, Sustainable Development, Education, Digital Learning, AI Literacy*

Back ground of the study:

Education is one of the most important foundations of sustainable development. It contributes not only to individual knowledge and skills but also to social inclusion, economic development, environmental awareness, innovation and responsible citizenship. The United Nations Sustainable Development Goal 4 seeks to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." UNESCO emphasizes that education is essential for achieving the wider set of Sustainable Development Goals (SDGs).

At the same time, Artificial Intelligence (AI) is rapidly changing educational practices. AI includes technologies such as machine learning, natural language processing, intelligent tutoring systems, learning analytics, automated assessment and generative AI. Recent research shows that AI in education has become a substantial research field, with studies examining applications, pedagogical approaches, research methods and the implications of AI for

teachers and learners. The emergence of generative AI tools has accelerated this transformation. Students can use AI systems for explanations, brainstorming, language support and personalized learning, while teachers can use them for lesson planning, assessment support, content creation and differentiated instruction. However, the rapid development of AI has also created concerns about privacy, bias, misinformation, academic integrity and unequal access. UNESCO therefore advocates a human-centred approach in which AI is used in ways that are ethical, safe, equitable and meaningful. The relationship between AI and sustainable development in education is consequently complex. AI can contribute to sustainability by improving educational access, quality and resource management, but the technology itself can also create new social, ethical and environmental challenges. Sustainable AI in education therefore requires more than simply introducing new technologies into classrooms. It requires consideration of educational purposes, social justice, environmental responsibility, teacher professionalism and the long-term interests of learners.

Major Benefits of AI for Sustainable Education

The literature indicates several potential benefits.

Personalized and learner-centred education: AI can adapt learning resources to individual needs and provide rapid feedback.

Increased accessibility: AI-based translation and assistive technologies can help learners overcome linguistic and accessibility barriers**.**

Improved teacher efficiency: Automation of routine tasks can potentially reduce administrative workloads and allow teachers to spend more time on teaching and learner interaction.

Data-informed decision-making: AI can identify patterns in educational data that may assist teachers and administrators.

Support for lifelong learning: AI-enabled learning platforms can provide flexible learning opportunities beyond conventional educational settings.

Innovation in pedagogy: Generative AI and intelligent learning technologies can encourage new approaches to curriculum design, assessment and collaborative learning**.**

Objectives of the study:

- To examine the concept and applications of Artificial Intelligence in education.
- To analyze the relationship between AI and sustainable development in education.

Literature Review:

Nuankaew, Nasa-Ngium & Nuankaew (2025) Artificial *Intelligence and Educational Data Mining Technologies for the 4th SDG Quality Education: A Systematic* ***Review.*** **This** systematic review examined research published from **2020–2024**. From 366 initially identified studies, 19 were included in the detailed review. The study found that AI can contribute to SDG 4 through **personalized learning, inclusive education, accessibility, predictive analytics, virtual classrooms and educational data mining**. It also identified algorithmic bias and data privacy as major concerns. This is one of the most directly relevant studies because it explicitly connects AI applications with **SDG 4**.

Apata et al. (2025) *Artificial Intelligence in Higher Education: A Systematic Review of Contributions to SDG 4 (Quality Education) and SDG 10 (Reduced Inequality)*The researchers

conducted a systematic literature review using several academic databases. From 1,673 records, **51 empirical studies** were retained. The review found that AI can support more **student-centred, personalized, accessible and equitable education**. Remote learning technologies and AI-supported educational systems were identified as mechanisms that can improve access and flexibility. Particularly useful for discussing the relationship between AI, **quality education and educational inequality**.

Toha (2025) *Artificial Intelligence, Sustainability and Higher Education: A Systematic Literature Review Toward Sustainable Higher Education (SHE) Framework.*Toha reviewed literature from 2015–2024 using the PRISMA framework and databases including Scopus and Web of Science. The study investigates the intersection of AI, sustainability and higher education and proposes a conceptual framework for AI-driven sustainable higher education. : This study is valuable for developing a theoretical framework linking AI with sustainable higher education, rather than looking at AI merely as an educational technology.

AlSagri & Sohail (2024) *Evaluating the Role of Artificial Intelligence in Sustainable Development Goals with an Emphasis on "Quality Education* ."This research specifically examines how AI can contribute to the Sustainable Development Goals, with particular emphasis on quality education. The researcher discusses the potential of AI and generative AI technologies to address educational challenges within the SDG framework.

Sustainable Social Development through AI and Data Science in Education (2023) *Sustainable Social Development through the Use of Artificial Intelligence and Data Science in Education during the COVID Emergency: A Systematic Review Using PRISM* This systematic review examined the use of AI, big data and learning analytics in education during the COVID-19 period. It found that these technologies can support personalized education, prediction of learning outcomes and identification of students at risk of dropping out. Very useful for discussing AI's contribution to educational continuity, student retention and personalized learning.

Research Methodology:

The study adopts a descriptive research design to explore the concepts, applications and benefits of Artificial Intelligence for Sustainable Development in Education. The approach is qualitative, utilizing content analysis to review existing literature on the topic. Key aspects of the methodology include.

Data Collection: Secondary data were sourced from peer-reviewed journal articles, academic publications and reputable online databases, studies published in 2003 to 2005 were prioritized to ensure relevance and recency.

Analysis Process: A content analysis framework was employed to identify recurring themes, insights, and trends in the reviewed literature. The data were categorized into thematic areas such concepts, applications and benefits.

Scope of the study: The research focuses on Artificial Intelligence for Sustainable Development in Education used in diverse contexts, including higher education. Both qualitative and quantitative aspects of previous studies were examined to provide a holistic understanding.

Limitations: As the study relies on secondary data, findings are interpretative and dependent

on the quality of reviewed literature. The absence of primary data collection limits the scope for contextual insights.

Findings of the study: From the literature review it can be analyzed that:

- AI can contribute to SDG 4 through **personalized learning, inclusive education, accessibility, predictive analytics, virtual classrooms and educational data mining**.
- AI can support more **student-centred, personalized, accessible and equitable education**. Remote learning technologies and AI-supported educational systems were identified as mechanisms that can improve access and flexibility.
- **Sustainability and higher education** and proposes a conceptual framework for AI-driven sustainable higher education
- AI is valuable for developing a theoretical framework linking AI with **sustainable higher education**, rather than looking at AI merely as an educational technology
- The potential of AI and generative AI technologies to address educational challenges within the SDG framework
- These technologies can support personalized education, prediction of learning outcomes and identification of students at risk of dropping out. Very useful for discussing AI's contribution to educational continuity, student retention and personalized learning.

Conclusions & Suggestions:

The literature suggests that AI can become an important instrument for sustainable educational development, but its contribution depends on how it is designed, implemented and governed. The strongest argument for AI in sustainable education is its potential to improve personalization, accessibility, resource allocation and lifelong learning. These functions directly relate to SDG 4 and, indirectly, to other SDGs. However, sustainability should not be equated with technological advancement. A technologically advanced education system is not necessarily sustainable if it increases inequality, compromises privacy, weakens teacher autonomy or generates excessive environmental costs. Consequently, the appropriate question is not whether education should adopt AI, but **how AI can be implemented in ways that strengthen educational quality, equity, human agency and long-term sustainability. A** sustainable model of AI in education should therefore combine technological innovation with teacher professionalism, ethical governance, inclusive infrastructure and sustainability education. Artificial Intelligence has considerable potential to contribute to sustainable development in education. Through personalized learning, intelligent tutoring, accessibility technologies, learning analytics, teacher support and institutional resource optimization, AI can contribute to the achievement of SDG 4 and support broader educational and social objectives. Nevertheless, AI also introduces substantial challenges. Digital inequality, privacy concerns, algorithmic bias, misinformation, academic integrity, teacher preparedness and environmental impacts require careful consideration. The literature increasingly supports a **human-centred model of AI in education.** UNESCO's guidance emphasizes that AI should **b**e used ethically, safely, equitably and in ways that are pedagogically meaningful. Therefore, the sustainable integration of AI requires more than investment in technology. It requires investment in teachers, students, digital infrastructure, ethical governance and research. AI

should ultimately function as a tool for strengthening human learning and educational opportunity rather than replacing the human purposes of education.

Recommendations

Based on the literature, the following recommendations are proposed:

1. **Develop AI literacy programmes** for teachers, students and educational administrators.
2. **Integrate AI literacy into teacher education** and continuing professional development.
3. **Establish institutional AI policies** addressing privacy, academic integrity, transparency and responsible use.
4. **Ensure equitable access** to digital infrastructure and AI-supported learning.
5. **Use AI as a complement to teachers**, not as a replacement for human educational relationships.
6. **Redesign assessment practices** to emphasize critical thinking, creativity, problem-solving and authentic learning.
7. **Strengthen data protection mechanisms** for learners and teachers.
8. **Evaluate AI systems for bias and fairness** before large-scale implementation.
9. **Promote environmentally responsible AI**, considering energy consumption and technological life cycles.
10. **Conduct longitudinal research** to evaluate the long-term educational and sustainability outcomes of AI.

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ARTIFICIAL INTELLIGENCE AS A CATALYST FOR INCLUSIVE AND EQUITABLE EDUCATION: OPPORTUNITIES, CHALLENGES, AND PATHWAYS FOR ALL LEARNERS

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Abstract

Artificial intelligence (AI) is rapidly transforming education, and its capacity to advance inclusive and equitable learning has become a central theme in contemporary scholarship. This thematic paper synthesizes recent literature to examine how AI can support learners with diverse needs, including those with disabilities, and the conditions under which it risks deepening existing inequalities. The review finds that AI-driven personalization, assistive technologies, and teacher-support tools offer genuine opportunities to expand access, participation, and outcomes. However, algorithmic bias, the digital divide, privacy concerns, and uneven teacher readiness threaten to entrench exclusion. The paper argues that AI is not inherently inclusive; its impact depends on human-centered design, inclusive data practices, robust governance, teacher preparation, and deliberate investment in infrastructure, and it concludes with pathways for realizing AI as an equity-first project in education.

Keywords: Artificial intelligence; Inclusive education; Educational equity; Assistive technology; Universal Design for Learning; Algorithmic bias; Digital divide

1. Introduction

Inclusive and equitable education is a global commitment enshrined in Sustainable Development Goal 4 and reaffirmed in international frameworks such as the Salamanca Statement-1994 and the Convention on the Rights of Persons with Disabilities-2006. Sustainable Development Goal 4 explicitly links inclusion with equity, calling for inclusive and equitable quality education and lifelong learning for all (Yang, 2025). Yet decades of research document a persistent gap between policy rhetoric and classroom reality, marked by teacher unpreparedness, resource shortages, infrastructural deficits, and attitudinal barriers that the broader inclusive-education literature has repeatedly identified (Graham et al., 2020).

Into this landscape has arrived artificial intelligence, a technology that is transforming how education is designed, delivered, and experienced. AI now underpins adaptive learning platforms, intelligent tutoring systems, automated assessment, learning analytics, and a growing array of assistive technologies. Proponents argue that AI can personalize instruction at scale, reduce teacher workload, and open access for learners who have historically been excluded (Roshanaei et al., 2023; Zhang, 2024). Critics caution that the same technologies can encode bias, widen the digital divide, and displace the human relationships at the heart of

inclusive pedagogy (Kizilcec & Lee, 2022; Yadav, 2024).

This thematic paper examines whether AI can serve as a genuine catalyst for inclusive and equitable education. It synthesizes recent literature to map the conceptual foundations, current applications, opportunities, and risks of AI in education, and it proposes pathways for realizing AI as an equity-first, human-centered project. The central argument is that AI is not inherently inclusive; its outcomes are decided by design choices, data practices, governance, and the contexts in which it is deployed.

The studies underpinning this paper span bibliometric analyses, systematic and narrative reviews, conceptual papers, and a small number of empirical case studies, and together they show a field that is expanding rapidly but still lacks strong implementation evidence. The central argument, therefore, is that AI should not yet be treated as a proven solution for inclusive and equitable education: the evidence base is strongest on potential and risk, but much weaker on durable, equitable impact under real classroom conditions

2. Understanding Inclusive and Equitable Education

Inclusive education is grounded in the principle that all learners, including those with disabilities and marginalized identities, should participate meaningfully in mainstream educational settings. Equity, in this framing, is distinct from equality: it demands fairness of access, participation, and outcomes rather than identical treatment. The historical trajectory of special education has moved from segregation toward integration and, more recently, toward genuine inclusion, a shift reflected in policy frameworks worldwide (Singh, S. 2024).

Universal Design for Learning (UDL) has emerged as a leading framework for operationalizing this vision, organizing instruction around multiple means of representation, expression, and engagement so that curricula are accessible by design rather than through retrofitted accommodation (Mary, 2023; Spencer, 2011). UDL aligns closely with the affordances of technology, which can deliver content in multiple modalities and offer learners flexible pathways to demonstrate understanding (Spencer, 2011). Technology-supported UDL is increasingly recognized as a route to inclusive and equitable classrooms, though its success depends on pedagogical design and institutional context (Mary, 2023).

Despite these advances, implementation remains uneven. Schools struggle with inadequate infrastructure, shortages of trained educators, rigid curricula, and weak support systems, while teachers often report positive attitudes toward inclusion but low confidence in their capacity to enact it (Pranyoto, Y. H., & Berangka, D. 2025). These persistent barriers form the benchmark against which AI's contribution to inclusive education must be assessed: a technology that merely automates exclusion is no advance at all.

3. Artificial Intelligence in Education: An Overview

Artificial intelligence in education encompasses a family of technologies, including machine learning, natural language processing, computer vision, and generative models, applied to learning and teaching. Current applications include adaptive and personalized learning systems that adjust content, pace, and feedback in real time (Akavova et al., 2023; Xaveria et al., 2025), intelligent tutoring systems that emulate one-to-one instruction, automated assessment and grading, learning analytics that identify at-risk learners, and assistive technologies such as speech-to-text, text-to-speech, and screen readers (Ahmed et al., 2025).

The appeal of AI for educators lies in its capacity for scale and personalization. Adaptive systems can continuously monitor learner performance and tailor instruction to individual needs, a task impossible for a single teacher in a large classroom (Akavova et al., 2023). Systematic reviews of adaptive learning confirm gains in engagement and outcomes, while also noting persistent challenges around interpretability, privacy, and scalability in low-resource settings (Xaveria et al., 2025). Reviews of AI in education similarly emphasize both the promise of personalized, accessible learning and the risks of socio-economic disparities in access (Zhang, 2024).

Yet deployment remains uneven. Most AI applications are concentrated in well-resourced, technology-rich environments, and their benefits do not automatically reach the learners who need them most. This unevenness is itself an equity concern that runs through the remainder of this paper.

4. Opportunities: How AI Can Advance Inclusion and Equity

The literature identifies four principal ways in which AI can advance inclusive and equitable education.

First, AI enables personalized learning for diverse needs. Adaptive platforms can tailor content, pacing, and feedback to individual learners, supporting students with varying abilities, learning styles, and preferences (Ahmed et al., 2025; Xaveria et al., 2025). Reviews of AI-powered assistive tools report improvements in academic engagement, independence, and social inclusion for students with learning disabilities, autism, and motor impairments (Koranteng, 2025). Personalized learning aligns closely with UDL principles, offering multiple pathways to representation, expression, and engagement (Mary, 2023).

Second, AI expands accessibility through assistive technology. Speech recognition, text-to-speech, automatic captioning, and language translation help learners with sensory, motor, and cognitive disabilities participate more fully (Ahmed et al., 2025; Rodríguez Torres et al., 2023). Integrative reviews of AI in higher education find that such tools improve accessibility, engagement, and academic performance for students with disabilities (Dumitru et al., 2025). Systematic reviews of AI-powered assistive technologies confirm significant enhancements in learning outcomes, accessibility, and personalized support for diverse learners (Cabanes & Galigao, 2025).

Third, AI supports teachers. AI can automate administrative tasks, generate progress reports, and provide real-time feedback, freeing educators to focus on pedagogical guidance and relational work (Akavova et al., 2023; López et al., 2025). Systematic reviews note that AI reduces the administrative burden on educators, enabling them to prioritize direct support for learners (López et al., 2025).

Fourth, AI can reach the unreached. AI-enabled platforms can deliver quality learning to remote, rural, and underserved populations, support multilingual learners, and identify learning difficulties early (Supramaniam et al., 2024; Zhang, 2024). In principle, AI can bridge geographic, economic, and social barriers that have historically limited access to quality education (Supramaniam et al., 2024).

5. Challenges and Risks

The same technologies that promise inclusion can also reproduce or amplify exclusion. Five

risks dominate the literature.

Algorithmic bias is the most widely documented concern. AI systems trained on unrepresentative data can encode and amplify societal inequalities, producing unfair predictions and recommendations that disadvantage marginalized learners (Kizilcec & Lee, 2022; Yin et al., 2024). Cultural underrepresentation, opaque decision-making, and weak governance undermine fairness in assessment, learning recommendations, and resource allocation (Hoca & Nuredin, 2025). Empirical work links perceived algorithmic bias directly to threats to educational equity, underscoring the need to address the black-box nature of educational AI (Farheen et al., 2025).

The digital divide is a second risk. AI depends on connectivity, devices, and electricity, precisely the resources that excluded learners often lack, and without deliberate intervention AI can widen rather than narrow educational inequalities (Juyal et al., 2025; Supramaniam et al., 2024; Zhang, 2024).

Privacy and surveillance constitute a third concern. Data-intensive systems raise questions about consent, ownership, and the monitoring of vulnerable children (Pawar & Khose, 2024; Zhang, 2024).

Teacher and institutional readiness is a fourth risk. Many educators lack training to use AI critically and effectively, and inadequate infrastructure limits implementation in underfunded schools (Juyal et al., 2025; López et al., 2025).

Finally, there is the risk of dehumanization. Over-reliance on automated systems can displace the human relationships central to inclusive pedagogy, and the preservation of human connection must be weighed against efficiency gains (Pawar & Khose, 2024; Yadav, 2024).

6. Pathways Forward

Realizing AI's potential for inclusive education requires deliberate action across five fronts.

Human-centered design should position AI as a complement to teachers, not a replacement, and participatory design that includes learners with disabilities in development and evaluation is essential (Holstein & Doroudi, 2022; Safdar et al., 2024). Inclusive data practices require representative datasets, transparency, and fairness audits to prevent bias from being encoded into systems (Hoca & Nuredin, 2025; Yin et al., 2024).

Robust policy and governance frameworks must establish accessibility standards, accountability mechanisms, and ethical guidelines for AI in education (López et al., 2025; Zhang, 2024). Teacher preparation should embed AI literacy and inclusive pedagogy in both pre-service and in-service training, since educator readiness is a precondition for equitable implementation (Cabanes & Galigao, 2025; López et al., 2025).

Finally, closing the digital divide requires sustained investment in infrastructure, connectivity, and affordable tools, alongside longitudinal research on equity outcomes (Juyal et al., 2025; Supramaniam et al., 2024). None of these pathways is sufficient alone; they must be pursued together.

7. Conclusion

Artificial intelligence offers a genuine opportunity to advance inclusive and equitable education. The literature demonstrates real gains in personalization, accessibility, teacher support, and reach, particularly for learners with disabilities and those in underserved contexts.

Yet AI is not inherently inclusive. Algorithmic bias, the digital divide, privacy risks, uneven teacher readiness, and the threat of dehumanization can all entrench the very exclusions inclusive education seeks to remove.

The evidence converges on a clear conclusion: the impact of AI on equity is decided by design choices, data practices, governance, and context, rather than by the technology itself. Pursuing AI as an equity-first, human-centered project, with participatory design, inclusive data, robust policy, teacher preparation, and investment in infrastructure, offers the most credible path toward education that is genuinely inclusive and equitable for all learners.

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ANALYZING THE GLOBAL PERSPECTIVES ASPECTS OF THE EMPLOYABILITY SKILLS IN THE PRESENCE CURRICULUM OF POSTGRADUATE OF KUVEMPU UNIVERSITY

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Abstract

The higher education system in India is experiencing a transition phase from a conventional education system, or teacher-centred mode of instruction, to a progressive education system that is more student-centred and employment-oriented (UGC, 2012). The Choice Based Credit System (CBCS) was introduced by the University Grants Commission (UGC) in 2015 for graduate and postgraduate degrees and certificate programmes at the higher education level. Students can select multidisciplinary, intra-disciplinary, and skill-based courses based on the student's interests and goals (primary soft skill-oriented courses). Holistic development enables students to gain both hard and soft skills, increasing their employability and job prospects. But also India is currently facing a huge employability challenge with reference to graduate & Postgraduates students. Though unemployment is a challenge, the bigger issue is lack of employability skills in graduate students. Various studies and surveys conducted in this area reveal 70 to 75% of graduates are not employable. Skill development has therefore become an essential component of higher education. Universities and colleges are increasingly expected to integrate employability skills into their curricula through some aspects such as Academic Learning, Experiential Learning, Career Maturity, Professional Skills, Career Management, Meaningful Connections, and Global Perspective. The present study analyse the Employability Skills of aspects in the Global Perspective discipline of Arts, Science and Commerce postgraduate curricula of Kuvempu University.

Keywords: *Employability Skill, Global Perspectives, Higher Education, Postgraduates.*

Introduction:

The 21st century has witnessed a transmutation in the world of work, but not only in India, but in every country in the world. As the world of work undergoes an unprecedented transformation, countries are confronted with the challenge of an increasing mismatch between skills and jobs. Skills and the Future of Work (ILO 2018). Every organization needs every 7 M of Man, Money, Machine, Material, Method and Marketing, Measurement to be used in its daily operations. However, of all these resources, 'Man' (referring to manpower, employers, labour etc.) Therefore, the integration of employability into the program provides students with the opportunity to develop their skills, experience and knowledge to help them make a successful transition from education to employment. It is vital that all students have a certain level of employability activity built into their academic curriculum. According to the World Trade Organization, GDP could rise by 3 to 5 per cent in 2035 if India focuses on skills

development and training. But skills development alone is not sufficient to increase employability, as highlighted in the India Skills Report 2021. In Curriculum should give more requirement for more interaction between students and workplace. Through curriculum giving students the opportunity to explore their career interests, internships, hands-on experience, integrating industry-relevant skills, digital competencies, experiential learning, and career development into academic programmes higher education institutions can enhance graduate employability while contributing to national development and global competitiveness. Global perspectives learning is one of the aspects in the graduate employability curriculum.

Need and Importance of the Study:

The main role of higher education is to trained students by improving their knowledge, skills, attitudes and capacities to empower students as critical and reflective learners for life. In our country, the minimum qualification prescribed for many jobs even at the clerical level job is a University degree. The degree includes many skills, knowledge and capabilities for students entering a college and earning a degree with employability. But the large proportion of the products of the education system are found to lack employable skills. It has considerably reduced the credibility of the higher education system. The utility of higher education in assuring employment remains questionable. Many graduate and postgraduate students do not get jobs in their respective fields.

However, as most students continue their education, it is not easy for them to enter the labour market. For example, according to the estimates of the National Association of Software and Service Companies (NASSCOM), only 25 per cent of graduates are employable, and 75 per cent is not easily employable. Therefore, it is important to ensure equitable distribution and access to skills-development opportunities. There are several reasons for the lower level of employability in higher education, like system/ structural issues, inadequate practical and skill-based training, rapid technological changes, outdated teaching methods, unavailability of teachers, and infrastructure, outdated syllabus, absence of career counselling facilities, practical competencies, transferable skills, and industry-oriented experiences and so on. Hence, it creates a gap between higher education & employability. Therefore, recruiters today expect students to have some additional set of skills and Global perspectives curriculum required for employment known as employability skills. Changing education systems in the 21st century is an array of ways to develop employability through curricula. Good curriculum design will attract more interest in developing a number of skilful practices. So, the present study was undertaken to investigate the inducing aspects of employability in the postgraduate curriculum of Kuvempu University to explore the aspects of employability among postgraduate students. The identifying the opinions of postgraduate teachers & students about the Global perspectives employability aspects of presence PG curriculum.

Concept of Employability Skills:

Employability skills are necessary to obtain, maintain and succeed in a career.

The UK Commission for Employment and Skills (2009) defined, employability skills as “the skills almost everyone needs to do almost any job”. The Allen Consulting Group Report (2006) refers the employability skills by several other names, including key skills, core skills, life skills, generic skills, essential skills, key competencies, necessary skills and transferable

skills. Employability Skills refer to specific skills essential for employment.

Definition of Curriculum: According to Nation & Macalister (2010) define Curriculum as a guide in designing courses that consist of outer cycle namely Principles, Environment, and needs that involve practical and theoretical considerations that will have a major effect in guiding the actual process of course production.

Dimensions of Employability Curriculum: Employability Curriculum is based on seven dimensions of employability: Academic Learning, Experiential Learning, Career Maturity, Professional Skills, Career Management, Meaningful Connections, and Global Perspective. (The University of Kansas, KU University Career Centers. 2014) (Peter Knight and Mantz Yorke, 2004).

Global Perspective: The global perspective is a vision of things that considers the entire world as an integrated system and community, this can be achieved through an awareness of social, economic, and cognitive contexts such as nationality, ethnicity, culture, community, and language, and systems of the world and applying that perspective in the context of work.

Methodology: The survey design was chosen for this study because it was found to be most appropriate to collected information directly about teachers regarding aspects of employability in the PG curriculum.

Sampling Design: The population of this study includes Arts, Science and Commerce teachers selected from 14 departments with 76 teachers serving in the selected department were considered for the random sampling technique for this study.

Tool used for the Study*:* The investigator was Used the following tool for the collection of relevant data. Teacher's opinion regarding the availability Employability Skills of Postgraduate Curriculum Developed by Shilpa.V and Dr. S.S. Patil.

Statistical Techniques: The researcher used Percentage analysis. Inferential Analysis and Interpretation.

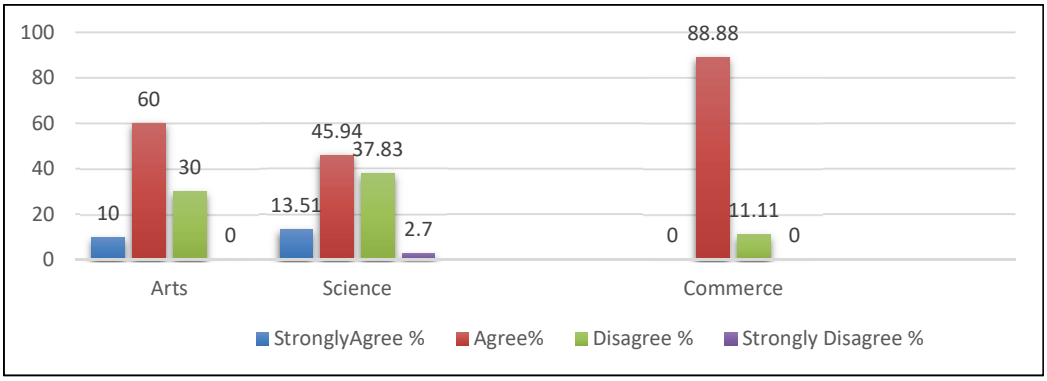
Objective-1: To identify the presence of Global perspective related aspects of Employability skills in selected Postgraduate Curricula of Kuvempu University as perceived by Teachers of Postgraduate departments**.**

Hypothesis-1: There is no significant difference between the opinions of the teaching faculty of Arts, Science and Commerce discipline with reference to the aspects of Employability in the Curriculum.

1. The postgraduate curriculum provides opportunities to engage with and work with alumni, the community, employers, professional organizations, voluntary organizations etc.

Group Statistics	Discipline	Responses									
		Strongly Agree		Agree		Disagree		Strongly Disagree		Total %	
		N	%	N	%	N	%	N	%	N	%
Employability Aspects of curriculum	**Arts**	3	10	18	60	9	30	0	**0**	**30**	**100**
	Science	5	13.51	17	45.94	14	37.83	1	2.70	**37**	**100**
	Commerce	0	0	8	88.88	1	11.11	0	0	**9**	**100**
	Total	8	10.52	43	56.57	24	31.56	1	1.31	**76**	**100**

Figure- 1: Shows the percentage scores of the opinion of the PG teachers of Arts, Science, and Commerce regarding the aspect that the PG curriculum provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations etc,



The percentage scores of the opinion of the PG teachers of Arts, Science, and Commerce regarding the aspect that the PG curriculum provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations etc, was calculated. Table (1) revealed that 10% of Arts teachers Strongly Agree, 60% Agree and 30% disagree. Among the Science teachers 13.51% Strongly Agree, 45.94% Agree, 37.83% disagree and 2.7% Strongly disagree. Among the Commerce teachers, 88.88% Agree, 11.11% Agree. No commerce teachers Strongly Agree and Arts Commerce teachers strongly disagree.

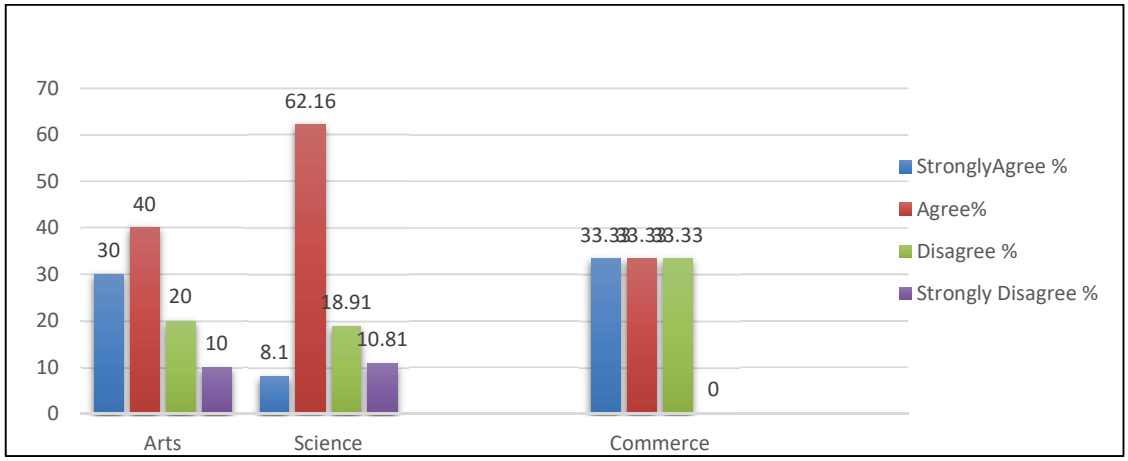
It is clear that majority of the teachers of all the three discipline either strongly agree or agree that the curriculum of their respective subjects provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations etc. There is less disagreement and very less strongly disagreement about the above mentioned employability aspects.

However the Commerce teachers are more positive in the opinion (Agree= 88.88%) about the aspects of provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations etc, Followed by Arts PG Teachers (Strongly Agree=10%, Agree=60%) Science PG Teachers (Strongly Agree=13.51%, Agree=45.94%).

2. The postgraduate curriculum includes cultural awareness, foreign languages, international understanding, global perspectives to identify international opportunities.

Group Statistics	Discipline	Responses									
		Strongly Agree		Agree		Disagree		Strongly Disagree		Total %	
		N	%	N	%	N	%	N	%	N	%
Employability Aspects of curriculum	**Arts**	9	30	12	40	6	20	3	10	**30**	**100**
	Science	3	8.10	23	62.16	7	18.91	4	81	**37**	**100**
	Commerce	3	33.33	3	33.33	3	33.33	0	0	**9**	**100**
	Total	15	19.73	38	50	16	21.05	7	9.21	**76**	**100**

Figure- 2: Shows the percentage scores of the opinion of the PG teachers of Arts, Science, and Commerce, regarding the aspect that the PG curriculum includes cultural awareness, foreign languages, international understanding, global perspectives to identify international opportunities.



The percentage scores of the opinion of the PG teachers of Arts, Science, and Commerce regarding the aspect that the PG curriculum includes cultural awareness, foreign languages, international understanding, global perspectives to identify international opportunities, was calculated. Table (2) revealed that 30% of Arts teachers Strongly Agree, 40% Agree, 20% disagree and 10% Strongly disagree. Among the Science teachers 8.1% Strongly Agree, 62.16% Agree, 18.91% disagree and 10.81% strongly disagree. Among the Commerce teachers, 33.33% Strongly Agree, 33.33% Agree and 33.33% Strongly disagree. No commerce teachers strongly disagree.

It is clear that majority of the teachers of all the three discipline either strongly agree or agree that the curriculum of their respective subjects includes cultural awareness, foreign languages, international understanding, and global perspectives to identify international opportunities. There is less disagreement and very less strongly disagreement about the above mentioned employability aspects.

However the Science teachers are more positive in the opinion (Strongly Agree=8.1% Agree=62.16%)) about the aspects of cultural awareness, Foreign languages, international understanding, global perspectives to identify international opportunities. Followed by Arts PG Teachers (Strongly Agree=30%, Agree=40%) Commerce PG Teachers (Strongly Agree=13.51%, Agree=45.94%).

Findings of the Study:

In the present study investigator has attempted to find the significant difference between the opinions of the teaching faculty of Arts, Science, and Commerce discipline with reference Global perspectives first aspects of Employability in the Curriculum. Researcher observed from the opinions of the PG teachers curriculum includes curriculum focuses on behavioural aspects of provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations in their curriculum seems to be more agreement with regard to the Commerce teachers followed by Arts teachers compared to that of Science teachers. The opinions of the teaching faculty of Arts, Science, and Commerce

discipline with reference Global perspectives second aspects of Employability in the Curriculum. Researcher observed from the opinions of the PG teachers curriculum includes curriculum focuses on behavioural aspects includes cultural awareness, Foreign languages, international understanding, global perspectives to identify international opportunities in their curriculum seems to be more agreement with regard to the Science teachers followed by Arts teachers compared to that of Commerce teachers.

Conclusion:

The present study was carried out to explore the opinion of the teaching faculty of Arts, Science, and Commerce discipline. The Commerce teachers are more positive opinion of curriculum focuses on behavioral aspects of provides opportunities to engage with and work with alumni, the community, Employers, professional organisations, voluntary organisations. The Science teachers are more positive opinion of curriculum focuses on behavioural aspects includes cultural awareness, foreign languages, international understanding, and global perspectives to identify international opportunities. Hence Arts, Science and Commerce teachers has suggested that PG Curriculum should be interdisciplinary approach to learning covers all the social, economic, and environmental dimensions. Study materials should be available in both global as well as local languages. Students should be given opportunities to participate in presentations and such to build confidence, soft skills. Organizing workshops, discussion with expert, demonstrations of skills, MOCK interviews and training programs for the students. Interaction with peers from various universities to have a global perspective and develop broad thinking. Government initiatives like the Skill India Mission, National Education Policy (NEP), and Digital India, alongside private sector investments, have made India's talent highly employable on a global scale.

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EMPOWERING FUTURE EDUCATORS: SKILL DEVELOPMENT STRATEGIES FOR ENHANCING EMPLOYABILITY AMONG B.ED. STUDENTS

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Abstract

The changing nature of education and employment has created new expectations from prospective teachers. A professional degree in education provides essential theoretical and pedagogical knowledge, but contemporary teachers also require communication skills, digital competence, critical thinking, creativity, collaboration, problem-solving, leadership, emotional competence and the ability to learn continuously. Therefore, strengthening the employability of B.Ed. students requires a shift from qualification-oriented teacher education towards competency-oriented professional preparation. This article discusses the significance of skill development in improving the employability of B.Ed. students and examines strategies that teacher education institutions can adopt to prepare future educators for changing professional demands. The discussion focuses on communication skills, digital literacy, pedagogical competence, critical thinking, creativity, interpersonal skills, leadership, reflective practice, research competence and adaptability. Experiential learning, microteaching, teaching practice, project-based learning, digital pedagogy, peer learning, career guidance, professional portfolios and school-institution partnerships are suggested as important approaches for developing these competencies. Particular attention is given to digital competence because technology has become an integral part of teaching, learning, assessment and professional development. UNESCO's ICT Competency Framework for Teachers identifies digital competencies as an important component of pre-service and in-service teacher preparation (UNESCO, 2018). The article concludes that B.Ed. programmes should systematically integrate employability skills into curriculum, pedagogy, practical training and assessment. A skill-oriented approach can help future teachers become professionally confident, technologically capable, reflective and adaptable educators who are prepared to respond to the needs of contemporary educational institutions.

Keywords: *Skill Development, Employability, B.Ed. Students, Teacher Education, Professional Competence, Digital Skills, Future Educators*

Introduction:

Teacher education occupies a central position in the development of an effective education system. The quality of teachers has a direct influence on classroom processes, learner participation and educational outcomes. Traditionally, teacher education programmes have concentrated on developing knowledge of educational psychology, curriculum, pedagogy, assessment and classroom teaching. Although these areas remain fundamental, the responsibilities of teachers have expanded considerably in recent years.

The contemporary teacher works in an environment influenced by digital technology, diverse learning needs, changing curricula and new approaches to assessment. Teachers are increasingly expected to use digital resources, communicate effectively, collaborate with colleagues, design learner-centred activities, analyse classroom problems and continuously improve their professional practice. Consequently, employability of B.Ed. students should be understood in a broader sense than simply possessing a teaching qualification.

Employability refers to the combination of knowledge, skills, attitudes and personal qualities that enables an individual to obtain employment, perform effectively in a professional setting and adapt to changing workplace requirements. For B.Ed. students, employability includes both teaching-specific competencies and transferable skills that support professional effectiveness.

The increasing importance of digital competence further strengthens the need for a skills-oriented approach. UNESCO notes that digital competencies have become important for participation in society, lifelong learning and employment, while teacher preparation needs to include effective use of technology for teaching and learning (UNESCO, 2023).

Therefore, B.Ed. institutions need to move beyond a purely theoretical model of teacher preparation and create learning environments in which prospective teachers can practise, demonstrate and evaluate professional competencies.

Concept of Employability in Teacher Education:

Employability is a multidimensional concept. It does not refer only to obtaining a job immediately after completing a programme. It also includes the capacity to perform effectively, respond to professional challenges, acquire new knowledge and remain relevant in a changing work environment.

For B.Ed. students, employability can be viewed through three broad dimensions:

Professional Competence

Professional competence includes lesson planning, classroom management, teaching methods, assessment, inclusive practices, subject-specific pedagogy and understanding of learners.

Transferable Skills

Transferable skills include communication, teamwork, leadership, creativity, problem-solving, critical thinking, decision-making and interpersonal relationships.

Digital and Future-Oriented Competence

Digital competence includes the ability to use technology meaningfully for teaching, learning, assessment, communication, content creation and professional development. UNESCO's ICT Competency Framework for Teachers provides a structured framework for integrating digital competencies into teacher education and professional learning.

Thus, employability should be developed as an integrated component of teacher preparation rather than as a separate activity conducted only before campus recruitment.

Importance of Skill Development among B.Ed. Students

Skill development is important because the professional role of a teacher requires the integration of knowledge and practice. A student may possess considerable theoretical knowledge but may experience difficulty in classroom communication, technology integration or classroom management without sufficient practical preparation.

Skill-oriented teacher education can help B.Ed. students:

- apply theoretical knowledge in real classroom situations;
- communicate ideas clearly and confidently;
- use digital technologies for educational purposes;
- manage diverse classroom situations;
- work effectively with colleagues;
- solve educational problems systematically;
- develop creative approaches to teaching;
- undertake classroom-based research;
- reflect upon and improve their own teaching; and
- adapt to changing educational and professional requirements.

UNESCO's teacher competency framework identifies areas including curriculum and assessment, pedagogy, application of digital skills, organisation and administration, and professional learning. These areas demonstrate that effective teacher preparation requires a combination of pedagogical, technological and professional competencies.

Essential Skills for Enhancing Employability of B.Ed. Students:

Communication Skills

Communication is fundamental to teaching. A teacher must explain concepts, ask questions, provide feedback, listen to students and communicate with parents and colleagues. B.Ed. students should therefore receive regular opportunities to practise oral and written communication. Activities such as seminars, group discussions, debates, presentations, storytelling, role play and mock teaching can improve communication confidence. Effective communication also involves listening. Prospective teachers should learn to understand learners' questions, concerns and perspectives rather than concentrating only on delivering content.

Digital Competence

Digital competence has become an important component of professional teaching. B.Ed. students should be familiar with presentation tools, online learning platforms, digital assessment, educational applications, multimedia resources, open educational resources and virtual learning environments.

However, digital competence should not be restricted to knowing how to operate devices. The important issue is whether technology is being used appropriately to improve learning. UNESCO's ICT Competency Framework describes digital competencies across areas such as teaching and learning, administration and continuing professional development.

B.Ed. students can develop digital competence by preparing digital lesson plans, designing online quizzes, creating instructional videos, developing e-content and conducting technology-supported teaching demonstrations.

Pedagogical Skills

Pedagogical competence remains the foundation of teacher employability. Prospective teachers should develop competence in lesson planning, selection of teaching methods, classroom interaction, questioning techniques, assessment and classroom management.

Teaching practice should therefore be treated as a major professional learning opportunity.

B.Ed. students should be encouraged to plan lessons, teach them, receive feedback and revise their strategies.

Critical Thinking

Teachers frequently encounter complex educational situations. They need to analyse problems before deciding how to respond. Critical thinking can be developed through case studies, classroom problem analysis, educational debates, action research and reflective discussions. Instead of simply asking students to reproduce information, teacher education should encourage them to interpret evidence and justify professional decisions.

Problem-Solving Skills

Classrooms contain problems related to learning difficulties, student motivation, attendance, behaviour, assessment and classroom diversity. Prospective teachers need the ability to identify problems and develop practical solutions. Problem-based learning can provide opportunities for B.Ed. students to work on realistic educational situations and develop decision-making abilities.

Creativity and Innovation

Creative teachers can design learning experiences that capture students' attention and encourage active participation. Creativity can be developed through instructional material preparation, innovative lesson planning, educational games, project work, storytelling, arts-integrated activities and technology-supported teaching. Innovation does not necessarily mean using sophisticated technology. It can also involve developing a new teaching strategy, adapting an existing method to a particular group of learners or creating an inexpensive teaching aid.

Collaboration and Teamwork

Teaching is increasingly collaborative. Teachers work with colleagues, administrators, parents, community members and other professionals. B.Ed. programmes should provide opportunities for collaborative projects, peer teaching, group assignments and institutional activities. Such experiences help students learn how to divide responsibilities, negotiate ideas and achieve common objectives.

Leadership Skills

Teachers perform several leadership functions in schools. They may coordinate activities, lead committees, organize events, guide students and participate in institutional initiatives.

Leadership skills can be developed by assigning B.Ed. students responsibilities for seminars, cultural programmes, community activities, educational exhibitions and student-led projects.

Emotional and Interpersonal Competence

Teachers interact with learners from different backgrounds and with varying emotional and educational needs. Empathy, patience, active listening, cooperation and emotional awareness are therefore essential. Role play, group counselling activities, peer interaction and classroom simulations can help B.Ed. students understand interpersonal situations and develop appropriate professional responses.

Research and Reflective Skills

Teachers should be capable of examining their own classroom practices and identifying areas for improvement. Research activities and reflective practice can help students develop this

ability. B.Ed. students can be encouraged to undertake small classroom-based investigations, maintain reflective journals and analyse feedback from teaching practice. Such activities can promote evidence-based professional decision-making.

Strategies for Skill Development:

Experiential Learning

Skill development becomes meaningful when students receive opportunities to learn through experience. Teaching practice, school internships, field visits, community activities and classroom observations enable B.Ed. students to connect theoretical learning with professional situations. Experiential activities should include preparation, actual performance, feedback and reflection. This process helps students understand not only what they have learned but also how effectively they can apply it.

Microteaching

Microteaching provides a structured environment for practising individual teaching skills. B.Ed. students can focus on explanation, questioning, reinforcement, introduction, stimulus variation and classroom interaction. Repeated practice followed by constructive feedback can gradually improve teaching competence and confidence.

Peer Learning

Peer learning allows students to learn from one another. B.Ed. students can observe their classmates' teaching, provide feedback and discuss alternative teaching strategies. Peer learning also promotes communication, cooperation, self-evaluation and professional reflection.

Project-Based Learning

Project-based learning can integrate several employability skills simultaneously. A group of B.Ed. students may undertake a project related to inclusive education, digital learning, environmental education, community awareness or school improvement. Such projects can develop research, communication, teamwork, leadership, creativity and problem-solving skills.

Digital Pedagogy Training

Digital training should be incorporated systematically into the B.Ed. programme. Students can be asked to develop digital teaching resources and demonstrate how these resources support particular learning objectives. UNESCO's framework emphasizes that digital competencies should be incorporated into curriculum design, teacher training and continuing professional development.

Mock Interviews and Demonstration Lessons

Employability preparation should include activities that simulate actual recruitment situations. Mock interviews can help students improve professional communication and confidence.

Similarly, demonstration lessons can prepare students for teacher recruitment processes in which candidates may be required to teach a short lesson before a selection panel.

Professional Portfolio Development:

A professional portfolio can provide evidence of a student's development. It may contain:

- curriculum vitae;
- lesson plans;

- teaching-learning materials;
- digital resources;
- teaching practice records;
- certificates;
- research projects;
- reflective journals;
- assessment activities; and
- evidence of participation in seminars and workshops.

Such a portfolio can help students present their competencies more effectively to prospective employers.

Career Guidance and Mentoring

Career guidance should be integrated into teacher education rather than being restricted to the final stage of the programme. Faculty members and experienced teachers can mentor students regarding career opportunities, professional expectations, interview preparation and further education.

School-Institution Partnerships

Strong collaboration between B.Ed. institutions and schools can improve practical preparation. Schools can provide opportunities for observation, teaching practice, mentoring and classroom-based projects.

Such partnerships can also help teacher education institutions understand the competencies expected from beginning teachers.

Continuous Professional Development

Employability should be viewed as a continuing process. B.Ed. students should develop the habit of learning beyond the formal programme through online courses, workshops, professional networks, conferences and self-directed learning.

The digital transformation of education makes continuous professional learning particularly important because teachers must continually update their technological and pedagogical knowledge.

Role of Teacher Education Institutions:

Teacher education institutions have a significant responsibility in developing employable future teachers. Skill development cannot be achieved through isolated workshops alone. It should be integrated throughout the curriculum and supported through institutional practices.

Teacher education institutions should:

1. integrate employability competencies into course objectives;
2. provide adequate opportunities for teaching practice;
3. strengthen digital infrastructure and digital pedagogy;
4. encourage project-based and experiential learning;
5. organize communication and personality-development activities;
6. provide mentoring and career guidance;
7. promote research and reflective practice;
8. develop partnerships with schools;
9. organize seminars, workshops and professional development activities; and

10. use competency-based assessment alongside conventional examinations.

The UNESCO ICT Competency Framework also emphasizes that effective implementation requires institutional leadership and supportive conditions for teacher professional development.

Assessment of Employability Skills:

An important issue is the assessment of skills. If B.Ed. students are evaluated primarily through written examinations, several important competencies may remain unmeasured.

A comprehensive assessment system should include:

- teaching demonstrations;
- practical examinations;
- portfolios;
- presentations;
- project work;
- peer assessment;
- self-assessment;
- classroom observation;
- reflective journals; and
- internship performance.

Such assessment can provide a more complete picture of whether students are capable of applying their knowledge in authentic professional situations.

Challenges in Skill Development:

Several challenges may affect the effective implementation of employability-oriented teacher education. First, excessive emphasis on theoretical examinations may reduce opportunities for practical skill development. Second, differences in students' prior exposure to technology can create unequal levels of digital competence. Third, inadequate infrastructure may limit opportunities for technology-supported learning. Fourth, insufficient interaction between teacher education institutions and schools may weaken practical preparation.

Another challenge is the rapid pace of technological change. A digital tool learned during teacher education may become less relevant later. Consequently, teacher education should focus not only on specific technologies but also on the ability to learn, evaluate and adapt to new technologies.

UNESCO highlights the continuing importance of digital competency development for learning and employment, while also recognizing issues such as unequal access and the digital divide.

Suggestions:

The following measures may strengthen the employability of B.Ed. students:

1. **Introduce an employability-skills component** within teacher education programmes.
2. **Strengthen practical teaching experiences** through meaningful school internships.
3. **Provide regular digital pedagogy training** rather than one-time ICT workshops.
4. **Conduct communication and interview-skills programmes** for prospective teachers.

5. **Promote student-led seminars and activities** to develop leadership.
6. **Use case studies and problem-based learning** to develop critical thinking.
7. **Encourage action research** to develop inquiry and problem-solving abilities.
8. **Develop professional portfolios** for every B.Ed. student.
9. **Establish stronger school-college partnerships** for mentoring and practical exposure.
10. **Adopt competency-based assessment** to evaluate practical and transferable skills.
11. **Encourage lifelong learning** through MOOCs, workshops and professional learning communities.
12. **Create career guidance and placement support systems** within teacher education institutions.

Conclusion:

The preparation of future teachers requires a comprehensive approach that combines academic knowledge, pedagogical competence, practical experience and employability skills. The changing educational environment has expanded the role of teachers beyond traditional classroom instruction. Teachers are now expected to communicate effectively, integrate technology, work collaboratively, solve problems, demonstrate creativity, respond to learner diversity and continuously improve their professional practice.

For this reason, skill development should become an integral part of B.Ed. education. Communication, digital competence, pedagogical skills, critical thinking, creativity, leadership, collaboration, emotional competence, research ability and reflective practice can collectively contribute to stronger professional readiness.

The emphasis on digital competence is particularly important. UNESCO's ICT Competency Framework for Teachers provides a comprehensive basis for developing teachers' abilities to use technology for teaching, learning, administration and professional development. At the same time, employability should not be reduced to technological proficiency. Human qualities such as empathy, communication, creativity, adaptability and professional responsibility remain central to effective teaching.

Ultimately, the goal of teacher education should be to produce **future-ready educators who are knowledgeable, skilled, confident, reflective, adaptable and committed to lifelong professional learning**. When B.Ed. programmes systematically integrate skill development with academic and practical preparation, teacher education can make a stronger contribution to both graduate employability and the quality of education.

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A PROPOSED STUDY OF PROFESSIONAL DEVELOPMENT AND JOB SATISFACTION AMONG TEACHER EDUCATORS AND ITS IMPACT ON STUDENT TEACHERS' ACADEMIC ACHIEVEMENT

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Abstract

Teacher educators occupy a central position in teacher education because they contribute to the academic, pedagogical and professional preparation of prospective teachers. Their professional development and job satisfaction are therefore important considerations in strengthening the quality of teacher education. The National Curriculum Framework for Teacher Education emphasizes the professional preparation of teacher educators and the importance of continuing professional development, while the National Education Policy 2020 gives considerable importance to continuous professional learning and professional growth (National Council for Teacher Education [NCTE], 2009; Ministry of Education, 2020). The present paper proposes a future empirical study to examine the relationship between professional development and job satisfaction among teacher educators and to investigate their possible relationship with student teachers' academic achievement. The proposed study is based on the assumption that professionally engaged and satisfied teacher educators may be better positioned to provide effective teaching, mentoring, feedback and academic support to student teachers. Previous Indian research has reported a significant positive relationship between professional development and job satisfaction among teacher educators, but comparatively less attention has been given to examining whether these factors are associated with the academic achievement of student teachers (Kaur & Bhullar, 2019). The proposed study will employ a descriptive-correlational research design. Teacher educators from selected teacher education institutions and their student teachers will constitute the proposed sample. Data will be collected through an appropriate professional development scale, a job satisfaction scale and student teachers' academic achievement records. Descriptive statistics, Pearson's product-moment correlation and multiple regression analysis may be used after data collection. No empirical findings are presented in this paper because data have not yet been collected. The study is expected to provide a framework for understanding how teacher educators' professional growth and workplace satisfaction may relate to student teachers' academic outcomes and may offer implications for institutional professional development, supportive working environments and quality improvement in teacher education.

Keywords: *Teacher Educators, Professional Development, Job Satisfaction, Student Teachers, Academic Achievement, Teacher Education, Professional Competence, Continuous Professional Development*

1. Introduction

Teacher education is an important component of the educational system because it prepares prospective teachers with the knowledge, skills, attitudes and professional dispositions required for effective teaching. The quality of teacher preparation is influenced by several

factors, including curriculum, institutional resources, pedagogical practices and the competence of teacher educators. The National Curriculum Framework for Teacher Education (NCFTE) identifies teacher educators as an important component of the teacher education system and gives attention to their professional preparation and development (NCTE, 2009).

Teacher educators perform multiple professional roles. They teach prospective teachers, supervise practical experiences, provide academic guidance, engage in research, assess student learning and contribute to curriculum development. These responsibilities require continuous updating of knowledge and professional competencies. The NCFTE emphasizes continuing professional development as an opportunity for professionals to reflect on their practice, deepen academic knowledge and engage with research related to learners and education (NCTE, 2009). The importance of continuous professional development has also been emphasized by India's National Education Policy 2020. NEP 2020 states that teachers should receive continuous opportunities for self-improvement and learning about innovations and advances in their profession. It envisages professional development through multiple modes, including workshops and online professional learning, and specifies a target of at least 50 hours of continuous professional development opportunities annually for teachers (Ministry of Education, 2020). Alongside professional development, job satisfaction is an important dimension of professional life. Job satisfaction broadly concerns an individual's positive or negative evaluation of their work and working conditions. In teacher education, factors such as professional autonomy, institutional support, workload, recognition, interpersonal relationships and opportunities for professional growth may influence how teacher educators experience their work. Indian research has already examined the relationship between professional development and job satisfaction among teacher educators. Kaur and Bhullar (2019), for example, studied 120 teacher educators in Punjab and reported a significant positive relationship between professional development and job satisfaction. However, the relationship between these teacher-educator variables and the academic achievement of student teachers provides an opportunity for further investigation. The present paper therefore proposes a research framework that connects teacher educators' professional development and job satisfaction with student teachers' academic achievement.

2. Background and Rationale of the Study

Teacher educators influence student teachers not only through formal classroom instruction but also through mentoring, modelling professional behaviour, providing feedback and facilitating reflective learning. A teacher educator who regularly updates professional knowledge may be able to introduce student teachers to contemporary pedagogical approaches, educational technologies, assessment practices and research-based perspectives.

Professional development can take several forms, including workshops, seminars, conferences, refresher programmes, research activities, peer learning, professional learning communities, mentoring and self-directed learning. The NCFTE identifies continuing professional development as an important means of exploring and improving professional practice, updating disciplinary knowledge and engaging in research concerning learners and education (NCTE, 2009). Job satisfaction may also influence professional engagement. Recent research on teacher educators has examined the relationship between work-related factors,

well-being and job satisfaction, indicating the importance of understanding teacher educators' professional experiences rather than focusing exclusively on student outcomes.

The proposed study is therefore based on the idea that professional development and job satisfaction may be interconnected and that both may have implications for the quality of academic support provided to student teachers.

3. Review of Related Literature

3.1 Professional Development of Teacher Educators

Professional development is generally understood as an ongoing process rather than a single training event. It may involve formal courses as well as informal learning, reflection, collaboration and research. The NCFTE recognizes continuing professional development as an important part of professional growth. It describes professional development as involving reflection on practice, updating knowledge and engaging with research related to learners and education (NCTE, 2009). NEP 2020 similarly places continuous professional development within the broader vision of improving teaching quality. The policy encourages professional learning through workshops, online modules and opportunities for teachers to share ideas and good practices (Ministry of Education, 2020).

3.2 Professional Development and Job Satisfaction

An especially relevant Indian study was conducted by Kaur and Bhullar (2019). Their study, *Professional Development of Teacher Educators in Relation to Job Satisfaction*, involved 120 teacher educators from colleges of education in Punjab. The researchers reported a significant positive relationship between professional development and job satisfaction among the teacher educators studied. This previous finding provides a useful foundation for the proposed research. However, the proposed study moves beyond examining only the relationship between professional development and job satisfaction by considering **student teachers' academic achievement as a possible outcome variable**.

3.3 Job Satisfaction among Teacher Educators

Earlier Indian research has also examined job satisfaction among teacher educators. An entry in NCERT's Online Survey of Research in Education describes Kaur's 2001 doctoral research on job satisfaction, professional and educational interests, creativity and attitude towards teaching among teacher educators at different levels of teacher education in Punjab. The study used teacher educators from NTT, ETT and B.Ed. institutions and examined differences associated with institutional and demographic variables. Such research demonstrates that job satisfaction among teacher educators has been a subject of investigation in India for several decades. Nevertheless, changing expectations regarding technology, research, professional development and teacher education provide reasons for continued investigation.

3.4 Professional Development and Student Learning

Research on professional development in the broader teaching profession suggests that participation in professional development can be associated with teachers' professional characteristics and job satisfaction. Yoon and Kim (2022), for example, identified different patterns of teachers' participation in professional development and found differences in self-efficacy and job satisfaction across participation profiles. Such findings cannot automatically be generalized to teacher educators or to student teachers' academic achievement. This

distinction is important. The proposed study therefore seeks to examine the relationship empirically rather than assuming that professional development automatically produces higher academic achievement.

4. Research Gap

The review indicates three important points.

First, professional development is recognized as an important component of teacher education policy and professional growth in India (NCTE, 2009; Ministry of Education, 2020).

Second, previous Indian research has already established an empirical interest in the relationship between professional development and job satisfaction among teacher educators. Kaur and Bhullar (2019) specifically reported a significant positive relationship between these two variables. Third, there is scope to extend this line of inquiry by examining whether teacher educators' professional development and job satisfaction are associated with **student teachers' academic achievement**. Thus, the novelty of the proposed study should be presented carefully. It does **not** claim that professional development and job satisfaction among teacher educators have never been studied. Rather, it proposes an integrated framework connecting these variables with student teachers' academic achievement.

5. Statement of the Problem

"Professional Development and Job Satisfaction among Teacher Educators: A Proposed Study of Their Impact on Student Teachers' Academic Achievement."

The term "impact" in the title refers to the proposed investigation of possible predictive relationships. Because the study has not yet been conducted, the paper does not claim causal impact.

6. Objectives of the Study

The proposed study will have the following objectives:

1. To assess the level of professional development among teacher educators.
2. To assess the level of job satisfaction among teacher educators.
3. To determine the level of academic achievement of student teachers.
4. To examine the relationship between professional development and job satisfaction among teacher educators.
5. To examine the relationship between teacher educators' professional development and student teachers' academic achievement.
6. To examine the relationship between teacher educators' job satisfaction and student teachers' academic achievement.
7. To examine whether professional development and job satisfaction together predict student teachers' academic achievement.

7. Hypotheses

The following null hypotheses may be tested after data collection:

H01: There is no significant relationship between professional development and job satisfaction among teacher educators.

H02: There is no significant relationship between teacher educators' professional development and student teachers' academic achievement.

H03: There is no significant relationship between teacher educators' job satisfaction and

student teachers' academic achievement.

H04: Professional development and job satisfaction do not significantly predict student teachers' academic achievement.

8. Proposed Methodology

8.1 Research Design

The proposed study will adopt a **descriptive-correlational research design**. The descriptive component will determine the levels of professional development and job satisfaction, while the correlational component will examine relationships among the variables.

A correlational design is appropriate because the purpose is initially to examine associations rather than to claim causal effects.

8.2 Population

The proposed population will comprise teacher educators working in recognized teacher education institutions and student teachers enrolled in teacher education programmes.

8.3 Sample

A suitable sample may be selected from government, aided and private teacher education institutions. The researcher may use stratified random sampling to obtain representation from different types of institutions.

The final sample size should be determined using an appropriate sampling procedure and, preferably, a power analysis before data collection.

8.4 Variables

Independent:

- Professional development
- Job satisfaction

Dependent Variable:

- Student teachers' academic achievement

8.5 Tools

The researcher may use:

1. A standardized or researcher-developed **Professional Development Scale for Teacher Educators**.
2. A standardized **Job Satisfaction Scale** suitable for teacher educators.
3. Official academic records or semester examination scores to measure student teachers' academic achievement.
4. A demographic and professional information schedule.

The selected instruments should be examined for reliability and validity before administration.

8.6 Data Collection Procedure

After obtaining permission from the concerned teacher education institutions, informed consent should be obtained from participants. Teacher educators may complete the professional development and job satisfaction instruments. Student teachers' academic achievement may be obtained from officially available institutional records, subject to institutional permission and ethical requirements.

8.7 Proposed Data Analysis

After data collection, the following statistical techniques may be used:

- Mean
- Standard deviation
- Percentage
- Pearson's product-moment correlation
- Multiple regression analysis
- t-test or ANOVA, if additional subgroup comparisons are included

The level of significance may be fixed at **0.05**.

No numerical results are reported in the present paper because the proposed study has not yet been conducted.

9. Educational Implications

If future empirical evidence supports the proposed relationships, teacher education institutions may consider professional development as an integral component of institutional quality improvement. First, institutions may provide systematic professional development opportunities addressing pedagogy, research, assessment, inclusive education and educational technology. Second, professional development should not be restricted to one-time workshops. Continuous learning, reflection, peer collaboration and research-oriented professional development may provide more sustained opportunities for professional growth. This direction is consistent with the emphasis on continuing professional development in NCFTE and NEP 2020 (NCTE, 2009; Ministry of Education, 2020). Third, institutions should pay attention to working conditions that may influence job satisfaction, including professional autonomy, recognition, workload, institutional leadership and opportunities for career advancement. Fourth, student teachers' academic achievement should be considered alongside other indicators of teacher education quality. Academic marks alone cannot capture the complete development of a future teacher.

10. Limitations of the Proposed Study

The proposed study has several anticipated limitations.

First, a correlational design cannot by itself establish causality. Even if a statistically significant relationship is found between teacher educators' professional development and student teachers' academic achievement, it would not prove that professional development caused the achievement. Second, student teachers' academic achievement is influenced by numerous factors, including prior achievement, motivation, learning opportunities, institutional environment, assessment practices and individual differences. Third, self-report measures of professional development and job satisfaction may be affected by participants' perceptions and response tendencies. Fourth, if the sample is restricted to selected institutions or a particular geographical region, generalization of findings may be limited. Future studies may therefore adopt longitudinal, mixed-method or multilevel designs to examine the issue in greater depth.

11. Conclusion

Teacher educators are important contributors to the quality of teacher preparation. Their professional responsibilities require continuous learning, reflection, research engagement and a3aptation to changing educational needs. Indian policy documents, particularly the NCFTE 2009 and NEP 2020, recognize the importance of professional development and continuing

professional learning in strengthening educational quality (NCTE, 2009; Ministry of Education, 2020). Existing Indian research has already demonstrated interest in the relationship between professional development and job satisfaction among teacher educators. Kaur and Bhullar (2019) reported a significant positive relationship between the two variables among teacher educators in Punjab. The proposed study seeks to extend this area of research by examining professional development and job satisfaction in relation to student teachers' academic achievement. It does not assume that these variables automatically produce higher achievement. Instead, it proposes an empirical investigation of whether meaningful relationships exist. The study may ultimately help teacher education institutions understand the importance of investing in the professional growth and workplace well-being of teacher educators. If supported by future empirical evidence, such an approach could contribute to improved academic guidance, mentoring and learning opportunities for student teachers. At this stage, however, **no empirical conclusion can be drawn** because data have not been collected. The value of the present paper lies in establishing a theoretically and policy-informed research framework that can be tested through a future empirical study.

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ROLE OF ARTIFICIAL INTELLIGENCE IN ADDRESSING INDIVIDUAL DIFFERENCES IN MATHEMATICS LEARNING

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Abstract

Mathematics is a subject in which learners differ considerably in their prior knowledge, learning pace, reasoning abilities, interests, motivation, confidence, and problem-solving strategies. Traditional classroom instruction often follows a common pace and uniform instructional approach, making it difficult for teachers to respond adequately to these individual differences. Artificial Intelligence (AI) offers new possibilities for creating personalized and adaptive mathematics learning environments. AI-powered educational tools can analyse learners' responses, identify learning gaps and misconceptions, provide immediate feedback, recommend appropriate learning resources, and adjust the difficulty of mathematical tasks according to individual needs. This paper examines the role of AI in addressing individual differences in mathematics learning, particularly from the perspective of teacher education. It discusses AI-supported personalized learning, intelligent tutoring systems, adaptive assessment, feedback, mathematical problem-solving, learning analytics, and differentiated instruction. The paper also highlights the changing role of teachers from information providers to facilitators, mentors, and designers of meaningful learning experiences. Finally, it discusses challenges such as digital inequality, accuracy of AI-generated responses, data privacy, overdependence on technology, and the need for teacher supervision. The paper argues that AI should complement, rather than replace, the professional role of mathematics teachers and can contribute to more inclusive, learner-centred, and responsive mathematics education.

Keywords: *Artificial Intelligence, Mathematics Learning, Individual Differences, Personalized Learning, Adaptive Learning, Intelligent Tutoring Systems, Learning Analytics, Teacher Education*

1. Introduction

Mathematics learning is not a uniform process. Students enter the classroom with different levels of mathematical knowledge, abilities, experiences, interests, learning speeds, and attitudes towards mathematics. Some students understand mathematical concepts quickly, while others require additional explanations, examples, practice, and encouragement. Similarly, some learners are confident in problem-solving, whereas others experience difficulty because of misconceptions, fear of mathematics, or inadequate foundational knowledge. In a conventional classroom, a teacher has to teach a group of learners within a limited period. Although teachers use different pedagogical strategies to address learner diversity, it can be difficult to provide continuous individualized instruction and feedback to every student. Artificial Intelligence provides an opportunity to address this challenge by supporting personalized and adaptive learning.

AI refers to computational systems capable of performing tasks that normally require aspects of human intelligence, such as pattern recognition, prediction, language processing, reasoning, and decision-making. In mathematics education, AI can analyse students' responses and

learning patterns and use this information to provide differentiated learning experiences.

The significance of AI is therefore not merely technological. Its educational value lies in its potential to help teachers understand individual learners and provide appropriate support at the appropriate time.

2. Individual Differences in Mathematics Learning

Individual differences refer to variations among learners in characteristics that influence learning. In mathematics, these differences may occur in several areas:

- Prior mathematical knowledge and prerequisite skills
- Learning pace and cognitive readiness
- Mathematical reasoning and problem-solving ability
- Spatial and numerical understanding
- Learning interests and motivation
- Confidence and attitudes towards mathematics
- Language proficiency
- Ability to identify and correct errors
- Preferred ways of representing mathematical ideas

For example, while learning algebra, one student may have difficulty understanding variables, another may struggle with equations, and another may require challenging applications. Giving the same worksheet to all three students may not address their actual learning needs.

Consequently, mathematics instruction needs to move towards approaches that recognize learner diversity while maintaining common learning objectives.

3. AI and Personalized Mathematics Learning

Personalized learning aims to provide learning experiences that respond to individual learners' needs, abilities, progress, and interests. AI can strengthen personalized learning by continuously analysing learner data and adapting instructional content.

An AI-supported mathematics learning system can identify whether a student has mastered a particular concept. If the learner demonstrates difficulty with fractions, for example, the system may provide prerequisite activities involving equivalent fractions before moving to more complex operations.

Similarly, an advanced learner can receive challenging problems involving mathematical reasoning and applications instead of repeatedly practising already-mastered skills.

Thus, AI can support a learning pathway in which the content, difficulty, pace, practice and feedback are adjusted according to learner needs.

4. Role of AI in Addressing Individual Differences

4.1 Identification of Learning Gaps

One of the important contributions of Artificial Intelligence (AI) in mathematics learning is its ability to identify individual students' learning gaps and misconceptions. In a traditional classroom, teachers generally depend on classroom observation, assignments, tests, and students' responses to identify difficulties. However, AI-supported learning systems can analyse a much larger range of learner responses, including patterns of incorrect answers, repeated mistakes, time taken to solve problems, and performance across different mathematical concepts. Based on this analysis, AI can identify specific areas in which a

learner requires additional support.

For example, if a student repeatedly makes errors while adding fractions with unlike denominators, an AI system can recognize the recurring misconception and recommend activities related to equivalent fractions and finding common denominators before progressing to more complex operations. Similarly, difficulties in algebraic manipulation or geometry can be detected through patterns of errors. Such diagnostic information enables teachers to provide targeted remedial instruction, differentiated learning activities, and timely intervention according to each learner's needs.

4.2 Adaptive Learning

AI can dynamically adjust the level of difficulty of mathematical tasks. When a learner demonstrates mastery, the system can gradually introduce more complex problems. When the learner struggles, it can provide simpler examples, hints, visual representations, or additional practice.

Adaptive learning therefore prevents two common problems: advanced learners becoming bored because of insufficient challenge and struggling learners becoming frustrated because the content is too difficult.

4.3 Individualized Feedback

Feedback is essential in mathematics because students need to understand not only whether an answer is correct but also why an error occurred.

AI-based systems can provide immediate feedback and hints. For example, rather than simply stating that an algebraic answer is incorrect, an AI tutor can prompt the learner to check the operation performed in a particular step.

However, teacher verification remains important because AI-generated explanations may sometimes be incomplete or incorrect.

4.4 Supporting Different Learning Paces

Students do not learn mathematical concepts at the same speed. AI-supported platforms can allow learners to revisit concepts, practise additional problems, or progress to advanced content according to their individual readiness.

This flexibility is particularly useful in mixed-ability classrooms.

4.5 Supporting Mathematical Problem-Solving

AI can generate mathematical problems at different levels of complexity. It can provide routine exercises for foundational learning and non-routine problems for students who require higher levels of challenge.

AI can also encourage students to consider alternative solution methods. This can promote mathematical reasoning rather than mere memorization of procedures.

4.6 Learning Analytics

AI can analyse large amounts of learning data, including response patterns, time spent on activities, frequency of errors, and progress across concepts.

Teachers can use such information to answer questions such as:

- Which students require additional support?
- Which mathematical concepts are difficult for the class?
- What types of errors are common?

- Which students are ready for enrichment activities?

Learning analytics can therefore support evidence-based instructional decisions.

4.7 Supporting Differentiated Instruction

AI can assist teachers in preparing differentiated learning materials. For example, a teacher may create three levels of activities:

Level 1: foundational practice

Level 2: application and problem-solving

Level 3: higher-order and challenging problems

AI can help generate variations of questions while the teacher determines their mathematical validity and pedagogical suitability.

5. AI and Inclusive Mathematics Education

AI has the potential to make mathematics learning more inclusive. Learners who require additional practice can receive individualized support without being singled out in front of their peers. Students can also access explanations in different forms, such as text, diagrams, examples, and step-by-step guidance.

For multilingual classrooms, AI-supported tools may also assist with language-related barriers by providing explanations in familiar languages. However, the quality and accuracy of translations must be carefully monitored by teachers.

AI can therefore support the principle that different learners may need different pathways to achieve meaningful mathematical learning.

6. Changing Role of the Mathematics Teacher

The introduction of AI does not reduce the importance of teachers. Instead, it changes and potentially expands their role.

The mathematics teacher becomes:

- A **learning facilitator** who guides students in using AI meaningfully.
- A **diagnostician** who interprets AI-generated learning data.
- A **content expert** who verifies mathematical accuracy.
- A **mentor** who supports motivation, confidence and persistence.
- A **designer of learning experiences** who combines technology with appropriate pedagogy.
- An ethical guide who teaches students responsible use of AI.

For B.Ed. teacher education, this transformation is particularly important. Future teachers need technological competence together with pedagogical and mathematical knowledge. AI literacy should therefore become part of professional development for mathematics teachers.

7. Challenges and Concerns

Despite its potential, AI-based mathematics learning has several challenges.

Digital inequality: Not all students have equal access to devices, reliable internet, or AI-based learning platforms.

Accuracy: AI systems can occasionally generate incorrect mathematical solutions or misleading explanations. Teacher verification is therefore essential.

Overdependence: If students depend excessively on AI for solving problems, their independent reasoning and persistence may decline.

Data privacy: Student learning data must be collected, stored, and used responsibly.

Reduced human interaction: Mathematics learning involves communication, collaboration, questioning, and emotional support. Technology cannot completely replace these human dimensions.

Teacher preparedness: Teachers need appropriate training to select, evaluate, and integrate AI tools effectively.

Therefore, AI should be viewed as a supportive pedagogical tool rather than a replacement for teachers or students own mathematical thinking.

8. A Proposed AI-Supported Model for Mathematics Learning

A simple framework for AI-supported personalized mathematics learning can be represented through five stages:

Diagnose → Personalize → Learn → Receive Feedback → Reflect

First, AI-supported assessment identifies the learner's existing knowledge and misconceptions. Second, learning activities are personalized according to individual needs. Third, the learner engages with mathematical concepts and problems. Fourth, AI provides immediate feedback and recommendations. Finally, the learner reflects on the solution process, errors, and learning progress.

The teacher remains involved throughout all five stages by interpreting learner information, validating AI recommendations, providing human guidance, and designing meaningful mathematical experiences.

This model combines the strengths of AI with the professional judgement of teachers.

9. Implications for B.Ed. Teacher Education

Teacher education institutions have an important role in preparing future teachers for AI-supported classrooms. B.Ed. programmes should provide opportunities for teacher trainees to:

1. Understand the educational possibilities and limitations of AI.
2. Develop AI literacy and digital competence.
3. Design personalized mathematics activities.
4. Interpret learning analytics.
5. Evaluate the mathematical accuracy of AI-generated content.
6. Use AI to prepare differentiated worksheets and assessments.
7. Develop students' critical thinking and responsible AI use.
8. Maintain meaningful teacher-student interaction.

Teacher trainees should understand that effective AI integration requires the combination of content knowledge, pedagogical knowledge and technological knowledge.

10. Conclusion

Individual differences are a fundamental reality of mathematics classrooms. A uniform teaching approach cannot always meet the needs of learners who differ in prior knowledge, learning pace, reasoning ability, confidence, motivation, and problem-solving skills. Artificial Intelligence offers significant possibilities for addressing these differences through personalized learning, adaptive instruction, immediate feedback, learning analytics, differentiated practice, and intelligent tutoring.

However, the success of AI in mathematics education depends not on technology alone but on

thoughtful pedagogical integration. Teachers must remain central in interpreting learner needs, verifying mathematical content, encouraging reasoning, supporting motivation, and developing responsible learning habits.

For B.Ed. faculty and teacher educators, the key challenge is therefore not simply to teach future teachers how to use AI, but to help them understand when, why, and how AI can be used pedagogically to improve mathematics learning.

AI has the potential to move mathematics education from a predominantly one-size-fits-all model towards a more responsive and learner-centred approach. When combined with effective teaching, human interaction, mathematical reasoning, and reflective learning, AI can become a powerful tool for creating more inclusive and personalized mathematics classrooms.

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EFFECTIVENESS OF CONSTRUCTIVIST TEACHING METHODS ON MATHEMATICS ACHIEVEMENT AMONG IXTH STANDARD STUDENTS

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Abstract

This study examined the effectiveness of the constructivist method of teaching, relative to the conventional method, on the Mathematics achievement of IXth standard students, and the interaction of teaching method with gender and locale on gain scores. A pre-test–post-test experimental design was used with an Experimental group (n=30, constructivist method) and a Control group (n=30, conventional method). Independent- and paired-samples t-tests, a two-way ANOVA with Tukey's post-hoc test, and ANCOVA were applied ($p < 0.05$). The groups were equivalent at pre-test, but the Experimental group scored significantly higher at post-test ($t = 9.67$, $p < .001$). A significant Group × Gender interaction on gain scores ($F=9.13$, $p = .004$) showed girls in the Experimental group gained the most. The findings support wider use of constructivist strategies in secondary Mathematics teaching, with attention to gender-based differences in response.

Keywords: Constructivism, Conventional Method, Academic Achievement, Mathematics, Secondary Students.

1. Introduction:

Mathematics achievement at the secondary level is strongly shaped by the instructional method used in the classroom. conventional, lecture-based teaching relies on demonstration, repetition and drill and has been associated with weak conceptual understanding despite adequate procedural fluency (Naz & Qayyum, 2025). constructivist pedagogy, by contrast, positions the learner as an active builder of knowledge through discovery, discussion and engagement with real-life problems, and has been reported to produce significantly larger achievement gains than conventional instruction in comparable secondary-level settings (Banu & Mahmood, 2019; Akendita et al., 2024). In India, the National Curriculum Framework (NCERT, 2005) has explicitly recommended such a shift toward learner-centred, constructivist classroom practice. Because IXth standard students are at a stage where abstract algebraic reasoning begins to consolidate, the method used to teach Mathematics at this level has particular significance for both immediate achievement and long-term conceptual growth. this study compares the constructivist and conventional methods using a pretest–posttest design and further examines whether the effect of method differs by gender and locale.

2. Need and Importance of the Study:

The National Curriculum Framework (NCF,2005) has endorsed constructivist pedagogy at

the policy level, conventional lecture-and-drill instruction continues to dominate secondary Mathematics classrooms in practice. existing studies confirm that constructivist instruction generally improves Mathematics achievement (Banu & Mahmood, 2019; Naz & Qayyum, 2025) and that this benefit may be reinforced through improved student self-efficacy (Akendita et al., 2024), but comparatively few studies examine whether this advantage holds equally for boys and girls or for rural and urban students, within the same sample. Evidence on such moderating factors matters for teachers and curriculum planners, since a method that benefits one subgroup may need adaptation to benefit another equally. this study addresses that gap by evaluating both the overall effect of the constructivist method and its interaction with gender and locale on gain scores.

3. Review of Literature:

Banu and Mahmood (2019) compared a constructivist 5E approach with the conventional transmission method among 64 Class IX students in Warangal, India, in a pretest–posttest design. The groups were equivalent at pretest, but the constructivist group scored significantly higher at posttest, with a large effect size, indicating substantially greater improvement in Mathematics achievement than conventional teaching.

Akendita et al. (2024) used structural equation modelling with 260 senior high school students in Ghana and found that socio-constructivist Mathematics teaching had a significant direct positive effect on achievement, partially mediated by students' mathematics self-efficacy suggesting constructivist teaching also works by building students' confidence in their own mathematical ability.

Naz and Qayyum (2025) compared a problem-solving, constructivist-aligned strategy with conventional lecture instruction among 300 Grade 9 students in Pakistan. The experimental group's mean score rose by 18.6 points from pretest to posttest, against a 4.7-point rise in the control group, with the posttest difference highly significant.

Across these studies, from India, Ghana, and Pakistan, constructivist or constructivist-aligned methods consistently produced significantly greater achievement gains than conventional instruction, with groups typically equivalent before treatment. Few of these studies, however, examine whether this advantage differs by gender or locale within the same sample — the gap the present study addresses.

4. Objectives of the Study:

1. To compare the pre-test and post-test academic achievement in Mathematics of IXth standard students taught through the constructivist method (Experimental group) and the conventional method (Control group).
2. To study the interaction effect of teaching method (constructivist vs. conventional) with gender (boys, girls) and locale (rural, urban) on the gain in academic achievement in Mathematics of IXth standard students.

5. Hypotheses of the Study:

1. There is no significant difference between the Experimental group (constructivist method) and the Control group (conventional method) with respect to pre-test and post-test academic achievement in Mathematics of IXth standard students.

2. There is no significant interaction effect of teaching method (Experimental group and Control group) with gender (Boys, Girls) and locale (Rural, Urban) on the gain in academic achievement in Mathematics of IXth standard students from pre-test to post-test.

6. Methodology:

Research Design:

A Quantitative, Pre-Test–Post-Test Experimental Design was used, with an Experimental group taught through the constructivist method and a Control group taught through the conventional method.

Sample: 60 IXth standard students (30 Experimental, 30 Control), each group comprising 15 boys/ 15 girls and 15 rural/15 urban students.

Statistical techniques Used: Independent- and paired-samples t-tests (Objective 1); two-way (2 × 2) ANOVA with Tukey's post-hoc test and ANCOVA (Objective 2). SPSS v.23.0 was used.

7. Results And Discussion:

7.1 Post-test Comparison between Experimental and Control Groups

The Experimental and Control groups did not differ significantly at pre-test ($t = 0.11$, $df = 58$, $p = .915$), confirming baseline equivalence. Table 1 presents the posttest comparison.

Table 1. Independent-samples t-test comparing posttest Mathematics achievement between the Experimental and Control groups.

Groups	n	Mean	SD	t-value	df	P-value	Sign
Experimental group	30	44.70	13.55				
Control group	30	18.93	5.39	9.6738	58	0.0001	S

The Experimental group ($M = 44.70$, $SD = 13.55$) scored significantly higher than the Control group ($M = 18.93$, $SD = 5.39$) at post-test, $t(58) = 9.67$, $p < .001$. H01 is therefore rejected: the constructivist method produced significantly greater Mathematics achievement than the conventional method, consistent with Banu and Mahmood (2019) and Naz and Qayyum (2025).

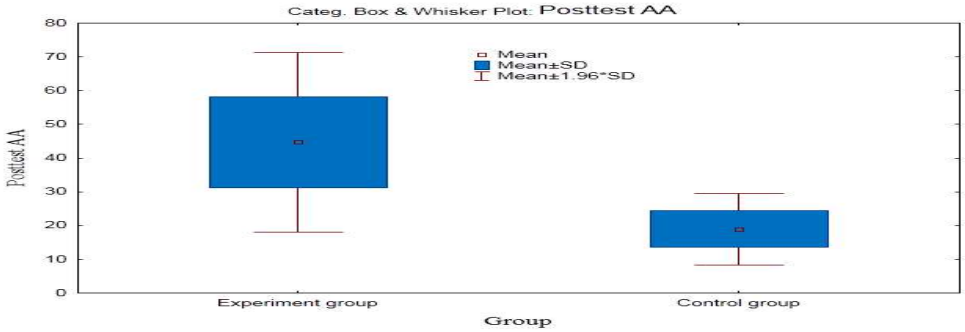

Figure 1. Posttest Mathematics achievement of the Experimental and Control groups.

7.2 Interaction of Teaching Method with Gender on Gain Scores

A two-way ANOVA (Table 2) tested the interaction of teaching method with gender on

gain scores.

Table 2. Two-way ANOVA: teaching method × gender on gain scores.

Source of variation	SS	df	MS	F	p	Signi.
Group	9856.02	1	9856.02	188.9677	0.0001	S
Gender	558.15	1	558.15	10.7013	0.0018	S
Group × Gender	476.02	1	476.02	9.1266	0.0038	S
Error	2920.80	56	52.16			
Total	13810.98	59				

The main effects of Group, $F(1, 56) = 188.97$, $p < .001$, and Gender, $F(1, 56) = 10.70$, $p = .002$, were significant, as was the Group × Gender interaction, $F(1, 56) = 9.13$, $p = .004$. H02 is therefore rejected. Tukey's post-hoc test showed girls in the Experimental group ($M = 33.87$, $SD = 11.86$) gained significantly more than boys in the Experimental group ($M = 22.13$, $SD = 8.01$), $p = .0004$, while Control-group boys and girls did not differ ($p = .998$). This partial gender-moderation of the constructivist advantage echoes the mediating role of student factors such as self-efficacy reported by Akendita et al. (2024).

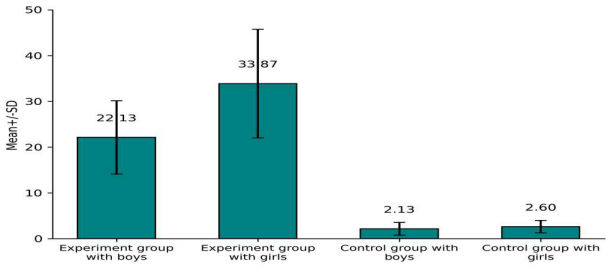

Figure 2. Interaction of teaching method with gender on gain scores.

8. Findings:

1. No significant difference between the Experimental and Control groups in pretest Mathematics achievement ($t = 0.11$, $df = 58$, $p = .915$), confirming baseline equivalence.
2. A significant difference between the Experimental and Control groups in posttest Mathematics achievement, with the Experimental group significantly higher ($t = 9.67$, $df = 58$, $p < .001$).
3. A significant main effect of Group on gain scores from pre-test to post-test, $F(1, 56) = 188.97$, $p < .001$.
4. A significant main effect of Gender on gain scores, $F(1, 56) = 10.70$, $p = .002$.
5. A significant Group × Gender interaction on gain scores, $F(1, 56) = 9.13$, $p = .004$, with girls in the Experimental group showing the greatest gain ($M = 33.87$) compared with boys in the Experimental group ($M = 22.13$).
6. Within the Control group, no significant difference in gain scores between boys and girls ($p = 998$), indicating the gender-based difference was specific to the constructivist condition.

9. Educational Implications and Recommendations:

- Introduce conceptually demanding topics through constructivist activities (discovery, discussion, real-life problems) before consolidating with conventional drill ahead of examinations.
- Train teachers in facilitative questioning and allow a transition period before formal assessment when shifting from conventional to constructivist practice.
- Broaden assessment to include open-ended, project-based tasks alongside timed, procedure-based tests.
- Since the constructivist advantage was larger for girls, monitor and adapt implementation to ensure boys benefit equally, e.g., through differentiated grouping.
- Phase the balance of methods across the year — constructivist-led early on for conceptual depth, conventional drill closer to examinations for speed and accuracy.

10. Conclusion:

The study concluded that constructivist teaching methods were more effective than conventional teaching in improving the mathematics achievement of IXth standard students. Since both groups were statistically equivalent before the intervention, the significantly higher posttest achievement of the Experimental group can be attributed to the constructivist approach. The findings also indicated that girls benefited more from constructivist teaching than boys, highlighting the need for teachers to ensure balanced participation and support for all learners. These results reinforce the value of learner-centred strategies such as guided discovery, collaborative learning, discussion, and real-life problem-solving in secondary mathematics classrooms. However, the study was limited by its small sample size and single-school setting, which restrict the generalizability of the findings. Future research should involve larger and more diverse samples, longer intervention periods, and additional variables such as prior achievement, socio-economic status, teacher characteristics, and mathematics self-efficacy to provide a more comprehensive understanding of the effectiveness of constructivist teaching in mathematics education.

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ACHIEVEMENT IN MATHEMATICS AMONG PRIMARY SCHOOL STUDENTS THROUGH BLENDED (HYBRID) TEACHING

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Abstract

Mathematics achievement is a key indicator of academic success, and improving it through innovative teaching approaches remains a major educational priority. This study examined the effectiveness of Blended (Hybrid) Teaching on the Mathematics achievement of Grade 5 students in a Government Higher Primary School in Vijayapura district, Karnataka. A pre-test–post-test experimental design was adopted with 60 students, equally divided into an Experimental Group (n=30) taught through Blended Teaching and a Control Group (n=30) taught through the conventional method. Statistical analysis using paired-samples and independent-samples t-tests revealed significant improvement in Mathematics achievement in both groups from pre-test to post-test (p< .001). While no significant difference was found between the groups at the pre-test stage, the Experimental Group achieved significantly higher post-test scores than the Control Group t(58)=2.70, p=.009. Although the Experimental Group demonstrated a greater mean gain in achievement, the difference in gain scores was not statistically significant. The findings indicate that Blended (Hybrid) Teaching is more effective than conventional teaching in enhancing Mathematics achievement among primary school students and supports its integration into elementary Mathematics classrooms.

Keywords: *Blended Learning, Hybrid Teaching, Mathematics achievement, primary school students, experimental study.*

Introduction:

Mathematics is a fundamental subject that develops logical reasoning, critical thinking, problem-solving and decision-making skills, while providing the foundation for learning science, engineering and technology (NCTM, 2014). However, many students face difficulties in mathematics due to traditional teacher-centred teaching methods and limited opportunities for active learning (Hattie, 2023). With the rapid advancement of Information and Communication Technology (ICT), Blended (Hybrid) Teaching, which combines face-to-face instruction with technology-supported learning, has emerged as an effective approach to enhance students' engagement and academic achievement (Graham, 2021; Hrastinski, 2019). furthermore, the National Education Policy (NEP) 2020 advocates the integration of technology into classroom instruction to improve educational quality and promote competency-based learning (Government of India, 2020). Therefore, the present study examines the effectiveness of Blended (Hybrid) Teaching in improving the Mathematics

Achievement of primary school students.

Review of Literature:

Egara and Mosimege (2024) investigated the effect of a blended learning approach on secondary school learners' Mathematics achievement and retention using a non-equivalent control-group, pre-test–post-test quasi-experimental design, with participants drawn from two secondary schools and divided into experimental and control groups using simple random sampling. The study found that students in the experimental group demonstrated significantly higher Mathematics achievement and better retention than students taught through conventional instruction and the authors concluded that blended learning promotes active participation, collaborative learning and improved academic performance in Mathematics (Egara & Mosimege, 2024).

Kumar, Gangwar, and Mehrotra (2023) carried out a meta-analytical study examining the effectiveness of the blended learning approach on the academic achievement of learners, synthesising findings from studies published between 2015 and 2021 that were identified through purposive sampling. The meta-analysis reported an overall positive and substantial effect of blended learning on academic achievement across the studies reviewed, and the authors concluded that blended learning is an effective pedagogical approach that supports meaningful learning and improves educational outcomes (Kumar et al., 2023).

Makkar and Sharma (2022) conducted an experimental study titled "Effect of Blended Learning on Academic Achievement in Mathematics among IX Grade Students," involving 65 students of a school in Amritsar, divided into an experimental group (n =33) and a control group (n=32) taught the same geometry content over a period of weeks. Although the two groups did not differ significantly on the pre-test, the experimental group achieved a significantly higher post-test mean (18.78) than the control group (15.34), $t(63) = 2.32$, $p < .05$, leading the authors to conclude that blended learning is an effective instructional approach for improving Mathematics achievement (Makkar & Sharma, 2022, pp. 1352–1353).

Need and Importance of the Study:

Mathematics achievement is a key indicator of students' academic success and cognitive development. Recent international evidence has shown a decline in Mathematics performance, highlighting the need for effective and innovative teaching approaches (OECD, 2023). Blended (Hybrid) Teaching, which combines face-to-face instruction with digital learning resources, enhances student engagement, provides timely feedback and encourages independent learning, although effective teacher guidance is essential for successful implementation (Rasheed et al., 2020). The present study is significant as it provides empirical evidence on the effectiveness of Blended (Hybrid) Teaching in improving Mathematics Achievement among primary school students in a government school. The findings will be useful for teachers, teacher educators, school administrators and policymakers in promoting technology-integrated Mathematics instruction in line with the recommendations of the National Education Policy (NEP) 2020.

Objectives of the Study:

1. To study the difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Experimental Group.

2. To study the difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Control Group.
3. To compare the Mathematics Achievement scores of higher primary school students between the Experimental Group and the Control Group at pre-test and post-test.

Hypothesis of the Study:

1. There is no significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Experimental Group.
2. There is no significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Control Group.
3. There is no significant difference between the Experimental Group and the Control Group with respect to pre-test and post-test Mathematics Achievement scores among higher primary school students.

Methodology:

Research Method:

The present study employed the **Experimental Method** of research.

Research Design:

A **two-group pre-test–post-test experimental design** was adopted, in which both groups were assessed before and after the instructional intervention, the Experimental Group receiving the Hybrid Teaching Method and the Control Group receiving the Traditional Method, as summarized in Table 1.

Table 1. Pre-test–Post-test Two-Group Experimental Design

Group	Pre-test	Treatment	Post-test
Control Group	✓	Traditional Method	✓
Experimental Group	✓	Hybrid Teaching Method	✓

Sample of the Study:

The sample for the present study consisted of 60 Grade 5th students studying Mathematics in a Government Higher Primary School, Shanti Nagar, Toravi, Vijayapura Taluk, Vijayapura District, Karnataka. The students were divided into two equivalent groups of 30 each, namely the Experimental Group and the Control Group with equal representation of gender in each group (15 boys and 15 girls), giving a total sample of 30 boys and 30 girls. The Experimental Group was exposed to the Hybrid Teaching Programme developed by the investigator, while the Control Group received instruction through the conventional method with allocation carried out to ensure equivalence with respect to academic background and learning characteristics.

Table 2. Distribution of the Sample by Group and Gender:

Group	Boys	Girls	Total
Control Group (Traditional Method)	15	15	30
Experimental Group (Hybrid Teaching)	15	15	30
Total	**30**	**30**	**60**

Sampling Procedure and Technique:

A Purposive Sampling Technique was employed to select the Government Higher

Primary School as a school suitable for implementing the Hybrid Teaching Programme. From this school, a sample of 60 Grade 5th students was selected and assigned to the Experimental and Control Groups using **Simple Random Sampling,** with **Stratified Representation** by Gender applied to ensure equal participation of boys and girls in both groups, based on their prior academic performance in Mathematics.

Data Analysis

1.Objective 1: To study the difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Experimental Group.

Null Hypothesis.1:There is no significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Experimental Group.

Alternative Hypothesis.1: There is a significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Experimental Group.

Table 3. Mean, SD, and Paired t-test for Pre-test and Post-test Mathematics Achievement Scores Experimental Group (N = 30)

Test	N	Mean	SD	Mean Diff.	df	Calc. t-value	Table value (0.05)	Significance
Pre-test	30	13.43	1.65					
Post-test	30	16.47	1.14	3.03	29	10.20	2.045	Significant ($p < .001$)

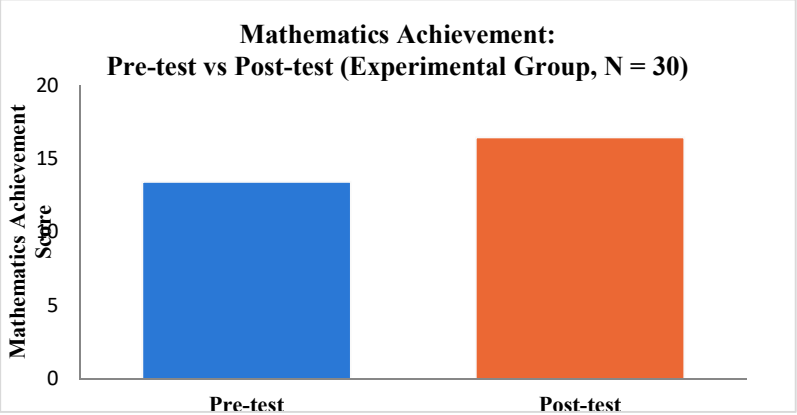


Table 3 shows the Experimental Group's Mathematics Achievement scores rose from a pre-test mean of 13.43 (SD = 1.65) to a post-test mean of 16.47 (SD = 1.14), a gain of 3.03 points, with less variability among students after the intervention.

A paired-samples t-test confirmed this gain is statistically significant: $t(29) = 10.20$, exceeding the critical value of 2.045 at $p < .05$, and significant even at $p < .001$. Hypothesis 1 (no significant difference) is therefore rejected, and the alternative hypothesis is **accepted.**

This confirms a reliable improvement within the Experimental Group; the effect size was large, Cohen's $d_r = 3.03 / 1.63 = 1.86$ (using the SD of the difference scores reported in Table 5), though as a single-group pre-post design it cannot on its own attribute the gain specifically

to the treatment, a question addressed through direct comparison with the Control Group under Objective 3.

2.Objective 2: To study the difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Control Group.

Null Hypothesis.2: There is no significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Control Group.

Alternative Hypothesis.2: There is a significant difference between the pre-test and post-test Mathematics Achievement scores of higher primary school students in the Control Group.

Table 4. Mean, SD, and Paired t-test for Pre-test and Post-test Mathematics Achievement Scores Control Group (N = 30)

Test	N	Mean	SD	Mean Diff.	df	Calc. t-value	Table value (0.05)	Significance
Pre-test	30	12.93	1.28					
Post-test	30	15.67	1.15	2.73	29	10.60	2.045	Significant ($p < .001$)

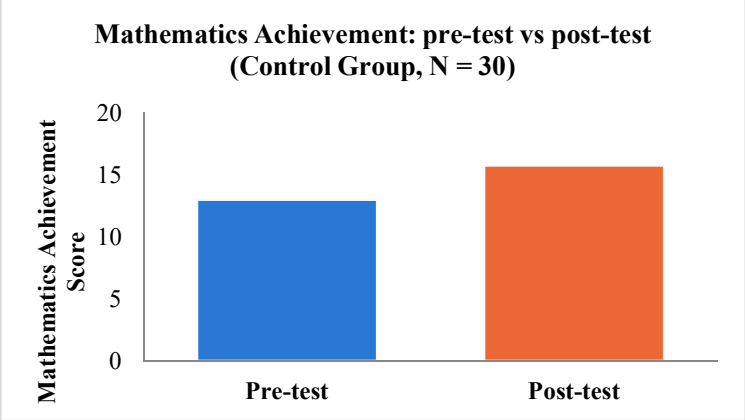


Table 4 shows the Control Group's Mathematics Achievement scores also rose, from a pre-test mean of 12.93 (SD = 1.28) to a post-test mean of 15.67 (SD = 1.15), a gain of 2.73 points. A paired t-test confirmed this gain is significant: $t(29) = 10.60$, exceeding the critical value of 2.045 at $p < .05$, and significant at $p < .001$. This gain also reflected a large effect size, Cohen's $d_r = 2.73 / 1.41 = 1.94$ (Table 5). Hypothesis 2 (no significant difference) is therefore rejected, and the alternative hypothesis is **accepted.**

Notably, the Control Group's improvement (2.73 points) was numerically similar to that of the Experimental Group (3.03 points; Table 3), and both within-group changes were statistically significant. Such gains in a control condition are not unexpected, since regular classroom instruction, repeated exposure to the same test, or maturation over the intervention period can independently produce genuine pre-post improvement even in the absence of an experimental treatment. Consequently, the more direct test of the treatment's effectiveness lies in comparing the Experimental and Control Groups' post-test scores and gain scores against each other, rather than relying on each group's within-group significance alone; this comparison is addressed under Objective 3 below.

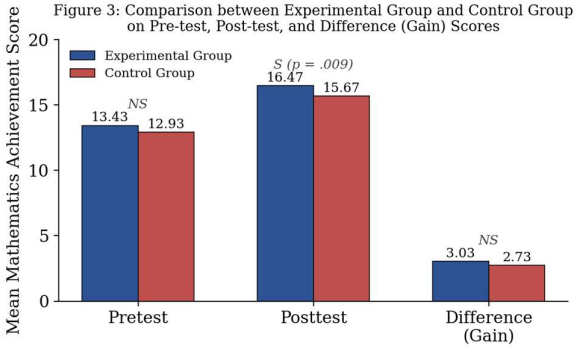
3.Objective 3: To compare the Mathematics Achievement scores of higher primary school students between the Experimental Group and the Control Group at pre-test and post-test.

Null Hypothesis 3*: There is no significant difference between the Experimental Group and the Control Group with respect to pre-test and post-test Mathematics Achievement scores among higher primary school students.*

Alternative Hypothesis.3: *There is a significant difference between the Experimental Group and the Control Group with respect to pre-test and post-test Mathematics Achievement scores among higher primary school students.*

Table 5. Results of Independent t-test (Unpaired t-test) between Experimental Group and Control Group with respect to Pre-test and Post-test Mathematics Achievement Scores among Higher Primary School Students

Time	Groups	n	Mean	SD	SE	t-value	p-value
Pre-test	Experimental Group	30	13.43	1.65	0.30		
	Control Group	30	12.93	1.28	0.23	1.3075	0.1962, NS
Post-test	Experimental Group	30	16.47	1.14	0.21		
	Control Group	30	15.67	1.15	0.21	2.7043	0.0090, S
Difference	Experimental Group	30	3.03	1.63	0.30		
	Control Group	30	2.73	1.41	0.26	0.7620	0.4491, NS



From the results of Table 5 and Figure 1, it is observed that:

The results of Table 5 and Figure 1 indicate that there was no significant difference between the Experimental and Control Groups in their pre-test Mathematics Achievement scores (t = 1.3075, p = 0.1962), confirming that both groups were comparable before the intervention. However, a significant difference was observed in the post-test Mathematics Achievement scores (t = 2.7043, p = 0.0090), with the Experimental Group performing significantly better than the Control Group. Although the Experimental Group showed a slightly higher mean gain score (3.03) than the Control Group (2.73), the difference in gain scores was not statistically significant (t = 0.7620, p = 0.4491). Thus, the findings indicate that Blended (Hybrid) Teaching resulted in significantly higher post-test Mathematics Achievement, while the difference in improvement (gain scores) between the two groups was not statistically significant. The corresponding between-group effect sizes (Cohen's d, pooled

SD) were small at pre-test (d = 0.34), medium to large at post-test (d = 0.70), and small for the gain-score comparison (d = 0.20), consistent with the pattern of statistical significance reported above.

Discussions:

The present study found that the Experimental Group showed a statistically significant improvement in Mathematics Achievement after the implementation of Blended (Hybrid) Teaching. This finding is in agreement with Makkar and Sharma (2022), Egara and Mosimege (2024), and the meta-analysis by Kumar, Gangwar, and Mehrotra (2023), all of whom reported that blended learning significantly enhances students' academic achievement compared to conventional teaching methods.

The study also revealed that the Control Group improved significantly in Mathematics Achievement, although the difference in gain scores between the Experimental and Control Groups was not statistically significant. This may be because the Control Group also received systematic and well-planned conventional classroom instruction throughout the intervention period. As noted by Hattie (2023), effective classroom teaching itself can produce substantial learning gains, thereby reducing the observable difference between instructional approaches.

Nevertheless, the Experimental Group recorded a higher mean gain than the Control Group, supporting the views of Graham (2021) and Hrastinski (2019) that Blended (Hybrid) Teaching integrates face-to-face instruction with technology-supported learning, providing greater flexibility, immediate feedback, and opportunities for self-paced practice. These features are likely to enhance students' understanding and contribute to improved Mathematics Achievement, even when the difference in gain scores is not statistically significant.

Findings:

- There was a statistically significant, positive difference between the pre-test and post-test Mathematics Achievement scores of the Experimental Group, $t(29) = 10.20$, $p < .001$; the null hypothesis H_{01} is rejected and the alternative hypothesis H_{11} ("there is a significant difference…") is **accepted.**
- There was a statistically significant, positive difference between the pre-test and post-test Mathematics Achievement scores of the Control Group, $t(29) = 10.60$, $p < .001$; the null hypothesis H_{02} is rejected and the alternative hypothesis H_{12} ("there is a significant difference…") is **accepted.**
- There was no statistically significant difference between the Experimental Group and the Control Group with respect to pre-test Mathematics Achievement scores, $t(58) = 1.3075$, $p = .1962$; the null hypothesis H_{03} is accepted for this comparison, confirming that the two groups were equivalent at baseline.
- There was a statistically significant, positive difference between the Experimental Group and the Control Group with respect to post-test Mathematics Achievement scores, $t(58) = 2.7043$, $p = .0090$; the null hypothesis H_{03} is rejected and the alternative hypothesis H_{13} is accepted for this comparison, confirming that the Experimental Group achieved significantly higher Mathematics scores than the Control Group after the intervention.

- The between-group difference in gain (difference) scores was not statistically significant, $t(58) = 0.7620$, $p = .4491$; for this specific comparison the null hypothesis H_{03} is accepted, even though the Experimental Group's mean gain (3.03 marks) was numerically larger than the Control Group's (2.73 marks).
- Both instructional methods produced large practical effects on their own within-group gains (Cohen's $d > 1.8$), and the Experimental Group additionally achieved a significantly higher absolute post-test score than the Control Group, indicating an overall positive effect of Blended (Hybrid) Teaching on Grade 5 Mathematics achievement.

Suggestions:

- Teachers may adopt Blended (Hybrid) Teaching as a viable supplementary strategy for Mathematics instruction at the primary stage, given the significant and educationally large gain it produced.
- Future studies should use larger and multi-school samples to increase the statistical power available for detecting between-group differences in gain scores.
- Longer intervention periods and delayed post-tests are recommended to examine whether the achievement gains associated with Blended Teaching are sustained over time and translate into improved retention, as suggested by Egara and Mosimege (2024).
- School administrators should ensure adequate digital infrastructure and teacher training before scaling up Blended Teaching programmes in government primary schools, given the documented implementation challenges of the online component (Rasheed et al., 2020).
- Subsequent research should examine potential moderating variables, such as gender, prior achievement level, and access to digital devices at home, in explaining variation in students' response to Blended Teaching.

Conclusion:

The present study investigated the effectiveness of Blended (Hybrid) Teaching on the Mathematics Achievement of Grade 5 students using a pre-test–post-test experimental design. The findings revealed that both the Experimental and Control Groups showed significant improvement in Mathematics Achievement after the intervention. The two groups were statistically equivalent at the pre-test, confirming their initial comparability. However, the Experimental Group achieved significantly higher post-test scores than the Control Group, demonstrating the positive impact of Blended (Hybrid) Teaching. Although the difference in gain scores between the groups was not statistically significant, the Experimental Group recorded a higher mean gain, indicating the potential advantage of the blended approach. Overall, the findings support the effectiveness of Blended (Hybrid) Teaching in enhancing Mathematics Achievement among primary school students and recommend its wider integration into Mathematics classrooms in accordance with the objectives of the National Education Policy (NEP) 2020. Further studies with larger samples are recommended to validate these findings.

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ARTIFICIAL INTELLIGENCE AND THE FUTURE OF PEDAGOGY: BUILDING ADAPTIVE LEARNING ENVIRONMENTS

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Abstract

Artificial Intelligence (AI) is reshaping pedagogy by enabling learning environments that adapt to the pace, preferences, and needs of individual learners. This conceptual thematic paper examines how AI-enabled adaptive learning intersects with established pedagogical theory to reimagine teaching and learning for a digitally mediated era. Drawing on recent scholarship in AI in Education (AIED), the paper synthesizes theoretical foundations, including constructivism, connectivism, self-regulated learning, and Universal Design for Learning, with emerging applications such as intelligent tutoring systems, learning analytics, and generative AI. It examines how these developments support personalized learning pathways, dynamic curriculum adaptation, and inclusive practice, while critically weighing opportunities against persistent challenges of algorithmic bias, data privacy, digital divides, and teacher preparedness. Situating the discussion within global policy frameworks such as UNESCO's guidance on generative AI and India's National Education Policy 2020, the paper argues that the future of pedagogy lies not in automation but in human-AI collaboration grounded in ethical governance and educator agency. The paper contributes a synthesized conceptual framework for adaptive learning ecosystems and offers implications for teachers, institutions, and policymakers navigating AI-enabled educational transformation.

Keywords: *Adaptive learning; Artificial intelligence in education; Educational Technology; Generative AI; Human-centered pedagogy; Learning analytics; Personalized learning.*

Introduction

Education systems worldwide are undergoing a period of sustained technological transformation, and Artificial Intelligence (AI) has emerged as one of its most consequential drivers. Over the past decade, AI in Education (AIED) has evolved from isolated intelligent tutoring experiments into a broad ecosystem of learning analytics platforms, adaptive content engines, and, more recently, generative AI tools capable of producing human-like text, feedback, and instructional material (Zawacki-Richter et al., 2019; Holmes et al., 2019). This evolution has coincided with a parallel shift in pedagogical thinking, away from uniform, teacher-centered delivery and toward learner-centered, differentiated, and data-informed instruction. Adaptive learning environments, in which instructional pacing, content, and feedback respond dynamically to learner performance and behaviour, represent the practical convergence of these two trajectories. The rationale for this thematic paper is therefore twofold: first, to critically synthesize how AI technologies are redefining pedagogical practice, and second, to examine the theoretical, ethical, and policy conditions under which adaptive learning environments can be built responsibly. The discussion is situated within global educational transformations, including the rapid diffusion of generative AI following the release of publicly available large language models, and is aligned with the United Nations

Sustainable Development Goal 4 on inclusive and equitable quality education (UNESCO et al., 2023). The significance of this theme lies in its dual promise and risk: AI can extend personalized support to learners at unprecedented scale, yet it can equally entrench inequity if adopted without pedagogical and ethical grounding.

Understanding Artificial Intelligence and Adaptive Pedagogy

AIED refers to the application of machine learning, natural language processing, and data analytics to support teaching, learning, and educational administration (Zawacki-Richter et al., 2019). Within this broad field, adaptive learning environments constitute intelligent learning ecosystems in which algorithms continuously interpret learner data, such as response accuracy, response time, and engagement patterns, to adjust the sequencing, difficulty, and modality of content in real time (Al-Emran & Shaalan, 2023). Personalized learning, a closely related construct, denotes the broader pedagogical goal of tailoring goals, pace, and instructional approach to individual learners, of which AI-adaptive systems are one enabling mechanism (Essa et al., 2023).

Human-centered AI reframes these systems not as replacements for teachers but as decision-support tools that augment professional judgement (Guilherme, 2019). Smart education extends this logic to physical and virtual learning spaces instrumented with sensors, dashboards, and connected devices, while data-driven instruction describes the broader pedagogical shift toward using learning analytics to inform curricular and assessment decisions. The relationship between AI and pedagogy is therefore not unidirectional: pedagogical theory shapes how adaptive algorithms are designed and evaluated, while AI capabilities simultaneously expand what personalized, responsive teaching can look like in practice (Ivanova et al., 2024).

Theoretical Perspectives Supporting AI-Enabled Pedagogy

AI-enabled adaptive learning is best understood not as a standalone innovation but as an extension of established learning theories. Constructivism and social constructivism frame learning as an active, socially mediated process of knowledge construction; adaptive systems that sequence problems according to a learner's zone of proximal development operationalize this idea computationally (Vygotsky, 1978). Connectivism extends this further by conceptualizing learning as the formation and navigation of networks of information, positioning AI-curated content pathways as a technological expression of networked knowledge construction (Siemens, 2005).

Experiential learning theory emphasizes cycles of concrete experience, reflection, and active experimentation, which adaptive simulations and AI-powered feedback loops can support by shortening the feedback cycle (Kolb, 1984). Self-Regulated Learning (SRL) theory is particularly salient, as adaptive dashboards and AI tutors can scaffold learners' goal-setting, monitoring, and reflection processes (Zimmerman, 2002). Universal Design for Learning (UDL) offers a framework for using AI to provide multiple means of engagement, representation, and expression, thereby advancing accessibility and inclusion (CAST, 2018). The TPACK framework clarifies how educators must integrate technological, pedagogical, and content knowledge when adopting AI tools (Mishra & Koehler, 2006), while the SAMR model offers a hierarchy for evaluating whether AI use merely substitutes existing practice or

redefines it altogether (Puentedura, 2006). Finally, the Community of Inquiry framework, with its emphasis on cognitive, social, and teaching presence, provides a lens for ensuring that AI-mediated interaction does not erode the relational core of online and blended learning (Garrison et al., 2000). Collectively, these frameworks indicate that adaptive learning environments are pedagogically sound only when their design is anchored in theories of how humans actually learn, rather than in technological capability alone.

Emerging Themes in AI-Driven Pedagogical Innovation

Several interconnected themes characterize current AIED scholarship. Personalized and adaptive learning platforms adjust content sequencing based on real-time performance data, while intelligent tutoring systems simulate one-to-one instructional dialogue at scale (Holmes et al., 2019). AI-assisted lesson planning tools help teachers generate differentiated materials, and AI-supported formative assessment systems provide immediate, criterion-referenced feedback that would be difficult to deliver manually across large cohorts. Learning analytics and predictive analytics extends this capability by identifying at-risk learners and informing timely intervention (Strielkowski et al., 2024).

The emergence of generative AI has intensified these trends, enabled on-demand explanation, question generation, and multilingual support, while simultaneously raising questions about academic integrity and the authenticity of learner-produced work (Kasneci et al., 2023). AI-powered feedback systems are increasingly embedded within collaborative learning platforms, supporting peer interaction alongside individualized guidance. In parallel, AI is being positioned as an enabler of inclusive education, competency-based learning that certifies mastery rather than seat-time, and lifelong learning pathways that extend beyond formal schooling into continuous professional and civic learning (UNESCO et al., 2023).

Building Adaptive Learning Environments

Building an effective adaptive learning environment requires the integration of several interdependent components. Personalized learning pathways are generated when algorithms map learner performance against curricular objectives to recommend the next most appropriate learning activity. Dynamic curriculum adaptation extends this to the institutional level, allowing course sequences to be reorganized in response to aggregate learner data. Continuous assessment, embedded within the learning process rather than reserved for periodic examinations, allows real-time learner support, in which struggling students receive scaffolded hints before disengagement occurs.

These mechanisms have documented implications for student engagement and learning autonomy, as learners gain greater visibility into their own progress and can exercise choice over pacing and resources (Essa et al., 2023). When designed with UDL principles, adaptive systems also advance accessibility and inclusion for learners with diverse needs. Smart classrooms, equipped with sensing and analytics infrastructure, extend adaptive logic into the physical environment, while dashboards designed for teacher decision-making ensure that AI outputs inform, rather than replace professional judgement. Internationally, adaptive platforms have been piloted across contexts ranging from large-scale supplementary learning platforms in India to intelligent tutoring initiatives in East Asian and European higher education systems, illustrating both the scalability of the approach and the importance of contextualizing

it to local infrastructure and language needs (Ivanova et al., 2024).

Table 1. Traditional Instruction versus AI-Enabled Adaptive Learning

Dimension	Traditional Pedagogy	AI-Enabled Adaptive Pedagogy
Pacing	Fixed, cohort-based	Individualized, performance-based
Content sequencing	Predetermined syllabus order	Dynamically reordered by learner data
Assessment	Periodic, summative	Continuous, formative and predictive
Feedback	Delayed, teacher-mediated	Immediate, AI-assisted, teacher-verified
Role of teacher	Primary content deliverer	Facilitator and data-informed decision-maker

Source: Developed by the author, synthesizing Al-Emran and Shaalan (2023) and Holmes et al. (2019).

Opportunities and Challenges

AI-enabled pedagogy offers substantial opportunities. It can improve learning outcomes through timely, individualized feedback; empower teachers by automating routine administrative and diagnostic tasks; and extend flexible, learner-centered instruction to previously underserved populations, thereby supporting inclusive education (Strielkowski et al., 2024). It further enables data-informed decision-making at classroom and institutional levels, and fosters innovation in curriculum design and assessment.

These opportunities, however, are counterbalanced by significant challenges. Algorithmic bias can emerge when training data underrepresent certain learner populations, producing systematically less accurate recommendations for those groups. Data privacy concerns are heightened by the continuous collection of behavioural and performance data from minors, prompting UNESCO to recommend age-appropriate safeguards and clear data-governance protocols (UNESCO et al., 2023). The digital divide, encompassing gaps in connectivity, device access, and digital literacy, risk widening rather than narrowing educational inequity if adaptive systems are deployed without infrastructural investment. Teacher preparedness remains uneven, as many educators report limited training in interpreting and acting on AI-generated insights (Zawacki-Richter et al., 2019). Additional concerns include threats to academic integrity posed by generative AI, the risk of learner overdependence on automated systems, and the absence, in many jurisdictions, of coherent governance and regulatory frameworks for educational AI.

Table 2. Opportunities and Challenges of AI in Education

Opportunities	Challenges
Improved, individualized learning outcomes	Algorithmic bias and unfair recommendations
Teacher empowerment and workload reduction	Data privacy and protection of minors
Inclusive, flexible access to learning	Digital divide in infrastructure and access
Innovation in assessment and curriculum	Uneven teacher preparedness and AI literacy

design	
Timely, data-informed decision-making	Governance gaps and regulatory uncertainty

Source: Developed by the author, drawing on UNESCO et al. (2023) and Zawacki-Richter et al. (2019).

The Future of Pedagogy

Emerging discourse increasingly frames the trajectory of AI-enabled schooling as a movement toward 'Education 5.0' or 'Pedagogy 5.0', a paradigm oriented around human-AI collaboration rather than automation for its own sake. In this vision, AI literacy becomes a foundational competency for both students and educators, comparable in importance to traditional literacy and numeracy, and is explicitly promoted through frameworks such as UNESCO's AI competency framework for students (Miao & Shiohira, 2024). Intelligent classrooms are anticipated to combine adaptive content delivery with human facilitation that preserves relational and social dimensions of learning, consistent with the Community of Inquiry framework (Garrison et al., 2000). Future-ready teachers will need fluency not only in subject content but in evaluating, customizing, and ethically deploying AI tools, positioning digital citizenship, and critical evaluation of AI outputs as core professional competencies. Sustainable AI integration will depend on institutions embedding governance, transparency, and periodic algorithmic auditing into procurement and deployment practices. At a systemic level, AI is expected to support lifelong learning by enabling flexible, stackable, and continuously updated learning pathways that extend well beyond the boundaries of formal schooling, contributing to broader global educational transformation aligned with SDG 4.

Implications for Educational Stakeholders

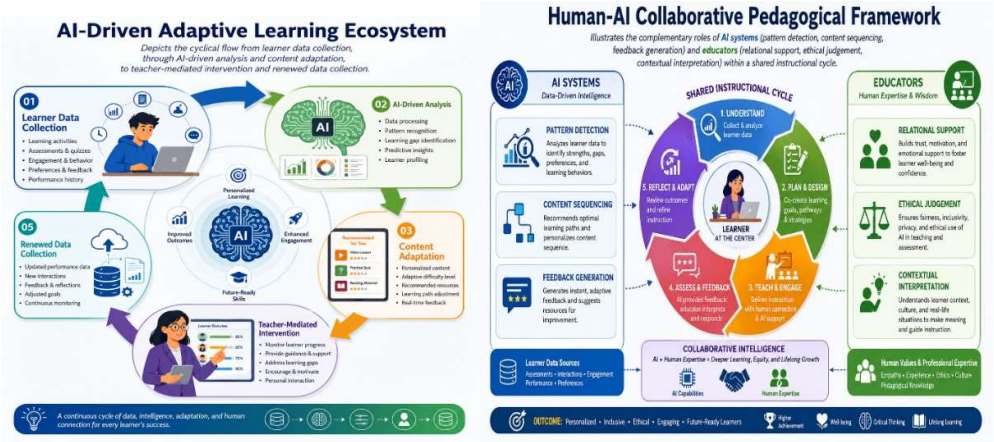
For teachers, the central implication is a shift in professional identity from primary information source to facilitator, curator, and interpreter of AI-generated insight; ongoing professional development in AI and data literacy is therefore essential. Teacher educators must correspondingly revise pre-service curricula to embed TPACK-aligned training in adaptive technologies. School leaders are called upon to build institutional capacity for responsible AI adoption, including infrastructure, data governance policy, and staff training pathways.

Curriculum developers should design content and assessment structures that are modular and machine-readable without sacrificing depth or critical thinking. Educational institutions must invest in equitable access to hardware, connectivity, and multilingual AI tools, particularly in under-resourced settings. Policymakers, informed by frameworks such as NEP 2020 and international guidance from UNESCO, should establish clear regulatory guardrails covering data privacy, algorithmic accountability, and age-appropriate use (UNESCO et al., 2023; Jolly & Kaur, 2025). Researchers are encouraged to strengthen the currently weak connection between AIED development and pedagogical theory identified in prior systematic reviews (Zawacki-Richter et al., 2019), while students themselves require structured opportunities to develop AI literacy and self-regulation skills so that adaptive systems support, rather than substitute for, their own agency as learners.

Table 3. Future Competencies for AI-Ready Educators

Competency	Description
AI and data literacy	Ability to interpret learning-analytics dashboards and AI-generated recommendations critically
Ethical judgement	Capacity to identify bias, privacy risk, and inappropriate AI use in classroom contexts
Pedagogical integration (TPACK)	Skill in blending technological, pedagogical, and content knowledge when selecting AI tools
Human-AI collaboration	Ability to delegate routine tasks to AI while retaining relational and mentoring roles
Continuous adaptability	Willingness to update practice as AI tools and institutional policy evolve

Source: Developed by the author, informed by Mishra and Koehler (2006) and Miao and Shiohira (2024).



Conclusion:

This paper has argued that AI is redefining pedagogy by enabling adaptive learning environments capable of personalizing pace, content, and feedback at scale. This transformation is most productive when grounded in established learning theories, from constructivism and connectivism to Universal Design for Learning and TPACK, rather than treated as a purely technical undertaking. The analysis has shown that opportunities for improved outcomes, inclusion, and teacher empowerment are real, but so are the risks of algorithmic bias, privacy erosion, digital inequity, and eroded teacher preparedness. The future of pedagogy, as this paper has framed it, lies in deliberate human-AI collaboration rather than automation for its own sake, supported by coherent institutional and national policy frameworks such as those articulated by UNESCO and, in the Indian context, by NEP 2020 and NCF 2023. Responsible, ethically governed integration of AI, anchored in pedagogical theory and educator agency, offers the most credible pathway toward building adaptive learning environments that are both intelligent and humane.

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IMPACT OF ICT AND PEDAGOGICAL COMPETENCY ON TEACHER EFFECTIVENESS OF SECONDARY SCHOOL TEACHERS IN BELAGAVI CITY

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Abstract

Information and Communication Technology (ICT) has become an integral component of contemporary education. The integration of ICT requires teachers to possess not only digital skills but also appropriate pedagogical competencies. The present study examines the relationship between ICT competency, pedagogical competency and teacher effectiveness among secondary school teachers in Belagavi City. The proposed study follows a quantitative research approach and a descriptive-correlational design. A sample of 57 secondary school teachers is considered. ICT competency, pedagogical competency and teacher effectiveness constitute the major variables. Data are proposed to be collected through structured rating scales covering ICT use, digital teaching practices, lesson planning, instructional strategies, classroom management, assessment and professional effectiveness. Descriptive statistics, Pearson's product-moment correlation and multiple regression are proposed for analysis. The illustrative results indicate positive relationships among ICT competency, pedagogical competency and teacher effectiveness. The study emphasizes that professional development should integrate technology with pedagogy rather than treating ICT as an isolated technical skill. Because actual responses were not available at the time of preparation, the numerical statistical results included in this manuscript are explicitly illustrative and must be replaced with actual calculations before empirical publication.

Keywords: ICT Competency, Pedagogical Competency, Teacher Effectiveness, Secondary School Teachers, Digital Pedagogy, Technology Integration, Belagavi City.

Introduction:

Information and Communication Technology had become an important component of contemporary education. The rapid expansion of computers, smartphones, digital learning platforms, multimedia resources, online assessment systems and artificial intelligence-based educational applications had changed the ways in which teachers prepare lessons, present information, communicate with learners and assess learning.

The role of the teacher had consequently expanded beyond the traditional function of transmitting information. Teachers were increasingly expected to act as facilitators, learning designers, mentors, digital-resource users and assessors. UNESCO's ICT Competency Framework for Teachers identifies digital competencies that support teaching and learning, assessment, school organization and continuing professional development (UNESCO, 2018).

In India, the importance of technology in education had also been recognized at the policy level. The National Education Policy 2020 emphadizes the use and integration of technology for improving teaching-learning and evaluation processes, supporting teacher preparation and professional development (Ministry of Education, 2020).

However, effective ICT integration cannot be achieved merely by providing digital infrastructure. Teachers needed to possess the knowledge and ability to select appropriate technology according to the subject matter, learning objectives and needs of students. Mishra and Koehler (2006) developed the Technological Pedagogical Content Knowledge framework to explain the interaction among technology, pedagogy and content knowledge requiredd for effective technology integration.

Thus, ICT competency and pedagogical competency were closely related to contemporary teacher effectiveness. The present study focused on these competencies among secondary school teachers in Belagavi City.

Background of the Study

The increasing availability of digital technology had created opportunities for teachers to provide flexible and engaging learning experiences. Digital presentations, educational videos, simulations, virtual laboratories, online quizzes, electronic textbooks and learning-management platforms can supplement traditional classroom teaching.

Nevertheless, the educational value of technology depends largely on how teachers use it. UNESCO (2018) emphadizes that digital competencies should be connected with teaching and learning, assessment and professional learning. Similarly, NEP 2020 recognizes technology as an important support for teaching-learning, evaluation and teacher professional development (Ministry of Education, 2020).

Rathnabai (2024) emphadized systematic capacity building for technology-pedagogy integration among in-service teachers. Lyngdoh (2025) also highlighted ICT-related challenges and the need for stronger training and pedagogical alignment. These developments demonstrated the need to examine teachers' ICT competency alongside their pedagogical competency.

ICT Competency and Teacher Effectiveness

ICT competency referred to a teacher's ability to use digital technologies appropriately for educational purposes. It encompasses basic digital literacy, information searching, digital communication, digital-content creation, online teaching, digital assessment and professional development.

ICT competency supported teacher effectiveness by enabling teachers to access current educational resources, present difficult concepts through multimedia, provide interactive learning activities, conduct formative digital assessment, provide rapid feedback and communicate through digital platforms. UNESCO (2018) places ICT within broader teaching, assessment and professional practice rather than treating it as a purely technical skill.

Pedagogical Competency and Teacher Effectiveness

Pedagogical competency is a fundamental component of effective teaching. It includedd lesson planning, instructional strategies, classroom management, assessment, questioning, motivation and learner-centred practices. An effective teacher needs to understand not only what to teach but also how to teach it.

The TPACK framework emphadizes that effective technology integration requiredd interaction among technological knowledge, pedagogical knowledge and content knowledge (Mishra & Koehler, 2006). Koehler, Mishra, and Cain (2013) further explained that

technology integration requiredd teachers to understand how technological knowledge interacts with pedagogy and content.

Technology-Pedagogy Integration

Technology was expected to not simply be added to an existing lesson. Teachers needed to determine whether a particular technology improves learning and how it should be integrated. A science teacher may use a simulation to demonstrate an otherwise difficult experiment, while a social science teacher may use digital maps and historical archives. In each case, technology becomes meaningful only when connected with appropriate pedagogy.

The TPACK framework provided a theoretical foundation for this integration and emphadizes the interaction among technology, pedagogy and content knowledge (Mishra & Koehler, 2006).

Need and Significance of the Study

The study was significant because of the increasing digitalization of education, changing teacher roles, the importance of pedagogical competency, professional development needs, the local educational context of Belagavi City and the policy emphadis on technology integration under NEP 2020. The findings could help school administrators and teacher educators identify areas for professional development.

Statement of the Problem

"Impact of ICT and Pedagogical Competency on Teacher Effectiveness of Secondary School Teachers in Belagavi City."

Objectives of the Study

1. To assess the level of ICT competency among secondary school teachers in Belagavi City.
2. To assess the level of pedagogical competency and teacher effectiveness among secondary school teachers in Belagavi City.
3. To examine the relationship between ICT competency, pedagogical competency and teacher effectiveness among secondary school teachers.
4. To determine the combined contribution of ICT competency and pedagogical competency to teacher effectiveness among secondary school teachers.

Hypotheses of the Study

H_o1: There is no significant relationship between ICT competency and teacher effectiveness among secondary school teachers.

H_o2: There is no significant relationship between pedagogical competency and teacher effectiveness among secondary school teachers.

H_o3: There is no significant relationship between ICT competency and pedagogical competency among secondary school teachers.

H_o4: ICT competency and pedagogical competency did not significantly predict teacher effectiveness among secondary school teachers.

Conceptual Framework

ICT Competency → Teacher Effectiveness ← Pedagogical Competency

The framework assumed that ICT competency and pedagogical competency may independently and jointly contribute to teacher effectiveness. The theoretical foundation is consistent with the TPACK framework (Mishra & Koehler, 2006).

Operational Definitions

- ICT Competency: The knowledge, skills and ability of secondary school teachers to use digital technologies for teaching, learning, assessment, communication and professional development.
- Pedagogical Competency: The ability of teachers to plan, organize and implement effective teaching-learning activities, use appropriate instructional strategies, manage classrooms and assess learners.
- Teacher Effectiveness: The extent to which teachers successfully perform instructional and professional responsibilities, including planning, teaching, classroom management, student engagement and assessment.
- Secondary School Teachers: Teachers working in recognized secondary schools within Belagavi City.

Review of Related Literature

UNESCO's ICT Competency Framework for Teachers provided a comprehensive framework for teacher digital competence, including pedagogy, curriculum, assessment, school organization and professional development (UNESCO, 2018).

Mishra and Koehler (2006) introduced TPACK to explain the knowledge requiredd for effective technology integration. Koehler et al. (2013) further explained its significance for technology-supported teaching.

Rathnabai (2024) emphadized systematic capacity building that integrates content, pedagogy and ICT among in-service teachers. Lyngdoh (2025) examined ICT competency, awareness and challenges among school teachers and highlighted the need for ICT-related training and pedagogical alignment.

The National Education Policy 2020 provided an important policy context by emphadizing technology in teaching-learning, evaluation and teacher professional development (Ministry of Education, 2020).

Research Gap

Existing literature demonstrated considerable interest in ICT competency and technology integration. However, there is a need to examine ICT competency and pedagogical competency simultaneously as factors associated with teacher effectiveness. Many studies focus on technical ICT skills, whereas contemporary frameworks emphadize the integration of technology with pedagogy and content. There is also value in localized research among secondary school teachers in Belagavi City. The present study addressed this gap through the proposed model ICT Competency + Pedagogical Competency → Teacher Effectiveness.

Methodology

Research Approach: Quantitative research approach.

Research Design: Descriptive-correlational research design.

Population: Secondary school teachers working in recognized secondary schools in Belagavi City.

Sample: 57 secondary school teachers (N = 57). The sample was intended to represent teachers from different categories of secondary schools in Belagavi City.

Geographical and Demographic Profile

The study was geographically restricted to Belagavi City, Karnataka. The following table presents an illustrative distribution of the 57 proposed respondents.

Tools for Data Collection

Three scales were proposed: (1) ICT Competency Scale covering digital literacy, internet use, digital content creation, multimedia teaching, digital communication, online platforms, digital assessment and digital safety; (2) Pedagogical Competency Scale covering lesson planning, instructional strategies, classroom management, learner-centred teaching, questioning, motivation, assessment and feedback; and (3) Teacher Effectiveness Scale covering instructional effectiveness, student engagement, classroom management, communication, assessment, feedback, professional responsibility and adaptability. A five-point Likert scale was used.

Data Collection Procedure

Permission was obtained from concerned school authorities. The purpose of the study was explained to teachers and participation should be voluntary. Questionnaires was administered personally or electronically. Responses were coded and entered into statistical software, and incomplete responses screened before analysis.

Statistical Techniques

Frequency and percentage; mean and standard deviation; Pearson's product-moment correlation; and multiple regression analysis were recommended.

Data Analysis and Interpretation:

The statistical analysis was presented using the responses of 57 secondary school teachers. The results were interpreted using descriptive statistics, Pearson's correlation and multiple regression.

Table 1. Geographical and Demographic Profile of the Proposed Sample (N = 57)

Variable	Category	Frequency	Percentage
Gender	Male	30	52.63
	Female	27	47.37
School Management	Government	19	33.33
	Aided	16	28.07
	Private Unaided	22	38.60
Teaching Experience	Below 5 years	15	26.32
	5–10 years	20	35.09
	Above 10 years	22	38.60
Qualification	Graduate	12	21.05
	Postgraduate	38	66.67
	M.Ed./Other	7	12.28
ICT Training	Received	41	71.93
	Not received	16	28.07

The demographic profile of the proposed sample indicates that, out of the 57 respondents, 30 (52.63%) were male and 27 (47.37%) were female, showing a relatively balanced gender distribution. With regard to school management, 22 respondents (38.60%)

were from private unaided schools, followed by 19 (33.33%) from government schools and 16 (28.07%) from aided schools. In terms of teaching experience, the largest proportion, 22 respondents (38.60%), had more than 10 years of experience, while 20 (35.09%) had 5–10 years and 15 (26.32%) had less than 5 years of experience. Regarding educational qualification, 38 respondents (66.67%) were postgraduates, 12 (21.05%) were graduates, and 7 (12.28%) possessed M.Ed. or other qualifications. Further, 41 respondents (71.93%) had received ICT training, whereas 16 (28.07%) had not received such training. Overall, the sample represents teachers with varied professional backgrounds, qualifications, school-management affiliations, and levels of ICT training.

Table 2. Descriptive Statistics of Major Variables

Variable	N	Mean	SD	Level
ICT Competency	57	78.42	8.16	High
Pedagogical Competency	57	82.67	7.24	High
Teacher Effectiveness	57	84.31	6.87	High

Table 2 presents the descriptive statistics of the major variables among the 57 respondents. The mean score for **ICT Competency** was **78.42** with a standard deviation of **8.16**, indicating a high level of ICT competency among the respondents. **Pedagogical Competency** recorded a mean of **82.67** and a standard deviation of **7.24**, which also indicates a high level of pedagogical competency. **Teacher Effectiveness** had the highest mean score of **84.31** with a standard deviation of **6.87**, suggesting a high level of teacher effectiveness among the respondents. Overall, the findings indicate that the proposed sample demonstrates **high levels of ICT competency, pedagogical competency, and teacher effectiveness**.

Table 3. Pearson Correlation among ICT Competency, Pedagogical Competency and Teacher Effectiveness

Variables	ICT Competency	Pedagogical Competency	Teacher Effectiveness
ICT Competency	1.00	.58**	.64**
Pedagogical Competency	.58**	1.00	.72**
Teacher Effectiveness	.64**	.72**	1.00

Note. **p < .01; N = 57.

Table 3 presents the Pearson correlation coefficients among ICT competency, pedagogical competency, and teacher effectiveness. The results indicate a moderate positive and statistically significant relationship between ICT competency and pedagogical competency ($r = .58$, $p < .01$). ICT competency also showed a moderately strong positive and statistically significant relationship with teacher effectiveness ($r = .64$, $p < .01$). Further, pedagogical competency demonstrated a strong positive and statistically significant relationship with teacher effectiveness ($r = .72$, $p < .01$). These findings suggest that teachers with higher ICT competency tend to have higher pedagogical competency and greater teacher effectiveness. Similarly, higher pedagogical competency is associated with higher teacher effectiveness. However, as these are correlation coefficients, the findings indicate association rather than causation.

Table 4. Multiple Regression Analysis Predicting Teacher Effectiveness

Predictor	B	SE	β	t	P
Constant	28.16	7.41	—	3.80	<.001
ICT Competency	0.31	0.09	.37	3.44	.001
Pedagogical Competency	0.46	0.10	.51	4.67	<.001

Table 4 presents the results of the multiple regression analysis conducted to determine the contribution of ICT competency and pedagogical competency in predicting teacher effectiveness. The results show that ICT competency is a significant positive predictor of teacher effectiveness ($B = 0.31$, $\beta = .37$, $t = 3.44$, $p = .001$). This indicates that an increase in ICT competency is associated with an increase in teacher effectiveness, when pedagogical competency is statistically controlled. Similarly, pedagogical competency is a significant positive predictor of teacher effectiveness ($B = 0.46$, $\beta = .51$, $t = 4.67$, $p < .001$). Among the two predictors, pedagogical competency has the larger standardised regression coefficient ($\beta = .51$), suggesting that it makes a stronger unique contribution to teacher effectiveness than ICT competency in this model. Overall, both ICT competency and pedagogical competency significantly and positively predict teacher effectiveness.

Major Findings

- The illustrative dataset indicated relatively high ICT competency.
- Pedagogical competency is also relatively high.
- Teacher effectiveness demonstrated a comparatively high mean score.
- ICT competency is positively associated with teacher effectiveness.
- Pedagogical competency showed a stronger positive association with teacher effectiveness.
- ICT competency and pedagogical competency are positively related.
- The illustrative regression model indicated that both competencies jointly contribute to teacher effectiveness.

Discussion

The illustrative findings are consistent with the theoretical position that technology integration is most effective when combined with sound pedagogy. Teachers with appropriate ICT skills was better able to access resources, prepare multimedia lessons, communicate with learners and conduct technology-supported assessment. UNESCO (2018) similarly places ICT within broader teaching, assessment and professional practice.

The relationship between pedagogical competency and teacher effectiveness is theoretically expected because effective teaching requiredd planning, instructional strategy, classroom management and assessment. The TPACK framework explained why technological knowledge needs to interact with pedagogical and content knowledge (Mishra & Koehler, 2006).

The findings are also relevant to NEP 2020, which emphadizes technology in teaching-learning, evaluation and teacher professional development (Ministry of Education, 2020). Rathnabai (2024) similarly emphadizes systematic capacity building that integrates content, pedagogy and ICT.

Educational Implications

Teachers were expected to continuously develop ICT skills and learn to integrate digital tools into subject-specific pedagogy. School administrators were recommended to provide infrastructure, technical support and professional learning opportunities. Teacher education programmes should incorporate technology-integrated lesson planning and digital assessment. Educational authorities were recommended to design professional-development programmes around technology-pedagogy integration rather than basic computer literacy alone.

Recommendations

1. Organize regular ICT-integrated pedagogy workshops.
2. Provide practical training in digital content creation and assessment.
3. Link ICT training with subject-specific teaching methods.
4. Provide reliable digital infrastructure and technical assistance.
5. Encourage teachers to develop digital teaching materials.
6. Establish professional learning communities for sharing ICT-integrated practices.
7. Include emerging technologies and responsible digital practices in professional development.
8. Conduct larger studies across Belagavi district.

Limitations

The statistical analysis was presented using the responses of 57 secondary school teachers. The results were interpreted using descriptive statistics, Pearson's correlation and multiple regression.

Suggestions for Further Research

Future studies could use larger samples, compare government, aided and private schools, compare urban and rural teachers, examine subject-wise differences, investigate school leadership and ICT support, study digital competency and student achievement, investigate artificial intelligence use in education, and conduct longitudinal research following ICT professional development.

Conclusion

ICT had become an important component of contemporary education, but effective educational technology use depends on teachers' ability to integrate technology with appropriate pedagogy. The present study focused on ICT competency and pedagogical competency as factors associated with teacher effectiveness among secondary school teachers in Belagavi City.

The proposed framework is supported by TPACK, which emphadizes the interaction among technological, pedagogical and content knowledge (Mishra & Koehler, 2006). UNESCO's ICT Competency Framework similarly demonstrated that teacher digital competence encompasses teaching, assessment and professional development (UNESCO, 2018). NEP 2020 also emphadizes technology integration in teaching-learning, assessment and teacher professional development (Ministry of Education, 2020).

The illustrative analysis suggests positive relationships among ICT competency, pedagogical competency and teacher effectiveness, with pedagogical competency showing a

comparatively stronger association. These numerical results must be replaced with genuine results after data collection. Effective digital education ultimately requiredd more than hardware and software; it requiredd teachers with the knowledge, confidence and pedagogical capacity to use technology purposefully.

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ANALYTICAL PERSPECTIVE ON TEACHER STRATEGIES FOR STUDENT ENGAGEMENT AMID CLASS ROOM CONFLICT

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Abstract

Classroom conflict as the mirror of teacher education and inadequate preparation for the discipline. When student engage in disruptive behaviour teacher are forced to divert attention from instruction to discipline, which diminishes effective teaching time. Teacher education program to improved students life skill, higher teacher retention and greater classroom innovation .Teacher education program play a crucial role in the Managing classroom conflict and behaviour management, they are strike synthesis the importance of the teacher education outline persistent and emerging challenges, effective teacher education programs equips with strong subject knowledge , classroom conflict Strategies and reflective practice. Trend and experience teachers improve students learning outcomes and reduce classroom conflicts and fosters 21st century skills. The study investigates the challenges of class room conflicts and how teacher education program pay significant challenges in adequate preparation and miss alignment between training and classroom conflict realities. The study deal with the different kinds of behaviour challenges and interpersonal relationship between teachers and students face are in classroom Society. The study emphasizes the importance of classroom conflict is not only a school issue but also a reflection of teacher education qualities, Reflective teachers who provide quality education to every learners more align with cognitive thinking, lack of practical exposure during teachers training program . Intern's teacher mainly focused on subject knowledge, content delivery and active learning but its meaning has changed over time.

Keywords*: student engagement, disruptive behaviour, teacher education, teaching strategies in class.*

INTRODUCTION

Teacher education is one of the most important foundation of a strong and effective education system, the teacher must create a safe stimulating and inclusive learning environment that enables every child to learn .Reflective teachers provide quality education to every learner more aligned with cognitive thinking teacher education has always been Centre to education but it's meaning change to overtime. High quality teachers training ensure that classroom cultivate critical thinking rather than more Rote memorization. Behaviour is the mirror of in which everyone shows there image of the society and its reflecting we will stand in future. Student's behaviour plays an important role in a creating a positive learning environment However teacher and student face of biggest challenge interpersonal communication gap and lack of participation. Students fill the communication gap through the digital platform and any other activities .The 1966 "policy was first to say teacher must be trained not just subject". Experiencing student engagement has highlighted the need to understand it causes consequence and implication for effective teaching and strategies.

Objective of the study:

To explore strategies used by the teacher and promoting responsibilities and cooperation.

How to manage students' behaviours and classroom conflict.

Why behavioural changes do face every teacher in his classroom.

How does teacher student communication gap affects positive learning environment

Need for the study: this study aims to evaluate the classroom conflicts to face teachers in his class room. A curriculum maybe excellent and Technology may be advance but without competent and committed teachers educational goal cannot be fully achieved. Teacher education program prepare educators to teach modern technology and design thinking. **Why the shift matter how it is happened and what means for the future.**

Reason behind of class room conflict and students disengagement:

Miss interpretation and weak relationship of lead to more classroom conflict when students do not participate positively teacher may feel their efforts are in effective.

Teacher have little behaviour management training and used only trial and error method.

No study classroom monitoring, some students suffer to regulate frustration and Burnout which is direct effect student Social Skill and wellbeing.

Teacher have better classroom management skills but experience fever to manage disruptive behaviour problem. We do not have a better strategies reduce classroom description and conflicts there is not a one size fits all

Lack of classroom management experience among trainee teachers

Insufficient practical experience in classroom conflict

Difficulty in developing effective classroom practice skills, miss interpretation and poor communications skill.

The findings of the study: the study revealed a significant relationship between trained experience teachers among untrained and an experience teachers. . Teacher education program should be include behaviour management training and evidence base communication strategies. Trained teacher know the student psychology of learning and how to make knowledge accessible to every unique mind .Competent teachers can explain concept clearly, select suitable teaching Strategies and address learning difficulties effectively. **Trained and experienced teachers is like a candle it consume itself to light the way for others.** Teachers have a better classroom management skills align with the student's cognitive style, to managing disruptive behaviour and class room conflict.

Conclusion: Teacher and students relationship in the foundation of civilization it is not about the feeling a mind, teacher education program can be integrated training in classroom conflict management to equip future with effective Strategies for fostering creativity. Professional training encourage teachers to understand students listen to them respect their individuality, teachers are mirror of the society reflecting we will stand in future. Integrating Training Institute as the Bedrock of national programs progress and manage to effective strategies for fostering creativity and with different abilities.

IMPACT OF GENERATIVE AI TOOLS ON TEACHING EFFECTIVENESS AND LEARNING ENGAGEMENT

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Abstract

Generative Artificial Intelligence has emerged as an important technological development in the field of education. Tools such as ChatGPT, Gemini, Microsoft Copilot and other AI-based applications can generate text, explanations, questions, lesson plans, examples, summaries and learning activities. Their increasing use has created new possibilities for improving teaching effectiveness and student learning engagement. purpose of this study is to systematically assess the role of Generative AI in classroom teaching, with a specific focus on how teacher supervision shapes its effectiveness. Recent research indicates that GenAI can positively influence learning outcomes, motivation, and cognitive, behavioural and emotional engagement, although its effectiveness depends on how, where and under what conditions it is used. This article discusses the uses, benefits, challenges and educational implications of generative AI tools, with particular attention to teaching effectiveness and learning engagement. It argues that GenAI should complement rather than replace teachers and should be integrated through appropriate pedagogical, ethical and human-centred practices.

Keywords: *Generative AI, ChatGPT, teaching effectiveness, learning engagement, personalized learning, artificial intelligence, education.*

Introduction:

Technology has become an important component of contemporary education. Among recent technological developments, Generative Artificial Intelligence has attracted considerable attention because it can produce new content in response to natural-language instructions. Technology has always played a big role in education. Every new tool has changed how students learn. Artificial intelligence (AI) is shaping the future of education among the many advancements and making a big impact on teaching method.

Generative AI tools can support teachers in lesson planning, preparation of instructional materials, question generation, assessment, feedback and differentiated instruction. For students, they can provide explanations, examples, personalized assistance and opportunities for interactive learning. A 2025 systematic review of pedagogical applications in higher education found that Generative AI is being used across different instructional contexts and disciplines, with generators, re-imaginers and assistants among the commonly applied types.

Therefore, it is important to examine not merely whether AI is used in education, but whether its use actually improves teaching effectiveness and encourages students to participate actively

in learning.

Significance of Generative AI Tools on Teaching:

Generative AI refers to artificial intelligence systems capable of producing new content such as text, images, audio, video, computer code and other forms of media based on user instructions. In education, these systems can function as teaching assistants, learning companions, content-generation tools and feedback-support systems.

Generative AI tools in teaching changing education and improving personalised learning and making teaching more efficient and opening up new ways to create interactive lessons. However, teacher must use wisely to balance it benefits with ethical concerns with the right approach can make more engaging, accessible and effective for learners everywhere. AI based diagnostic tools can examine students to identify certain misconceptions in subjects and also great at finding patterns in students work and finding common lexical mistakes.

Examples include ChatGPT, Google Gemini, Microsoft Copilot and AI-supported educational applications. Their educational value depends largely on the quality of the prompts, the teacher's pedagogical decisions and the learner's ability to evaluate and use the generated information critically.



Use of Generative AI in Teaching:

Generative AI in teaching and learning making it more adaptive and effective. Different AI tools can adjust problem difficulty and type based on individual student performance, providing a tailored learning experience. A learning tool that uses AI to customize lessons to each learner’s pace and skill level.

Generative AI Generative AI can be used in several areas of teaching:

- **Lesson Planning**

Teachers can use AI to develop lesson plans, learning objectives, classroom activities and teaching strategies according to the subject and level of learners.

- **Preparation of Teaching Materials**

AI can help generate summaries, examples, worksheets, discussion questions, quizzes, case studies and presentation content. This can reduce routine preparation time and allow teachers to devote more attention to classroom interaction.

- **Personalized Instruction**

AI can provide explanations at different levels of complexity and can support differentiated learning. Students who require additional assistance can receive explanations or examples suited to their learning needs.

- **Assessment and Feedback**

Teachers can use AI to generate assessment questions, rubrics and formative feedback. AI-assisted feedback can provide students with immediate suggestions for improving their work, although teacher verification remains important.

- **Interactive Learning**

AI-based conversational systems can allow students to ask questions and receive immediate responses. This can promote active participation and provide opportunities for individual or small-group learning.

Impact on Teaching Effectiveness:

Teaching effectiveness refers to the teacher's ability to facilitate meaningful learning through appropriate planning, instructional strategies, classroom interaction, assessment and feedback.

Generative AI can contribute to teaching effectiveness in the following ways:

- Improved lesson preparation: Teachers can generate initial lesson materials more quickly.
- Variety in instructional strategies: AI can suggest different teaching methods and classroom activities.
- Differentiated teaching: Content can be adapted to different learner levels.
- Immediate resource generation: Teachers can create examples, questions and activities according to specific learning objectives.
- Assessment support: AI can assist in developing formative assessments and feedback.
- Teacher productivity: By reducing some routine tasks, AI may allow teachers to focus more on mentoring, discussion and higher-order learning. A 2025 systematic review of GenAI applications in teaching identified a growing range of classroom uses and emphasized that its educational effectiveness depends on instructional context and strategy rather than simply on the presence of the technology.

Impact on Learning Engagement:

Learning engagement is a multidimensional concept generally involving students' behavioural, cognitive and emotional participation in learning.

Generative AI can influence these dimensions in several ways:

- Behavioural Engagement
- Interactive AI activities can encourage students to participate, practise, ask questions and complete learning tasks.
- Cognitive Engagement
- AI can support students in exploring concepts, comparing ideas, generating explanations and solving problems. A 2025 systematic review and meta-analysis found a medium positive effect of ChatGPT-based learning on overall student engagement, with a particularly strong effect reported for cognitive engagement.
- Emotional Engagement
- Personalized assistance and immediate responses may make learning more accessible and interesting, potentially increasing students' interest and confidence.

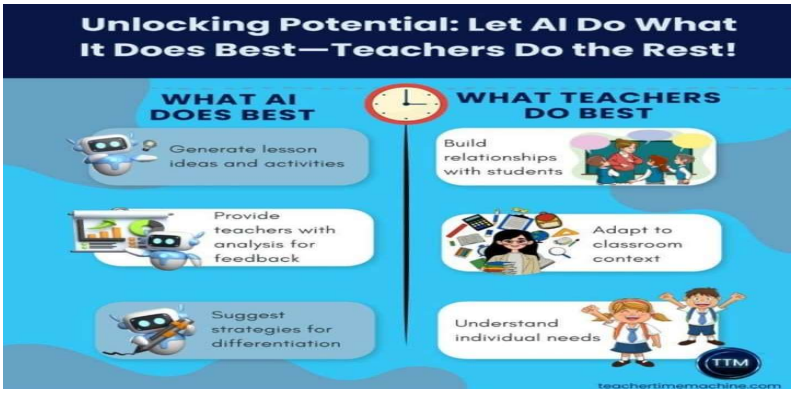
- Recent meta-analytic evidence also reports positive effects of GenAI on university students' motivation and multiple dimensions of engagement, particularly cognitive and emotional engagement in individual and small-group learning contexts.

Benefits of Generative AI in Education:

The major benefits include:

- Personalized learning experiences.
- Increased student participation.
- Immediate feedback and assistance.
- Support for teachers in lesson preparation.
- Creation of diverse learning resources.
- Development of interactive learning activities.
- Support for self-directed learning.
- Assistance with language learning and writing.
- Opportunities for collaborative and problem-based learning.
- Support for differentiated and inclusive instruction.

A recent meta-analysis of experimental studies found an overall positive effect of GenAI on learning outcomes, while also showing that the size of the effect varies according to educational level, subject, intervention duration and other contextual factors.



Challenges and Limitations:

Despite its potential, GenAI also presents important challenges.

❖ **Accuracy of Information**

AI systems can generate incorrect or misleading information. Therefore, teachers and students should verify important information using reliable sources.

❖ **Overdependence on AI**

Excessive dependence on AI may reduce students' independent thinking, problem-solving and learning effort. Research on ChatGPT engagement has also identified over-reliance as a potential risk.

❖ **Academic Integrity**

Students may use AI to complete assignments without developing the required knowledge and skills. Teachers therefore need assessment strategies that emphasize reasoning, application and authentic performance.

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❖ **Privacy and Data Protection**

The use of AI tools may involve student information and educational data. UNESCO recommends a human-centred approach that includes attention to data privacy, ethical validation and appropriate regulation.

❖ **Digital Inequality**

Not all students have equal access to devices, reliable internet connections or AI tools. Unequal access can increase existing educational inequalities.

❖ **Teacher Preparedness**

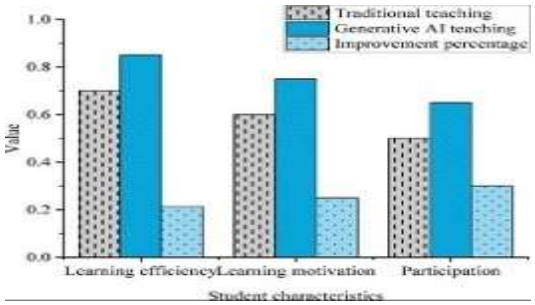
Teachers need AI literacy and professional development to use GenAI effectively. UNESCO emphasizes the need for teacher training and human-centred integration of GenAI into education.

Role of the Teacher in the Age of Generative AI:

Generative AI should not replace the teacher. The teacher continues to play a central role in motivating students, developing critical thinking, managing classroom interaction, understanding individual learners and providing emotional and social support. The teacher should act as a facilitator, evaluator, mentor and ethical guide while using AI as a supporting technology. UNESCO's guidance similarly emphasize that AI should support human agency and should not displace the unique role of teachers in higher-order thinking and human interaction.

Suggestions for Effective Use:

For effective implementation of GenAI in education: Provide AI-literacy training for teachers and students. Use AI in alignment with clearly defined learning objectives. Verify AI-generated information before using it. Encourage students to critically evaluate AI responses. Combine AI activities with teacher-led discussion and collaboration. Develop clear institutional policies for responsible AI use. Protect student privacy and personal data. Design assessments that measure genuine understanding and application. Ensure equitable access to AI-supported learning. Use AI to enhance, not replace, meaningful human interaction.



Conclusion:

Generative AI represents an important opportunity for transforming teaching and learning. It can support teachers in lesson planning, content development, assessment and personalized

instruction while providing students with interactive and flexible learning opportunities. Current research generally indicates positive effects on learning outcomes and engagement, although the effects vary according to context and method of implementation. The impact of GenAI ultimately depends on how teachers and learners use it. Responsible integration requires teacher competence, critical evaluation, ethical awareness, data protection and appropriate pedagogical design. Therefore, generative AI should be viewed not as a replacement for teachers but as a powerful educational support tool. When used thoughtfully and responsibly, it can contribute to improved teaching effectiveness, greater learning engagement and more personalized educational experiences.

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ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS ALIGNMENT WITH NEP 2020

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Abstract

Artificial Intelligence is playing a vital role in improving the quality of education. It is not only providing different teaching methods to students but also helping in making the teaching learning process effective. The Ancient Indian Education system was based on the holistic development of the learner to make teaching effective. only learner centered teaching method are being developed but the teacher is also being made effective. the use of Artificial Intelligence has been made. AI is used for personalized learning through which creative activities are made available to students according to their needs. AI based program students with explanation and help in skill practice. It also helps in adaptive assessment, through which the difficulty level of question can be increased or decreased according to the learner's level, Feedback can be provide through it and student – teachers can provide feedback and assessment according to the performance of the students. Inclusive education can also be promoted through AI. Its translation, text to speech and assistive technologies can help in identifying and understanding the learning needs of different learners, AI help teachers to provide data informed teaching. The most important thing is that according to the traditional method all student were given the same worksheet, but AI can provide questions according to the performance of the students and can make them difficult or simple. However, the role of teacher cannot be replaced because pedagogy is not only technology human interaction, values, creativity, and critical thinking are also important. At present many teachers take help of AI to access essential services. NEP-2020 has also emphasized sustainable development and AI contribute to achieving this objective.

KEYWORDS – *Artificial Intelligence, Pedagogical Innovation, NEP – 2020*

INTRODUCTION

Education is not merely a teaching tool, but it is important to understand that AI is becoming a new form of education used in various ways making the learning process more effective. In this AI is not only changing the traditional role of teachers but is also transforming the entire process of education. With the use of Artificial Intelligence education is moving towards AI supported pedagogy. Earlier the technology was used through one medium to deliver some content, such as smart board videos, PPT, digital textbook etc. This means that AI was used as a medium for providing learning resources. However now AI can do much more, it can analysis students' performance, interaction, feedback, learning pathways and recommendations. In this topic, teachers, content, and students become responsible for their learning. For this, AI supported pedagogy can help teachers and students. Teachers can use AI generated data or information as a basis for making pedagogical decisions, one size fits all and

one size fits one approaches are discussed in this topic that's mean the same teaching approach cannot be suitable for every student. For example, a student may need one lesson and another student may need a different assessment or learning method. While talking about teachers, it can also be said that AI can help teachers in many ways like –

(1) To provide basic explanation to students
(2) To provide text based or deep learning
(3) To identify the practical needs of different students
(4) To help students reach an advanced level
(5) To identify the concepts that students find difficulties and provide appropriate support

In this way AI can become a pedagogical assistant for teachers. AI can provide support for pedagogical innovation and provide a strong foundation for teachers in their work. Now talk about assessment, quizzes, can be prepared and final judgement can be made on the basis of AI. Continue assessment can also be conducted instead of depending only on examination, students learning can be evaluated continuously. The performance of learners can be regularly monitored through an assessment model, and formative feedback can be provided so that students can improve their learning. It is possible that a student can be made better through this process, it can also help in understanding the learning process. AI does not only provide answer rather it makes the feedback loop faster and more responsive. With AI, the role of teachers does not become less important rather AI performs repetitive task while the teacher role becomes more focused on providing information, designing learning, facilitating learning and monitoring. Teachers can identify what material generated by AI is appropriate for a particular student and how reliable that material is the teacher also need to check the content generated by AI and determine whether it is appropriate or not Along with AI teachers also need pedagogical judgement. It is important to understand whether AI is actually improving students thinking or whether or it is creating dependency. AI should help students to develop critical thinking rather than simply depending on it for answer. The teacher's role remains important because there should be a balance between AI and teacher. The disadvantage of AI for learners can also become an opportunity for them. If a student uses AI only for searching, then through that search they may obtain the answer to any questions. Education should not be limited only to getting answers. Students thinking, questioning, reasoning, analysis, and conclusion making abilities should also be developed. AI has a five-dimensional accessibility aspect, including translation, speech to text, text to speech, personalized resources etc. Technology can provide learning resources according to the needs of different students with innovation and equity. AI and NEP-2020 both focuses on the use of technology in education. NEP-2020 should promote learner centered approach, flexibility, experiential learning, inclusion of students. and tech integration. These aspects can help in making education more accessible, flexible, inclusive and technology -integrated.

Objectives

(1) To discuss the role of Artificial Intelligence in Modern education.
(2) To examine the role of Artificial Intelligence in evaluation assessment and learning resources.
(3) To promote inclusive and sustainable development through Artificial Intelligence.

(4) To highlight the integration of AI in Education.

Research Methodology

The subject of the proposed research is based on systematic literature review design integrated with pedagogical innovation to analyze implication for teacher AI collaboration, learner autonomy and inclusive education. Used predefined inclusion and exclusion criteria which directly related with AI and practice of pedagogical to analyze process framework.

Literature Review

(1) Gian, Nguyen Mish. (2026). The Role of Artificial Intelligence in pedagogical Innovation and strategic Management in Higher Education. Journal of Artificial Intelligence and Technological Development – In this Author has explained how AI is being used at the pedagogical level or classroom level, management level, and institutional level. Author has discussed the benefits of AI, while also discussing algorithmic bias, privacy issues and issues related to technology. Ethical boundaries and ethics by design have also been included, but some gaps can also see here that is Proper integration of NEP-2020 was not found. Empirical evidence in the Indian context is included which not sufficient. There is no quantitative measurement of student performance.

(2) Neto, Alcides Feitosa. (2026) Artificial Intelligence in the pedagogical process: Technological innovation, Transparency, Limits and Responsibility. IOSR Journal of Research and Method in Education. Here the writer has described the Integration of AI in the pedagogical process, ethical issues of different elements, supervision, evaluation, responsibility and intellectual authorship. It also described that there is no empirical study on actual students. There is not detailed study of the actual experiences of teachers and no sufficient evidence regarding students' perception. There is no specific analysis of these, so the Indian context of Education has not been given a specific focus. There is no comparative evaluation of specific AI tools.

(3) Moin, Md Alaun. (2026) Curriculum Design and pedagogical Innovation in the Time of Artificial Intelligence: Conceptual and Empirical Investigation, Journal of Applied Artificial Intelligence in Education. Author explained in his Article to Integration of AI within the curriculum, pedagogical Innovation, assessment redesign, teacher AI competency, ethical governance, ethical awareness and transparency. Equity and student-centered education have also been included. But there are also some research gaps that is the sample consists of 100 stakes holders, The authors have mentioned the limitation of the sample and it is not generalizable. It is a cross-sectional study, which is a very important limitation. A longitudinal study should be conducted; there is no systematic empirical analysis of NEP-2020.There is also no framework for the integration of the Indian Knowledge System (IKS).

(4) Guan, Chong. (2020) Artificial Intelligence innovation in Education: A twenty-year data-driven historical analysis. International Journal of Innovation Studies – This paper explained the evolution of AI and Deep Learning in Education research trends, students profiling, student performance, dropout risk, prediction, academic achievement, paradigm shifts and personalized learnings. There are some research

gaps identified by me which is there is no connection with the research papers on the Indian Knowledge system, there is no direct empirical measurement of teacher competency, Indian Education policy context has not been covered, the alignment of NEP-2020 with the Indian Education system has not been examined.

Integration of AI in Education with Reference to NEP 2020

I want to say that the use of AI tools in education is not the only importance of it in education. The aim is to incorporate AI into the curriculum, pedagogy, assessment, teacher development, administration and learner development of the educational system. The objective is to understand the development of AI and to use it in the classroom to search the content and provide information to the student so that the learning of the students can become better. The use of AI tools should be done according to the educational needs. Before using it, pedagogical objectives and appropriate its applications should be identified. Human supervision should be ensured and the learning outcome should be seen as an AI tool. It should be used in the classroom to achieve the objective can be better. For student's educational use is important in Artificial Intelligence, it can help in formative assessment, question generation, feedback and learning process analysis. UNESCO has also said that this technology of AI learning and learning assessment can support but for this learning methodology needs thoughtful integration it provides teachers with customized content, learning designs, facilitator methods and evaluators, which can be further developed.

AI and NEP-2020 are related to each other where AI is used as a technology for student centered, flexibility and inclusiveness. Technology enabled education provides a learner centered approaches and helps learners according to their needs through content and feedback. Multidisciplinary approach of learning is also related to the boundaries of NEP-2020 technologies. It is critical thinking and creativity are introduced in this context. NEP-2020 mainly focuses on students critical thinking, problem solving and creativity. AI can also change the role of the teacher into a facilitator and mentor. NEP 2020 focuses on examination and evaluation through assessment and it also focus on learning outcomes and competencies .AI has the potential to make education inclusive by using translation, speech to text, text to speech, accessibility tools to address learning needs. Learners can get support according to their needs through this NEP 2020 provides opportunities to promote inclusiveness. Scientific study of student performance, dropout rates, teaching quality and curriculum effectiveness has become possible with the assistance of AI. In qualitative research, interviews, and documents can also be analyzed automatically. Although AI is extremely useful, problems such as data security, digital inequality, lack of technical training and ethical issues also arise. In conclusion. it can be said that through the combined efforts of AI and NEP2020, research methodologies are becoming more advanced, effective, and reliable. If technology is used in a balanced and ethical manner, Indian education and research can achieve new heights at the global level. Artificial Intelligence has not only changed the nature of education but also made the methodologies of educational research more scientific, rapid and accurate. The National Education policy 2020 (NEP-2020) places special emphasis on research, innovation and evidence -based policy making. This research article analyzes AI based research methodologies, their nature, utility, possibilities, and challenges. Research is the backbone of

any education system. NEP-2020 encourages the development of a research culture, innovation and multidisciplinary studies in India. AI has made traditional research methodologies more advanced, data – driven and authenticate. Artificially Intelligence is a technology in which machines are capable of learning, analyzing reasoning and making decisions. Through the coordination of AI and NEP-2020, Indian educational research can become more scientific, reliable and globally oriented. In the coming time, the success of research will depend on how wisely and ethically we use technology.

Conclusion

In this topic, many contents have been covered whereas the conclusion of this research paper is as by using AI, the learning process can be made more adaptable, interactive, inclusive, and learner centered. Through this, AI can change learning activities according to the needs of learners. Its move away from the one size fits all approach and making learning flexible. In this assessment is not only evaluation but is also a part of learning progress. It has the possibility of inclusiveness for all type of learner, which promotes equity and provides learning opportunities to all learners. The combination of NEP-2020 and Artificial Intelligence is leading Indian educational research into a new era. It is not only advancing research methods but also providing new opportunities to students, teachers and policymakers. By overcoming the challenges with effective solutions and moving forward, it is certain that future education will be more inclusive, data driven and effective. The present scenario of technology is the new era of information and communication technology. The nature of education is no longer limited to being classroom centered, it has now become digital, online and technology assisted. AI has made the teaching -learning process more personalized, effective and accessible. NEP-2020 also gives priority to technological integration and digital empowerment in education.

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STUDENT ENGAGEMENT AND WELL-BEING

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Abstract

Student engagement and well-being are closely interconnected components that significantly influence students' academic success, personal growth, and overall quality of life in educational settings. Student engagement refers to the level of interest, motivation, participation, and involvement that students demonstrate in academic and extracurricular activities. Well-being, on the other hand, encompasses students' physical, mental, emotional, and social health, as well as their overall sense of happiness, satisfaction, and belonging. Understanding the relationship between these two dimensions is essential for creating supportive and effective learning environments. This paper explores the relationship between student engagement and well-being and how active participation in learning activities can influence students' overall health and educational experiences. Higher levels of engagement can promote motivation, confidence, social connectedness, and a sense of purpose, which may contribute positively to students' emotional and psychological well-being. Similarly, students who experience positive well-being are more likely to participate actively in classroom activities, develop meaningful relationships with peers and teachers, and demonstrate greater motivation toward their studies. Thus, engagement and well-being can reinforce each other and create a positive cycle that supports academic and personal development. The paper also highlights the importance of supportive teaching practices, positive peer relationships, inclusive learning environments, and opportunities for student participation in promoting both engagement and well-being. Conversely, low engagement, academic pressure, social isolation, and inadequate institutional support may negatively affect students' mental health and academic performance. Therefore, educational institutions should adopt holistic approaches that address both academic and well-being needs. By recognizing and strengthening the connection between student engagement and well-being, institutions can enhance academic achievement, student retention, resilience, and overall educational satisfaction. Ultimately, fostering an environment where students feel motivated, supported, valued, and connected can contribute to their long-term success and healthier educational experiences.

Key words: student engagement and well-being, resilience

INTRODUCTION:

Education plays a crucial role in shaping students' academic success, personal development and future opportunities. Student engagement and well-being refers to the level of students active participation, interest and involvement in learning activities. Student well-being refers to the overall physical, emotional, psychological and social health of students. Students engagement could be described as the holy grail of learning due to its relationship with positive educational outcomes both inside and outside of school. student engagement is a part

of educationally purposive activities. It is correlated to positive outcomes of student success and development like satisfaction, persistence academic achievement and social engagement.

MEANING OF STUDENT ENGAGEMENT AND WELL-BEING

- Student engagement and well-being refers to a student's active participation in learning and their overall physical, mental and emotional health within an educational setting.
- Student engagement can be understood as a developmental process comprised of student thoughts, feelings, beliefs, and behaviors in relation to the schooling context and his or her lifelong learning trajectory.
- Student well-being is a positive state of mental, emotional, and physical functioning that allows learner to thrive.
- Well-being is experiencing happiness, life satisfaction, joy, and positive emotions while avoiding severe distress.
- Having a sense of purpose, personal growth, autonomy, and fulfilling one's true potential.
- **Resilience** means the ability to cope with academic pressure, setbacks, failures, or personal problems and still remain motivated and continue their studies.

Importance of student engagement

- **Better Memory and Learning**

Active engagement helps students process and retain information more effectively. Students who participate in discussions, practical activities, problem-solving exercises, and collaborative learning are more likely to understand and remember concepts.

- **Higher Academic Achievement**

Engaged students generally devote greater effort to academic tasks and are more likely to complete assignments and prepare for examinations. Consistent participation can therefore contribute to improved academic performance.

- **Development of Critical Thinking**

Engagement encourages students to question information, analyze problems, discuss different perspectives, and develop solutions. These activities promote critical thinking and higher-order cognitive skills.

- **Positive Behavior**

Students who feel connected to their educational environment are more likely to demonstrate positive classroom behavior. Engagement can reduce disengagement, absenteeism, and disruptive behavior.

- **School and Institutional Connection**

Engagement helps students develop a sense of belonging to their school, college, or university. When students feel that they are respected and valued members of an educational community, they are more likely to participate actively.

- **Increased Confidence**

Successful participation in academic and social activities can improve students' self-confidence and self-efficacy. Completing difficult tasks and contributing to classroom discussions can help students develop belief in their own abilities.

Importance of well-being

Well-being is a multidimensional construct that includes emotional and social health. Also it influences not only academic performance but also student's ability to life challenges.

- **Mental Health:** mental health is a critical element of student well-being. high level of stress, anxiety, and depression can hinder a student's ability to engage fully in the educational experience. Positive mental health promotes resilience and adaptive coping mechanisms that enhance engagement.
- **Physical Health:** It affects cognitive function and, consequently, engagement. Good nutrition, regular exercise, etc are vital for maintaining energy levels and focus.
- **Social Relationships:** social support from peers, family, and educators plays key role in influencing student well-being. Strong relationship foster a sense belonging and community, both impacting engagement and emotional health.
- **Personal Agency:** Autonomy and a sense of control over one's life choices significantly and enhance well-being. When students feel empowered to make decisions regarding their loving.

DIMENSIONS OF ENGAGEMENT

- **Behavioral engagement:** Involves attendance, rule-following, and participation in school activities, which builds self-efficacy and confidence.
- **Emotional engagement:** Reflects feelings of belonging and interest toward peers and teachers ,serving as a primary drive for overall student happiness.
- **Cognitive engagement:** Represents the mental investment and psychological effort a learner dedicates to mastering difficult concepts.

DIMENSIONS OF WELL-BEING

- **Emotional:** Emotional well-being involves recognizing and managing emotions, coping with stress, developing confidence, and maintaining resilience.
- **Physical:** Physical well-being includes healthy nutrition, sufficient sleep, physical activity, personal health, and healthy lifestyle practices.
- **Social:** Social well-being involves developing supportive relationships with peers, family members, teachers, and the wider educational community.
- **Intellectual:** Intellectual well-being involves curiosity, creativity, critical thinking, learning new skills, and developing an interest in lifelong learning.
- **Spiritual:** Spiritual well-being may involve finding meaning and purpose in life and developing personal values and beliefs. It does not necessarily refer only to religious practices.
- **Environment:** Feeling safe, comfortable, and connected to the physical environment, including the classroom, campus, home, and community.
- **Occupational:** Experiencing satisfaction and purpose in academic work, setting meaningful goals, managing responsibilities, and maintaining a healthy balance between study and other activities.

- **Financial:** Having basic financial security, developing responsible money-management skills, and feeling confident about managing financial needs and decisions.

THE INTERCONNECTEDNESS OF ENGAGEMENT AND WELL-BEING

Student engagement and well-being are closely interwoven dimensions of the educational experience, reflecting how learners interact with academic tasks, peers and institutional supports, and how these interactions influence their psychological health. Engagement is characterized by students' vigor, dedication and absorption in their studies, whereas well-being encompasses positive effect, life satisfaction and the absence of distress such as burnout. Engaged students tend to exhibit high levels of well-being; they are more likely to have positive relationships, practice good mental health and adopt healthier lifestyles. Likewise, students with better well-being engage more deeply in their educational experiences.

1. **Positive outcomes of engagement:** Students who are engaged in their learning often report greater satisfaction with their educational experience, leading to higher retention rates and improved academic performance, active participation in class and extracurricular activities can foster a sense of achievement and purpose, contributing positively to overall well-being.
2. **Impact of well-being on engagement :** Students with high level well-being are more likely to participate actively in their academic environment. Positive emotions, reduced stress, and supportive relationship enhance students cognitive and emotional investments in their studies, thereby increase engagement. Several factors influence the extent to which students engage in their studies and their levels of well-being.

HOW WELL-BEING BOOSTS ENGAGEMENT

The connection goes both ways. Students who feel healthy and happy have more energy for school.

- **Positive moods:** Good emotional health increases motivation to learn.
- **Better focus:** students without burnout or severe distress can invest more cognitive effort into though tasks.
- **Lower stress and burnout:** Managing stress and preventing burnout keeps workers positive, motivated, and willing to go the extra mile.
- **Grater loyalty:** When get the supports learners feel cared for and twice as likely to stay engaged.
- **Better problem –solving:** A healthy balanced mental state helps to think creatively and solve hard problems.

HOW ENGAGEMENT BOOSTS WELL-BEING

When student actively participate in school, their mental health improves in clear ways:

- **Lower stress:** Engaged learners find better ways to handle anxiety and bounce back from failure.
- **Higher confidence:** taking part in group tasks and discussions builds self-esteem.
- **Stronger connections:** Working with friends and mentors creates a safe community network.

- **Sense of purpose:** connecting daily tasks to a larger goal gives people meaningful direction, which increases life satisfaction.
- **Autonomy and control:** having a say in how work gets done reduces frustration and prevents chronic stress.
- **Flow and immersion:** being deeply absorbed in an activity –know as flow- helps quiet anxious thoughts and cultivates positive emotions.
- **Reduced burnout:** Higher involvement and motivation lead to lower emotional exhaustion and fewer stress – related health complaints.

FACTORS INFLUENCING STUDENT ENGAGEMENT AND WELL-BEING

- **Teaching practices :** Effective teaching practices, such as differentiated instruction, active learning and fostering a positive classroom environment, enhance student engagement. Educators who build positive relationships with students and who demonstrate enthusiasm for their subjects typically see high engagement levels.
- **School Environment** : A supportive and inclusive school culture can significance boosts student well-being engagement. Safety, respect, and a sense of community are essential elements of an environment that encourages students participation.
- **Parental Involvement**: Families play an important role in student engagement and well-being. Active parental involvement can promote academic success and emotional support, reinforcing positive attitudes toward learning.
- **Peer influence** : peers significantly impact each others engagement levels and well-being. Supportive peer relationships can enhance social engagement with negative interactions may lead to disengagement and lower well-being.

ROLE OF TEACHERS AND EDUCATIONAL INSTITUTIONS

Teachers and educational institutions have a significant responsibility in promoting student engagement and well-being. Teachers can create engaging classrooms by using interactive teaching methods, encouraging questions, recognizing student achievements, and providing constructive feedback.

Educational institutions should also create opportunities for students to participate in sports, cultural activities, clubs, leadership programs, and community activities. Such experiences can support social development and confidence.

Counseling and mental health support should be accessible to students who experience significant academic or personal difficulties. Institutions should encourage students to seek help without fear of stigma.

Student voice is another important element. Students should have opportunities to express their opinions about learning activities, institutional policies, and support services. Giving students an appropriate degree of autonomy can strengthen their sense of belonging and responsibility.

NEP 2020 Recommendations Related to Student Engagement and Well-Being

The **National Education Policy (NEP) 2020** emphasizes holistic development rather than focusing only on academic achievement.

- **Holistic development:** Education should support students' intellectual, emotional, social, physical, and ethical development rather than concentrating only on examination results.
- **Student-centered learning:** NEP 2020 promotes engaging and interactive learning experiences in which students actively participate in the learning process. Curriculum and pedagogy should encourage creativity, critical thinking, and meaningful participation.
- **Mental health and well-being:** The policy recognizes psycho-social well-being, good health, fitness, and emotional development as important components of quality education.
- **Sports and physical activities:** Students should have opportunities to participate in sports, physical education, cultural activities, clubs, and other activities that support physical and social well-being.
- **Counseling and emotional support:** NEP 2020 recommends counseling systems in educational institutions to help students manage stress, emotional difficulties, and adjustment-related concerns.
- **Positive and supportive learning environment:** Schools and higher education institutions should provide safe, inclusive, stimulating, and supportive environments where students feel respected and valued.
- **Student participation:** Students should receive opportunities to participate in sports, arts and culture clubs, eco-clubs, activity clubs, community service, and other activities. Such participation can strengthen engagement, confidence, belonging, and social development.
- **Inclusive education:** NEP 2020 emphasizes equitable and inclusive educational opportunities for students from different social, economic, and educational backgrounds.
- **Flexible curriculum:** Greater flexibility and choice in learning can help students pursue their interests, abilities, and aspirations, thereby increasing motivation and engagement.
- **Experiential learning:** Learning through activities, projects, discussions, practical experiences, and problem-solving is encouraged to make education more meaningful and engaging.
- **Teacher development:** NEP emphasizes continuous professional development of teachers so that they can use effective and innovative teaching approaches.
- **Reduced examination pressure:** The policy encourages competency-based and formative assessment and seeks to move away from excessive dependence on high-stakes examinations.
- **Life skills and resilience:** Education should help students develop communication, cooperation, problem-solving, decision-making, and other life skills that enable them to cope with challenges and develop resilience.

CONCLUSION

Student engagement and well-being are essential and interconnected aspects of a successful educational experience. Student engagement involves students' active participation, interest, motivation, and commitment to learning, while well-being includes their physical, emotional, psychological, social, and intellectual health. The discussion in this paper highlights that these two factors influence one another and play an important role in students' academic achievement, personal growth, and overall development. Students who are actively engaged in learning are more likely to experience greater confidence, satisfaction, motivation, stronger relationships, and a sense of purpose. At the same time, students with positive well-being are more capable of concentrating, participating in classroom activities, managing academic pressure, and maintaining motivation toward their studies. Therefore, engagement and well-being can create a positive cycle in which one strengthens the other. In conclusion, promoting student engagement and well-being is essential for creating meaningful, supportive, and effective educational experiences. When students feel valued, connected, supported, and motivated, they are more likely to succeed academically and develop resilience to overcome challenges. Thus, educational institutions, teachers, families, and peers should work together to foster environments that promote both active engagement and positive well-being, ultimately helping students achieve sustainable academic and personal success.

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ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCES AND HUMANITIES

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Abstract

Artificial Intelligence (AI) is revolutionizing education by offering creative methods for teaching and learning in a variety of fields, including social science. With a focus on how AI may improve student engagement, critical thinking, personalized learning, and access to a variety of educational resources, this article explores the use of AI in social science education. Teachers may create interactive learning exercises, analyze social data, create educational resources, and provide students fast feedback with the use of AI-powered solutions. These technologies can also help with data analysis, virtual debates, simulations, and the investigation of complicated social topics from several angles in social science education. But integrating AI also raises issues with academic integrity, bias, false information, data privacy, digital inequality, and the evolving role of educators. Thus, proper teacher training, ethical standards, digital literacy, and critical assessment of AI-generated information are necessary for the effective usage of AI. In order to provide more inclusive, engaging, and learner-centered social science education, the essay makes the case that AI should support teachers rather than take their place. Students' analytical, digital, and critical-thinking abilities can be enhanced by thoughtful AI integration, which also equips them to comprehend and act ethically in a society that is becoming more and more reliant on technology.

Keywords: *Artificial Intelligence (AI), Social Science Education and analytical*.

Introduction

The sector of education is undergoing major changes as a result of the quick growth of artificial intelligence (AI). Teaching, learning, assessment, content development, and educational decision-making are all being supported by AI-based tools. Teachers are required to not only comprehend the potential of AI in this evolving educational environment, but also to apply it ethically and successfully to enhance students' educational experiences. There are many prospects for the effective integration of AI in social science education, which focuses on society, human behavior, culture, politics, economics, history, and social interactions. Teaching social science frequently necessitates that students grasp difficult ideas, consider other viewpoints, analyze data, and hone their critical and analytical thinking abilities. It can occasionally be challenging to relate these ideas to students' real-world experiences when using traditional teaching approaches. Through interactive learning exercises, individualized materials, virtual simulations, data analysis, intelligent tutoring systems, and AI-assisted conversations, AI can open up new possibilities. These programs can assist students in delving deeper into social issues and interacting with course content in a way that best suits their unique needs and skills. AI can help social science instructors with lesson planning, creating educational resources, evaluating students, and giving feedback. AI tools can be used by

educators to create inquiries, arrange data, create lesson plans, and pinpoint learning challenges. AI should not, however, be seen as a simple substitute for traditional instruction or the function of the instructor. Values, ethical reasoning, interpretation, empathy, and comprehension of various human experiences are all part of social science education—areas where human judgment and instructor supervision are still crucial. **Importance in AI-Based Social Science Education**

Artificial intelligence (AI) has emerged as an essential technical resource in modern schooling. Its application in social science education can benefit both teachers and students by making the teaching-learning process more interactive, individualized, accessible, and engaging. Because social science is concerned with human society, culture, history, politics, economics, citizenship, and social interactions, AI can give new avenues for investigating difficult challenges and integrating classroom learning to real-world scenarios.

1. **Enhances Learning Experience**

AI can make social science learning more interactive through simulations, virtual environments, digital storytelling, interactive questions, and educational applications. These approaches can help students understand difficult concepts more easily.

2. **Supports Personalized Learning**

Students differ in their learning abilities, interests, and pace. AI can provide differentiated learning materials and activities according to individual needs. This can help learners receive additional explanations, practice, and resources when required.

3. **Promotes Critical Thinking**

AI can expose students to multiple perspectives on social, political, economic, and cultural issues. Teachers can use these resources to encourage students to compare viewpoints, examine evidence, identify assumptions, and develop independent conclusions.

4. **Facilitates Fast Information Access**

Students may find, arrange, summarize, and investigate vast amounts of knowledge with the use of AI tools. In social science, where students regularly work with historical records, statistics, social studies, case studies, and research materials, this is especially helpful.

5. Increases Student Involvement

Activities that make use of technology can boost students' engagement and interest. AIpowered tests, interactive learning exercises, conversational tools, and simulations can make the classroom more interesting..

6.Assists Teachers

Lesson plans, discussion topics, exercises, worksheets, case studies, and evaluation materials can all be created with the help of AI. Teachers can spend more time engaging with kids as a result of the everyday workload being lessened.

7. Promotes Research Abilities

AI can assist students investigate research subjects and expose them to a variety of knowledge sources. Students can learn how to develop questions, gather information, compare sources, and assess evidence with the right pedagogical direction.

8. Makes Complex Social Issues Easier to Understand

Numerous social science ideas entail intricate connections between various elements. In order

to help students comprehend topics like population change, economic inequality, migration, political systems, and social transformation, artificial intelligence (AI) can aid with data presentation, visualization, and simulation development.

9. Promotes AI and Digital Literacy

AI in social science education aids in the development of digital abilities that are becoming more and more important in social, professional, and academic contexts. Pupils can understand how AI functions, identify its limitations, and make responsible use of it

10. Encourages Inclusive Education

AI-based educational resources can support students with varying learning needs and offer various learning material types. AI can help create more inclusive learning opportunities when used carefully.

Role of Teacher in AI-Based Social Science Education

Artificial Intelligence (AI) is creating new possibilities in education by supporting teaching, learning, assessment, research, and educational management. In social science education, AI can provide access to information, interactive learning resources, data analysis, simulations, and personalized learning.

1. Teacher as a Facilitator

The teacher facilitates learning by helping students use AI tools appropriately. Instead of simply transferring information, teachers create opportunities for students to explore social science topics, ask questions, investigate problems, and construct knowledge independently.

2. Teacher as a Learning Guide

Students may obtain large amounts of information from AI, but they may not always know how to interpret it. Teachers guide students in selecting relevant information, understanding concepts, comparing viewpoints, and connecting knowledge with real-life experiences.

3. Teacher as a Critical Thinker and Promoter of Critical Thinking

Social science involves different opinions, interpretations, and perspectives. Teachers encourage students to critically examine AI-generated information and identify facts, assumptions, opinions, and possible biases. They help learners develop logical reasoning rather than accepting information automatically.

4. Teacher as a Content Expert

Teachers possess subject knowledge that enables them to judge whether AI-generated material is accurate, relevant, and appropriate. They can correct misconceptions and provide explanations when AI-generated responses are incomplete or misleading.

5. Teacher as a Curriculum Designer

Teachers determine how AI can be incorporated into the social science curriculum. They select appropriate tools and learning activities according to curriculum objectives, students' educational levels, and classroom requirements.

6. Teacher as an Instructional Designer

Teachers can use AI to support the preparation of lesson plans, worksheets, questions, case studies, projects, simulations, and learning materials. They refine AI-generated resources and adapt them to students' needs rather than using them without evaluation.

7. Teacher as a Mentor

Students need personal guidance and encouragement during the learning process. Teachers act as mentors by understanding students' interests, abilities, difficulties, and aspirations. They provide emotional and academic support that AI cannot fully provide.

Conclusion

Artificial Intelligence (AI) is becoming a key instrument for changing social science teaching. Teaching and learning can become more interactive, adaptable, customized, accessible, and interesting with its use. AI can help students with knowledge exploration, comprehension of difficult ideas, data analysis, research skill development, and instant feedback. Additionally, it can help teachers with lesson planning, learning material preparation, assessment, and the creation of creative classroom activities. Through the development of digital literacy, critical thinking, creativity, problem-solving skills, and responsible citizenship, AI-based social science education has the potential to equip students for a technologically advanced society. The goal of education in the future should be to establish a harmonious coexistence of artificial and human intelligence.

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IMPACT OF 5E LESSON PLAN-BASED CONSTRUCTIVIST APPROACH IN SOCIAL SCIENCE ON THE ACADEMIC ACHIEVEMENT OF THE SECONDARY SCHOOL STUDENTS

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Abstract

The present study investigates the impact of the 5E lesson plan–based constructivist approach (Engage, Explore, Explain, Elaborate, and Evaluate) on the academic achievement of secondary school students in Social Science. Grounded in constructivist learning theory, the study emphasizes learner-centered instruction, active participation, and experiential learning as opposed to traditional teacher-centered methods. A quasi-experimental design was adopted, involving two groups: an experimental group taught through the 5E instructional model and a control group taught using conventional teaching methods of 9th grade students from CBSE. The sample consisted of secondary school students selected through purposive sampling. Data were collected using a standardized achievement test administered as both pre-test and post-test. The collected data were analyzed using appropriate statistical techniques such as mean, standard deviation, and t-test to determine the significance of differences between groups. The findings revealed that students exposed to the 5E constructivist approach demonstrated significantly higher academic achievement compared to those taught through traditional methods. Additionally, the approach fostered better conceptual understanding, critical thinking, and student engagement in Social Science learning. The study concludes that the 5E lesson plan–based constructivist approach is an effective pedagogical strategy for enhancing academic achievement among secondary school students. It recommends the integration of constructivist models in classroom teaching and teacher training programs to improve the quality of Social Science education.

Keywords: *5E Model, Constructivist Approach, Social Science Education, Academic Achievement, Secondary School Students, creativity intelligence and interest.*

Introduction

Education in the twenty-first century emphasizes learner-centered approaches that promote critical thinking, creativity, collaboration, and active participation among students. Traditional methods of teaching in Social Science often rely on rote memorization and teacher-centered instruction, which may limit students' understanding and application of concepts in real-life situations. In response to these challenges, constructivist approaches to teaching have gained significant importance in modern pedagogy. Constructivism views learning as an active process in which learners construct knowledge through experience,

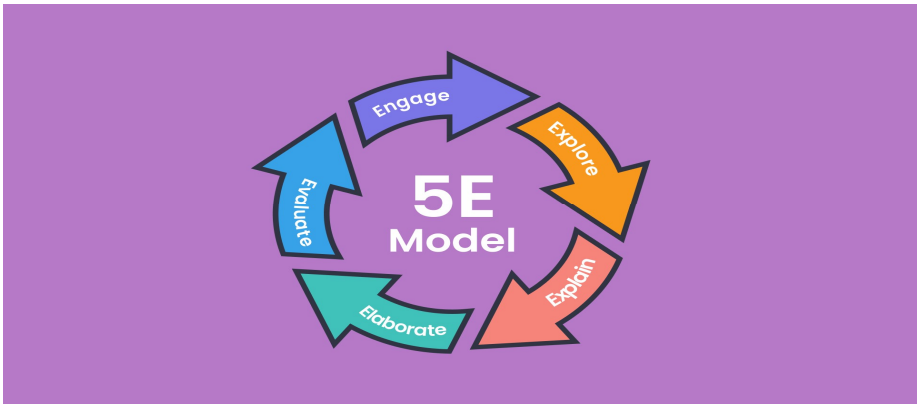
interaction, inquiry, and reflection.

Among the various constructivist models, the 5E lesson plan model has emerged as an effective instructional approach for enhancing classroom learning. Developed on the principles of constructivist theory, the 5E model consists of five phases: Engage, Explore, Explain, Elaborate, and Evaluate. This model encourages students to participate actively in the learning process, connect prior knowledge with new experiences, develop conceptual understanding, and apply knowledge meaningfully. The role of the teacher shifts from being a transmitter of knowledge to a facilitator of learning.

Social Science, as a school subject, plays a vital role in developing social awareness, democratic values, critical understanding, and problem-solving abilities among secondary school students. However, many students perceive Social Science as theoretical and less engaging when taught through conventional lecture methods. Therefore, innovative teaching approaches are required to make the subject more interactive, meaningful, and student-centered. The 5E lesson plan-based constructivist approach provides opportunities for experiential learning, discussion, collaborative activities, and reflective thinking, thereby improving students' academic achievement and interest in the subject.

Academic achievement is considered one of the important indicators of effective teaching and meaningful learning. Several educational studies have highlighted that constructivist teaching approaches significantly improve students' understanding, retention, motivation, and performance compared to traditional methods. In the context of secondary education, where learners undergo cognitive and social development, the implementation of the 5E instructional model can greatly influence their learning outcomes in Social Science.

The present study focuses on examining the impact of the 5E lesson plan-based constructivist approach on the academic achievement of secondary school students in Social Science. The study aims to compare the effectiveness of constructivist teaching with conventional teaching methods and to understand how active learning strategies contribute to improved academic performance. The findings of this study may provide valuable insights for teachers, curriculum planners, and educational researchers in adopting innovative pedagogical practices for enhancing the quality of Social Science education.



Need and significance of the study:

Bybee and colleagues translated decades of research into a brief and memorable set of five words that instructors could actually remember and use. The 5E model team reasoned that to

have significant impact on classroom instruction, a model would need to have a more tool-like quality than most scholarly models did at the time (Bybee et al., 2006 blue right-pointing triangle). The 5E model is based on both a conceptual change model of learning and a constructivist view of learning.

The former asserts that for conceptual learning and enduring understanding to occur,
the learner must become aware of and dissatisfied with their prior ideas about a topic, become receptive to new ideas, and then integrate new information encountered in a classroom into their existing conceptual framework (Posner et al., 1982 blue right-pointing triangle).

The former asserts that for conceptual learning and enduring understanding to occur,
the learner must become aware of and dissatisfied with their prior ideas about a topic, become receptive to new ideas, and then integrate new information encountered in a classroom into their existing conceptual framework (Posner et al., 1982 blue right-pointing triangle).

Review of Related Literature

1. **Lena Ballone (2004)** implemented and reported on inquiry-based teaching in science education. These reports argue that inquiry needs to be a central strategy of all science curricula. Using a learning cycle approach in the classroom helps to facilitate inquiry practices because learning cycles focus on constructivist principles and emphasize the explanation and investigation of phenomena. Bybee (2015) argues that the 5E model is still an effective method for teachers to design science lessons aimed at meaningful understanding and active construction of knowledge.
2. **Kimberly D Tanner (2010)** described in order matters: using the 5E model to align teaching with how people learn. For many instructors he has mentioned about the order of ideas. With the increasing use of active-learning strategies, class sessions are moving minutes. So, what is the optional order for sequencing these elements to maximize student learning of biology.
3. **Canbazoglu Bilici et.al. (2016)** assessed pre service teachers‟ TPACK through observations and lesson plans. The results showed that the TPACK-focused Science Methods course had an impact on pre-service teachers' TPACK to varying degrees. Most importantly, the course helped teachers gain knowledge of effective usage of educational technology tools. Conclusion: Teacher education programs should provide opportunities to pre-service teachers to develop their TPACK so that they can effectively integrate technology into their teaching.
4. **Namdar Bahadir (2018)** The purpose of this study was to investigate and better understand pre service science teachers' (PSTs') practices when critiquing and revising 5E (engage, explore, explain, elaborate, and evaluate) lesson plans. A single instrumental case study approach was used. The participants adopted some critiques on the essential features of inquiry and inquiry orientation of the lesson plans, such as formulating explanations. However, they failed to address critiques on organizing data and evaluating explanations by considering alternative explanations. After the critique activity, the inquiry orientations of half of the lesson plans increased. Implications for science teacher education concerning the 5E lesson plan critique activities are discussed.

Objectives of the study

1. To develop and validate lesson plan based on Herbartian (traditional) and constructivist approach(5E) model in social science in 9th standard.
2. To find out the reaction of the students and teachers towards constructive approach model of teaching

1) Objective:

To develop and validate lesson plan based on Herbartian (traditional) and constructivist approach(5E) model in social science in 9th standard.

1. Development of Lesson Plan Based on Constructivist approach Model

The Constructivist approach was proposed by **Rodger Bybee and his team**, which emphasizes meaningful learning by connecting new knowledge with the learner's existing cognitive structure. In this study, lesson plans in **Social Science** were developed using the principles of the Constructivist approach Model.

The development process involved the following steps:

1) **Selection of Topic**:

Suitable topics from the Social Science syllabus were selected based on their relevance and importance for secondary school students.

2) **Identification of Learning Objectives**:

Specific instructional objectives were framed in terms of knowledge, understanding, and application.

3) **Preparation of Constructivist approach**

An introductory organizer such as a concept map, diagram, chart, short explanation, or question was prepared to activate students' prior knowledge.

4) **Presentation of Learning Material**:

The teacher presents the lesson content in a structured and organized manner using examples, explanations, and teaching aids.

5) **Integration of New Knowledge**:

Students relate the new concepts with their existing knowledge through discussion, questioning, and activities.

6) **Evaluation and Feedback**:

At the end of the lesson, evaluation techniques such as quizzes, questions, and assignments are used to assess students' understanding. Through these steps, lesson plans were systematically designed to facilitate **meaningful learning and better retention of Social Science concepts.**

1. Validation of the Lesson Plan:

After developing the lesson plans, they were validated by experts to ensure their academic quality, relevance, and suitability for classroom teaching.

The validation process included the following steps:

1. Selection of Experts:

Experts in Education, Social Science, and Teaching Methodology were selected from universities, teacher education institutions, and experienced school teachers.

2.Preparation of Validation Tool:

A validation checklist or rating scale was prepared to evaluate the lesson plans based on

criteria such as:

- Clarity of objectives
- Relevance of constructivist approach
- Logical sequence of content
- Appropriateness of teaching methods
- Use of teaching aids
- Student participation
- Evaluation techniques

3. **Expert Review:**
   The developed lesson plans were submitted to the experts for review and suggestions.
4. **Modification of Lesson Plans**:
   Based on the feedback and suggestions of experts, necessary modifications and improvements were made in the lesson plans.
5. **Finalization of Lesson Plans:**
   After incorporating expert suggestions, the lesson plans were finalized for implementation in the experimental study.
   Thus, the lesson plans based on the Constructivist approach Model were systematically developed and validated by experts. This ensured that the lesson plans were pedagogically sound, scientifically organized, and suitable for improving students' academic achievement in Social Science.

2). Objective

To find out the reaction of the students and teachers towards constructive approach model of teaching

Reaction of the Students and Teachers towards Constructivist approach Model of Teaching:

1. **Introduction:**
   The Constructivist approach Model of teaching, developed by David P. Ausubel, is an important instructional strategy that helps students learn new concepts meaningfully by relating them to their prior knowledge. In the present study, the Constructivist approach Model was implemented in the teaching of Social Science to secondary school students. After the implementation of the lessons, the reactions of both students and teachers were collected through informal discussions, observation, and feedback. The responses indicated that the model had a positive influence on the teaching–learning process.
2. **Procedure followed in getting Reactions of students and teachers:**
   In the present study, the reactions of students and teachers towards the Constructivist approach Model of teaching were collected to understand their opinions and experiences regarding the effectiveness of this instructional strategy in teaching Social Science individually and summarized as follows:
3. **Reaction of Students towards Constructivist approach Model**
   The reactions of students towards the Constructivist approach Model were largely positive. Students expressed that the use of constructivist approaches such as charts, concept maps, introductory explanations, and questions at the beginning of the lesson helped them

understand the topic better. It enabled them to connect the new information with their previous knowledge and experiences.

Many students reported that the lessons taught through the Constructivist approach Model were clear, systematic, and easy to follow. The introduction of the lesson through an organizer provided them with a general framework of the topic, which helped them to grasp the main ideas more effectively. As a result, students felt more confident in understanding complex concepts in Social Science.

Students also mentioned that this method made the class more interesting and engaging. The use of visual aids, diagrams, and structured explanations attracted their attention and increased their curiosity to learn the topic in depth. The discussions and questioning sessions during the lesson encouraged students to participate actively in the classroom.

Another important reaction from the students was that the model helped in better retention of the subject matter. Since the information was presented in a meaningful and organized way, students were able to remember the content for a longer period of time. Some students also stated that they were able to recall the concepts easily during tests and examinations.

Furthermore, students felt that the Constructivist approach Model improved their thinking and understanding skills. Instead of memorizing facts, they were able to understand the relationships between different concepts. This helped them to develop a deeper understanding of Social Science topics.

However, a few students initially found it slightly difficult to adjust to the new method because they were more familiar with the traditional lecture method. But after a few classes, they became comfortable with the approach and appreciated its effectiveness.

4. Reaction of Teachers towards Constructivist approach Model:

The reaction of teachers towards the Constructivist approach Model was also highly favorable. Teachers observed that the model helped them to present the lesson content in a more organized and structured manner. The use of an constructivist approach at the beginning of the lesson helped them to introduce the topic clearly and prepare students mentally for learning new information.

Teachers reported that students showed greater attention and interest during the lessons taught through this model. The students were more attentive and participated actively in classroom discussions. This made the teaching process more interactive and effective.

Another important observation made by teachers was that the model helped in improving students' comprehension of difficult concepts in Social Science. When the lesson began with a general overview or organizer, students were able to understand the details of the lesson more easily.

Teachers also felt that the Constructivist approach Model encouraged meaningful learning rather than rote memorization. Students were able to relate new concepts with their existing knowledge, which helped them to develop a better conceptual understanding of the subject.

In addition, teachers stated that the model provided them with an opportunity to use various teaching aids such as charts, diagrams, maps, and concept maps. These teaching aids made the lesson more effective and helped students visualize the concepts clearly.

However, some teachers pointed out that the preparation of constructivist approaches requires

additional time and effort. Teachers need to carefully plan the lesson and design appropriate organizers to make the teaching effective. Despite this challenge, teachers agreed that the benefits of the model outweigh the difficulties.

Teachers also mentioned that the Constructivist approach Model is particularly useful in subjects like Social Science, where concepts are interconnected and require a clear understanding of relationships between ideas.

Overall Reaction

Overall, both students and teachers showed positive reactions towards the Constructivist approach Model of teaching. Students found the method interesting, understandable, and helpful in improving their academic achievement and retention of knowledge. Teachers appreciated the model for its ability to promote meaningful learning, active participation, and better organization of teaching content.

The findings suggest that the Constructivist approach Model can be effectively used in the teaching of Social Science at the secondary school level. It not only enhances students' understanding of the subject but also improves the overall quality of the teaching–learning process.

Educational Implications

1) The educational research and training agencies at state and national level may plan for training programs, workshops and orientation courses on constructivist approach model for pre-service and in-service teachers and teacher educators to enable them to develop an understanding and the required skills for the proper implementations of the models in actual classroom situations at different levels.
2) Especially, due weightage may be given to the programs for teacher educators at D.Ed., B.Ed. and M.Ed. level as the concept of models of teaching has been included in the syllabi of the said courses are reorganized recently giving room to the concept of models of teaching.
3) The attention of the directorates of textbooks at state and national level may be drawn towards sufficient provisions for identification and inclusion of constructivist approaches in the textbooks of all subjects of different levels in order to increase the teaching learning output.
4) The Constructivist approach Model provides teachers with a method for improving their presentations and enhancing students' abilities to learn from them.

Conclusions:

The effectiveness of constructivist approach model can be observed through the findings of the present study which has promoted active reception learning in experimental group i.e., Constructivist approach Group. Logically well-structured. constructivist approaches have played desired roles in the facilitation of integrative reconciliation between new content and the existing cognitive structure, and hence the constructivist approach model proved superior to traditional or conventional method of teaching. In other words the process of attainment of meaningful information and ideas is directly influenced by the constructivist approach model. Thus, it is evident that modern methods like constructivist approaches and the constructivist approach based self-learning strategies are very effective and useful instructional techniques in

the present context of the system of education in India. Needs and aspirations of average and above average students in terms of development of their academic achievement, Interest, Intelligence and creativity are well taken care through constructivist approach model of teaching. Hope that the findings of the present study would help to the classroom practitioners, administrators and policy makers.

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DIGITAL LIBRARIES AND THE FUTURE OF TEACHER EDUCATION

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Abstract

The rapid advancement of information and communication technologies has transformed higher education, particularly teacher education. Digital libraries have emerged as essential academic support systems for teachers, teacher educators, student-teachers and researchers, providing access to e-books, e-journals, online databases, multimedia resources and open educational resources. These services strengthen teaching, learning, research, professional development and lifelong learning while promoting flexible, accessible and learner-centred education. Digital libraries also encourage independent learning, critical thinking, research and innovation among student-teachers. This paper examines the concept, significance and major services of digital libraries in teacher education, highlighting their role in teaching-learning, research, professional development and information literacy. It also identifies challenges such as inadequate infrastructure, limited digital literacy and unequal access to technology, while exploring strategies and the future potential of digital libraries in the era of artificial intelligence and digital transformation.

Keywords: *Digital Libraries, Teacher Education, Digital Learning, Information Literacy, E-Resources, Educational Technology, Professional Development.*

Introduction

The twenty-first century has brought significant changes in the creation, storage, dissemination and use of information. Traditional libraries, once primarily centred on printed books and physical collections, have evolved into dynamic digital knowledge centres. Digital technologies now enable learners and researchers to access information resources anytime and from anywhere, making digital libraries an essential component of modern educational institutions. Teacher education plays a vital role in preparing competent teachers for schools and society. In the digital age, teachers require not only subject knowledge and pedagogical skills but also technological competence, information literacy, creativity and adaptability. Therefore, teacher education institutions must provide learning environments that help student-teachers develop these essential competencies. Digital libraries contribute significantly to this process by providing access to e-books, e-journals, theses, research reports, educational videos, online courses, institutional repositories and open educational resources. These resources enhance academic knowledge, research skills and awareness of contemporary developments in education. The growing importance of blended learning, online education and digital pedagogy has further increased the relevance of digital libraries. They support continuity in teaching, learning and research, particularly when physical access to institutions is limited. Thus, the effective integration of digital libraries can transform teacher education

by promoting personalized learning, collaborative research, innovation and continuous professional development.

Meaning and Concept of Digital Libraries

A digital library may be understood as an organized collection of digital information resources that are created, stored, managed and made accessible through electronic and network-based technologies. Unlike a traditional library, a digital library provides users with access to resources in electronic formats through computers, mobile devices and the internet.

Digital libraries may include:

- E-books and electronic textbooks
- E-journals and scholarly publications
- Online databases
- Digital repositories
- Theses and dissertations
- Conference proceedings
- Educational videos and multimedia resources
- Open educational resources
- Digital archives
- Online newspapers and magazines
- Research reports and project documents
- Learning management system resources

A digital library is not merely a collection of electronic documents. It is a system that facilitates the selection, organization, preservation, retrieval and dissemination of digital information. Effective digital libraries provide users with search facilities, metadata, subject gateways, remote access and user support services.

The concept of digital libraries is closely connected with the development of the knowledge society. In educational institutions, digital libraries function as important academic infrastructure by connecting learners and teachers with global sources of knowledge.

Objectives of Digital Library Services in Teacher Education

The major objectives of digital library services in teacher education institutions include:

1. To provide easy and timely access to quality academic and educational resources.
2. To support teaching, learning and research activities.
3. To promote independent and lifelong learning among student-teachers.
4. To develop information and digital literacy skills.
5. To provide access to current research and scholarly publications.
6. To support curriculum development and innovative pedagogical practices.
7. To facilitate remote and flexible access to information resources.
8. To promote collaboration and knowledge sharing.
9. To preserve institutional academic and research outputs.
10. To prepare future teachers for technology-enabled educational environments.

These objectives demonstrate that digital libraries have a broader educational role beyond the traditional function of storing and lending books.

Importance of Digital Libraries in Teacher Education

Digital libraries have become increasingly important in teacher education by supporting the development of academic, professional and technological competencies.

Access to Knowledge Resources: They provide student-teachers with access to books, journals and research publications on pedagogy, educational psychology, curriculum, assessment, inclusive education and educational technology.

Support for Flexible Learning: Twenty-four-hour access allows learners to use resources according to their individual needs and schedules, benefiting distance, working and blended-learning students.

Promotion of Independent Learning: Digital libraries encourage student-teachers to search, compare and evaluate information independently, promoting self-directed and lifelong learning.

Development of Research Competence: Access to journals, theses, dissertations and databases supports action research, educational research and evidence-based teaching.

Improvement of Teaching Quality: Teacher educators can use digital library resources to update their knowledge and enrich classroom teaching. Access to current literature enables them to incorporate new theories, teaching strategies and research findings into their instructional practices.

Major Digital Library Services for Teacher Education

Digital libraries can provide a variety of services designed to meet the academic and professional needs of teacher educators and student-teachers.

E-Book Services: Digital libraries provide access to electronic books on education, pedagogy, psychology, sociology, philosophy, technology and subject-specific teaching methods. E-books are convenient, searchable and easily accessible through computers and mobile devices.

E-Journal Services: Access to scholarly journals is essential for academic and research development. E-journals enable student-teachers and researchers to remain informed about recent developments in educational theory and practice.

Institutional Repositories: Institutional repositories preserve and provide access to the intellectual output of an institution. These may include research articles, dissertations, project reports, conference papers and faculty publications.

Digital Reference Services: Digital reference services enable users to receive academic assistance through electronic communication. Librarians can assist users in locating information, selecting databases and using digital resources.

Online Database Services: Academic databases provide access to specialized research literature. These resources are valuable for conducting literature reviews, research projects and advanced academic study.

Multimedia and Educational Resources: Digital libraries can provide access to educational videos, audio materials, simulations, presentations and interactive learning resources. Such materials are particularly useful for teacher education because they support the understanding of teaching methods and classroom practices.

Open Educational Resources: Open educational resources provide freely accessible teaching and learning materials. These resources can support teachers in developing lesson plans,

instructional materials and innovative classroom activities.

Remote Access Services: Remote access allows users to utilize library resources without physically visiting the institution. This service supports online, distance and blended learning.

Digital Libraries and the Teaching-Learning Process

Digital libraries can significantly enhance the teaching-learning process in teacher education by providing access to diverse learning materials such as research articles, case studies, educational videos and international publications. They promote active learning by encouraging student-teachers to search, evaluate and apply information, thereby developing critical thinking and inquiry skills.

Digital libraries also support collaborative and personalized learning through resource sharing, online discussions and access to materials based on individual academic needs. Furthermore, resources such as lesson plans, classroom videos, teaching demonstrations and case studies help student-teachers connect educational theory with practical teaching experiences.

Role of Digital Libraries in Developing Information Literacy

Information literacy is an essential competence for teachers in the digital age. It refers to the ability to identify information needs, locate relevant information, evaluate sources and use information ethically and effectively.

Digital libraries can help student-teachers develop the following competencies:

- Searching for reliable information.
- Using online catalogues and databases.
- Evaluating the credibility of digital sources.
- Identifying misinformation and unreliable content.
- Using citations and references appropriately.
- Understanding copyright and intellectual property.
- Avoiding plagiarism.
- Using information ethically.
- Organizing digital information.

Teachers who possess strong information literacy skills are better prepared to guide school students in the responsible use of information and technology.

Digital Libraries and Research in Teacher Education

Research is an important component of teacher education. Student-teachers and teacher educators require access to current and reliable information for conducting research studies.

Digital libraries support research by providing:

- Access to research journals.
- Literature review materials.
- Previous dissertations and theses.
- Research reports.
- Statistical and educational data.
- Citation and reference support.
- Institutional research repositories.

Digital access also makes it easier for researchers to study national and international developments. Researchers can compare educational systems, analyse current policies and

examine innovative teaching practices.

Furthermore, digital libraries support interdisciplinary research. Teacher education is closely connected with psychology, sociology, philosophy, technology and management. Digital resources enable researchers to access information across multiple disciplines.

Digital Libraries and Professional Development of Teachers

Professional development is a continuous process. Teachers must regularly update their knowledge and skills to respond to changes in curriculum, technology and society.

Digital libraries can support continuous professional development by providing access to:

- Online courses.
- Professional journals.
- Webinars and recorded lectures.
- Research publications.
- Educational policy documents.
- Teaching resources.

Through digital library services, teachers can engage in self-learning and professional reflection. They can also explore innovative practices used by educators in different parts of the world.

Digital libraries therefore contribute to the development of a culture of lifelong learning among teachers.

Emerging Technologies and the Future of Digital Libraries

The future development of digital libraries will be influenced by emerging technologies.

Artificial Intelligence: Artificial intelligence can improve information retrieval and user services. AI-based systems may provide personalized recommendations based on users' academic interests and information needs.

Cloud Computing: Cloud technology can improve the storage and accessibility of digital resources. It allows institutions to manage large collections and provide access from different locations.

Mobile Library Services: The increasing use of smartphones has created opportunities for mobile access to library resources. Mobile applications can make digital library services more convenient for students and teachers.

Data Analytics: Data analytics can help libraries understand user behaviour and improve services. Libraries can analyse resource usage and identify the academic needs of different groups of users.

Virtual and Immersive Learning: Virtual and immersive technologies may provide new opportunities for teacher education. Digital libraries could provide access to interactive simulations, virtual classrooms and immersive educational experiences.

Personalized Learning: Future digital libraries may become more learner-centred by providing personalized recommendations and adaptive learning resources based on individual academic needs.

Challenges in Implementing Digital Library Services

Despite their significant advantages, digital libraries face several challenges.

Inadequate Infrastructure: Many institutions lack sufficient computers, internet

connectivity, servers and technical facilities required for effective digital library services.

Digital Divide: Not all learners have equal access to digital devices and reliable internet services. This inequality may create barriers to the effective use of digital resources.

Lack of Digital Literacy: Some students and teachers may not possess sufficient skills to search, evaluate and effectively use digital information resources.

Financial Constraints: Subscription-based databases and digital resources can be expensive. Institutions may face difficulties in maintaining access to high-quality academic content.

Copyright Issues: Digital content must be used in accordance with copyright laws and licensing agreements. Institutions need to promote awareness about intellectual property and ethical use of information.

Cyber security and Privacy: Digital libraries must protect user information and institutional resources from unauthorized access, cyber threats and data breaches.

Resistance to Change: Some users may continue to prefer traditional methods of accessing information. Effective orientation and training are necessary to encourage the adoption of digital library services.

Strategies for Strengthening Digital Libraries in Teacher Education

Teacher education institutions should adopt systematic strategies to strengthen digital library services.

Develop Strong Digital Infrastructure: Institutions should provide reliable internet connectivity, sufficient computers, Wi-Fi facilities and secure digital platforms.

Conduct User Orientation and Training: Regular training programmes should be organized for student-teachers, faculty members and library professionals.

Promote Open Access Resources: Institutions should encourage the use of quality open-access journals, repositories and educational resources.

Integrate Digital Libraries with the Curriculum: Digital resources should be connected with classroom teaching, assignments, projects and research activities.

Strengthen Institutional Repositories: Teacher education institutions should preserve and showcase research publications, dissertations, conference papers and other academic outputs through institutional repositories.

Encourage Collaboration: Libraries should collaborate with faculty members, technology experts and educational institutions to improve services and resource sharing.

Develop Information Literacy Programmes: Information literacy should become an important component of teacher education programmes.

Ensure Inclusive Access: Digital library services should be accessible to all learners, including persons with disabilities and students from disadvantaged backgrounds.

Future Directions

The future of teacher education will be increasingly influenced by digital transformation. Digital libraries are likely to become integrated learning ecosystems rather than simply electronic collections of documents.

Future digital libraries may:

- Provide AI-assisted academic support.
- Offer personalized resource recommendations.

- Integrate with learning management systems.
- Support collaborative research environments.
- Provide interactive and multimedia learning resources.
- Strengthen open access to educational knowledge.
- Support multilingual information services.
- Provide mobile-first learning experiences.
- Promote inclusive and accessible educational resources.

The librarian's role will also continue to evolve. Future library professionals will function not only as custodians of information but also as digital learning facilitators, research support specialists, information literacy trainers and technology partners.

Teacher education institutions must therefore recognize digital libraries as strategic academic infrastructure for preparing future-ready teachers.

Conclusion

Digital libraries have the potential to transform teacher education by providing flexible access to knowledge, supporting research and professional development, promoting independent learning and strengthening information literacy. They enable student-teachers to access current educational resources and develop the competencies needed for teaching in a technology-driven society. Effective integration of digital library services requires adequate infrastructure, trained professionals, digital literacy and institutional support, while challenges related to access, affordability, copyright and cyber security must be addressed.

As future teachers need to learn continuously, evaluate information critically and integrate technology effectively, digital libraries can play a vital role in preparing competent, innovative and future-ready educators. Therefore, investment in digital library infrastructure and learner-centred services is essential for ensuring quality teacher education.

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ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE DEVELOPMENT: TRANSFORMING THE FUTURE

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Abstract

Sustainable development, defined as meeting present needs without compromising future generations, faces critical challenges including climate change, poverty, resource depletion, and inequality. Artificial Intelligence (AI) has emerged as a powerful enabling technology to address these challenges. This paper explores the role of AI in advancing the United Nations Sustainable Development Goals (SDGs). It examines AI applications across environmental sustainability, social equity, and economic growth. The study analyzes AI-driven solutions in climate modeling, precision agriculture, renewable energy optimization, smart cities, healthcare, and education. While highlighting immense potential, the paper also discusses ethical concerns, digital divide, energy consumption of AI itself, and governance issues. Through case studies and current literature, the paper argues that responsible, inclusive, and transparent deployment of AI is crucial for achieving a sustainable and equitable future by 2030 and beyond. It concludes with policy recommendations for integrating AI into national sustainability strategies.

Keywords*: Artificial Intelligence, Sustainable Development, SDGs, Climate Change, Machine Learning, Green AI, Smart Cities, Precision Agriculture: Pros and Cons of using AI.*

I Introduction:

Key Pioneers

John McCarthy: Named the field, created early AI logic standards, and shaped computer science at Stanford and MIT.

Alan Turing: British mathematician who created the foundational concept of machine thinking and the Turing Test

Geoffrey Hinton: Often called a "Godfather of AI" for his modern breakthroughs in neural networks and deep learning:

Types of AI

Artificial intelligence is divided into seven types across two main categories: three based on **capabilities** and four based on **functionality**.

Based on Capabilities (What AI can do)

- **Narrow AI (Weak AI):** Systems designed to perform a single, specific task, like virtual assistants or spam filters. This is the only type of AI that exists today.
- **General AI (AGI):** AGI :Artificial General Intelligence it is equal human Intelligence A theoretical form of AI that can match human intellect across any task, possessing the ability to reason and think independently.
- **Super AI (ASI):** A hypothetical future AI that surpasses human intelligence and ability in every way. ASI: Artificial Super Intelligence that exceeds humans intelligence

Based on Functionality (How AI works)

- **Reactive Machines:** Basic systems that react only to current inputs with no memory of past experiences

, such as IBM's Deep Blue chess computer.

- **Limited Memory AI:** Systems that use recent past data and short-term memory to make decisions, like self-driving cars.
- **Theory of Mind AI:** A theoretical future AI that can understand human emotions, beliefs, and social cues.
- **Self-Aware AI:** A conceptual future stage where AI possesses actual consciousness and self-awareness.

The concept of sustainable development rests on three pillars: environmental protection, social inclusion, and economic prosperity. In 2015, the United Nations adopted 17 Sustainable Development Goals as a universal blueprint. However, progress has been slow due to the complexity and interconnection of global problems. Traditional methods are insufficient to process the massive data required for effective decision-making.

Artificial Intelligence, which includes machine learning, deep learning, natural language processing, and computer vision, offers unprecedented capability to analyze complex systems, predict future scenarios, and optimize resource use. AI is not a silver bullet, but it is a transformative tool. According to PwC, AI could add $5.2 trillion to the global economy by 2030 while reducing greenhouse gas emissions by 4%.

II Artificial Intelligence for Environmental Sustainability (Planet)

1. Climate Change Mitigation and Monitoring:

AI is revolutionizing climate science. Machine learning models can analyze satellite imagery, ocean data, and atmospheric sensors to predict extreme weather events with higher accuracy. IBM's Green Horizon and Google's Flood Forecasting use AI to predict floods and pollution levels days in advance. AI also helps in carbon capture by optimizing materials that absorb CO2 efficiently.

2. Energy Management:

One of the biggest sources of emissions is energy. Artificial Intelligence optimizes energy grids through demand forecasting and supply balancing. Deep Mind applied Artificial Intelligence to Google's data centers and reduced cooling energy consumption by 40%. For renewable energy, Artificial Intelligence predicts solar and wind power generation, helping integrate them into the grid. Smart grids using Artificial Intelligence can automatically route power where it is needed, minimizing waste.

3. Biodiversity and Conservation:

AI-powered computer vision is used in projects like Wildlife Insights, which automatically identifies animal species from camera trap images, helping conservationists track endangered species. AI drones monitor illegal deforestation and poaching in real-time in the Amazon and Africa.

4. Circular Economy and Waste Management:

Artificial Intelligence robots like AMP Robotics use computer vision to sort recyclable waste with 99% accuracy, far faster than humans. Artificial Intelligence platforms also help

companies design products for reuse and predict product life-cycles to promote a circular economy.

III. AI for Social Sustainability(People)

1.Precision Agriculture and Food Security (SDG 2):

To feed 9.8 billion people by 2050, we must increase food production by 60% with less land and water. AI enables precision agriculture. Sensors, drones, and Artificial Intelligence algorithms analyze soil moisture, nutrient levels, and crop health. Platforms like Microsoft's FarmBeats and John Deere's See & Spray provide farmers with exact recommendations on when to irrigate, fertilize, and spray pesticide, reducing water use by 30% and chemical use by up to 90%.

2. Healthcare (SDG 3):

AI improves access to quality healthcare, especially in remote areas. AI diagnostics can detect diseases like tuberculosis, malaria, and diabetic retinopathy from medical images with accuracy matching doctors. During COVID-19, Artificial Intelligence models like Blue Dot predicted outbreak zones. AI also accelerates drug discovery, reducing the time from years to months.

3. Quality Education (SDG 4):

AI-powered personalized learning platforms adapt to each student's pace and style. Tools like Duolingo and Khan Academy's Khanmigo provide customized tutoring. Artificial Intelligence also translates educational content into local languages, bridging the educational divide.

4. Smart Cities and Sustainable Infrastructure (SDG 11):

Over 55% of the world's population lives in cities. AI optimizes traffic flow, reducing congestion and emissions. Pittsburgh's Surtrac system reduced travel time by 25% using Artificial Intelligence traffic lights. AI also manages water distribution, detects leakages, and optimizes public transport and waste collection routes.

IV. AI for Economic Sustainability (Prosperity)

1.Responsible Industry and Innovation (SDG 9):

AI optimizes manufacturing through predictive maintenance, reducing downtime and material waste. Digital twins – virtual replicas of factories – allow simulation to improve energy efficiency before actual implementation.

2.Decent Work and Economic Growth:

While there is fear of job loss, Artificial Intelligence can augment human work and create new green jobs like AI sustainability analysts, data ethicists, and renewable energy managers. AI tools also help small businesses access microfinance through alternative credit scoring based on non-traditional data.

V. Challenges and Ethical Considerations: Despite its potential, Artificial Intelligence for sustainability faces significant challenges:

a) Energy Footprint of AI: Training large AI models consumes huge energy. Training one large language model can emit as much CO2 as five cars in their lifetime. We need Green AI – developing energy-efficient algorithms.

b) Digital Divide: 2.6 billion people still lack internet access. If AI benefits are concentrated in developed countries, it will widen inequality.

c) Data Bias and Ethics: Biased data can lead to unjust decisions in loan allocation, healthcare, or disaster relief. Transparency, fairness, and accountability must be built into AI systems.

d) Governance: There is a lack of global standards for AI in sustainability. Strong policy frameworks are needed to ensure AI is used for public good.

Pros of using Artificial Intelligence

- Streamlines and automates repetitive tasks
- Saves time
- Saves humans from doing dangerous jobs
- Allows for new technological discoveries
- Lowers possibility of human error

Cons of using Artificial Intelligence

- Very expensive to execute.
- Potential loss of non-hazardous human jobs.
- Huge environmental cost to maintain.
- Can be used to plagiarize art and other online content
- Security risks from hackers.

VI. Water Resource Management

Water scarcity affects 40% of the global population. AI plays a vital role in sustainable water management. Machine learning algorithms analyze rainfall patterns, groundwater levels, and consumption data to predict droughts and optimize water allocation. In India, the Jal Shakti Abhiyan uses AI-based sensors to monitor groundwater depletion in Punjab and Rajasthan. Companies like Aquasuite use AI to manage wastewater treatment plants, reducing energy use by 25%. AI-powered leak detection systems in pipelines, like those used by London's Thames Water, can detect leaks within 2 meters accuracy, saving millions of liters daily.

VII. Disaster Risk Reduction and Early Warning Systems (SDG 13)

to secure transactions. AI chatbots also educate consumers about carbon footprints of products, encouraging eco-friendly choices.

VIII. Detailed Case Study: India and Artificial Intelligence for Sustainability

India, with its large population and vulnerability to climate change, provides a unique case. NITI Aayog's National Strategy for AI (2018) identifies agriculture, health, and environment as key focus areas.

- Agriculture: The AI Agri project in Maharashtra predicts cotton pest attacks using satellite images, helping 10,000 farmers reduce pesticide use by 35%.
- Air Quality: AirDelhi project uses AI and low-cost sensors to create hyperlocal pollution maps, helping government close polluting units.
- Energy: Tata Power uses AI to integrate 500 MW of solar power into Mumbai's grid without blackouts

IX. Policy Framework and Recommendations

To fully harness AI for SDGs, the following 5-point framework is recommended

1**.Open Data Ecosystem**: Governments should create open, anonymized datasets for climate, agriculture, and health. The EU's Copernicus satellite data is a good example.

2**.Green AI Standards**: Mandate carbon reporting for AI models and incentivize efficient algorithms. Research into neuromorphic computing and edge AI can cut energy by 80%.

3.Capacity Building: Integrate AI and sustainability into school curricula. UNESCO's AI literacy program aims to train 10 million teachers by 2027.

4.Public-Private Partnership: Create innovation hubs like India's AI for Social Good labs where startups work with NGOs.

5.Ethical Auditing: Every AI system deployed for SDGs must undergo bias, fairness, and environmental impact audits before rollout.

This extended analysis shows that AI is not just a technology, but a socio-technical system that must be aligned with human values and planetary boundaries.

Importance of Artificial Intelligence in Sustainable Development:

Artificial Intelligence (AI) has emerged as one of the most powerful tools for achieving sustainable development. Sustainable development means meeting present needs without compromising the ability of future generations to meet their own needs. It stands on three pillars: environmental protection, social equity, and economic prosperity. The United Nations' 17 Sustainable Development Goals (SDGs) aim to achieve this by 2030, but the world is currently off-track. AI provides the data processing power, predictive capability, and optimization needed to accelerate this progress.

1. Environmental Importance:

The greatest importance of AI is in protecting the planet. Climate change is the biggest threat to sustainability. AI models analyze huge amounts of satellite, ocean, and atmospheric data to predict extreme weather, floods, and cyclones 7-10 days in advance. Google's Flood Hub and GraphCast are saving millions of lives. AI also tracks greenhouse gas emissions from 352 million sources globally through projects like Climate TRACE, ensuring transparency in climate action.In energy, AI is crucial for the transition to renewable energy. Since solar and wind are intermittent, AI forecasts their generation 36 hours ahead, helping to balance the grid. DeepMind reduced Google's data center cooling energy by 40% using AI. Smart grids powered by AI reduce wastage and integrate electric vehicles efficiently.For biodiversity, AI automates monitoring. Systems like Wildlife Insights identify animal species from camera trap images with 97% accuracy, helping protect endangered species. AI drones detect illegal deforestation and poaching in real-time in the Amazon and African forests. In waste management, AI robots like AMP Robotics sort waste at 80 items per minute with 99% purity, promoting a circular economy.

2. Social Importance:

AI is vital for social sustainability, especially in food, health, and education. In agriculture, which uses 70% of fresh water, AI enables precision agriculture. It provides farmers with exact information on when to irrigate, fertilize, and spray, reducing water use by 30% and chemical use by 90%. In India, AI apps have increased yields by 30% for small farmers.In healthcare (SDG 3), AI improves access and quality. AI can detect tuberculosis, diabetic retinopathy, and cancer from scans in seconds with doctor-level accuracy. This is critical for rural areas where doctors are scarce. AI also accelerated drug discovery during COVID-19 and predicts disease outbreaks before they spread.In education (SDG 4), AI personalizes learning

for each student through platforms like Khan Academy and DIKSHA, which translates content into 20 Indian languages. AI also makes cities sustainable by optimizing traffic, which reduces travel time by 25% and emissions by 20%, and by detecting water leaks, saving millions of liters daily.

3. ECONOMIC IMPORTANCE:

Economically, AI promotes sustainable industry and responsible consumption. Predictive maintenance in factories reduces downtime by 30% and material waste. AI optimizes supply chains and delivery routes, cutting fuel consumption by 15-20%. It also promotes financial inclusion by providing alternative credit scoring for 300 million unbanked people, allowing small farmers and women entrepreneurs to get loans. In conclusion, AI is important because it turns data into action. It makes sustainability measurable, predictable, and optimizable. However, its own energy footprint and the digital divide must be managed through Green AI and inclusive policies. If used responsibly, AI can help achieve 134 out of 169 SDG targets, making it an indispensable catalyst for a greener, fairer, and more resilient future.

AI empowers 10 million small farmers with advisories in Kannada and other local languages on low-cost smartphones. For sustainable development to be truly inclusive, AI must reach the last mile. This requires open data, Green AI standards, and AI literacy for youth. Ultimately, AI is not replacing humans but augmenting human capability to protect the planet and ensure prosperity for all.

X. Conclusion:

Artificial Intelligence is a critical catalyst for achieving the Sustainable Development Goals. From predicting climate disasters to increasing crop yields and making cities smarter, its applications are vast and impactful. However, AI is a double-edged sword. Its own sustainability and ethical deployment must be ensured. The future lies in Responsible AI – AI that is inclusive, low-carbon, transparent, and human-centric. Governments, academia, industry, and civil society must collaborate to create open datasets, invest in green computing, and provide AI literacy to all. If governed wisely, AI can help us build a world that is not only more intelligent but also more sustainable, equitable, and resilient for future generations.

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ARTIFICIAL INTELLIGENCE–ENABLED TEACHING AND STUDENT LEARNING OUTCOMES: A META-ANALYTIC EVIDENCE SYNTHESIS FOR SHAPING SMART TEACHERS

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Abstract

Artificial intelligence (AI) is rapidly reshaping teaching, learning, assessment, and educational decision-making. This paper presents a focused meta-analytic evidence synthesis of published meta-analyses examining AI, generative artificial intelligence (GenAI), and ChatGPT-supported learning. The synthesis indicates consistently positive, though heterogeneous, effects across educational contexts. A 2025 meta-analysis of AI and academic achievement reported an overall effect size of 0.924, while a 2025 meta-analysis of GenAI and university learning reported an overall effect of g = 0.804. A 2026 meta-analysis of ChatGPT reported g = 0.670, and a three-level meta-analysis of GenAI in higher education reported a medium overall effect of g = 0.499. The latter study found stronger effects for understanding, cognitive and creative outcomes (g = 0.669) and higher-order learning (g = 0.504), with teaching method emerging as an important moderator. Collaborative learning (g = 1.026) and blended learning (g = 0.633) showed particularly strong effects. These findings suggest that AI is not educationally effective merely because it is technologically sophisticated; its value depends substantially on pedagogical design, teacher guidance, critical evaluation, and responsible assessment. Based on the synthesized evidence, the paper proposes a Smart Teacher Competence Framework comprising AI literacy, pedagogical integration, critical evaluation, ethical AI competence, assessment literacy, and reflective professional development. The paper argues that the future of AI in education should be conceptualized not as teacher replacement but as the strengthening of human professional judgment through informed and ethical use of AI.

Keywords: *Artificial intelligence, generative AI, smart teachers, learning outcomes, meta-analysis, teacher education*

1. Introduction

Artificial intelligence has become an important force in contemporary education. Intelligent tutoring systems, adaptive learning platforms, automated feedback, learning analytics, conversational agents, and generative AI are increasingly used to support teaching and learning. The rapid expansion of tools such as ChatGPT has intensified debate about the changing role of teachers and the competencies required for future classrooms.

Individual empirical studies often report different results because AI interventions vary in educational level, discipline, duration, technology, pedagogy, sample characteristics, and outcome measures. Meta-analysis is therefore valuable because it synthesizes evidence across studies and provides a broader estimate of effectiveness. Recent meta-analyses generally report positive effects of AI and GenAI on student learning, although substantial heterogeneity cautions against assuming that all AI applications are equally effective.

The present paper does not claim to conduct a new primary meta-analysis. Instead, it synthesizes published meta-analytic evidence and interprets its implications for teacher

education. This approach is particularly relevant to the theme of shaping smart teachers, because technology alone does not determine educational quality; teachers determine how technologies are pedagogically selected, critically evaluated, ethically governed, and meaningfully integrated.

2. Objectives of the Study

- To synthesize recent published meta-analytic evidence on AI, GenAI, and student learning outcomes.
- To examine major patterns and contextual factors associated with AI-supported learning.
- To identify the implications of meta-analytic evidence for the changing role of teachers.
- To propose a Smart Teacher Competence Framework for AI-enabled education.
- To discuss implications for teacher education and professional development

3. Methodological Approach

This study adopts a meta-analytic evidence synthesis approach based on selected published systematic reviews and meta-analyses examining the educational effects of Artificial Intelligence (AI), Generative AI (GenAI), and ChatGPT on student learning outcomes. Relevant published meta-analytic studies reporting quantitative evidence on academic achievement, cognitive and higher-order learning, and related educational outcomes were comparatively examined. The present study does not independently collect or statistically analyse the primary studies included in these published meta-analyses; therefore, the reported numbers of studies and effect sizes are presented as findings from the original reviews and are not newly calculated estimates. As the reviewed meta-analyses differ in participants, educational contexts, AI technologies, interventions, and outcome measures, their findings are narratively and graphically synthesized rather than statistically combined. The synthesized evidence is interpreted to examine its implications for shaping smart teachers, leading to the proposed Smart Teacher Competence Framework comprising AI literacy, pedagogical integration, critical evaluation, ethical AI competence, assessment literacy, and reflective professional development.

4. Meta-Analytic Evidence on AI and Learning

4.1 Overall evidence

A 2025 meta-analysis examining AI and students' academic achievement included 29 empirical studies involving 2,657 participants and reported a significant overall effect size of 0.924. The study also reported substantial heterogeneity, indicating considerable variation among interventions and contexts. A separate 2025 meta-analysis of GenAI and university students' learning outcomes synthesized 57 studies and 97 estimates and reported an overall effect of $g = 0.804$. A 2026 meta-analysis of 35 experimental studies involving ChatGPT reported an overall effect of $g = 0.670$. In addition, a three-level meta-analysis of 36 empirical studies and 132 effect sizes reported a medium overall effect of GenAI on higher-education learning outcomes ($g = 0.499$).

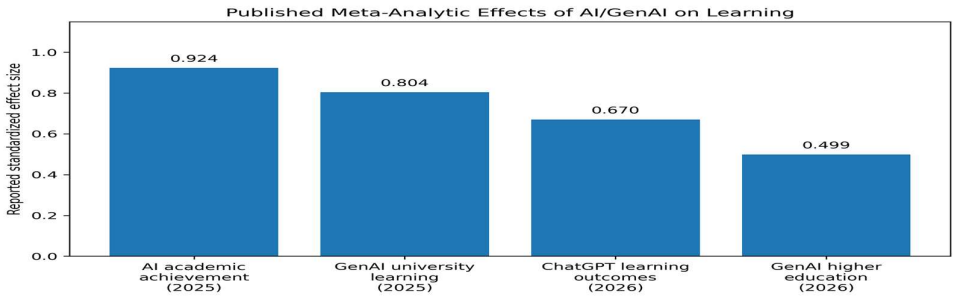

Figure 1. Published meta-analytic effect sizes of AI/GenAI on learning outcomes.

Figure 1 shows that the published meta-analyses consistently report positive average effects. However, the numerical values should not be ranked as if they represent identical interventions. Each review differs in population, educational context, AI technology, inclusion criteria, and outcome measurement. The strongest conclusion is therefore one of convergence: current quantitative syntheses generally support the educational potential of AI and GenAI, while simultaneously demonstrating the importance of context.

4.2 Effects across learning outcomes

The three-level meta-analysis of GenAI in higher education provides a more differentiated picture. The strongest significant effects were reported for understanding, cognitive and creative outcomes (g = 0.669), followed by higher-order learning (g = 0.504), dispositions (g = 0.452), and attainments (g = 0.363). Evidence for some other outcome categories was insufficient because too few effect sizes were available. These findings suggest that GenAI may contribute to learning in several domains, but the magnitude of benefit differs according to what is measured.

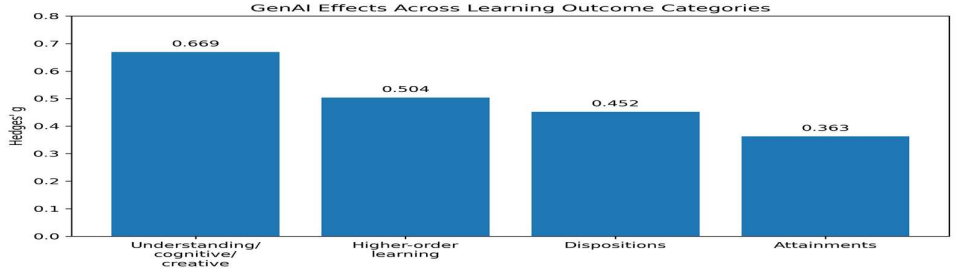

Figure 2. GenAI effects across learning outcome categories.

This pattern has direct implications for teachers. AI-supported activities should not be judged only by whether students produce better final answers. Educational designs should examine understanding, reasoning, creativity, motivation, higher-order thinking, and the capacity to evaluate information. Assessment systems that measure only finished products may fail to distinguish genuine learning from AI-assisted output.

4.3 Pedagogy as a critical moderator

One of the most important findings for teacher education concerns pedagogy. In the three-level meta-analysis, teaching method was the only significant moderator among the examined study-level moderators. Collaborative learning produced the strongest reported effect (g = 1.026), followed by blended learning (g = 0.633). Other reported approaches showed lower effects in the same analysis.

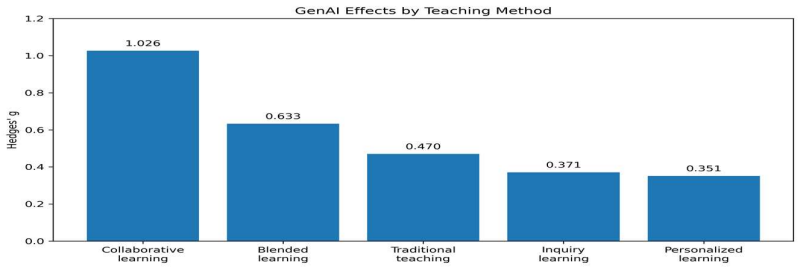

Figure 3. Reported GenAI effects by teaching method.

The implication is clear: AI should not simply be provided to students as an answer-producing system. Teachers can design collaborative tasks in which students compare AI outputs, verify claims, identify bias or inaccuracies, justify decisions, generate alternative explanations, and reflect on their learning. Such pedagogical orchestration can transform AI from a passive shortcut into a resource for inquiry and intellectual engagement.

5. Implications for Shaping Smart Teachers

The synthesized evidence indicates that teachers remain central to educational quality in AI-enabled environments. A smart teacher is not merely a teacher who can operate digital tools. Rather, a smart teacher combines technological understanding with pedagogical judgment, ethical responsibility, assessment competence, and reflective practice.

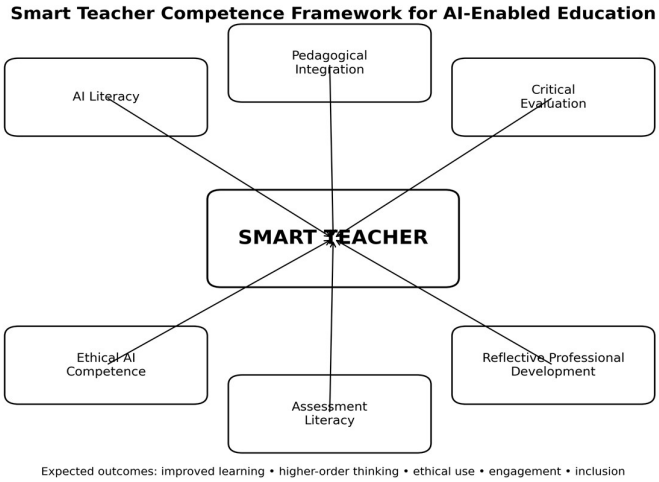

Figure 4. Proposed Smart Teacher Competence Framework for AI-enabled education.

AI Literacy: Teachers need a practical understanding of AI capabilities and limitations, including hallucinations, bias, privacy concerns, and unreliable outputs.

Pedagogical Integration: AI tools should be selected according to learning objectives and embedded within meaningful instructional activities rather than used for technology's sake.

Critical Evaluation: Teachers and students must verify AI-generated information, compare it with credible academic sources, and exercise professional judgment.

Ethical AI Competence: Responsible practice requires attention to privacy, bias, transparency, academic integrity, inclusion, and equitable access.

Assessment Literacy: AI-enabled environments require more authentic and process-oriented assessment, including oral explanation, reflection, performance tasks, portfolios, and evidence of reasoning.

Reflective Professional Development: Because AI technologies evolve rapidly, teacher learning must be continuous and supported through experimentation, collaboration, and critical reflection.

6. Implications for Teacher Education

Teacher education institutions should move beyond isolated technical training. AI competence should be integrated across curriculum studies, pedagogy, assessment, educational psychology, research methodology, and professional ethics. Student-teachers should learn to use AI for lesson planning while simultaneously evaluating the quality of AI-generated materials. They should design AI-supported learning activities, recognize bias and misinformation, establish responsible-use expectations, and develop assessments that remain valid in the presence of generative AI.

Professional development should also emphasize pedagogical decision-making. The evidence summarized in this paper suggests that the effectiveness of AI depends substantially on how it is embedded within learning. Consequently, training that focuses only on prompts or software features is insufficient. Teachers require opportunities to redesign learning activities and assessment practices.

7. Challenges and Limitations

The positive evidence should be interpreted cautiously. Published meta-analyses report substantial heterogeneity, meaning that average effects conceal important differences across settings. Short interventions may not demonstrate sustained learning, and researcher-developed assessments may sometimes align closely with intervention activities. In addition, publication bias and the rapid evolution of AI technologies remain concerns. The evidence base is also developing quickly, and conclusions about particular tools may change as technologies and educational practices evolve.

A further limitation of the present paper is that it is a synthesis of published meta-analytic evidence rather than a de novo systematic review with independently calculated effect sizes. It should therefore be presented as a meta-analytic evidence synthesis. Future research could undertake a fully registered systematic review and meta-analysis using primary studies, PRISMA procedures, independent screening, standardized effect-size extraction, heterogeneity analysis, moderator analysis, and publication-bias assessment.

8. Conclusion

Current meta-analytic evidence provides substantial support for the educational potential of AI and GenAI. Positive average effects have been reported for academic achievement, cognitive and creative outcomes, higher-order learning, affective-motivational outcomes, and other dimensions of student learning. At the same time, heterogeneity and moderator findings demonstrate that AI does not produce educational improvement automatically.

The central conclusion is that AI becomes educationally valuable through sound pedagogy. Teachers remain responsible for selecting appropriate technologies, designing learning experiences, questioning AI-generated information, protecting ethical standards, and assessing genuine understanding. The proposed Smart Teacher Competence Framework therefore places human professional judgment at the centre of AI-enabled education.

The future of education should not be conceptualized as a competition between teachers and

artificial intelligence. A more productive vision is an intelligent partnership in which capable teachers use AI critically and creatively to strengthen learning, while retaining responsibility for pedagogy, ethics, inclusion, and professional judgment.

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THE YOGIC UNDERSTANDING OF MIND, BEHAVIOR AND HUMAN POTENTIAL FOR STUDENT ENGAGEMENT

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Abstract

Rising rates of psychological distress, addiction, and suicidal behavior among young people in India have made the search for sustainable, low cost, and culturally rooted interventions urgent. The yogic tradition offers a detailed model of mind, its fluctuations and the layered structure of human personality, along with practical disciplines for regulating attention, emotion, and behavior. This article examines the yogic understanding of mind and behavior and connects it to the everyday pressures facing Indian youth today, including stress, behavioral change, poor food habits, impatience, addiction to gaming and mobile devices, concentration difficulties, and lifestyle linked conditions such as diabetes and heart disease. It closes with practical suggestions for good health protection and a note on seeking professional support for anyone personally affected by these issues.

Keywords: *Yogic Psychology, Youth Mental Health, Stress, Addiction, Lifestyle Disorders.*

Introduction:

Young people in India today face a distinct combination of stressors. Board examinations, entrance tests for engineering and medical colleges, family expectations around career and marriage, and constant social comparison on Instagram and WhatsApp all add to daily pressure. Mental health surveys across the country have repeatedly linked these pressures to rising anxiety, depression, self-harm ideation, and substance dependence among adolescents and young adults. These are not purely biomedical problems. (Bhide et al., 2023) They are also problems of meaning, self-regulation, and disconnection from a stable sense of identity, which is precisely the terrain the yogic tradition has mapped for centuries. Alongside psychological strain, physical health is also being reshaped by these same behavioral patterns. Irregular eating, disturbed sleep, and long hours of sedentary screen use are now appearing earlier in life among Indian youth, contributing to conditions once associated mainly with middle age.

Yogic philosophy describes the human being as composed of progressively subtler layers, moving from the physical body to the mind, vital energy, intellect, and an innermost layer of bliss. Gaining mastery over the intellect is said to bring a corresponding degree of control over energy, thought patterns, behavior, and overall quality of life. Behavioral change works best when it addresses more than just outward symptoms. In classical yoga psychology, chitta refers to the whole field of consciousness, including what modern psychology terms the unconscious, a repository of latent impressions called samskaras that quietly shape emotion, thought, and behavior even when a person is not directly aware of them. Vrittis are the fluctuations or whirlpools that arise in this field, and yoga is classically defined as the

discipline of stilling these fluctuations. Emotional turbulence, compulsive behavior, and addictive patterns can be understood, in this framework, as vrittis that have become habitual and self-reinforcing. (Anderson et al.; Neuroscience of Consciousness, 2021)

A central yogic insight is that conscious experience is observed by a deeper witness self, distinct from the passing states of the mind and body. Cultivating this witnessing awareness, the ability to notice a craving, an urge, or a painful emotion without being completely absorbed by it, is one of the tradition's most practically useful contributions to behavioral self-regulation. It maps closely onto contemporary mindfulness based approaches used in addiction and relapse prevention programmes. The following sections apply this understanding to the major problems facing Indian youth today, and close with practical suggestions for good health protection. (Patel, Yogic Psychology and the Mind)

Major Problems Facing Youths at present Situations:

1. Stress:

Stress is the most common complaint among Indian youth today, arising from board examination pressure, competitive entrance tests such as JEE and NEET, family expectations, and constant comparison with peers on social media. In the yogic framework, stress is essentially chitta vikshepa, a scattered and agitated state of mind in which attention is pulled in many directions at once, leaving no reserve of calm to draw on. (Kumar and Bharadwaj, 2016)

- A student preparing for the JEE or NEET examination while also checking social media notifications through the day often reports racing thoughts, disturbed sleep, and irritability, which reflects the classic pattern of scattered attention that yoga calls vikshepa.
- Constant comparison with the curated lives of friends and classmates on Instagram generates a steady, low grade stress even when nothing has actually gone wrong in a young person's own life, showing how a mental habit of comparison can create real physical strain.
- A regular practice of slow breathing, a few minutes of quiet sitting between study sessions, and dividing study time into fixed blocks can prevent attention from fragmenting across too many demands at once.

2. Behavioural Change:

Many young people in India show a noticeable shift in behavior, becoming irritable, withdrawn from family, suddenly aggressive, or visibly less motivated, often before they are able to explain what they are actually feeling. Yogic psychology attributes such shifts to accumulating unprocessed impressions that eventually surface as changed conduct, even when the underlying cause is not consciously understood by the person experiencing it. (International Journal of Innovations and Research Analysis, 114)

- A student who was previously outgoing may become withdrawn and short tempered after repeatedly failing to meet the marks expected by parents and teachers, and this change in behavior is often an expression of accumulated frustration and shame rather than simple bad attitude.

- Sudden anger over a small matter, such as losing an online match or being scolded for spending too long on the phone, often reflects a mind that was already carrying unexpressed stress, with the small incident acting only as the final trigger.
- Keeping a regular habit of writing down one's feelings, or talking openly with a trusted family member, teacher, or counsellor, helps release accumulated emotion before it builds into a larger behavioral change.

3. Food Habits:

Irregular meals, heavy reliance on packaged snacks and sugary cold drinks, and eating in front of a phone or television screen have become common among Indian youth, particularly in cities. Yoga treats food as directly shaping the quality of mind, holding that what is eaten, and the state of mind in which it is eaten, both influence mental clarity and emotional steadiness and not only physical health. (Patel, Yogic Psychology and the Mind)

- Skipping breakfast and depending on tea, coffee, or energy drinks to get through long study hours produces a short burst of alertness followed by a crash in concentration and mood later in the day.
- Eating dinner late at night while watching a web series or scrolling through reels, without paying attention to the meal itself, is linked among many students to poor digestion and disturbed sleep, illustrating the yogic idea that eating without awareness disturbs both body and mind.
- Keeping regular meal timings, choosing fresh home cooked food such as dal, rice, and vegetables over packaged snacks, and eating without a screen in front of oneself restores basic attentiveness to the body's own signals of hunger and fullness.

4. Lack of Patience:

A reduced tolerance for delay, wanting instant results, instant replies on WhatsApp, and instant entertainment on reels, is widely reported among youth who have grown up with constant digital stimulation. Yogic thought links this pattern to a mind trained by rapid stimulation, which gradually loses its capacity for sustained and calm effort, known in the tradition as dhriti or steadiness. (International Journal of Research, Vol. 9, Issue 3)

- A student who gives up on a difficult mathematics problem within a few minutes because the solution is not immediately visible, instead of persisting through trial and error, shows a reduced tolerance for the kind of productive struggle that learning requires.
- Frustration or restlessness when a video takes a few seconds to load, or when a friend does not reply to a WhatsApp message within minutes, reflects a mind that has been conditioned to expect immediate resolution to every small discomfort.
- Deliberately taking up an activity that requires sustained effort over time, such as learning a musical instrument, playing a sport, or reading a full book instead of short posts, helps rebuild the mind's tolerance for gradual progress.

5. Addiction and Bad Habits, Including Gaming and Mobile Phone Use:

Gaming applications such as PUBG and Free Fire, along with general smartphone overuse, have become among the most visible behavioral concerns for Indian youth today, alongside the older concern of substance use. In yogic terms, these patterns are vrittis that

have turned into self-reinforcing loops, where a craving arises, is immediately satisfied by a quick reward such as a game win or a new notification, and the loop grows stronger with every repetition, gradually weakening a young person's ability to resist it. (Neuroscience of Consciousness, Oxford Academic, 2021)

- A young person who intends to play a mobile game for only ten minutes before returning to studies often loses several hours instead, because the game is designed around exactly the kind of reinforcing reward pattern that yogic psychology describes as a strengthening vritti.
- Reaching for the phone immediately upon waking, before any conscious decision has been made to check it, shows how a habitual pattern can operate almost independently of a person's actual intention.
- Turning to smoking, vaping, or alcohol to manage social anxiety or boredom during college years follows the same reinforcing pattern of short term relief followed by a stronger craving the next time discomfort arises.
- Setting fixed phone free periods, using the yogic practice of pratyahara or deliberate withdrawal of the senses from a stimulus, and replacing the urge to check the phone with a brief breathing exercise, helps interrupt the loop before it strengthens further.

6. Concentration Problems:

Difficulty sustaining focus on a single task, whether studying, reading, or even a conversation, is frequently reported by young people who divide their attention across multiple screens and notifications throughout the day. Yoga treats one pointed attention, known as ekagrata, as a trainable ability rather than a fixed trait, developed through practices such as trataka, or focused gazing, and dharana, concentration on a single object. (Sharma, Sahare and Shrivastav, 2013)

- A student who reads the same paragraph of a textbook several times without absorbing its meaning, while a phone lies nearby buzzing with notifications, is experiencing attention fragmented across competing stimuli rather than any lack of intelligence or effort.
- Struggling to follow a full conversation with a friend or family member without glancing at a phone shows how this same fragmentation has moved from study time into everyday social life.
- A short daily practice of five to ten minutes of trataka or focused breath counting, along with physically removing the phone from the study space rather than merely silencing it, gradually rebuilds the span of attention.

7. Lifestyle Change During the Transition from School to College:

The move from school to college in India brings hormonal, social, and identity changes that reshape daily routines, sleep patterns, and self-image. Yogic tradition has historically paid close attention to different stages of life, recognizing that habits and expectations should match a person's current stage of development rather than being applied the same way throughout life. (International Journal of Research, Vol. 9, Issue 3)

- Sleep timing naturally shifts later during the teenage years, and when this is combined with early college lectures and late night use of phones, many students accumulate a chronic lack of sleep during exactly the years their body and mind are still developing.
- Moving away from home for college, or simply gaining greater independence after school, often removes the structure that parents previously provided, and without a new self-imposed routine this can quickly lead to irregular sleep, meals, and physical activity.
- Treating this period of life consciously as a stage that calls for new self-discipline, known in the yogic tradition as svadhyaya or self-study, and deliberately building a personal daily routine, helps prevent the drift into unhealthy habits that often begins at this age.

8.Diabetes Among Young People:

Type 2 diabetes, once considered a condition of middle age, is increasingly being diagnosed among younger people in India, a country already carrying one of the highest burdens of diabetes in the world. This trend is driven substantially by the same behavioral patterns described above, including irregular and sugar heavy food habits, long hours of sedentary screen time, and disturbed sleep, all of which affect the body's sensitivity to insulin over time. (Bhide et al., 2023)

- A young person who spends most of the time outside class seated in front of a screen, combined with frequent snacking on sweets, fried food, and sugary drinks, is accumulating exactly the risk factors of inactivity and excess sugar intake that are associated with early insulin resistance.
- Chronic, unmanaged stress raises the level of cortisol in the body, which can further disturb blood sugar regulation, showing how the mental and physical risk factors discussed in this article compound one another rather than acting separately.
- Regular physical movement such as yoga asana practice, walking, or any consistent sport, together with attention to meal regularity and stress reduction through breathing practices, addresses the underlying behavioral causes rather than only the eventual physical outcome.
- This information is general in nature. Diagnosis and management of diabetes require evaluation by a qualified medical professional.

9.Heart Attack and Cardiovascular Risk Among Younger Adults:

Cardiovascular events, once considered rare before middle age, are now being reported with growing frequency among younger adults in India, a trend widely linked to a combination of stress, poor sleep, sedentary habits, tobacco or substance use, and diets high in processed and fried food. These are the very behaviors described throughout this article. (Bhide et al., 2023; Anderson et al.)

- A young working professional putting in long, high pressure hours with little physical activity, poor sleep, and heavy reliance on tea, coffee, and packaged food is accumulating several cardiovascular risk factors at the same time, even without any single dramatic cause.

- Chronic stress that continues unmanaged over several years is increasingly recognized as a contributor to cardiovascular strain, reinforcing that mental and physical health cannot be treated as separate concerns.
- Regular moderate physical activity, breathing practices that support balance in the body's nervous system, sufficient sleep, and moderation in diet, combined with routine medical checkups rather than relying on lifestyle measures alone once risk factors are already present, form the most reliable protection.
- This information is general in nature and not a diagnostic or treatment guide. Any chest pain, breathlessness, or related symptoms require urgent medical evaluation and not self-management.

Suggestions for Good Health Protection in Youths:

The following measures combine yogic practice with contemporary evidence on youth mental and physical health. They are intended as complementary, preventive, and supportive measures and not as a substitute for clinical care where that is needed.

1.For the Individual:

- A short, consistent daily practice of breath awareness and quiet sitting builds a baseline of calm before stress has the chance to accumulate.
- Pausing to silently name an urge or emotion, such as recognizing it as anxiety or as a craving, rather than acting on it immediately, is a simple and direct way of applying witness consciousness in daily life. (Neuroscience of Consciousness, Oxford Academic, 2021)
- Deliberately structuring screen time, sleep, and diet supports mental steadiness, since yogic practice treats discipline over the senses as foundational to a stable mind.
- Fixed phone free periods, such as during meals, the first hour after waking, and the hour before sleep, interrupt reinforcing addictive habits before they strengthen further.
- Daily physical activity, whether yoga asana, walking, or a sport, supports both mental steadiness and long term protection against diabetes and cardiovascular risk.
- Consistent meal timing and home cooked, minimally processed food eaten without a screen supports both physical and mental health.
- A short daily concentration practice of five to ten minutes gradually rebuilds attention span.
- Keeping a regular habit of journaling or quiet self-reflection helps release the day's reactive moments before they accumulate into larger patterns.
- Protecting a consistent sleep and wake schedule is especially important during the transition from school to college described earlier in this article.

2.For Families and Educators:

- Modelling calm emotional responses and healthy screen habits teaches young people more effectively than rules alone, since they absorb behavior from the adults around them.
- Introducing simple breathing or mindfulness practices in schools as a normal, everyday habit, rather than only in response to a crisis, builds resilience before problems arise.
- Regular, low pressure conversations between parents or teachers and young people help early signs of distress or behavioral change to be noticed before they escalate.

- Supporting balanced, home cooked food and shared family mealtimes, where possible, keeps food choices from being left entirely to convenience.
- Encouraging physical activity and hobbies that require sustained attention offers a healthy counterbalance to fragmented, screen based stimulation.

3.For Institutions and Counsellors:

- Combining yoga based counselling with standard psychological care, tailored to each individual's needs rather than applied as a single fixed routine, offers a more complete form of support. (Bhide et al., 2023)
- Training peer support groups and frontline staff to recognize early signs of withdrawal, hopelessness, or substance and device related misuse allows prompt referral to professional services.
- Offering routine health screening, including basic metabolic and cardiovascular checks, for young people with sedentary and high stress lifestyles allows risk to be identified before symptoms appear.
- Treating recovery and behavioral change as a gradual retraining of attention and habit, with sustained follow up rather than a single intervention, leads to more lasting improvement.

Conclusion: The yogic understanding of mind and behavior offers more than a historical curiosity. It provides a coherent, practice based framework for addressing the everyday pressures behind youth stress, behavioral change, poor food habits, impatience, addictive digital and substance habits, concentration difficulties, and lifestyle linked conditions such as diabetes and heart disease in India today. These difficulties can be traced to an overstimulated mind that is constantly pulled outward, to accumulated unprocessed impressions, and to habits built around short term reward rather than sustained wellbeing. Combined with contemporary medical care, counselling, and community support, these principles can inform practical, low cost, and culturally resonant strategies for protecting both the mental and physical health of young people. (Anderson et al.; Bhide et al., 2023; International Journal of Innovations and Research Analysis, 114)

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AN ASSESSMENT OF GOVERNANCE AND IMPLEMENTATION MECHANISMS UNDER KARNATAKA STATE SKILL DEVELOPMENT POLICY 2025–2032

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Abstract

The Karnataka State Skill Development Policy 2025-2032 serves as an extensive strategic blueprint intended to reshape the state's workforce development framework by reinforcing employability, preparing workers with skills relevant to future industries, and encouraging inclusive economic involvement that corresponds with Karnataka's changing industrial structure. This research undertakes a critical examination of the policy from a governance standpoint, assessing its strategic intentions, institutional setup, and execution methods against the backdrop of Karnataka's varied regional and socioeconomic conditions. Utilizing a qualitative policy analysis approach, the investigation references the policy text itself, academic writings on skill governance, government publications, and current discussions concerning employability, organizational collaboration, and regional inequities within Karnataka's skill infrastructure. The conceptual framework combines political economy analysis, institutional theory, and public administration concepts to offer a thorough analytical basis. The assessment indicates that although the policy exhibits considerable insight in tackling crucial matters such as preparedness for Industry 4.0, combining education with skill development, encouraging entrepreneurship, and advancing technological proficiency, it nonetheless confronts considerable governance and execution hurdles. Notable obstacles consist of insufficient institutional coordination systems, marked infrastructure gaps between Bengaluru and underdeveloped areas, inadequate decentralized governance frameworks, financial viability concerns, uneven institutional capabilities, and ongoing societal prejudice against vocational training. The research concludes that the lasting achievement of Karnataka's skill development system relies not exclusively on sustaining clear policy guidance but fundamentally on creating responsible, localized, and regionally-conscious governance structures that can successfully transform policy objectives into fair socioeconomic results throughout every district in the state.

Keywords: *Kaushal Karnataka, Skill India, Vocational Development, Skill Development, Governance Framework, Institutional Coordination*

I. Introduction

Karnataka is home to one of India's most advanced and varied skill development systems, supported by its strong industrial base, technological supremacy, and wide-ranging institutional network for workforce growth. The state accounts for over 8.4 percent of the national GDP, with per capita income considerably higher than the national average (PPMSD,

2024). The state's skill ecosystem gains additional strength from Bengaluru's position as India's Information Technology center, together with expanding influence in fields like aerospace and biotechnology, which are progressively moving toward Industry 4.0 and skill development driven by market demand. Throughout its history, the state has introduced multiple skill policies, with each new policy building on past experiences and addressing fresh challenges in the quickly transforming economic environment.

The Government of Karnataka previously approved a state skill development policy named "Kaushalya Karnataka - Kushala Karnataka," covering the period from 2017 to 2030. This policy aimed to establish a "Skilled and Prosperous Karnataka" by providing the state's workforce with employable abilities, thereby encouraging faster economic development. The policy was consistent with the wider national objectives of Skill India (SDEL, 2017). Its primary focus was on bringing together government, business, and community organizations, with the goal of training about 13.4 lakh individuals each year, thus reaching over 1.88 crore young people by 2030. Inclusivity was given considerable importance, with special emphasis on women, Scheduled Castes, Scheduled Tribes, and people with disabilities. Training in emerging technologies like artificial intelligence and environmentally friendly industries was targeted, with nine main sectors identified: Information Technology and IT-enabled Services, healthcare, education, construction, tourism, agriculture, logistics, textiles, and food processing (SDEL, 2017). In spite of these bold targets, putting the previous policy into practice encountered numerous difficulties, such as poor coordination among various government departments, budget limitations, and inconsistent regional coverage.

While the earlier policy was still in effect, the state government created the new Karnataka State Skill Development Policy 2025-2032, learning from the experiences and drawbacks of what came before. The policy notes that the state's skill ecosystem is being built through multiple organizations like the Karnataka Skill Development Corporation (KSDC), Industrial Training Institutes (ITIs), polytechnic colleges, higher education institutions, Sector Skill Councils (SSCs), business partners, and training providers situated in both city and countryside areas. The policy strives to combine skill development with formal education via apprenticeships, work placements, business startup support, and technology-based educational platforms that are consistent with the National Education Policy 2020. At the same time, the system works to resolve problems like the lack of employability among graduates, mismatches between skills and job requirements, uneven development across regions, and the scarcity of good-quality training options, especially in less developed areas such as Kalyana Karnataka. By intensifying its emphasis on artificial intelligence, digital technologies, cutting-edge manufacturing, and business creation, Karnataka's skill system intends to establish the state as an internationally competitive, innovation-focused, and inclusive workforce center, while also promoting sustainable socioeconomic progress in every region.

The importance of this research lies in its careful examination of the governance aspects of skill development policy, which are frequently neglected in favor of technical and program-related considerations. Although many studies have looked at the content and results of skill development initiatives, relatively few have systematically analyzed the institutional and administrative structures through which these policies are put into effect. This paper addresses

that gap by offering a thorough governance analysis of Karnataka's newest skill development policy, pinpointing both its strengths and weaknesses, and suggesting ways to strengthen the effectiveness of its implementation.

This paper intends to evaluate the Karnataka State Skill Development Policy 2025-2032 from a governance perspective by looking at its strategic direction, institutional frameworks, and implementation concerns. The research will also explore how the policy proposes to handle problems of regional inequalities, job readiness, institutional collaboration, and equitable development within the context of the state's rapidly shifting economic environment. The particular goals of this study are: (1) to examine the strategic vision and policy priorities of the Karnataka State Skill Development Policy 2025-2032; (2) to assess the institutional structure and coordination systems suggested in the policy; (3) to pinpoint the main governance and implementation difficulties confronting the policy; and (4) to offer suggestions for strengthening the governance of Karnataka's skill ecosystem.

II. Review of Literature

This part attempts to build the conceptual groundwork for policy measures in skill development by investigating the political economy perspective, the institutional perspective, and the management perspective. The literature review focuses on four connected themes that are crucial for examining the governance of skill development.

2.1 Political Economy Perspective

Political economy is an interdisciplinary social science field that examines the connections among people, governments, and public policy. The production, distribution, and exchange of goods and services in human society are the central concerns of political economy. Questions regarding how markets are understood, what relationship exists between markets and government, and how employer and employee organizations affect the production and exchange of goods and services are topics of political-economic investigation (Busemeyer & Trampusch, 2019). Every institutional approach emphasizes the links between Vocational Education and Training (VET), the job market, and labor relations. The labor markets in which countries function have strong connections to their VET systems. Moreover, direct government involvement, corporatist networks, local business networks, institutional organizations, and free markets represent the five main types of skill provision in vocational education and training (Crouch et al., 1999).

The political economy perspective is especially useful for comprehending skill development in the Indian setting, where the government has a significant role in influencing workforce development policies while at the same time handling complicated relationships with private enterprise and civil society groups. This perspective helps clarify how power dynamics among these interested parties affect the creation and execution of skill policies. In Karnataka, the political economy of skill development is formed by the state's distinctive industrial makeup, featuring a dominant IT sector existing alongside conventional manufacturing and farming sectors. This variety generates competing demands on the skill development system, necessitating careful balancing of interests among various stakeholder groups.

2.2 Institutional Perspective

Assessing skill policies from an institutional viewpoint is essential for grasping the roles of

stakeholders and the main networking difficulties from social and economic perspectives. The environments—such as networks, fields, and cultures—in which organizations are embedded have an effect on institutions (Greenwood, Oliver, & Roy, 2008). Institutions are independent forces for change that determine who is allowed to take part in political processes, with institutional orientation referring to the significance of institutions in shaping political actions and results (Mohamed, 2021). Institutions shape decisions and ideas about what is possible and desirable by establishing the pattern of methods that are applied.

The institutional perspective highlights political institutions and the political setting to account for decisions made by ruling political parties (Murray, 2015). This perspective is based on the idea that the outside institutional environment has a fundamental effect on party motivations and actions. Research indicates that institutional theory can be applied in entrepreneurship research to provide useful insights (Steinhauser, Rocha, & Paula, 2022).

Policy changes to skill formation systems are affected by economic, political, and social development pressures. Solga (2020) proposed that worldwide influences would result in the convergence of national skill formation systems. Three aspects of skill formation institutions—cultural-cognitive, normative, and regulative—are essential, and all three are necessary for long-term viability (Solga & Powell, 2010). The research suggested a structure that combines institutional strategies with comparative-historical analytical techniques to evaluate the importance of changes in skill formation within the European setting.

In Karnataka's situation, the institutional perspective helps explain why skill development initiatives succeed or fail depending on the strength and effectiveness of the organizations that carry them out. The state's skill ecosystem consists of numerous institutions at different levels—state-level agencies like KSDC, district-level administrations, and local training providers. The effectiveness of the overall system depends greatly on the coordination among these institutions and their capacity to adjust to changing conditions.

2.3 Management Theory

The basis for management theory was established by Taylor in “The Principles of Scientific Management,” with the goal of helping managers create and grow businesses, and this approach was subsequently modified for use in public administration (Taylor, 1911). Gulick (1938) offered a structure that brought scientific management to government, creating the abbreviation POSDCORB (Planning, Organising, Staffing, Directing, Coordinating, Reporting, Budgeting) to define seven key management duties (Wallace, 2013).

The Hawthorne studies introduced additional adjustments, indicating that management theory developed with Theory X and Theory Y. Theory X implied managerial oversight and control, while Theory Y encouraged the alignment of personal and organizational objectives to foster creativity. Group theory proposed that effective groups create shared objectives, values, behavioral standards, and traditions (Frederickson et al., 2012).

Role theory suggested that each position or office is logical and defined in its connections with others, the organization as a whole, and the organization's objectives. Communication Theory proposed that public management interacts with how effectively communication works, bringing together social psychology, linguistics, and cybernetics (Frederickson et al., 2012). Management theory also saw the development of New Public Administration and new public

management concerning public administration.

The Minnowbrook II conference resulted in the creation of New Public Management, with main objectives including ensuring service quality for citizens, giving public administration more independence, and being open to ideas from the business sector (Chakrabarty & Chand, 2016). The influence of NPM is apparent in skill policies across the world. In India, the National Policy on Skill Development and Entrepreneurship (2015) set benchmarks and performance measures through the National Skills Qualifications Framework, while the entire Skill India mission responds to market demands, providing control over results.

2.4 Placing Skill Development in Karnataka in Context

Karnataka's skill development framework represents an application of national policies, adapted to meet regional expectations. In 2016, the state moved from a fragmented approach under the Labour Ministry to a more unified approach with the creation of the Skill Development, Entrepreneurship and Livelihood (SDE&L) Department to enable better coordination among departments for enhanced service delivery (KSDA, 2022). The Karnataka Skill Development Authority has been given responsibility for maintaining training standards and overall quality, creating guidelines for trainer preparation, establishing standards for skill training, and raising the quality of skill programs. Additionally, the Karnataka Skill Development Corporation carries out policy execution by coordinating implementation across various sectors to address skill deficiencies (KSDC, 2016). International cooperation and the integration of advanced manufacturing can be observed in certain skill development centers dedicated to promoting global best practices and satisfying industry requirements (GTTC, 2024).

III. Research Methodology

A qualitative policy analysis method is used in this research to examine the Karnataka State Skill Development Policy 2025-2032 from a governance perspective. The descriptive and analytical work relies mainly on secondary sources, including the policy document being examined, government publications, and economic reports. Academic literature dealing with skill development, vocational training, and public management has also been reviewed.

The research employs thematic analysis to investigate important policy areas such as job readiness, industry integration, institutional coordination, regional fairness, and infrastructure development within Karnataka's skill ecosystem. The policy is examined using the Political Economy Perspective, Institutional Perspective, and Management Theory. These theoretical frameworks help clarify the role and interactions of the state, labor market, institutions, and governance structures in skill development.

The study additionally applies a critical governance perspective to point out weaknesses and challenges in the policy and its execution, especially concerning decentralization, regional disparities, institutional capacity, and workforce preparedness. Because the paper is based only on policy interpretation and governance analysis, no primary surveys or quantitative statistical analyses were undertaken.

IV. Policy Analysis of the Karnataka State Skill Development Policy 2025-2032

4.1 Vision and Strategic Direction

The Karnataka State Skill Development Policy 2025-2032 sets out an overall vision aimed at

creating a workforce that is ready for the future, employable, and entrepreneurial, capable of assisting Karnataka in reaching its long-term economic targets. The policy places strong emphasis on active industry participation, technological advancement, innovation-based skill development, and institutional collaboration. One of the policy's main strengths is its recognition that traditional vocational education systems cannot adequately respond to the quickly transforming industrial environment shaped by artificial intelligence, automation, digitization, and advanced manufacturing technologies. As a result, the policy gives priority to skill development programs in machine learning, robotics, renewable energy, cybersecurity, and healthcare technologies.

A notable feature of the policy is its focus on measurable and data-informed decision-making in governance. The suggested Skill Index represents an important move toward establishing district-level benchmarking and performance assessment. The Kalikeya Jothe Kaushalya program is another effort aimed at embedding employability skills in school education from an early stage. Although the policy attempts to elevate skill development beyond poverty reduction by connecting it with innovation and entrepreneurship, it lacks detailed operational information about implementation structures, institutional accountability, and coordination among departments.

4.2 Connecting Education and Skills

The policy acknowledges that a major cause of Karnataka's employability problem is the gap between the skills provided by the formal education system and those needed in the job market. The policy supports stronger integration of educational institutions with skill development channels through apprenticeships, internships, hands-on learning, and curriculum changes linked to industry needs. This integration effort is clearly shown in the Kalikeya Jothe Kaushalya program, which connects skill-based education with standard schooling. It also backs the National Education Policy 2020 by promoting multidisciplinary education, competency-based learning, and adaptable academic paths. However, implementation capacity varies greatly among institutions, with many colleges and training centers struggling to find qualified teachers and up-to-date laboratory facilities.

4.3 Focus on Entrepreneurship and Innovation

Entrepreneurship holds a central place in Karnataka's workforce strategy, especially given the state's status as a leading startup center in India. The policy encourages entrepreneurial activities by providing individuals with innovative skills and offering incubation and financial literacy support. Cooperation with startups, digital entrepreneurs, and incubation facilities shows how Karnataka's knowledge economy is opening new pathways for workforce development. Nevertheless, entrepreneurial ecosystems remain extremely unbalanced across Karnataka, with Bengaluru dominating access to venture networks and innovation funding. Smaller cities have comparatively weak business support systems, and many skill development programs concentrate mainly on short-term training outcomes without adequate attention to post-training business sustainability.

4.4 Inclusivity and Regional Development

The policy gives priority to inclusive workforce development and balanced regional growth. Economic growth in Karnataka has not been spread evenly across regions, and differences in

educational access, industrial concentration, infrastructure quality, and employment opportunities continue to affect workforce participation across districts. The policy targets these inequalities through district-level skill development strategies, digital learning initiatives, and economically responsive planning systems. However, regional implementation capacity remains extremely uneven, with industrial corridors like Bengaluru-Mysuru having more robust institutional ecosystems compared to rural districts.

4.5 Governance and Institutional Coordination

The governance structure of Karnataka's skill ecosystem involves numerous institutions forming an extensive network. The policy correctly recognizes that institutional coordination is crucial for reducing duplication and improving workforce outcomes. However, institutional fragmentation continues to hinder implementation efficiency. Multiple departments still manage parallel programs with different standards and monitoring systems. Although the policy calls for convergence, it lacks operational detail about decision-making authority, complaint resolution systems, and accountability mechanisms across institutions. The previous skill development policy also highlighted coordination problems but achieved only limited success.

4.6 Infrastructure and Capacity Issues

Infrastructure quality continues to be a major factor affecting the success of workforce development programs. Many ITIs, polytechnics, and training centers still deal with outdated equipment, inadequate laboratory facilities, and shortages of trainers. While the policy promotes digitally-based learning systems, technological readiness varies greatly across institutions. Training for future skills requires ongoing professional development for teachers and regular curriculum updates. Although collaboration with industry and technology providers is encouraged, success will depend on reliable financial support and continuous quality evaluation.

4.7 Financial Sustainability Issues

Karnataka's skill ecosystem faces major financial sustainability challenges. Training providers often experience administrative delays, rising operational costs, and uncertain funding. Smaller institutions without financial reserves are especially vulnerable. Funding mechanisms often continue to emphasize enrollment and certification numbers over long-term workforce results, creating incentives for numerical growth while possibly neglecting training quality. Financial governance therefore remains an area needing significant reform.

4.8 Social Perception and Aspirational Challenges

Vocational education continues to face serious perception problems, with traditional academic paths typically associated with social advancement. The policy suggests repositioning skill development by connecting it with future technologies and entrepreneurship. However, public perceptions are influenced not only by policy messaging but also by labor market outcomes and wage levels. If skill development pathways do not consistently provide stable employment and career advancement, behavioral attitudes may remain resistant to change despite policy initiatives.

4.9 Monitoring, Outcomes, and Accountability

The policy emphasizes measurable outcomes and evidence-based governance through the

Skill Index. However, the overall monitoring framework remains too dependent on quantitative administrative indicators like enrollment numbers and certification rates. Quality placement indicators and long-term socioeconomic outcomes are still not well integrated into evaluation systems. The absence of integrated labor market tracking systems prevents a comprehensive understanding of workforce changes. Stronger outcome-based evaluation systems will be needed to determine the true developmental impact.

V. Conclusion

The Karnataka State Skill Development Policy 2025-2032 marks a significant change in how the state approaches workforce development, employability improvement, and industrial competitiveness. The policy attempts to align skill development with the requirements of Industry 4.0, digital transformation, and entrepreneurship-driven growth through measures such as the Skill Index tool, Kaushalya Jothe Kaikeya, and district-level skill development initiatives. However, despite its strategic ambitions, the policy continues to face structural and administrative challenges that may limit its effectiveness in implementation.

From a theoretical standpoint, the policy is fundamentally based on political economy, institutional theory, and management-oriented public administration approaches. In political economy terms, the policy captures the strong connection between industrial growth, labor market needs, and government-led workforce planning. The emphasis on industry cooperation aligns with corporatist models of skill formation (Crouch et al., 1999). Institutionally, the policy's effectiveness will be shaped by differences in institutional environments across Karnataka, with Bengaluru having well-developed foundations while less developed districts face structural limitations. The policy's management orientation reflects New Public Management principles, with features like performance-driven execution and outcome-linked delivery methods. However, excessive focus on performance measures without considering regional differences may lead to procedural compliance systems that value statistical success over actual workforce transformation. Good governance requires combining efficient management practices with socially aware, regionally sensitive implementation mechanisms. The policy's success will ultimately be judged not by the number of people trained but by tangible improvements in employment outcomes and quality of life for Karnataka's workforce.

The long-term sustainability of the skill ecosystem cannot depend only on departmental coordination; it must involve all stakeholders, including local government bodies, community representatives, and industry associations. It requires strong decentralized governance structures, locally adaptable implementation mechanisms, long-term institutional investment, and balanced integration between economic productivity and social inclusion across all regions.

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INDIAN KNOWLEDGE SYSTEM AND TECHNOLOGY IN TEACHER EDUCATION

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Abstract

The New Education Policy (NEP) 2020 has been launched to make over the Indian education system using holistic expansion of the learners. This structure provides an inclusive and integrated approach for the growth of the education system. The Indian Knowledge System (IKS) is one of the important aspects of the New Education Policy curriculum. Indian Knowledge System encompasses varied and prosperous inheritance knowledge of India that covers a range of domains such as science and technology, literature, philosophy, culture, medicine (ayurveda), and yoga. New Education Policy has focused on interdisciplinary knowledge, and it can incorporate the modern knowledge vested with Indian Knowledge System to address existing and future challenges. The Indian Knowledge System covers the knowledge possessions from the early to the current era. New Education Policy fosters the creation of language possessions and technology to make possible the Indian Knowledge System as it recognizes its significance for disseminating original knowledge. The role of technology in promoting the Indian Knowledge System (IKS) in teacher education is critical. And Technology facilitates the formation of language resources and tools that assist in the distribution of indigenous knowledge. It aids in the expansion of digital platforms and repositories where Indian Knowledge System can be methodically stored, accessed, and shared. Further in addition of Indian Knowledge System with New Education Policy will assist to appreciate the underlying current societal issues and to take out further research on these issues. Present paper focuses the bird eye on role of technology on Indian Knowledge System in different ways i.e. to understand the concept, research, evolve, preserve, promote and applying the IKS concepts through technology in Teacher Education.

Keywords: *Indian knowledge system, new education policy, contemporary knowledge, interdisciplinary knowledge and holistic development*

Introduction

The Indian knowledge system (IKS) will offer a transformative expedition into the depths of early Indian wisdom and its association to the National Education Policy (NEP) 2020. The National Education Policy (NEP) 2020 served as a guiding structure emphasizing holistic learning, suppleness, technology integration, teacher empowerment, and the recognition of native knowledge and cultural inheritance. These aspects cooperatively form the foundation for a transformative education system that prepares students for the complexities of the 21st century. India is a country with an antique civilization history and practices that are known to mankind. It is predictable to mount up some knowledge throughout its survival. This antique knowledge was potted on palm trees and transferred from generation to generation verbally. But over time there were unexpected changes in the knowledge alteration process and this native knowledge was lost. The newly introduced education system has attempted to offer this knowledge to people as demanded. Through present paper one can gain precious insights, discover key learning, and role of technology in promoting the Indian Knowledge System especially in Teacher Education in India.

Indian Knowledge System

The National Education Policy (NEP) 2020 in India also envisions an education system that draws from the country's well-off cultural and scientific inheritance. The NEP aims to generate a modern, Indian Knowledge based and advanced education system, and its impact on the education will be realized over time as a variety of initiatives are rolled out. Also, UGC recommends training in Indian Knowledge system and planned that the teachers will have to learn concerning educational references in the Vedas. Hence, Teacher education Curriculum envisaged Indian Knowledge System with reference to NEP 2020 is given below. And Indian Knowledge System (IKS) comprises three words namely: Indian, Knowledge, and System.

- **Indian**

It refers to Akhanda Bharata i.e. complete Indian subcontinent. It covers the area that spans from Burma on the east, modern-day Afghanistan on the west, the Himalayas on the north, and the Indian marine on the south. The antique Indian education included the teaching of eighteen Vidya Sthanas, or schools of learning, which were imparted in well-known centers such as Nalanda and Takshashila. India's worldwide reputation has been resultant from its contributions in the fields of Art, Architecture, Science, Technology, Craft, Engineering, Philosophy, and Practices. The majority of the foreigners those who were visited India for knowledge and dispersed this knowledge to the west and other parts of the globe. This is a part of Indian Knowledge System.

- **Knowledge**

Knowledge refers to the unspoken knowledge and it lies in the understanding of knowledge seekers. It is gained by insights into individual experiences, through observations, facing real-life problems, and solving them. Knowledge may live in literary and nonliterary forms. This unspoken knowledge is transferred systematically by way of proposing innovative theories, and frameworks, and in the form of fictional work i.e. in the form of open knowledge.

- **System**

System means a disciplined methodology and categorization scheme used to access a body of knowledge. The codification and categorization are based on the requirement, interest, and ability of the knowledge seeker so that he/she may access the intrinsic knowledge. This will help them increase insights from on the whole knowledge and know-how that dissimilar knowledge components rationally complement each other.

The Indian Knowledge System is the methodical transfer of antique and modern knowledge from one generation to another. It covers ancient knowledge from a range of domains to address current and future challenges. This knowledge exists in both fictional and non-literary works. And the mechanisms of Indian Knowledge system are in below diagram;



Role of Technology for Indian Knowledge System

- **Use of Technology for Understanding IKS**

a) Digitizing IKS Literature

- Scanning and Optical Character Recognition (OCR) to protectantique manuscripts
- Artificial Intelligence (AI) tools for translating and deciphering Sanskrit, Prakrit, and other antique scripts

b) Scientific Justification

- Lab-based experiments to check Indian Knowledge System principles (e.g., Ayurvedic medicines, metallurgical techniques)
- Facts analytics to correlate antique knowledge with modern scientific findings

c) Visualization and Simulations

- Virtual Realism (VR): Immersive experiences of antique monuments and practices.
- Simulations: Testing architectural designs from Vastu Shastra or engineering concepts in chronological texts.

d) Interactive Learning Platforms

- E-Learning modules and Massive Open Online Course's (MOOC) on topics like Yoga, Ayurveda, and Vedic Mathematics
- Mobile apps for easy to get to learning in local languages

e) Research Partnership

- Open repositories for mutual worldwide research on Indian Knowledge System
- Block chain for tracing document genuineness and intellectual property

f) Communal Media and Outreach

- Dumpy videos, info graphics, and podcasts to popularize Indian Knowledge System among adolescence
- Gamified apps to connect users in learning Indian Knowledge System principles

- **Use of Technology for Investigate on IKS**

a) Digitization and Admission

- ✓ High-resolution scanning and Optical Character Recognition (OCR) for antique manuscripts
- ✓ Digital records (e.g., National Manuscripts Mission) for global right to use to Indian Knowledge System texts

b) Artificial Intelligence (AI) and Machine Learning

- ✓ Decoding antique scripts like Brahmi and Grantha
- ✓ Analyzing historical texts to recognize patterns, interpolations, and context

c) Scientific Justification

- ✓ Laboratory investigate on Ayurvedic formulations and metallurgical techniques
- ✓ Simulation tools to test architectural principles and Vedic exorbitant models

d) Data Analytics

- ✓ Cross-referencing Indian Knowledge System concepts with current scientific findings
- ✓ Insights into chronological agricultural, medical, and environmental practices

e) Provenance block chain

- ✓ Ensuring genuineness of manuscripts and tracing their chronological origins

f) Two-way Research

- ✓ Cloud-based platforms for global collaboration on Indian Knowledge System studies
- ✓ Open – source repositories for distribution data and resources

g) Immersive Technologies

- ✓ Virtual Reality(VR) and Augmented Reality(AR) to recreate chronological environments and practices for empirical learning

h) Outreach and Distribution

- ✓ Publishing findings through e-books, online journals, and digital documentaries

Use of Technology to Evolve IKS

a) Modernizing Antique Practices

- Integrating Indian Knowledge System with contemporary scientific innovations (e.g., Ayurveda and biotechnology)
- Artificial Intelligence (AI) based enhancements in Vedic Mathematics for computational advancements

b) Digital Transformation

- Development of e-learning platforms and mobile apps for teaching Indian Knowledge System
- Use of Virtual Reality(VR) and Augmented Reality(AR) for immersive learning experiences, like exploring antique Indian architecture or rituals

c) Novel Applications of Indian Knowledge System

- Applying Indian Knowledge System principles in sustainable technologies (e.g., organic farming, waste management)
- Using conventional water conservation methods (step wells, tank irrigation) in current urban planning

d) Data-Driven Insights

- Big data analytics to revive and reinterpret Indian Knowledge System principles in modern contexts
- Computational models to replicate and adapt antique ecological and medical knowledge

e) Collaborative Novelty

- Open-source platforms for interdisciplinary investigate (e.g., combining Indian Knowledge System with Artificial Intelligence, robotics or renewable force)
- Blockchain for creating transparent systems to adapt and guard Indian Knowledge System knowledge

f) Globalization of Indian Knowledge System

- Distribution of Indian Knowledge System internationally through digital content like podcasts, videos and webinars
- Promoting Yoga, Ayurveda, and meditation practices as universal wellness solutions

Use of Technology to apply IKS

a) Sustainable farming and Water Management

- ❖ Technology: Internet of Things sensors and drones for precision farming

- ❖ Application: Implementing techniques from ***Vrikshayurveda and Krishi Parashara*** for organic farming and natural annoyance control

Example: Smart irrigation systems based on conventional tank and canal designs

b) Contemporary Healthcare Solutions

- ❖ Technology: Artificial Intelligence for diagnosing diseases and recommending Ayurvedic treatments
- ❖ Application: Modified healthcare combining ***Ayurveda*** with biomedical advances

Example: Apps providing herbal medicine suggestions based on ancient texts like ***Charaka Samhita.***

c) Sustainable Urban Planning

- ❖ Technology: Geographic Information System and reproduction tools for eco-friendly urban designs
- ❖ Application: Integrating ***Vastu Shastra*** principles for energy-efficient buildings

Example: Smart cities stimulated by antique urban layouts like ***Mohenjo-Daro***

d) Renewable Force and Environmental Conservation

- ❖ Technology: Planetary panels, wind force, and green technology
- ❖ Application: Leveraging ancient environmental practices for sustainable power use and resource management

Example: Bio-composting techniques from Indian Knowledge System to manage town waste

e) Education and Consciousness

- ❖ Technology: E-learning platform, Augmented reality (AR)/Virtual reality (VR) and gamification
- ❖ Application: Teaching ***Vedic Mathematics, Yoga*****,** and Sanskrit to contemporary learners

Example: Virtual reality(VR) experiences of antique monuments and rituals for cultural immersion

f) Cultural Conservation and Tourism

- ❖ Technology: Augmented reality (AR)/ Virtual reality (VR)and Artificial Intelligence-driven apps for tourism
- ❖ Application: Promoting inheritance sites and practices such as conventional crafts and performing arts

Example: Practical tours of historical sites like Nalanda and Hampi

g) Food and Nourishment

- ❖ Technology: Dietary analysis tools and databases
- ❖ Application: Promoting conventional Indian diets based on ***Ayurvedic principles***

Example: Artificial Intelligence powered apps recommending diets based on Dosha types

- **Use of Technology to Preserve IKS**

a) Digitization of Manuscripts

- o How: High-resolution scanning, optical character recognition (OCR), and digital records can preserve antique manuscripts

Example: Initiatives like the National Mission for Manuscripts (NMM) in India make use of technology to digitize and directory thousands of manuscripts

b) Make unclear Storage and Backups

- Ensures protected and long-term preservation of digital copies, preventing loss due to physical decompose

c) Artificial Intelligence for Language Deciphering

- Artificial Intelligence algorithms can assist decode and translate antique scripts like Brahmi, Devanagari, and Tamil-Brahmi into contemporary language

d) 3D Scanning

- Digitally preserving antique monuments, artifacts, and architectural marvels connected to Indian Knowledge System

Use of Technology to Promote IKS

a) Digital Platforms and Social Media

- Websites, You Tube channels, podcasts, and communal media platforms (Instagram, Facebook, Twitter)
- How: Sharing attractive content like tutorials on Vedic arithmetic, Yoga practices, or Ayurveda tips

Example: Platforms like "AYUSH" and "Yoga with Adrienne" popularizing antique wellness practices internationally

b) E-Learning and massive open online course's (MOOC)

- Online courses on platforms like SWAYAM
- How: Developing specialized courses on Ayurveda, Vastu Shastra, and Sanskrit language learning

Example: MOOCs offering lessons in Vedic Sciences or conventional Indian art forms

c) Virtual Reality(VR)and Augmented Reality (AR)

- Immersive technologies for interactive learning
- How: recreating antique monuments, rituals, and techniques for empirical education

Example: Virtual tours of Nalanda University or antique astronomical observatories like Jantar Mantar

d) Mobile Applications

- Apps focusing on Indian Knowledge System topics such as meditation and learning Sanskrit
- How: Delivering easy to get to tools for users to discover and practice Indian Knowledge System based knowledge

Example: Apps like "ThinkRight.me" for mindfulness and "Daily Ayurveda" for health guidance

e) Blockchain for Authenticity

- Blockchain technology to bear out and protect Indian Knowledge System knowledge
- How: preventing unlawful usage and ensuring genuine dissemination of antique texts and formulations

Example: Digital watermarks for Indian Knowledge System manuscripts

f) Artificial Intelligence and Machine Learning

- Language translation and content generation tackle

- How: translating antique Indian texts into contemporary languages and creating engaging, localized content

Example: Artificial Intelligence tools for decoding and explaining complex Sanskrit verses in easy terms

g) Gamification and Edutainment

- Interactive games and edutainment platform
- How: Teaching Indian Knowledge System concepts like Vedic arithmetic or Yoga through fun and attractive formats

Example: Games based on antique Indian epics and educational apps for children

h) Joint Knowledge Hubs

- Online repositories and investigate networks
- How: Platforms for scholars, practitioners and learners to split and access Indian Knowledge System resources

Example: Digital libraries like the National Mission for Manuscripts (NMM)

Challenges of the Indian Knowledge System

a. **Fragmentation and Lack of Accessibility Issue:** IKS is often scattered across ancient texts written in languages like Sanskrit, Pali, or Prakrit, making them inaccessible to the general population.

Effect: Knowledge remains confined to scholars, limiting its broader application.

b. **Loss of Original Context Issue:** Over centuries, many texts have been lost, misinterpreted, or corrupted due to oral transmission and lack of systematic preservation.

Effect: The original intent and methodologies are often diluted or misunderstood.

c. **Lack of Scientific Validation Issue:** Many IKS principles are not rigorously tested through modern scientific methods.

Effect: This leads to skepticism in academia and among the general public, reducing its credibility.

d. **Resistance to Modernization Issue:** Some proponents of IKS resist integrating traditional knowledge with modern science and technology.

Effect: This creates a gap between ancient wisdom and contemporary application.

e. **Limited Documentation Issue:** Incomplete documentation and lack of translations restrict the dissemination of IKS globally.

Effect: Many valuable insights remain unexplored and underutilized.

f. **Decline in Traditional Learning Systems Issue:** Gurukulas and traditional modes of teaching have been replaced by modern education systems.

Effect: Practical knowledge transfer has weakened, and younger generations are less familiar with IKS.

g. **Cultural and Regional Bias Issue:** IKS often reflects the socio-cultural context of its time, which may not align with modern values or global diversity.

Effect: Some practices may seem outdated or culturally specific, limiting universal acceptance.

h. **Commercial Exploitation Issue:** IKS especially in Ayurveda and Yoga, has faced commercialization without proper regulation.

Effect: This dilutes authenticity and undermines its core principles.

i. **Ethical Concerns Issue:** Certain practices (e.g., animal sacrifices in traditional rituals) may conflict with modern ethical standards.

Effect: Such practices face criticism and hinder acceptance in contemporary society.

j. **Lack of Integration in Education Issue:** IKS is rarely included in mainstream education curricula.

Effect: Students lack exposure to this rich heritage, resulting in a disconnect with traditional wisdom.

National Education Policy and Indian Knowledge System Inclusion

The National Education Policy 2020 has emphasized that Indian Knowledge System will be part of the set of courses and will be included scientifically. Indian Knowledge System along with tribal knowledge will be incorporated in mathematics, engineering, philosophy, yoga, medicine, sports, games literature, languages, and a variety of other domains. National Education Policy has paying attention on specific courses in tribal ethno-medicinal practices, forest management, and natural and natural farming. Beneath NEP, IKS will be educated as an optional course for secondary school students. These inputs will be delivered through contemporary technologies, fun games, and cultural swap over programs among different states. National Education Policy focuses on multilingualism and the Indian Knowledge Systemwarehouse has many languages. Under NEP students will be delivered curriculum in their native languages and Sanskrit the most very old language will be taught to all. By learning diverse languages, they will know the rich and varied culture of the nation. The multi-language formula will cover the aspects of Constitutional provisions and it will generate unity and honesty across the nation (National Education Policy 2020). It would be easy to comprise the history of Indian mathematics in usual math classes. The same could be done for structural design, philosophy, and Ayurveda. This is the goal of the National Education Policy 2020, but it will have to be done slowly. There are some challenges when it comes to integrating Indian Knowledge System with National Education Policy 2020. There is a lack of consciousness among the community and stakeholders about the significance of IKS. IKS is usually present in non-literary form and it has been passed verbally from one generation to another. It makes it tricky to develop and implement IKS-based courses and programs in educational institutions. There is no clear-cut curriculum about IKS and it is leaving educationists confused. Many stakeholders may see it as immaterial or outdated. As IKS is obtainable in different languages it may create barriers to those who are not knowledgeable with these languages. Furthermore, the colonial system of education has shaped a bias against the IKS in the Indian Education system. The Indian education system is largely paying attention on the Western knowledge system and it can generate difficulty in accommodating this system. There is also a shortage of well-qualified teachers to teach the IKS because it is not extensively adopted yet.

Conclusion

The inclusion of Indian Knowledge System in India may assist the stakeholders to know their cultural heritage and they may develop a deep understanding of the environment.

The Indian knowledge system provide a profound exploration of ancient Indian wisdom and its connection to the NEP 2020 revealed invaluable insights, encompassing the roots of Indian knowledge, the wisdom contained within ancient scriptures, and the limitless potential of Indian knowledge systems. Additionally, it generated thought-provoking questions regarding the integration of ancient knowledge into modern education, the protection and dissemination of indigenous wisdom, the balance between tradition and modernity, the influence of interdisciplinary approaches, and the promotion of understanding among the younger age group.

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ARTIFICIAL INTELLIGENCE IN WOMEN REPRODUCTIVE AND MATERNAL HEALTH: ADVANTAGES, CHALLENGES, AND FUTURE PERSPECTIVES

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Abstract

For a long time, talking about reproductive and maternal health has felt like navigating a maze with half the lights out. Information is scattered, clinics are far, stigma gets in the way, and a lot of women end up relying on outdated advice or no advice at all. Artificial intelligence is starting to change that, not by replacing doctors, but by putting reliable, personalized support directly in women's hands. This paper looks at how AI tools are reshaping education and access around pregnancy, fertility, contraception, and postpartum care. Think chatbots that answer questions at 2am without judgment. Voice assistants in local languages that explain what prenatal vitamins do, or what warning signs to watch for after delivery. Apps that learn a person's cycle, symptoms, and context, then tailor guidance instead of giving one-size-fits-all pamphlets. When these tools are designed with women, not just for them, they meet people where they already are: on a phone, in their language, on their schedule. The real shift happens in access. In places where hospitals are hours away or where cultural barriers make face-to-face questions hard, AI can bridge gaps. It can triage, flag high-risk symptoms, connect users to telehealth, and remind them about checkups or vaccines. It can also help community health workers by summarizing patient histories and suggesting next steps, so care is faster and more consistent. Of course, this only works if we get it right. Data privacy, bias in training data, and digital literacy matter. An AI that assumes everyone has stable internet or reads English will miss the women who need it most. The goal here is empowerment, not surveillance. That means transparent models, local partnerships, and content co-created with midwives, doctors, and the women using it. When done well, AI doesn't just deliver information. It builds confidence. Women can ask questions freely, make informed choices, and get timely care. By combining technology with human empathy, we can move from reactive care to education that prevents problems early, and from unequal access to support that actually reaches people.

Keywords: Artificial Intelligence, Women Reproductive health, Women Maternal Health, Advantages, Challenges

Introduction

Reproductive and maternal health are key components of women's well-being. Information and services relating to contraception, pregnancy, childbirth, breastfeeding, postpartum care, and family planning help women make informed decisions. Despite the advances in the healthcare sector, many women continue to face obstacles to access to reproductive and maternal healthcare. Women residing in rural or poor communities may face even more difficulties, such as a long way to the health institution, a lack of transport means, shortage of health workers, insufficient finances, social and cultural barriers, and lack of reliable information about health issues. All these obstacles can lead to delay in seeking health services and adversely affect women's reproductive and maternal health status.

Artificial intelligence (AI) is an emerging area for solving some of these obstacles. AI can be defined as computer-based systems that can carry out various operations related to human intelligence, such as learning from data, identifying patterns, processing language, making predictions, and decision making. In healthcare, AI is used to predict diseases, to provide assistance in clinical decisions, in medical imaging, personalization of health information, patient communication, and health system management. Within the reproductive and maternal health sector, AI can be used for pregnancy monitoring, identification of risk factors, health education, appointment reminders, symptom assessment, and communication between women and health providers. However, technical innovations cannot solve inequalities that exist in the healthcare system. AI algorithms may perpetuate existing inequalities by using incomplete or unrepresentative training data. Women may encounter privacy risks due to collection and processing of sensitive information about their reproductive health. Therefore this paper is to discuss how AI can empower women by reproductive and maternal health. At the same time, it will highlight Advantage, challenges and also ethical, social, technological, and practical challenges in this area.

Objective

To Understand the uses and advantages of AI in women's reproductive and maternal health

To Understand the impact and challenges of AI on women's reproductive and maternal health

Data collection and Analysis method

This study focuses on conducting a descriptive analysis using primary data collected through a questionnaire and secondary data obtained from publicly available government sources.

Reproductive and Maternal health

According to World Health Organisation Reproductive health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes. Reproductive health implies that people are able to have a satisfying and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to do so.

According to World Health Organisation Maternal health refers to the health of women during pregnancy, childbirth and the postnatal period. Each stage should be a positive experience, ensuring women and their babies reach their full potential for health and well-being.

Artificial Intelligence

Artificial Intelligence (AI) is a part of computer science that focuses on making machines work like humans. It enables computers to perform tasks such as learning, thinking, understanding language, and solving problems. AI uses data, algorithms, and computer power to make smart decisions, just like humans do. (AI) is a part of computer science that focuses on making machines work like humans. It enables computers to perform tasks such as learning, thinking, understanding language, and solving problems. AI uses data, algorithms, and computer power to make smart decisions, just like humans do.

Uses and advantages of AI in women's reproductive and maternal health

Easy access to health information: AI can provide women with simple and understandable information about menstruation, contraception, pregnancy, childbirth, breastfeeding, and postpartum care at any time.

Personalized health guidance: AI-based tools can provide information based on a woman's individual needs, age, pregnancy stage, or health concerns.

Early identification of pregnancy risks: AI can help identify warning signs and risk factors during pregnancy, encouraging women to seek medical attention at the right time.

Support for women in rural areas: Women living far from hospitals or health centres can use AI-based applications to obtain basic health information and guidance without travelling long distances.

Improved maternal health education: AI can explain complicated medical information in simple language, helping women better understand pregnancy, childbirth, nutrition, and newborn care.

24-hour assistance: AI-powered chatbots and virtual assistants can provide basic health information around the clock, which is useful when healthcare professionals are not immediately available.

Language-friendly communication: AI can support multiple languages and simplify medical terms, making health information more accessible to women with different educational and language backgrounds.

Improved continuity of care: AI-based digital tools can remind women about antenatal visits, medications, vaccinations, check-ups, and other important aspects of maternal care

Challenges of AI on women's reproductive and maternal health

Limited Digital Access: It is not the case that all women have access to smartphones, computers, a reliable internet connection, or digital healthcare applications, and this issue is more severe in rural and economically disadvantaged areas. A lack of knowledge about digital technologies: There is a possibility that some women do not possess sufficient knowledge or self-confidence when it comes to using AI-based health services, and because of their low level of digital literacy it is hard for them to understand and make the most of these technologies. Language Difficulties: Most AI healthcare tools give insufficient support for local and regional languages, so women who are uncomfortable using English or other major languages will find these tools of less use. Risk of Bias: AI systems base their learning on current health data; if this data fails to accurately represent various groups of women, the system might give rise to biased or less suitable recommendations. Reduced Human Connection: Although AI can offer information and advice, it is not able to completely take the place of the emotional support, physical examinations, and personal care given by doctors, nurses, and midwives. Problems relating to cost and infrastructure: To establish AI-based healthcare services it is necessary to have technology, properly trained staff, internet connectivity, and routine maintenance. It can be difficult to meet these requirements in healthcare settings that are low on resources. The absence of trust and awareness: Certain women and healthcare professionals might be reluctant to use AI since they are not familiar with the technology or because they doubt the reliability of the advice it gives.

Concerns which are ethical and legal: The application of AI in maternal and reproductive healthcare brings into question issues concerning consent, responsibility, transparency, and determination of who should be held accountable when an AI-assisted recommendation results in harm. There is a need for appropriate guidelines to make sure that AI is used in a safe and

responsible manner.

Future Perspectives

AI has the possibility of making reproductive and maternal healthcare more accessible, quicker and tailored to individual needs, but these benefits can only be obtained if the technology is used in conjuction with proper healthcare services and human assistance. The AI based tools should be created in simple and local languages so that women in rural and poorly served areas can use them without difficulty. Furthermore digital literacy courses can help women to learn how to use these technologies and to recognize reliable health information Healthcare professionals must be trained so that they can use AI tools effectively without stopping them from giving patients care that is oriented around people. AI should act as a support to doctors, nurses and community health workers not take their places. Furthermore strong measures need to be put in place to guard women's personal and medical information and to make sure that AI systems are accurate, fair and free from harmful bias overnments and healthcare organisation to put money into affordable digital health infrastructure in maternal and reproductive healthcare is limited. It is important to carry out regular evaluations of AI application in order to make sure that they are safe, effective and useful for various group of women. In the future it will be necessary for healthcare professionals, technology expert, policymakers, researches and communities to work together if AI is developed responsibly and is equally accessible it can become a useful tool for improving reproductive and maternal health for helping people make informed decision and for enabling women to take a more active role in their own healthcare.

Uses of AI in Maternal and Reproductive Health

1. Prediction of Pregnancy Risk: Using AI, it would be possible to Analis the health records of a woman in order to predict possible complications during pregnancy.
2. Fetal Monitoring: AI would help to analyse fetal heart rate and other monitoring indicators in order to detect potential problems.
3. Ultrasound Analysis: Using AI, one could analyse the ultrasound images in order to evaluate the development and growth of a fetus.
4. Identification of Warning Signs for Mother Complications: With the help of AI, it would be possible to identify the signs of pre-eclampsia, gestational diabetes, and other pregnancyrelated complications.
5. Infertility Assessment: AI would help fertility specialists to analyse various health data of a patient in order to assess her infertility and predict fertile periods.
6. Evaluation of Embryos for IVF: AI would assist fertility specialists in the evaluation and selection of embryos during the process of in-vitro fertilization.
7. Individualized Antenatal Care:The analysis of individual health data would allow healthcare professionals to give individualized recommendations concerning antenatal care and nutrition.
8. Remote Monitoring of Pregnant Women: AI-driven digital health apps would be able to facilitate remote monitoring of pregnant women in places where access to medical facilities is restricted.

9. Education on Reproductive Health Issues: Through AI chatbots and digital apps, information about such topics as menstrual cycle, contraception, pregnancy, and family planning could be provided.

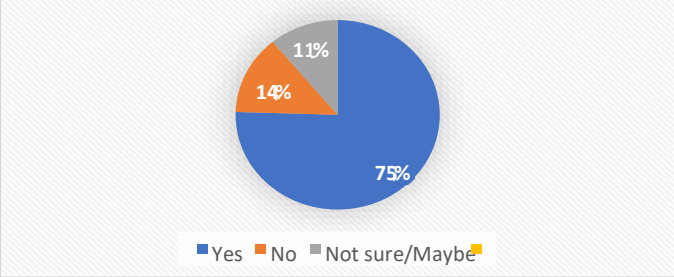
10. Postpartum Support: AI-based apps would give general information and reminders concerning postpartum care, breastfeeding, and care for babies.

Data Analysis:

The questionnaire was carried out on 20 participants, comprising 10 questions about Artificial Intelligence in reproductive and maternal health. Analysis of the response was done using frequency and percentage. Generally, the results suggest that there is a positive attitude towards AI in reproductive and maternal healthcare. From the 200 responses collected, 151 responses (75.5%) answered 'Yes', which shows that majority of the participants view positively the application and the use of AI in the healthcare field. 27 responses (13.5%) answered 'No', suggesting that there is a smaller percentage of the participants who disagreed or were not in support of the statement. 22 responses (11.0%) were 'Not sure/Maybe', indicating that some of the participants have some level of doubt about the role of AI. In general, the analysis suggests that the majority of the participants view positively the use of AI in reproductive and maternal health because of its usefulness in the future. There is need for the participants to be more aware about the application and use of AI in the healthcare field.

Question no	1	2	3	4	5	6	7	8	9	10
Yes	18	12	16	17	15	18	20	8	7	20
No	2	8	0	0	0	0	0	4	13	0
Not sure/maybe	0	0	4	3	5	2	0	8	0	0

Response	**Total**	**Percentage**
Yes	151	75.5%
No	27	13.5%
Not sure/Maybe	22	11.0%
Total	**200**	**100%**



World Health Organization (WHO):

The World Health Organization (WHO) recognizes Artificial Intelligence (AI) as a promising technology for improving sexual, reproductive and maternal health. WHO's 2024 technical brief on AI in sexual and reproductive health and rights highlights the potential of AI to improve access to health information, support screening and prediction, and assist healthcare

services.

This is directly related to the present study because lack of health information and limited access to healthcare can affect women's reproductive and maternal health, particularly in underserved communities. AI-based tools such as chatbots, digital health platforms and decision-support systems can provide women with timely information about menstruation, contraception, pregnancy, maternal care and possible health risks. From the perspective of women's empowerment, access to understandable and reliable health information can help women make informed decisions about their reproductive and maternal health. AI may also help overcome geographical barriers by providing health information digitally to women who have difficulty reaching healthcare facilities. However, WHO also highlights important challenges, including privacy, data protection, bias, misinformation, unequal access to technology and the need for human oversight. Therefore, AI should be used as a supportive tool rather than as a replacement for doctors, nurses or other qualified healthcare professionals.

GARBH-INi programme:

The GARBH-INi programme applies pregnancy-related clinical, ultrasonographic and biological data to design AI tools for pregnancy monitoring, gestational age assessment, and prediction of adverse birth outcomes, including preterm births. Thus, it shows how AI could help with health risk detection and decision-making by the healthcare specialists.

In terms of benefits, AI-based tools designed based on GARBH-INi could enable more precise pregnancy assessment, early health risk prediction, and personalised healthcare services. In particular, such technologies could be particularly useful in India, where women from rural and underprivileged areas may experience problems when receiving timely healthcare specialists' attention. At the same time, some challenges can be highlighted in connection with the GARBH-INI programme example. The AI systems need high-quality and diverse health data, clinical validation and healthcare professionals who could work with them. There is also an issue of confidentiality of women's health information, data use ethics, accuracy and bias, and inequality in access to digital technologies.

Findings:

The study on “Artificial Intelligence in Reproductive and Maternal Health: Advantages, Challenges, and Future Perspectives” found that most respondents have a positive perception of the role of AI in reproductive and maternal healthcare. The overall response showed that 75.5% of the responses were positive, indicating that participants generally recognize the usefulness and potential benefits of AI in healthcare. The findings suggest that AI may provide important advantages such as early identification of pregnancy-related risks, faster access to health information, improved healthcare support, and time-saving services. Respondents also showed confidence in the potential of AI to support pregnant women and improve maternal healthcare. At the same time, the study identified several challenges, including uncertainty about the accuracy of AI-generated health information, concerns about privacy, and limited willingness to depend completely on AI for reproductive and maternal health decisions. Some respondents were unsure about the future use of AI, showing the need for better awareness and education. Overall, the study indicates that AI has significant

potential to improve reproductive and maternal healthcare, but it should be used carefully and responsibly. The future use of AI should focus on accuracy, privacy, accessibility, ethical use, and collaboration between AI systems and healthcare professionals.

Conclusion

AI should not, however, be seen as a replacement for doctors, nurses, or other healthcare professionals. Before it can provide equal benefits to all women, problems such as privacy, data security, the spread of inaccurate information, digital literacy, unequal access to the internet, and affordability have to be dealt with. Particular attention should be given to women who live in rural, remote, and underserved areas. In general, the proper use of AI can improve reproductive and maternal healthcare and help to empower women. If technology is used together with good healthcare services, human supervision, and solid ethical protections, it can enable women to obtain reliable information, make well-informed decisions about their health, and get timely care. The future of AI in the area of reproductive and maternal health should therefore place equal emphasis on technological development as it does on accessibility, equality, safety, and meeting women's needs.

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A STUDY OF DIGITAL COMPETENCE AMONG SECONDARY SCHOOL TEACHERS

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Abstract

To ensure effectiveness and excellence in the teaching-learning process, teachers need to demonstrate both professional competence and a strong commitment to their responsibilities. In contemporary educational settings, techno-pedagogical competence enables teachers to integrate technological resources with appropriate pedagogical practices, thereby creating learning experiences that are engaging, effective and supportive for both learners and teachers.Techno-pedagogy represents the integration of three interrelated domains: content knowledge, pedagogical knowledge and technological knowledge. It extends beyond the mere use of digital tools and emphasizes the purposeful selection and application of technology to support specific teaching-learning objectives. Thus, techno-pedagogical competence may be understood as a teacher's ability to select, integrate and effectively utilize appropriate technologies in accordance with the content, learners' needs and instructional goals. A techno-pedagogically competent teacher should possess an adequate understanding of educational technologies, including their characteristics, functions, capabilities and instructional applications. Such competence enables teachers to evaluate different technological tools and select those that are appropriate to the subject content, learning context, learner characteristics and intended outcomes. Knowledge of technology alone, howver, does not ensure effective technology integration. Teachers need to understand how technological resources can be meaningfully aligned with appropriate pedagogical strategies. Such integration can promote active participation, interaction and meaningful learning. Teachers equipped with techno-pedagogical competence are therefore better positioned to design technology-supported learning environments that enhance student engagement, concentration and learning outcomes.

Keywords: *Content Knowledge, Pedagogical Knowledge, Technological Knowledge, Digital Teaching Competence, Technology Integration.*

Introduction

Education is a never-ending journey that helps people grow, learn and become strong enough to live worthwhile lives. Teachers know the details of their subjects. Can explain those details to their students. In addition to knowing the subject teachers must learn how to teach so that learning is clear and useful. In today's fast-moving world using technology inside schools has become a must for teachers. That is why teachers must build competence. Techno-pedagogical competence means using technology in a way that fits the way the teacher teaches. Adding technology to what teachers know is now more important than ever.

Teaching is an hard job that needs good subject knowledge many interests, strong teaching skills and the ability to meet each student's needs. Techno-pedagogical competence means the teacher can pick the technology combine it with good teaching and use it to make learning better. For a physical-education teacher with techno-pedagogical competence it is

important to know about the educational tools that exist and how to use them in different lessons and learning moments.

Technology helps spark ideas by turning creative thoughts into real tools, products and ways of doing things. Because of this education and technology are growing together. Technology gives ways to teach and learn. Techno-pedagogical competence of teachers can be seen through technology and teaching skills that Sana, Adhikary and Chattopadhyay (2018) listed. Those skills give a map for looking at how teachers mix technology into their teaching. Techno-pedagogical competence of teachers can. Keep improving if teachers follow several systematic strategies that Sana, Adhikary and Chattopadhyay (2018) suggest. These strategies are shown in Figure 1. Include:

- Strengthening English Language and Online Content Proficiency – helping teachers get better at reading, finding, judging and using online material in English.
- Developing Techno-Pedagogical Skills among Teachers – giving teachers training and chances to grow so they can blend technology with good teaching.
- Creating Sustainable Techno-Pedagogical Support Resources – building easy-to-use and lasting help digital tools and lesson material that make tech-based teaching smoother.
- Developing Techno-Pedagogical E-Content – making interactive subject-focused student-friendly tech-backed digital lessons, for better classroom work.
- Establishing Computer-Based Learning Resource Management Systems – setting up clear systems to sort, keep, reach and share digital learning materials using computers.
- Promoting Research and Development – urging continuous study trying new ideas inventing and building fresh tech and teaching ways to make learning better.

Objectives of the Study

To study the significant differences in techno-pedagogical competence among secondary school teachers with respect to selected demographic variables.

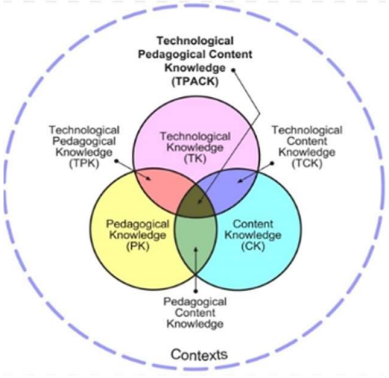


Figure 1: Showing Skills that Support Techno-Pedagogical Competence

Research Methodology

The present investigation adopted a descriptive research design using the survey method for the collection of relevant data. Descriptive research focuses on gathering information about a specific phenomenon and systematically organizing, classifying, tabulating, presenting, and interpreting the collected data. The population of the present study comprised secondary

school teachers working in private schools in Shivamogga District of Karnataka.

For the purpose of the study, the researcher selected a sample of 160 secondary school teachers from 14 private secondary schools, comprising 80 male and 80 female teachers. The sample was selected through the simple random sampling technique to ensure fair representation of the participants. The detailed distribution and classification of the selected teachers are presented in Figure 2.

Research Tool Used for Data Collection

For collecting the required data, the researcher employed the Techno-Pedagogical Competence Scale standardized by S. Rajasekhar and K. Sathya Raj (2013). The scale consists of 40 items designed to assess different dimensions of teachers' techno-pedagogical competence. The instrument covers the following four major areas:

- Use of Technology in Lesson Preparation
- Use of Technology for Motivating Learners
- Use of Technology in Classroom Presentation
- Use of Technology in Assessment and Evaluation

Statistical Techniques Used for Data Analysis

The data collected for the present study were systematically analyzed and interpreted using appropriate statistical techniques. The independent samples t-test was employed to determine the significance of differences in the techno-pedagogical competence of secondary school teachers across the selected groups.

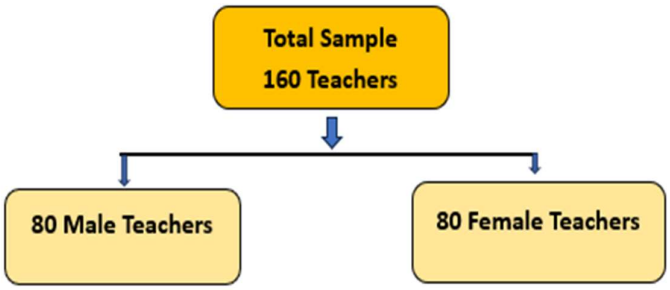


Figure 2: Showing classification of teachers as sample for the collection of data

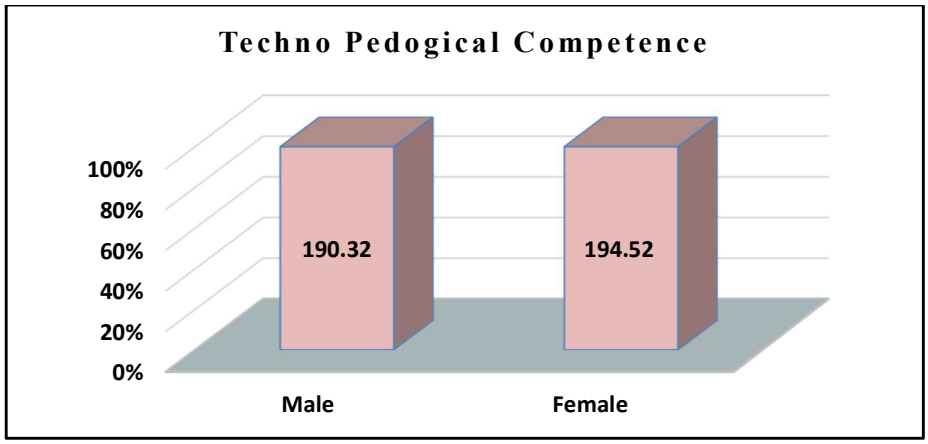
Result Analysis

A result concerning the difference in techno-pedagogical competence between male and female teachers working in private schools. To examine whether there is a significant difference in the techno-pedagogical competence of male and female teachers working in private schools, an independent samples t-test was employed. The obtained results were analyzed and are presented in Table 1.

Type of School	Variable	Gender	N	M	SD	SEd	t-ratio
Private Secondary Schools	Techno Pedagogical Competence	Male	80	190.32	24.52	4.54	1.36
		Female	80	194.52	25.81		

Table:01 Gender Differences in the Techno-Pedagogical Competency of Teachers

Working in Private Schools
(Table value at 0.05 and 0.01 level of significance is 1.98 and 2.62



Graph 1: Showing difference in techno-pedagogical competence of male and female teacher working in private schools

It is evident from the Table 1 that the obtained t-value is 1.36 which is found to be not significant. Therefore, it can be interpreted that there is no difference in techno-pedagogical competence of male and female teacher working in private schools. The difference in means scores is graphically presented in Graph 1.

Conclusion

Effective teaching requires teachers to possess a range of professional competencies, including techno-pedagogical skills, commitment to their profession, effective classroom-management abilities and the capacity to cope with occupational stress, irrespective of the subject they teach. The findings of the present study indicate that both male and female secondary school teachers working in private schools demonstrate a moderate level of techno-pedagogical competence.

Furthermore, the study reveals that the difference in techno-pedagogical competence between male and female secondary school teachers working in private schools is not statistically significant. This suggests that gender does not have a significant influence on the techno-pedagogical competence of secondary school teachers in the selected sample.

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PREPARATION OF TEACHER EDUCATION PROGRAMME FOR 21ST CENTURY EDUCATION AND DIGITAL COMPETENCIES, AI LITERACY FOR THE PROFESSIONAL DEVELOPMENT

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Abstract

The 21st century is remarked as Gen-Z and unrivalled changes in education due to rapid technological advancement, digital transformation, artificial intelligence (AI), and changing learner's needs, and evolving professional acceptances and expectations. These developments necessitate a comprehensive transformation of teacher education programmes to prepare teachers who are digitally competent, AI-literate, innovative, adaptable, and capable of facilitating meaningful learning in technology rich environments. Teacher education institutions have a major responsibility to equip future teachers with the knowledge, skills, attitudes, and ethical practices required to address the emerging demands of contemporary education. This seminar topic focuses on the preparation and restructuring of teacher education programmes in response to the requirements of 21st century education. It highlights the integration of digital competencies, artificial intelligence (AI) literacy, digital pedagogy blended and online learning, educational technologies, digital assessment, and technology enabled collaborative learning into teacher education. AI literacy is particularly important for developing in service and pre service teachers' ability to understand the basic concepts, applications, opportunities, limitations, and ethical implications of AI in education. Teachers need to learn not only how to use AI tools effectively but also how to critically evaluate AI generated information, protect data privacy, address algorithmic bias, and promote responsible and ethical use of technology.This paper further emphasizes continuous professional development of in service teachers and to become skilled through online learning platforms, communities of practice, digital portfolios, webinars, workshops, action research, and co-operative learning. It proposes competency based and practice oriented approaches that enable teacher educators and student teachers to develop digital pedagogical competence and lifelong learning habits. The integration of AI and digital technologies should adjunct, rather than replace, the teachers' professional judgment, creativity, empathy, and human relationships.This seminar presentation concludes that future ready teacher education requires a holistic dynamic curriculum, competent teacher educators, appropriate digital infrastructure, continuous professional development, and strong emphasis on ethics and human values. Preparing teachers for the 21st century is therefore not merely about technological proficiency it is about developing reflective, innovative, responsible, and lifelong-learning professionals capable of using digital technologies and AI to enhance the quality, equity, and effectiveness of education.

Keywords: *Teacher Education, Gen-Z, Digital Competencies, Artificial Intelligence, AI Literacy, Digital Pedagogy, Professional Development, Educational Technology, Lifelong Learning.*

1. Introduction: "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn."- **Alvin Toffler**

21st century has been leading by the Gen-Z and remarked as drastic changes in education system, society, technology, and the living style. The rapid growth of artificial intelligence (AI), digital technologies, online learning platforms, data driven systems, and emerging educational technologies has transformed the way knowledge is created, accessed, shared, and applied. In this changing knowledge ecosystem, teachers are no longer expected to function only as transmitters of knowledge but they are required to become facilitators of learning, designers of meaningful learning experiences, digital pedagogues, mentors, innovators, and lifelong learners. Teacher preparation plays a vital role in preparing teachers to respond effectively to these emerging demands. The quality of school education largely depends on the professional competence, technological preparedness, creativity, adaptability, and ethical awareness of teachers. Therefore, teacher education programmes need to move beyond traditional approaches and integrate 21st century skills, digital competencies, AI literacy, innovative pedagogies, critical thinking, collaboration, communication, creativity, problem solving, and lifelong learning.

Electronic media competency has become an essential component of professional teaching practice. Teachers need to possess the ability to use digital tools and platforms effectively for lesson planning, content development, communication, assessment, classroom management, collaborative learning, and professional development. Now the emergence of generative AI and other AI powered educational applications has created new opportunities as well as challenges for the educators. Teachers as well as the learners need to understand the basic concepts, possibilities, limitations, ethical implications, privacy concerns, bias, academic integrity, and responsible use of AI in teaching learning process.

Professional development should consequently be viewed as a continuous process rather than a onetime training activity. Continuous professional development through workshops, seminars, online courses, collaborative learning, action research, communities of practice, digital learning networks, and reflective practice can help teachers remain professionally competent in a rapidly changing educational environment.

The seminar topic on **"Preparation of Teacher Education Programme for 21st Century Education and Digital Competencies, AI Literacy for Professional Development"** focuses on the need to redesign and redefine teacher education programme in accordance with contemporary educational changes.

2. Contemporary 21st Century Education: The 21st century has begun on 1 January, 2001 and will be going to end on 31 December 2100 therefore we are in the 21st century. This era is marked as Gen.Z ,Gen.Z alpha and Gen.Z beta. Gen Z (Generation Z) means the generation of people generally born between about 1997 and 2012. Those who are born after 2013 they are called Gen.Z alpha and Gen.Z beta. The generation that grew up with smartphones, the internet, social media, and digital technology as a normal part of everyday life is called Gen.Z.

The 21st century has witnessed remarkable developments in information and communication technology, artificial intelligence, automation, digital platforms and global

connectivity. These changes have transformed the nature of knowledge, employment and social interaction. Consequently, education must move beyond merely providing information and should enable learners to apply knowledge creatively and responsibly in real-life situations.

3. Teacher Education in the 21st Century: Teacher education is the Teacher training programme of equipping teacher trainees with the competencies needed to teach effectively, manage classrooms, assess students, and contribute to educational development. It includes both pre service education which means before entering the teaching profession and in service education which means professional development during service.

Teacher Education in the 21st Century means the systematic preparation and continuous professional development of teachers to meet the changing technological, AI, digital, social, cultural, and economic needs of contemporary society. It goes beyond traditional subject knowledge and teaching methods by developing digital competence, AI literacy, critical thinking, creativity, collaboration, communication, ethical awareness, and lifelong learning skills.

- **The role of Teacher educators:** Teacher educators themselves must become lifelong learners and technology enabled professionals. The role of the teacher educator from a knowledge transmitter to a facilitator, mentor, learning designer, researcher, and technology enabled professional. They should be a role model for innovative pedagogy, digital competence, reflective practice, research orientation and ethical use of AI.
- **Essential Competencies required by future teachers:** Trained teachers of Teacher Education in the 21st century need a broad range of competencies to respond effectively to the changing needs and aspirations of learners and society. They should possess strong digital and technological competencies, including the ability to use digital learning platforms, educational technologies, and Artificial Intelligence (AI) responsibly. They need critical thinking, creativity, problem solving, communication, AI communication, collaboration, and adaptability to create meaningful and learner centred educational experiences. Teachers should also demonstrate pedagogical and assessment competencies, understanding diverse learning needs and using innovative teaching strategies and formative assessment techniques. Emotional intelligence, empathy, ethical awareness, cultural sensitivity, inclusivity, and social responsibility are equally important for creating safe and supportive learning environments. The future teachers along with them should develop research skills, lifelong learning attitudes, professional ethics, leadership qualities, and continuous professional development so that they can remain effective, innovative, and responsible educators in the rapidly changing 21st century educational landscape.
- **Digital Competencies required for the Teachers:** Digital competencies refer to the knowledge, skills, attitudes, and abilities required to use digital apparatus effectively, safely, responsibly, and creatively for teaching, learning, communication, professional work, and problem solving.

- **Key Components of Digital Competencies**
  - **Digital Literacy**: It is the ability to access, understands, evaluate, and use digital information.
  - **Digital Communication**: It involves using email, video conferencing, messaging, and collaborative platforms effectively.
  - **Digital Content Creation**: It is the ability to Create presentations, videos, e content, digital worksheets, and interactive learning materials
  - **Digital Collaboration**: It is the attitude of working and sharing resources through online platforms.
  - **Digital Safety**: It is the awareness of protecting personal data, privacy, passwords, and digital identity.
  - **Information Literacy**: It is the ability of identifying reliable information and avoiding misinformation.
  - **Digital Problem Solving**: It is application skill of using technology to solve educational and professional problems.
  - **Responsible Digital Citizenship**: It means using technology ethically, respectfully, and responsibly.
  - **AI Literacy**: Artificial Intelligence is the technical advancement that enables computer based machines to learn, think, understand, and perform tasks in an intelligent manner just like similar to intelligent human beings. This is the new era of literacy which means understanding and using AI tools appropriately, critically, and ethically.
- **Realignment of Teacher education programmes:** In the 21st century demands a shift from traditional teacher preparation towards competency based, technology enabled, and student centred and inclusive professional education. The programmes should integrate digital competencies, AI literacy, critical thinking, creativity, communication, collaboration, problem solving, media and information literacy, socio-emotional skills, and ethical use of technology into the curriculum. Greater emphasis should be placed on experiential learning, project based learning, blended and online learning, contemporary assessment practices, multilingual and culturally responsive pedagogy, inclusive education, and school-community engagement. Student teachers should be trained to use emerging technologies such as Artificial Intelligence, Learning Management Systems, digital content creation tools and educational applications responsibly and effectively. Continuous professional development, reflective practice, action research, internships and collaboration with schools should become integral components of teacher education. The reoriented teacher education programmes can prepare teachers who are competent, adaptable, innovative, ethical and lifelong learners**,** capable of responding effectively to the changing educational needs of the 21st century.

4. **Professional Development of Teacher in AI Era:** Professional Development of Teachers (PDT) is the continuous process of learning. It helps the teachers for improving teachers' knowledge, skills, competencies, attitudes, and professional practices throughout their careers. It enables teachers to update themselves to respond effectively to

changing educational needs, new technologies; diverse learner's needs, and emerging pedagogical approaches. In simple words it means the continuous learning and growth of a teacher to become a more effective and competent educator.

- **Components of Professional Development of Teachers:**
  - **a) Updated Subject Knowledge**: Professional development enables the teachers to update and deepening knowledge of the subject they taught.
  - **b) Contemporary Pedagogical Skills**: It helps the teachers learning innovative and learner centred teaching methods.
  - **c) Digital & media Competencies**: Developing skills in ICT, digital resources, and AI assisted teaching.
  - **d) Assessment Competencies of teachers:** Professional development Improves techniques of formative, summative, and competency based assessment of students.
  - **e) Classroom Management Skills:** Developing effective strategies for managing diverse classrooms needs.
  - **f) Research and Innovation**: Engaging in action research, reflection, and evidence based teaching.
  - **g) Professional Ethics**: Professional development Strengthens commitment, responsibility, values, and ethical practices.
  - **h) Lifelong Learning**: Continuously updating professional knowledge through workshops, seminars, conferences, MOOCs, peer learning, and other learning opportunities.
- **Key Areas of Professional Development:** In the AI era the professional development of teachers refers to effectively integrate Artificial Intelligence (AI), digital technologies, and innovative pedagogies into professional development. AI is transforming the role of teachers from being primarily transmitters of information to becoming facilitators, mentors, learning designers, critical thinkers, and ethical guides.
  - a) **AI Literacy**: Ability to understand the basic concepts, applications, and limitations of AI and familiarity with generative AI tools and AI assisted educational platforms.
  - b) **Lesson Planning using AI:** Ability to use AI to generate lesson ideas, learning activities, questions, and teaching resources.
  - c) **AI Enhanced Assessment:** Developing quizzes, rubrics, question banks, and formative assessment activities with AI assistance.
  - d) **Ethical values for using AI in teaching learning Process:** Understanding privacy, data protection, bias, misinformation, copyright, and academic integrity and teaching students responsible and ethical use of AI.
  - e) **Critical Thinking and AI Verification**: Training the teachers to verify AI generated information; Identifying hallucinations, misinformation, and biased outputs.
  - f) **Continuous Professional Development**: Participating in workshops, webinars, MOOCs, FDPs, conferences, and professional learning communities. It also involves Engaging in action research on AI supported teaching and sharing innovative practices with colleagues.

g) **Digital Pedagogical Competence**: Integrating AI with traditional and digital teaching methods. It also involves designing technology-enhanced and learner-centred learning experiences.

5. Conclusion: The preparation of teacher education programmes for 21st century education requires a fundamental shift from traditional, content centred approaches towards skill based, technology enabled, student centred and nation making teacher preparation. Teachers are no longer merely transmitters of knowledge rather than they are facilitators, mentors, designers of meaningful learning experiences and lifelong learners who must confidently navigate a rapidly changing digital and AI driven educational environment. Therefore, teacher education programmes should systematically integrate digital competencies, AI literacy, critical thinking, creativity, communication, collaboration, problem solving, digital citizenship, data literacy and ethical awareness into both pre-service and in service teacher education. AI should be viewed not as a replacement for teachers but as a powerful tool that can support personalised learning, innovative pedagogy, assessment, professional development and inclusive education while preserving human values and teacher agency. Continuous professional development, hands-on technology integration, reflective practice, experiential learning and strong collaboration between teacher education institutions and schools are essential for preparing future-ready teachers. Ultimately, a reimagined teacher education programme should empower teachers to use technology and AI effectively, ethically, critically and creatively, enabling them to respond to the diverse needs of 21st century learners and contribute meaningfully to an inclusive, equitable, innovative and knowledge driven society.

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GENERATIVE AI AS A PEDAGOGICAL TOOL IN BIOLOGY EDUCATION: A REVIEW OF OPPORTUNITIES, CHALLENGES, AND THE TRANSFORMATION OF TEACHING AND LEARNING

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Abstract

Generative Artificial Intelligence (GenAI) is reshaping educational practices by producing explanations, examples, questions, summaries, and other learning resources from natural-language prompts. Biology education is particularly relevant to this development because the discipline involves complex terminology, abstract processes, dynamic systems, data interpretation, and three-dimensional structures. This review examines the pedagogical potential of GenAI in Biology education, focusing on personalised learning, conceptual understanding, lesson planning, assessment, scientific inquiry, and learner engagement. It also examines challenges related to hallucinations, scientific inaccuracy, plagiarism, cognitive offloading, bias, privacy, data security, and unequal access. The review is based on recent systematic reviews, peer-reviewed literature, and international reports, with particular attention to studies addressing science education, teacher education, assessment, and AI literacy. The literature indicates that GenAI can support flexible explanations, differentiated learning, teacher preparation, feedback, and inquiry when its use is aligned with explicit learning goals. However, access to GenAI alone does not constitute pedagogical innovation; teacher mediation and verification remain essential. The paper therefore proposes a Human–AI–Learner framework comprising seven stages: purpose, generate, verify, contextualise, engage, reflect, and demonstrate. The framework positions the teacher as a learning designer, scientific validator, pedagogical facilitator, critical-thinking mentor, and ethical guide. Effective integration of GenAI in Biology education ultimately depends less on the sophistication of the technology than on the quality of pedagogical decisions, scientific verification, learner agency, and responsible use. The review also highlights the implications of GenAI for Biology teacher education and argues that AI literacy should be developed alongside disciplinary knowledge, pedagogical knowledge, and ethical judgement. By combining these dimensions, Biology educators can use GenAI to extend learning opportunities without transferring responsibility for scientific accuracy or educational decisions to an AI system.

Keywords: Generative Artificial Intelligence; Biology Education; Pedagogical Tool; Personalised Learning; AI Literacy; Scientific Reasoning; Teacher Education

1. Introduction

The twenty-first century has brought substantial changes to education through digital innovation. Generative Artificial Intelligence (GenAI) extends earlier digital technologies by enabling interactive generation of explanations, examples, questions, and other learning resources. Its educational significance is reflected in the development of competency frameworks that emphasise human agency, ethics, AI foundations and applications, AI pedagogy, and professional learning (Miao & Cukurova, 2024).

Biology education provides a particularly relevant context for examining GenAI. Biology

operates across levels of organisation from molecules and cells to organisms, populations, communities, and the biosphere. Learners must understand processes such as DNA replication, transcription, translation, cellular respiration, photosynthesis, physiology, and immunity while also interpreting diagrams, analysing data, applying terminology, and transferring knowledge to unfamiliar situations. GenAI can provide alternative explanations and examples, but biological accuracy is essential; therefore, learners must critically evaluate AI-generated information rather than accept it without verification.

Recent reviews indicate growing research interest in GenAI and science education. Cheung et al. (2025) reviewed 22 empirical studies and identified both productive integrations and tensions between GenAI and the epistemic and social aims of science education. Gunsaldi et al. (2025) reviewed GenAI-assisted learning in science education and reported emerging evidence concerning learning outcomes, conceptual mastery, scientific and digital literacy, personalised learning, and motivation. These findings suggest that the central question is not simply whether GenAI should be used, but how it can be integrated effectively and responsibly into Biology teaching and learning.

2. Objectives of the Review

The review aims to:

1. Examine emerging research on GenAI in Biology and science education.
2. Identify major pedagogical applications of GenAI in Biology teaching and learning.
3. Consider its contribution to personalised and learner-centred learning.
4. Examine pedagogical, ethical, and academic challenges.
5. Analyse implications for the changing role of Biology teachers.
6. Identify research gaps and future directions.

3. Review Methodology

This paper adopts a narrative review approach based on recent systematic reviews, peer-reviewed publications, and international reports. Search terms included “Generative AI,” “GenAI,” “artificial intelligence,” “Biology education,” “science education,” “AI pedagogy,” “teacher education,” “personalised learning,” “AI literacy,” and “Generative AI assessment.” Priority was given to recent literature addressing GenAI in science education, student learning, teacher education, assessment, scientific reasoning, pedagogical practice, and ethical issues. The literature was organised thematically around personalised learning and conceptual understanding; instructional design and teacher support; assessment and feedback; scientific inquiry and critical thinking; ethical issues; and teacher competencies and professional development.

4. Generative AI in Biology Education: An Emerging Landscape

GenAI can be considered at three interconnected levels. At the learner level, it can provide explanations, examples, practice opportunities, and dialogue. At the teacher level, it can assist with lesson planning, resource preparation, assessment, and feedback. At the pedagogical level, it can support inquiry, personalised learning, and reflective practice. Qian (2025) similarly identifies pedagogical applications related to learning support, assessment, critical skills, learner autonomy, and teacher–student–AI collaboration.

However, access to a GenAI chatbot should not itself be considered pedagogical innovation. Cheung et al. (2025) emphasise the importance of aligning GenAI interventions with the epistemic aims of science education. In Biology, this means connecting AI-supported activities to disciplinary knowledge, scientific reasoning, evidence evaluation, and authentic learning outcomes.

5. Pedagogical Opportunities

5.1 Personalised Learning

Students differ in prior knowledge, learning pace, language proficiency, and conceptual difficulty.

GenAI can provide alternative explanations, examples, practice questions, and different levels of challenge. For example, a learner struggling with Mendelian inheritance may request a simpler explanation and additional examples, whereas a more advanced learner may request application-based or higher-order questions. Such flexibility can support learner autonomy, but personalisation should remain teacher-directed because AI-generated learning pathways may not match curriculum requirements or individual needs.

5.2 Strengthening Conceptual Understanding

Biology contains many abstract and interconnected concepts. GenAI can present stepwise explanations, comparisons, analogies, and question-driven explanations for topics such as DNA replication, transcription, translation, cellular respiration, and hormonal regulation. Nevertheless, simplified analogies can create misconceptions. Teacher mediation and verification against authoritative biological sources are therefore necessary.

5.3 Planning and Teacher Support

GenAI can assist teachers in preparing lesson plans, learning objectives, discussion prompts, worksheets, case studies, and differentiated activities. This can reduce routine preparation time and allow greater attention to teaching and learner support. However, AI-generated plans should be treated as drafts. Teachers must evaluate their curriculum alignment, scientific accuracy, developmental appropriateness, and contextual relevance (Qian, 2025).

5.4 Assessment and Feedback

GenAI can generate multiple-choice questions, short-answer questions, case scenarios, higher-order questions, and preliminary feedback. At the same time, easy access to AI-generated answers challenges assessment practices that reward simple reproduction of information. Assessment should therefore emphasise reasoning, application, explanation, practical skills, reflection, and authentic performance.

5.5 Scientific Inquiry and Reasoning

GenAI can itself become an object of scientific inquiry. Learners may examine an AI-generated explanation, identify its claims, test those claims against scientific evidence, identify inaccuracies, revise the explanation, and justify their conclusions. Such activities can turn AI use into an opportunity to develop scientific reasoning and critical evaluation rather than passive information consumption.

5.6 Learner Engagement

Interactive AI systems can encourage learners to ask questions, seek clarification, and explore ideas. Nevertheless, engagement should not be treated as an outcome in itself. Meaningful

engagement must be connected to clearly defined conceptual and scientific learning gains.

6. Challenges and Ethical Considerations

6.1 AI Hallucinations and Scientific Accuracy

GenAI may produce information that appears convincing but is factually incorrect. In Biology, inaccurate explanations can create persistent misconceptions. Consequently, AI-generated biological information should be checked against recognised textbooks, peer-reviewed literature, and other reliable scientific sources.

6.2 Academic Integrity and Plagiarism

GenAI can produce essays, assignments, and examination responses rapidly, creating concerns about inappropriate use and academic integrity. Rather than relying solely on prohibition, institutions should establish clear expectations for responsible AI use, attribution, and verification. Assessment should also require learners to demonstrate their own reasoning and understanding.

6.3 Cognitive Offloading

Easy access to generated answers may reduce learners' willingness to struggle with challenging problems. A more productive approach is to ask learners to formulate an explanation or solution first and then use GenAI to compare, critique, and improve their work. This preserves learner agency while using AI as a scaffold.

6.4 Bias

GenAI outputs may reflect biases in training data or fail to represent the nuances of particular issues. Learners therefore require AI literacy that enables them to identify assumptions, compare outputs with credible sources, and treat AI responses as material for inquiry rather than unquestionable authority.

6.5 Privacy and Data Security

The use of AI systems raises questions about the information entered into platforms and how such information may be processed. UNESCO guidance emphasises human agency, ethical use, and protection of learners and educators (Miao & Holmes, 2023). Educational institutions should therefore establish responsible practices for data protection and AI use.

6.6 Digital Divide

Unequal access to devices, reliable internet connectivity, and AI tools can create disparities in learning opportunities. Responsible integration should therefore consider accessibility and should not make essential learning dependent on resources that some learners cannot access.

7. Redefining the Role of the Biology Teacher

GenAI does not necessarily eliminate the need for Biology teachers; rather, it can transform their roles. Teachers increasingly act as learning designers, scientific validators, pedagogical facilitators, critical-thinking mentors, ethical guides, and lifelong learners. The AI competency framework for teachers highlights the importance of AI literacy for ethical and effective educational use (Miao & Cukurova, 2024). Biology teachers do not need to become computer scientists, but they require sufficient AI literacy to evaluate outputs, design appropriate activities, and protect scientific and educational quality.

8. Implications for B.Ed. and Biology Teacher Education

Teacher education programmes should incorporate AI literacy and provide student teachers

with opportunities to use GenAI for Biology-related explanations, questions, examples, lesson activities, and assessment tasks. Student teachers should also be trained to verify AI-generated biological information using recognised textbooks and scientific literature. They need experience in identifying hallucinations, bias, privacy risks, and inappropriate dependence on AI. Teacher education should further address the ethical, social, pedagogical, and professional implications of GenAI. Spasopoulos et al. (2025) highlight the growing relevance of GenAI in pre-service science teacher education, reinforcing the need for structured preparation rather than uncritical adoption.

9. Research Gaps and Future Directions

The literature remains broader in science education than in Biology education specifically.

Future research should therefore examine Biology-specific applications and learning outcomes.

Longitudinal studies are needed to determine whether reported benefits persist over time.

Comparative studies should examine guided and unguided GenAI use and investigate whether AI-supported learning improves biological reasoning and conceptual understanding rather than only short-term performance.

Research is also needed in Indian Biology classrooms and teacher education contexts, particularly concerning language, accessibility, curricular relevance, and teacher readiness.

Further studies should investigate pedagogical strategies that enable learners to detect, verify, and correct scientifically inaccurate AI-generated information. These directions shift attention from whether GenAI can be used to which pedagogical conditions optimise learning with GenAI.

10. Proposed Human–AI–Learner Framework for Biology Education

Based on the reviewed literature, a Human–AI–Learner framework is proposed with seven stages.

Stage 1 – Purpose: The teacher identifies the intended learning gain and determines whether GenAI has genuine pedagogical value.

Stage 2 – Generate: The teacher or learner uses GenAI to generate explanations, questions, examples, or activities.

Stage 3 – Verify: The teacher checks the generated content against reliable biological references.

Stage 4 – Contextualise: The information is aligned with curriculum requirements, learner needs, and the specific Biology context.

Stage 5 – Engage: Learners question, discuss, investigate, explore, reflect, and collaborate with the material.

Stage 6 – Reflect: Learners critically evaluate the learning process and the accuracy of the AI-generated information.

Stage 7 – Demonstrate: Learners independently demonstrate mastery through appropriate assessment strategies.

The framework places human judgement between GenAI use and educational outcomes. It positions GenAI as a support for learning rather than an end in itself and reinforces the need for scientific verification and teacher mediation.

11. Conclusion

GenAI has the potential to enrich Biology education through personalised explanations, interactive learning, teacher support, assessment assistance, and opportunities for scientific inquiry. Recent reviews indicate promising applications while also identifying concerns related to overreliance, scientific accuracy, higher-order reasoning, academic integrity, and social learning (Cheung et al., 2025; Gunsaldi et al., 2025; Marzano, 2026). These findings suggest that GenAI is not inherently beneficial or harmful; its educational value depends on how it is mediated. For Biology education, scientific accuracy is particularly important. Teachers and learners must distinguish between AI-generated information and information verified through credible scientific sources. Therefore, responsible GenAI integration should prioritise human judgement, learner agency, critical evaluation, ethical practice, and disciplinary accuracy. The central issue is not whether GenAI should be used in Biology education, but how it can be used to support scientifically rigorous, learner-centred, inquiry-based teaching and learning.

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FROM TOOL ADOPTION TO PROFESSIONAL JUDGEMENT: REFRAMING RESTRAINT AS A CORE COMPETENCY IN TEACHER AI EDUCATION

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Introduction

When educators began to integrate generative AI into classrooms prior to teachers receiving adequate formal education on how to utilize generative AI tools appropriately, international organizations established competency frameworks for A.I. education. UNESCO led the charge with its A.I. Competency Framework for Teachers, which outlined the necessary skills for educators to develop toward competent use of AI in the classroom. These models however have one major flaw: each assumes that increased use of AI tools will lead to increased professional competence. Using an A.I. tool intentionally and at a point when you are choosing to abstain from using it is considered a deficiency, an anxiety, or a lack of skill. This article challenges the premise. By examining UNESCO's guidelines, and scholarly literature about developing A.I. literacy (Long & Magerko, 2020), and recent systematic review articles (Almatrafi, Johri, & Lee, 2024) we developed a three tier framework of operational adoption, critical evaluation, and professional judgment. Based upon our examination we determined that purposeful and reasoned rejection of A.I. use (which we define as pedagogical restraint) is not a deficiency. Rather it represents the highest level of professional judgment. Framing pedagogical restraint as a competency can immediately affect how teachers receive training and how teachers are evaluated. Given the unique characteristics of Indian educational systems, characterized by linguistic diversity and varying levels of resources available to schools, framing pedagogical restraint as a competency is essential if the goals of National Education Policy (NEP) 2020 are to be achieved. This paper provides no empirical data. It presents an argument that the definition of an educator's professional identity in an age of automation should include the justifiability of an educator's decisions regarding whether or not to automate parts of the educational process The most visible benchmark to date is UNESCO's "AI Competency Framework for Teachers (Miao & Cukurova, 2024), a framework that represents how educational developers map developmental milestones to help guide teachers' from elementary to advanced uses of AI in their teaching. The second was created based on prior work (protecting teacher autonomy and using the commonly referenced by Long and Magerko (2020), widely used definition of AI literacy as the ability to communicate with, critically evaluate, and effectively utilize AI systems. In each of these works there is an implied message: that continuous professional growth is one continuous ladder where any level of greater proficiency will translate directly to increased frequency, depth, and complexity of use of software. While this view is certainly clear; however it is also theoretically incorrect. The way that current definitions define competency solely based upon activity creates a very large gap: a teacher's intent to not use AI in a particular instance of

instruction has no legitimate conceptual basis. All non-use can be seen as either reluctance to use technology, fear/technology phobia, or professional incompetence. However, many skilled teachers have made purposeful choices to withhold technology throughout their entire careers. For example, a teacher makes the decision not to allow an automated grading program generate feedback about a young students creative writing piece because she feels that the young writer needs encouragement and a relationship. A teacher chooses to reject a pre-made lesson plan provided by an automated program that incorporates a national education standards curriculum because it does not include the local/cultural nuances that are present in her region. A teacher continues to provide time-consuming, human led dialogues for class discussions to give students the opportunity to think through problems in their minds so that they may learn at their own pace. These are not examples of digital illiteracy. These are examples of instructional restraint.

We argue that restraint should be considered a key aspect of professional competency as opposed to the lack of technical skills. Omitting this competency from current frameworks would skew the focus of teacher preparation programs and create inaccurate and biased methods to measure teacher performance during professional development. Furthermore, omitting this competency would leave educators without resources and support when pressured by schools and districts to demonstrate "visible technology" usage for its own sake.

Problem Statement and Research Gap

The UNESCO competency model for AI literacy consists of fifteen competencies across five categories and various levels of development. While it repeatedly emphasizes the importance of human accountability in decision-making processes within AI systems, the UNESCO model describes a linear progression of increasing complexity - where educators begin at awareness and progress to application and then to creating; each step involves adding new abilities to the educator's skill set to increase capability. Similarly, Long and Magerko (2020) in their original definition of AI literacy also assume a linear progression based upon the educator using more advanced capabilities through AI. In their model, the critical thinking process of evaluating is something that educators do when using an AI system and is never defined as a reason to turn off the machine. Almatrafi, Johri, and Lee (2024), authors of a recent systematic review of five years of AI literacy literature identified six common construct categories within AI literacy literature: recognize, know/understand, apply/use, evaluate, create, navigate ethically. Not one of these categories identifies abstaining from the use of an AI tool as an independent measureable construct. "Navigating Ethically", however, is the most similar category to describing abstaining from AI. However, as Almatrafi, Johri, and Lee (2024) identify, researchers have consistently operationalized navigating ethically as using an AI tool ethically, rather than choosing not to use an AI tool. It was reasonable that researchers would emphasize the positive aspects of AI usage in its early years. There were numerous institutional barriers that had to be overcome prior to researchers being able to assert the educational value of AI. Additionally, Zawacki-Richter et al. (2019) illustrated in their systematic review of literature on higher education that technological and administrative priorities dominated pedagogical views in the literature. Prior to developing theories regarding the limitations of AI tool use, researchers had to argue for the use of tools in order to develop

theories about those limitations. Those days are over. Today generative tools are widely used. However, the conceptual vocabulary surrounding educators' attitudes towards AI tools has yet to evolve to include a formal vocabulary that allows educators to articulate why they might want to evaluate an AI tool, understand the full range of features available in an AI tool and make a deliberate decision to exclude that tool from a lesson plan.

Conceptual Framework

Developing Vocabulary

Constructing this missing vocabulary will require bringing together three different lines of theoretical thought. First, is UNESCO's founding concept of teacher agency: educators must always be responsible for the pedagogical outcomes in any classroom, whether or not technology is present in the classroom. True agency, however, can't simply represent the ability to choose what to do with a tool; true agency must also include the power to argue against the use of tools. The obligation of being accountable mandates having the right to say no.

Secondly, there's the difference between descriptive AI literacy (the understanding of how algorithms operate) and applied AI competency (the skillful application of this knowledge). If an educator realizes that a foundation model generates citations randomly, repeats culturally biased stereotypes, or loses important nuances of language through translation; then competent practice will involve taking action based upon that realization. Sometimes the actions taken may require adjustments to prompts. More often than not, they'll result in refusing to utilize the tool.

Almatrafi et al. (2024) have developed an inventory of critical evaluation competencies necessary for educators to evaluate AI-generated materials. However, the literature has failed to provide evidence validating non-use as a valid conclusion of the evaluation process.

Third, the idea of professional judgement in teacher preparation continues to exist. Professional judgement involves evaluating multiple pedagogically appropriate, ethically appropriate and situationally appropriate variables while under conditions of real classroom uncertainty. Teaching is not merely completing a list of procedures. Therefore, AI competency will need to include situational judgement regarding when algorithmic support would be appropriately incorporated within a particular instruction sequence.

Main Analytical Discussion

Pedagogical restraint remains unaccounted for in contemporary models because current competency models resemble ladders. As each rung ascends, so too does the complexity of using software. Ladder-based models work very well for developing sequential technical skills such as writing programs or analyzing large datasets. However, professional judgment moves in two directions.

At first glance, she sits at the bottom of the “application” level of a standard competency ladder. But, as it turns out, there is much more to her thought process. She understands the limitations of algorithms better than a colleague who mechanically inserts his or her AI-generated lesson plan directly into a lesson record. Unfortunately, she will receive no credit from the ladder. The ladder will classify her informed refusal to utilize the software as an operational failure. As a result of this gap in the ladder, three negative outcomes occur in

practice:

1. Misleading Professional Development: Programs designed to measure adoption are based on how frequently an educator uses the software rather than on how well they have used their pedagogical expertise. Since educators are measured by how often they use their software, training programs will promote visible, frequent use of software regardless of whether the educator's reason for using the software was to support student learning or merely due to a desire to check all the boxes required by an administrator.
2. Incorrectly Classified Teacher Ability: Teachers who exhibit cautious restraint when deciding whether to utilize technology may incorrectly be classified as having difficulty utilizing technology. These educators would then be penalized, or be required to attend additional training sessions, while educators who continue to mindlessly paste AI-generated content into lesson records are rewarded.
3. Reduced Teacher Authority: The absence of an established method of evaluating restraint creates difficulty for educators to explain their choice of not using the software when explaining such choices to school administrators, supervisory staff members, and/or parents who believe that innovative education must include extensive amounts of screen-time. The resulting pressure to utilize technology without critical evaluation will create top-down pressures to rapidly implement untested technology.

Professional Judgement is the decisive top tier. It helps to convert critical thinking about pedagogy to pedagogically justifiable actions. Pedagogic restraint refers to the ethically justified and situational rational basis upon which a teacher decides not to deploy AI tools. As such, the restraint depicted here is not antithetical to competency but is instead an overt manifestation thereof, occurring in tandem with deliberated deployment as part of the same evaluative process.

This model diverges from traditional hierarchical depictions of skills in two respects. Firstly, these layers are non-linear. For example, a teacher may exhibit advanced professional judgment using only elementary operational tools because their ability to make judgments is what guides their decision-making rather than proficiency in technical feats. Secondly, this model depicts adoption and restraint as complementary outcomes. This enables educators to explicitly measure teachers' professional judgment, and therefore eliminate the necessity of assessing teachers' ability to rapidly operate the software.

Implications for Teacher Education and Professional Development

Adoption of this model necessitates a transformation of teacher education. Rather than solely emphasizing tutorial training on software, teacher training programs should incorporate scenario-based training exercises where trainees must engage in debate regarding and defense of both their decision to employ AI, and their decision not to do so. Moreover, evaluation rubrics used by training programs must focus beyond assessment of operational fluency to determine the degree to which a candidate has considered learners' privacy, developmental suitability, linguistic integrity and cognitive engagement when employing AI.

This view is particularly relevant in India. National Education Policy (NEP) 2020 seeks to strike a balance between digital education initiatives and robust requirements for equitable, multilingual and student centered pedagogy. In addition, given the linguistic diversity of many

classrooms in India, teachers will need to regularly make the determination of whether English-centric models can be employed to support instruction in regional languages without compromising the cultural nuances that students bring into those classrooms. Rehman, Dar, and Rasool (2025), in their examination of AI literacy within Indian higher education and the Viksit Bharat 2047 vision, suggest that India requires frameworks that are contextually relevant versus ones that have been adopted wholesale from outside the country. A restraint-inclusive framework provides an opportunity for Indian teacher education programs to pursue the technological objectives outlined in NEP 2020 without presuming that each time AI is utilized, it will inherently represent better pedagogical practice than careful consideration not to utilize AI.

Challenges and Limitations

This model is conceptual and has not been empirically tested; its practical value depends on future work operationalising Professional Judgement, including restraint, into observable indicators or assessment items, which lies beyond the scope of this paper. There is also a risk that "restraint" could be misapplied as a rationalisation for avoiding AI engagement altogether, rather than as a reasoned, case-specific judgement; the model depends on restraint being justified and articulable, not simply asserted, and teacher-education programmes would need to guard against the former reading. Finally, the model's three layers, while conceptually distinct, will in practice interact and overlap in ways a short conceptual paper can only gesture toward; a fuller treatment would need to engage with how institutional pressures, workload, and infrastructural access shape the space in which teachers can realistically exercise judgement at all.

Conclusion

This paper has argued that current AI-competency frameworks for teachers, though valuable, are structured around a logic of increasing engagement that leaves no positive place for the reasoned refusal to engage. Drawing on UNESCO's competency and ethics guidance and on foundational and recent AI-literacy scholarship, it has proposed a three-layer model, Operational Adoption, Critical Evaluation, and Professional Judgement, in which pedagogical restraint is reframed as a defining feature of advanced competence rather than a deficit. For teacher education and professional development, and particularly for Indian teacher-preparation programmes navigating NEP 2020's dual commitments to technology integration and equitable pedagogy, this reframing suggests that what should be cultivated and assessed is not simply a teacher's fluency with AI tools but their capacity to account, defensibly and reflectively, for when those tools belong in the classroom and when they do not. A smart teacher, on this account, is not defined by how much AI they use, but by how well they can justify the choices they make about it.

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TEACHING EFFECTIVENESS OF DEGREE COLLEGE LECTURERS IN RELATION TO SCIENTIFIC CREATIVITY, ATTITUDE TOWARDS ARTIFICIAL INTELLIGENCE, AND SCIENTIFIC ATTITUDE

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Abstract

The present study was undertaken to investigate the teaching effectiveness of degree college lecturers in relation to scientific creativity, attitude towards artificial intelligence, and scientific attitude. The study was conducted among 200 degree college lecturers working in different degree colleges of Kalaburagi District of Karnataka. A descriptive survey method was adopted for the study. Teaching Effectiveness, Scientific Creativity, Attitude towards Artificial Intelligence, and Scientific Attitude were considered as the major variables. Data were collected using standardized/researcher-developed rating scales. The data were analyzed using percentage, mean, standard deviation, independent sample t-test, F-test (ANOVA), and Pearson's product-moment correlation (r-test). The findings are expected to reveal whether teaching effectiveness differs significantly according to selected demographic variables and whether it is significantly related to scientific creativity, attitude towards artificial intelligence, and scientific attitude. The study has implications for teacher education, professional development, AI-integrated teaching, and improvement of the quality of higher education.

Keywords: *Teaching Effectiveness, Degree College Lecturers, Scientific Creativity, Artificial Intelligence, Scientific Attitude,*

1. Introduction:

Higher education plays a vital role in the intellectual, scientific, social, and economic development of a nation. The quality of higher education largely depends upon the quality and effectiveness of teachers. Degree college lecturers are responsible not only for transmitting subject knowledge but also for developing critical thinking, creativity, scientific temper, problem-solving abilities, and technological competencies among students.

Teaching effectiveness is a multidimensional concept that involves the lecturer's ability to plan and organize instruction, present subject matter effectively, use appropriate teaching methods and learning resources, motivate students, manage the classroom, assess learning outcomes, and provide constructive feedback.

In the contemporary educational environment, scientific creativity has become increasingly important. Scientific creativity enables lecturers to generate new ideas, identify problems, formulate hypotheses, design innovative approaches, and solve problems in novel ways. A

scientifically creative lecturer can provide students with learning experiences that go beyond memorization and encourage inquiry and innovation.

The rapid development of Artificial Intelligence (AI) has brought significant changes to higher education. AI-based tools can support lesson planning, content generation, personalized learning, assessment, research, data analysis, and academic administration. However, effective use of AI depends substantially on lecturers' knowledge, acceptance, confidence, and attitude towards AI. A positive attitude towards AI may encourage lecturers to explore innovative pedagogical practices.

Similarly, scientific attitude is essential for effective teaching. Scientific attitude includes objectivity, curiosity, open-mindedness, rationality, critical thinking, intellectual honesty, willingness to verify facts, and respect for evidence. Lecturers possessing a strong scientific attitude are likely to encourage students to think logically and critically.

Therefore, it is worthwhile to examine the relationship between teaching effectiveness and these three important characteristics—scientific creativity, attitude towards AI, and scientific attitude—among degree college lecturers.

2. Need and Significance of the Study:

The higher education system is undergoing rapid transformation because of technological development, changing learner needs, competency-based education, and the emergence of artificial intelligence.

The present study is significant for the following reasons:

1) Improvement of teaching quality: It helps identify factors associated with effective teaching among degree college lecturers.
2) Promotion of scientific creativity: Scientific creativity can help lecturers adopt innovative teaching strategies.
3) AI integration: Understanding lecturers' attitudes towards AI can support effective and responsible integration of AI into higher education.
4) Development of scientific attitude: Scientific attitude promotes evidence-based teaching and critical thinking.
5) Professional development: The findings can help colleges design appropriate faculty development programmes.
6) Policy formulation: Educational administrators can use the findings to develop training programmes for lecturers.
7) Regional relevance: The study provides empirical information regarding degree college lecturers in Kalaburagi District of Karnataka.

3. Statement of the Problem:

Teaching Effectiveness of Degree College Lecturers in Relation to Scientific Creativity, Attitude towards Artificial Intelligence, and Scientific Attitude.

4. Operational Definitions of the Terms:

1) Teaching Effectiveness:

In the present study, Teaching Effectiveness refers to the degree to which a degree college lecturer successfully plans, organizes, presents, manages, assesses, and evaluates the teaching-learning process and achieves the intended learning outcomes.

2) Scientific Creativity:

Scientific creativity refers to the ability of a lecturer to generate original and useful ideas, identify problems, formulate alternative explanations, think divergently, and develop innovative solutions in scientific and academic contexts.

3) Attitude towards Artificial Intelligence:

Attitude towards Artificial Intelligence refers to the lecturer's degree of awareness, acceptance, perceived usefulness, confidence, willingness, and positive or negative disposition towards the use of AI in teaching, learning, assessment, research, and academic activities.

4) Scientific Attitude:

Scientific attitude refers to a disposition characterized by curiosity, objectivity, rationality, open-mindedness, critical thinking, willingness to examine evidence, intellectual honesty, and readiness to modify conclusions based on evidence.

5) Degree College Lecturers:

In the present study, degree college lecturers refer to teachers working in undergraduate degree colleges located in Kalaburagi District of Karnataka.

5. Objectives of the Study:

The study was conducted with the following objectives:

1) To find out whether there is a significant difference in teaching effectiveness with respect to Gender
2) To find out whether there is a significant difference in teaching effectiveness with respect to teaching experience
3) To determine the relationship between teaching effectiveness and scientific creativity.
4) To determine the relationship between teaching effectiveness and attitude towards artificial intelligence.
5) To determine the relationship between teaching effectiveness and scientific attitude.

6. Hypotheses of the Study:

The following null hypotheses may be formulated:

1) H01: There is no significant difference in the teaching effectiveness of degree college lecturers with respect to gender.
2) H02 : There is no significant difference in teaching effectiveness among lecturers with different levels of teaching experience.
3) H03: There is no significant relationship between teaching effectiveness and scientific creativity.
4) H04: There is no significant relationship between teaching effectiveness and attitude towards artificial intelligence.
5) H05: There is no significant relationship between teaching effectiveness and scientific attitude.

7. Methodology:

7.1 Method:

The **Descriptive Survey Method** was adopted for the present study.

7.2 Population:

The population consisted of lecturers working in degree colleges in Kalaburagi District of

Karnataka.

7.3 Sample:

A sample of 200 degree college lecturers was selected from different degree colleges of Kalaburagi District.

A suitable sampling procedure such as stratified random **sampling** were adopted to ensure representation of lecturers from different types of colleges and demographic groups.

8. Tools for Data Collection:

The following tools have been used:

1. Verbal Test of Scientific Creativity by V.P. Sharma and J.P. Shukla (2006).
2. Attitude towards Artificial Intelligence Scale Prepared and Standardized by Investigator
3. Scientific Attitude Scale Developed by Dr. J.K. Sood and R.P. Sandhya
4. Teaching Effectiveness Scale Developed by Dr. Pramod Kumar & D.N. Mutha

9. Statistical Techniques:

The collected data may be analyzed using:

1) Mean: To determine the average score.

2) Standard Deviation: To determine the variability of scores.

3) Independent Sample t-Test: To determine significant differences between two groups.

4) F-Test / One-Way ANOVA: To determine significant differences among three or more groups.

5) Pearson Product-Moment Correlation (r-Test): To determine the relationship between the major variables.

The level of significance may be fixed at: **0.05 and 0.01 levels.**

10. Data Analysis based on hypotheses:

1. **H01: There is no significant difference in the teaching effectiveness of degree college lecturers with respect to gender.**

Table 2: Mean, SD and *t*-Value of Teaching Effectiveness by Gender

Gender	N	Mean	SD	*t*-value	Significance
Male	120	78.42	8.16	1.52	Not Significant
Female	80	80.18	8.31		

Note: Critical *t*-value at 0.05 level of significance (df = 198) ≈ **1.97**.

The above table presents the comparison of teaching effectiveness of degree college lecturers with respect to gender. The sample consisted of 200 lecturers, of whom 120 were male and 80 were female. The mean teaching effectiveness score of male lecturers was 78.42, with a standard deviation of 8.16, whereas the mean score of female lecturers was 80.18, with a standard deviation of 8.31. Thus, female lecturers obtained a slightly higher mean teaching effectiveness score than male lecturers. The obtained *t*-value was 1.52. The critical *t*-value at the 0.05 level of significance for 198 degrees of freedom is approximately 1.97. Since the obtained *t*-value (1.52) is less than the critical *t*-value (1.97), the difference between the mean teaching effectiveness scores of male and female lecturers is not statistically significant at the 0.05 level. Therefore, the null hypothesis is retained. It may be concluded that there is no significant difference in the teaching effectiveness of male and female degree college

lecturers. Although female lecturers show a somewhat higher average teaching effectiveness score (80.18) than male lecturers (78.42), the difference is not large enough to be considered statistically significant. Hence, gender does not appear to have a significant influence on the teaching effectiveness of degree college lecturers in the present hypothetical study

2. **H02 : There is no significant difference in teaching effectiveness among lecturers with different levels of teaching experience.**

Table 3: ANOVA of Teaching Effectiveness According to Teaching Experience

Source of Variance	SS	df	MS	F	Significance
Between Groups	1,286.40	2	643.20	4.62	Significant
Within Groups	27,411.60	197	139.15		
Total	28,698.00	199			

Critical F-value at 0.05 level of significance for df = (2, 197) is approximately 3.04.

The above table shows the results of the one-way ANOVA conducted to determine whether there is a significant difference in the teaching effectiveness of degree college lecturers with respect to their teaching experience. The total sum of squares is 28,698.00, of which 1,286.40 is attributed to differences between the three experience groups, while 27,411.60 is attributed to differences within the groups. The corresponding degrees of freedom are 2 and 197, respectively. The mean square between groups is 643.20, and the mean square within groups is 139.15. The obtained F-value is 4.62. The critical F-value at the 0.05 level of significance for degrees of freedom 2 and 197 is approximately 3.04. Since the obtained F-value (4.62) is greater than the critical F-value (3.04), the result is statistically significant at the 0.05 level. Therefore, the null hypothesis is rejected. It may be concluded that there is a significant difference in the teaching effectiveness of degree college lecturers with low, medium, and high teaching experience. The significant F-value indicates that at least one of the three experience groups differs significantly from another in teaching effectiveness. However, ANOVA alone does not indicate exactly which groups differ. Therefore, a post-hoc test such as Tukey's HSD may be conducted to identify the specific pairs of experience groups showing significant differences. Overall, the hypothetical findings suggest that teaching experience is significantly associated with the teaching effectiveness of degree college lecturers. This may indicate that lecturers' teaching effectiveness tends to vary according to their level of professional teaching experience.

3. **H03: There is no significant relationship between teaching effectiveness and scientific creativity.**

Table 4: Correlation between Teaching Effectiveness and Scientific Creativity

Variables	N	*r*-value	Significance
Teaching Effectiveness × Scientific Creativity	200	**0.58**	**Significant at 0.01 level**

The obtained r-value of 0.58 is significant at the 0.01 level.

The above table presents the relationship between teaching effectiveness and scientific creativity among degree college lecturers. Pearson's product-moment correlation coefficient was employed to determine the nature and strength of the relationship between the

two variables. The obtained correlation coefficient between teaching effectiveness and scientific creativity is 0.58 for a sample of 200 lecturers. The correlation is positive, indicating that lecturers who possess higher levels of scientific creativity tend to demonstrate higher levels of teaching effectiveness. The obtained r-value of 0.58 indicates a moderate to moderately strong positive relationship between teaching effectiveness and scientific creativity. Since the correlation is statistically significant at the 0.01 level, the observed relationship is unlikely to have occurred merely by chance. Therefore, the null hypothesis of no significant relationship between teaching effectiveness and scientific creativity is rejected. It may be concluded that there is a significant positive relationship between teaching effectiveness and scientific creativity among degree college lecturers. In practical terms, the finding suggests that scientifically creative lecturers may be more effective in their teaching, possibly because scientific creativity can support innovative teaching methods, problem-solving, experimentation, critical thinking, and the development of engaging learning experiences. Thus, the hypothetical result indicates that scientific creativity is an important correlate of teaching effectiveness among degree college lecturers.

4. H04: There is no significant relationship between teaching effectiveness and attitude towards artificial intelligence.

Table 5: Correlation between Teaching Effectiveness and Attitude towards AI

Variables	N	*r*-value	Significance
Teaching Effectiveness × Attitude towards AI	200	0.64	Significant at 0.01 level

The obtained r-value of 0.64 is significant at the 0.01 level.

The above table presents the relationship between teaching effectiveness and Attitude towards AI among degree college lecturers. Pearson's product-moment correlation coefficient was used to determine the direction and strength of the relationship between the two variables. The obtained correlation coefficient between teaching effectiveness and Scientific Creativity is 0.64 for a sample of 200 lecturers. The positive value of the correlation coefficient indicates that there is a positive relationship between the two variables. This means that lecturers with more favourable Attitude towards AI tend to have higher levels of teaching effectiveness. The magnitude of the *r*-value (0.64) indicates a moderately strong positive correlation between teaching effectiveness and Attitude towards AI. Since the obtained correlation is statistically significant at the 0.01 level, the relationship is considered statistically significant. Therefore, the null hypothesis stating that there is no significant relationship between teaching effectiveness and Attitude towards AI is rejected. It may be concluded that there is a significant positive relationship between teaching effectiveness and lecturers' attitudes towards Artificial Intelligence.

5. H05: There is no significant relationship between teaching effectiveness and scientific attitude.

Table 6: Correlation between Teaching Effectiveness and Scientific Attitude

Variables	N	*r*-value	Significance
Teaching Effectiveness × Scientific Attitude	200	0.61	Significant at 0.01 level

The obtained r-value of 0.61 is significant at the 0.01 level.

The above table presents the relationship between teaching effectiveness and scientific attitude among degree college lecturers. Pearson's product-moment correlation coefficient was used to determine the direction and strength of the relationship between the two variables. The obtained correlation coefficient between teaching effectiveness and scientific attitude is 0.61 for a sample of 200 lecturers. The positive value of the correlation coefficient indicates that lecturers with a more favourable scientific attitude tend to demonstrate higher levels of teaching effectiveness. The magnitude of the *r*-value (0.61) indicates a moderately strong positive relationship between teaching effectiveness and scientific attitude. Since the obtained correlation coefficient is statistically significant at the 0.01 level, the relationship is statistically significant. Therefore, the null hypothesis stating that there is no significant relationship between teaching effectiveness and scientific attitude is rejected. It may be concluded that there is a significant positive relationship between teaching effectiveness and scientific attitude among degree college lecturers. The finding suggests that lecturers possessing a strong scientific attitude—characterized by objectivity, curiosity, rational thinking, open-mindedness, critical thinking, willingness to verify evidence, and systematic problem-solving—are more likely to employ effective teaching practices. Thus, the result indicates that scientific attitude is an important correlate of teaching effectiveness among degree college lecturers. Strengthening scientific attitude among lecturers may therefore contribute to the development of innovative, evidence-based, rational, and learner-centred teaching practice

6. Conclusion:

The present study focuses on an important contemporary issue in higher education by examining the teaching effectiveness of degree college lecturers in relation to scientific creativity, attitude towards artificial intelligence, and scientific attitude. In the context of rapid technological transformation, lecturers need not only strong subject knowledge but also creativity, scientific thinking, and readiness to adopt emerging technologies. Scientific creativity can facilitate innovative approaches to teaching and problem solving, while a positive and responsible attitude towards AI can support the integration of emerging technologies into teaching, assessment, and research. Scientific attitude, meanwhile, provides a foundation for rational, objective, evidence-based, and reflective teaching practices. The study of these variables among 200 degree college lecturers in Kalaburagi District can therefore provide useful evidence for improving professional development programmes and the quality of higher education. The results obtained through *t*-test, F-test, and Pearson's *r*-test will provide an empirical basis for understanding group differences and relationships among the major variables.

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IMPACT OF AI IN TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: POSSIBILITIES AND CHALLENGES

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Abstract

The 21st century is a century of AI because the whole world is eagerly waiting for the upliftment of human lifestyle. At the same time, education is an integral part of human life. Then we must understand the relationship between Teacher Education and Professional Development with AI. These two terms are the two faces of one coin. Teacher Education is one of the most popular terms of the 21st century because it is directly connected with the development of the country. How much we maintain the quality of teacher education it strengthens our education system. The government has made several reforms in it. On the other hand we must adopt 'AI' in Teacher Education it is more valuable. However, professional development is the base for the teacher development. In service teacher training programmes are the integral part of professional development. Every in-service training provides the insight of the aims and objectives of programme. It is essential also.

Key words: *Artificial intelligence (AI), Teacher Education, Professional Development, In-service Teacher training programme.*

Introduction:

Artificial intelligence (AI) is more of a broader term because it is used in every sector. Especially in education, it is being used effectively. The advancement was done in Education through the educational technology. AI technologies in schools can support more time for student engagement and learning experiences. The smart classroom is an integral part of using AI in education, and it supports students' skill development for future work. Smart campus operations can harness AI to boost student engagement and introduce new types of content and operations. AI gives more confidence and inspiration to both teachers and students. For better learning outcomes in education, we must use AI systematically. The use of educational technology in schools is becoming more mainstream. AI can take many shapes and forms in education. Incorporating intelligent AI technology into schools can also help teachers, staff and administrators by automating repetitive or time- consuming tasks, freeing time to focus on enabling student success.

During this digital age, Artificial Intelligence has emerged as a transformative force, which revolutionises all sectors of human life. The advancement in teacher education and professional development is a major requirement of the modern age. The traditional method of teaching lacks new inventions. But the modern method of teaching is the best option of

uplifting the educational system of the country. Education is a major resource of human beings. The ultimate aim of education is the modification of behaviour and cultivation of mind. The whole county needs a change in every sector; among them education is one. In that way we can adopt those new methods in teaching, and it is need for the hour.

Methodology:

The paper is exploratory in nature and the information is gathered by reviewing various article intelligence (AI) drawn from articles available on journals, magazines and other internet resources. In all the paper is based on secondary sources of information.

Objectives:

The objectives of this study as follows;

1. To assess the role of artificial intelligence on professional development and teacher education.
2. To explore the changes in the Education sector after implementing AI.
3. To compare modern day teaching with ancient method of teaching.

Review of literature:

1. Khairul Jamaludin (2026) "the role of AI in Higher Education, teacher training, and professional development: Teachers' perspective". The study aimed to evaluate the role of AI in higher education, teacher training and professional development from the teachers' perspective.
2. James Gordon "Teacher Professional Formation in the Age of AI". This paper examines how artificial intelligence (AI), especially large language models (LLMs), is reshaping the way new teachers engage in professional formation during their initial teacher education (ITE) and early workplace experiences.

AI's role in teacher Education and professional development:

At first Teacher training programs depend upon in-person seminars workshops and classroom practice which generally lack personalized approach. With the help of AI these limitations can be solved. Some important roles of AI for teacher Education professional development are discussed below:

- **AI provide personalized teacher Education**:

AI provides personalized teacher training programs by analyzing their strengths and weakness. Ai can collect data related to a teacher's progress and provide guidance regarding improvement in the area as per need of the teacher. With the help of AI teachers can access modules, courses according to their pace and style and also received feedback.

- **Virtual simulation and AI chatbots**:

the creation of virtual classroom enabled by AI technology and it helps teachers to practice lessons with simulated students. By these AI technology and it helps teachers to practice lessons with simulated students. By these AI driven simulations, teachers can refine their teaching techniques and also familiarize with various classroom situations which help them in their teaching task with real students. Moreover, AI chatbots provide on demand support to teachers by answering questions and offering professional development courses.

- **AI and Continuous Professional Development:**

previously teacher professional development depended upon formal workshops and seminars

which might not happen regularly. But now through virtual workshops, online learning and assessment platforms, AI provides opportunity for continuous professional development to teachers. AI driven tools help teachers in continually upgrading their knowledge and skills by providing them immediate feedback, assessment and suggestions for further development. These platforms updated teachers with the latest educational trends, technologies and pedagogies.

- **AI in classroom management and pedagogical improvement:**

AI provides data driven insights into student performance, their behavior, and learning patterns. With the help of AI tools, teachers can identify students who need extra attention or different pedagogical approaches. By this data driven analysis teacher can adjust their teaching strategies to enhance learning outcomes, which is a key objective of NEP 2020. Additionally, AI helps teachers in integrating advanced pedagogical tools like adaptive learning systems which assist students in their progress and also teachers can manage diverse needs of students in their classrooms.

- **AI and Inclusion and Diversity**:

AI helps to make an environment that accommodates all students irrespective of their background, making it possible that no child is left behind. AI related tools empower teachers in creating a more inclusive learning environment as it helps teachers in recognizing the specific learning needs of students as well as children with special needs or learning disabilities. AI provides differential teaching methods, strategies to cater the needs of the students.

- **AI provide Real time data and feedback for improvement:**

AI works on it as it provides data related to students' engagement, performance and progress. Also guide teachers in delivery of their lesson and students' participation during teaching session. Teachers can receive immediate feedback and accordingly make necessary adjustments.

- **AI and Bridging the gap in remote and underserved areas:**

Lack of resources and infrastructure, especially in rural and remote areas is a noteworthy challenge in teacher training programs in India. AI platforms provide solutions to this challenge by offering remote access to high quality teacher training programs. Noe there is no need to travel long distances to attend training sessions but they can access from anywhere and anytime as per their own convenience.

- **Improving Emotional intelligence:**

AI can assist teachers in developing emotional intelligence, which is critical for creating positive classroom environments. AI applications can help teachers reflect on their interactions with students and provide suggetions for improving classroom management. For instance, AI can analyse the tone of voice, body language, and overall classroom sentiment, offering recommendations for strengthening relationships with students and improving overall enagement.

- **Administrative support and AI:**

By automating many administrative tasks AI helps teachers in their administrative tasks AI helps teachers in their administrative work. Teachers are overburdened by time-scheduling,

attendance and grading tasks and AI tools assist them by alleviating this burden so that teachers can devote more time and attention to teaching and professional development.

- **Improves Efficiency**:

AI improves efficiency of teachers by assisting them in planning, assigning tasks and supervision of learner's activities. AI makes teaching learning tasks easier and also minimizes paperwork among teachers.

- **AI and collaborative teacher network**:

Through virtual network, educators across countries collaborate with each other, discuss their strategies with one another, share their ideas and resources. And thus, engage in a collective problem solving approach, solving each other's matters and help in their professional development through peer to peer interaction and mutual support.

- **AI tools for Teacher Training and Professional Development**:

In India, Teacher training and Professional development programs are progressively transforming by Artificial Intelligence.

- **Initiatives by National Council of Educational Research and Training (NCERT):**

NCERT also takes an initiative to provide educators hands-on experience regarding AI tools. CIET under NCERT conducts training programs in order to enhance skills of teachers to utilize AI tools effectively in the teaching learning process.

- **Generative AI:**

"Generative AI for educators" is free and self- paced course which is by Google in collaboration with MIT RAISE. This two-hour course is designed for middle and high school teachers. After completion educators received certificates which helped them in professional development. This course provides Practicle applications of AI to help in personalizing instruction, save time and enhance lesson creativity.

- **Brisk Teaching's AI tools**:

this is free AI tools for educators which include AI lesson plan generator and students' instant feedback mechanisms, which help teachers in enhancing efficiency in their routine activity and increasing effectiveness in the classroom teaching learning process.

- **OpenAI Training course**:

This course provides free training in Artificial Intelligence and prompt Engineering. OpenAI works in partnership with Common Sense Media. This course helps teachers in how to use ChatGPT in their teaching learning process, how to create lesson contents and organize other administrative tasks in a better way.

- **India AI Portal:**

This National AI portal was launched by the Government of India, which offers a repository of AI-related resources, including articles, news, research papers and educational resources. This portal helps educators to access AI tools and remain updated on the latest developments of the Indian education system by integrating AI.

- **Canva**:

Canva is an online Graphic design platform which provides templates, fonts, photos, and design elements for creation of professional design. It is a user- friendly drag and drop interface which assists in creation of presentation, posters, for resume, brochures, social media

graphics and many more.

These are all AI tools and platforms contribute to the teacher education and training course and also on professional development in India on a large scale.

Challenges and the way forward: Discussion and Suggestions

Although the role of Artificial Intelligence in Teacher training and professional development is crucial but several challenges must be considered:

- **Cost and Accessibility to technology:**

AI based teacher training tools need high quality devices and internet connectivity but due to digital divide, in rural and underserved areas access to technology is limited. There is an urgent need for high-speed internet connectivity, infrastructure, and availability of low-cost devices. Therefore, there is a requirement of policies and initiatives by Government and stakeholders to address these issues.

- **Data security and Privacy:**

AI tools and platforms require data related to students' performance, their behavior pattern, educational outcomes, biometric information of teachers-students. These are very sensitive data which need to be protected and prevented from misuse. It is important to implement data protection measures to safeguard privacy. Therefore, there must be clear ethical guidelines established to direct the use of AI in education.

- **Balance between AI and Human Connection:**

AI can enhance professional development but it cannot provide emotional support, mentorship or peer interaction which is crucial for growth of teachers and students. AI cannot replicate completely. The human element of teaching remains irreplaceable. Therefore, there must be a balance between leveraging technology and human connection for teacher growth.

- **Teacher training to use AI efficiently:**

Teachers must be trained to use AI tools effectively and efficiently. For this there must be integration of AI into teachers training programs and ensure that teachers must be comfortable with new technologies.

- **Dependence on Technology**:

In the current scenario there is a concern that teachers and students might become heavily dependent upon technology that is on AI tools and platforms for answers and solutions of their educational queries. It could lead to decline in critical analysis and problem- solving abilities of students. Moreover, technology has limitations also and it could hinder learning experiences. It is utmost important that AI assist to enhance not to replace the conventional teaching methods.

- **Quality and Relevance of content**:

The quality of the content available on AI platforms is another significant challenge that needs to be addressed. There is important questions that AI content and educational materials are correct, up-to-date and relevant to the curriculum.

Educational Implications:

- Teacher training programmes should integrate AI literacy and digital pedagogy.
- Institutions should provide continuous professional development on ethical AI use.
- Policymakers should ensure equitable access to AI-based training resources.

- Teacher educators should emphasise human- centred and reflective AI integration.

Conclusion

AI is reshaping teacher training and professional development by offering personalized, data-driven solutions that empower educators to enhance their teaching practices continuously. From real time feedback to virtual simulations, AI has the potential to improve both the efficiency and effectiveness of teacher development.

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A STUDY OF ACADEMIC ACHIEVEMENT AND ACHIEVEMENT MOTIVATION OF 10th STANDARD STUDENTS

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Abstract

The present study used to find out the important relationship between academic achievement and achievement motivation of 10th standard students. Achievement motivation refers to the specific needs for identifying these phenomena. Achievement motivation and academic achievement as a natural and inevitable essential outcome of 10th standard students' growth and development. In this study to find out the relationship of the achievement motivation with Academic Achievement of 10th standard students. It was concluded from the study that achievement motivation was strongly and positively correlated and significant. It can be concluded based on the findings of this study that students of rural showed higher achievement motivation as compared to students of urban. Here achievement motivation Scale and Academic Achievement scores used. The results differences in achievement motivation and academic achievement of 10th standard students between rural and urban concluded in this study.

Key words; *Achievement motivation. Academic Achievement, Secondary school, variables, hypothesis, Objectives. Statistical Techniques. 10th standard students.*

Introduction

One aspect of this theory is that individuals are motivated to either avoid failure or achieve success. In the former situation, the individual is more likely to select easy or difficult tasks, thereby either achieving success or having a good excuse for why failure occurred. In the latter situation, the individual is more likely to select moderately difficult tasks which will provide an interesting challenge, but still keep the high expectations for success.

Concept of Academic Achievement

Achievement refers to the scholastic or academic achievement of the student at the end of an educational programmed. Academic performance according to the Cambridge University Reporter (2003) is frequently defined in terms of examination performance. Academic achievement refers to what the students have learned what skills the students have learned and is usually measured through assessments like standardized tests, performance assessments and portfolio assessments (Santrock 2006). The descriptive assessment information will usually be translated through grading system such as Grade Point Average (GPA) and course grade. The study will make use of Cumulated Grade Point Average (CGPA) since it provides information of the students' academic performance across time.

Academic achievement performance, which is measured by the examination results, is one of the major goals of a school. Hayle (1986) argued that schools are established with the aim of imparting knowledge and skills to those who go through them and behind all this is the idea of enhancing good academic performance

Concept of Achievement motivation

Achievement motivation is the internal psychological drive that compels an individual to pursue success, set high standards of excellence, and persist through challenges Achievement is undoubtedly the most thoroughly studied motive. It was first identified in Henry A. Murray's list of "psychogenic" needs as "n(eed) Achievement," and described in the following terms: To accomplish something difficult. To master, manipulate or organize physical objects, human beings, or ideas. To do this as rapidly and as independently as possible

Achievement motivation refers the internal motivation that gives people the drive to work towards success, cope with obstacles, and reach high levels of excellence (Bronstein & Heckhausen, 2018). Classical theories of achievement motivation imply that people with higher achievement motivation levels are associated with the choice of moderately challenging tasks, favorable work conditions in which clear feedback is obtained, and greater persistence when confronted with challenges (Elliot & McGregor, 2001).

The Problem

The present investigation is titled as: "**A Study of Achievement Motivation and Academic Achievement of 10th standard students".**

Objectives of the Study

1. To study the difference between 10th standard students of low and high achievement motivation with respect to academic achievement.
2. To study the interaction effect of gender (Boys and Girls) and achievement motivation (Low and high) on academic achievement of 10th standard students.

Significance of the Study

The specific needs for identifying these phenomena of achievement motivation and academic achievement as a natural and inevitable essential outcome of 10th standard students growth and development rather than among pathological symptom. The achievement motivation and academic achievement becomes important in the student life of individual 10th standard students. As the students are the pillars of the future generations their value pattern of achievement motivation and academic achievement are vital. So the present study intends to measure the achievement motivation and academic achievement of 10th standard students

Variable of the Study : In the present study the following variables were considered:

- Achievement Motivation
- Academic Achievement of students

Hypotheses of the Study

Hypothesis: There is no significant difference between 10th standard students of low and high achievement motivation with respect to academic achievement.

Hypothesis: There is no significant interaction effect of gender (Boys and Girls) and achievement motivation (Low and High) on academic achievement of 10th standard students

Research Tools Used

The following tool has been employed for collecting data for the present study.

- Achievement Motivation Scale
- Academic Achievement Score

Population and Sample

The sample of the present study consists of 600 10th standard students. The required sample was selected using stratified random sampling technique. 600 students were different secondary schools were drawn for the present investigation.

Data Collection

The investigator was collected the data from 600 10th standard students of Davanagere district. The investigator has requested the Headmasters of schools and personally administered the tool to the students. Clear-cut instruction was given to fill up the responses to the items in the tools. The collected data was systematically pooled for analyses.

Statistical Techniques

For the analysis of data collected, differential analysis, such as mean, standard deviation, ANOVA, t-test, analysis was used.

Data Analyses

Table-1: Results of t-test between 10th standard students of Low and High Achievement Motivation with Respect to Academic Achievement

Achievement motivation	Mean	SD	SE	t-value	p-value	Signi.
Low achievement motivation	358.85	59.30	3.47	-32.6897	0.0001	<0.05, S
High achievement motivation	518.45	44.56	2.80			

From the results of the above table, it can be seen that, a significant difference is observed between 10th standard students of low and high achievement motivation respect to academic achievement (t=-32.6897, p<0.05) at 0.05 level of significance. Hence, the null hypothesis is rejected and alternative hypothesis is accepted. It means that, the secondary school students with high achievement motivation have significantly smaller academic achievement as compared to 10th standard students with low achievement motivation.

Table-2: Pair-wise Comparison of Interaction Effects of Gender (Boys and Girls) and Achievement Motivation (Low and High) on Academic Achievement of 10th standard students by Tukeys Multiple Posthoc Procedures

Interactions	Boys with low AM	Boys with high AM	Girls with low AM	Girls with high AM
Mean	365.79	503.27	363.49	511.78
SD	62.72	41.60	58.90	46.95
Boys with low AM	-			
Boys with high AM	p=0.0001*	-		
Girls with low AM	p=0.2000	p=0.0001*	-	
Girls with high AM	p=0.0001*	p=0.6941	p=0.0001*	-

*p<0.05

From the results of the above table, it clearly showed that,

- The secondary school boy students with low achievement motivation and 10th standard boy students with high achievement motivation differ significantly with respect to

academic achievement at 0.05 level of significance. It means that, the 10th standard boy students with high achievement motivation have higher academic achievement as compared to the 10th standard boy students with low achievement motivation.

- The 10th standard boy students with low achievement motivation and 10th standard girl students with high achievement motivation do not differ significantly with respect to academic achievement at 0.05 level of significance. It means that, the 10th standard boy students with low achievement motivation and 10th standard girl students with high achievement motivation have similar academic achievement.
- The 10th standard boy students with low achievement motivation and 10th standard girl students with high achievement motivation differ significantly with respect to academic achievement at 0.05 level of significance. It means that, the 10th standard girl students with high achievement motivation have higher academic achievement as compared to the 10th standard boy students with low achievement motivation.
- The 10th standard boy students with high achievement motivation and 10th standard girl students with low achievement motivation differ significantly with respect to academic achievement at 0.05 level of significance. It means that, the 10th standard boy students with high achievement motivation have higher academic achievement as compared to the 10th standard girl students with low achievement motivation.
- The 10th standard boy students with high achievement motivation and 10th standard girl students with high achievement motivation do not differ significantly with respect to academic achievement at 0.05 level of significance. It means that, the 10th standard boy students with high achievement motivation and 10th standard girl students with high achievement motivation have similar academic achievement.
- The 10th standard girl students with low achievement motivation and socially secondary school girl students with low achievement motivation differ significantly with respect to academic achievement at 0.05 level of significance. It means that, the 10th standard girl students with high achievement motivation have higher academic achievement as compared to the 10th standard girl students with low achievement motivation.

Findings of the Study

- The 10th standard students with high achievement motivation have significantly smaller academic achievement as compared to 10th standard with low achievement motivation.
- The 10th standard boy students with high achievement motivation have higher academic achievement as compared to the 10th standard boy students with low achievement motivation.
- The 10th standard boy students with low achievement motivation and 10th standard girl students with high achievement motivation have similar academic achievement.
- The 10th standard girl students with high achievement motivation have higher academic achievement as compared to the 10th standard boy students with low achievement motivation.

- The 10th standard boy students with high achievement motivation have higher academic achievement as compared to the 10th standard girl students with low achievement motivation.
- The 10th standard boy students with high achievement motivation and 10th standard girl students with high achievement motivation have similar academic achievement.
- The 10th standard girl students with high achievement motivation have higher academic achievement as compared to the 10th standard girl students with low achievement motivation.

Implications of the Study

On the basis of findings of the study and the observations made by the investigator during the study, a few recommendations which may help in developing suitable programmes to improve achievement motivation in relation to academic achievement of children of 10th standard have been offered.

1. It is observed that the achievement motivation is an important factor in academic achievement of 10th standard to improve their social background by encouraging them in school context to achieve more goals in the society. It is necessary to admit the 10th standard to boost their achievement motivation.
2. The study reveals that the 10th standard girl students with high achievement motivation differ with the 10th standard boy students with low achievement motivation and the girls students are higher academic achievement. Hence it can be concluded that the 10th standard boy students are study hard and try to meet their goals in improving their academic performance and to think more towards achievement motivation and academic achievement.

Conclusion

The 10th standard students with high achievement motivation have smaller academic achievement as compared to 10th standard students with low achievement motivation.

The 10th standard boys and girls are similar in their achievement motivation and girl students with high achievement motivation have higher academic achievement when compared to 10th standard boy students also 10th standard boy students with high achievement motivation have higher academic achievement as compared to the 10th standard girl students with low achievement motivation.

The 10th standard boys and girl students need orientation to support proper direction towards achievement motivation and better academic achievement.

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ARTIFICIAL INTELLIGENCE USAGE FOR PROMOTING SUSTAINABLE DEVELOPMENT AMONG COLLEGE STUDENTS

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Abstract

Artificial Intelligence (AI) has emerged as one of the most influential technological developments of the twenty-first century and is increasingly being applied to address complex social, economic, and environmental challenges. In the context of higher education, college students are among the major users of AI-enabled technologies, including generative AI tools, intelligent learning platforms, data analysis applications, virtual assistants, and recommendation systems. These technologies have the potential to support sustainable development by improving access to knowledge, promoting efficient use of resources, encouraging innovation, and helping individuals understand and address sustainability-related challenges. However, the extent to which college students use AI for purposes that contribute to sustainable development remains an important area for investigation. The present study examines Artificial Intelligence usage for promoting sustainable development among college students. The study adopts a descriptive survey method. A sample of 150 college students was selected using an appropriate sampling technique. Data were collected using a structured tool designed to assess students' usage of AI in relation to sustainable development. The study focuses on major dimensions such as academic and learning-related AI usage, environmental sustainability, social responsibility, innovation and problem-solving, and responsible and ethical use of AI. The formulated hypotheses and objectives were tested using appropriate statistical technique t-test and F-Test. The study is significant because higher education institutions play an important role in preparing young people to respond to contemporary global challenges. Understanding how students use AI can help educators and policymakers develop appropriate strategies for integrating AI with sustainability education. The study is expected to contribute to the growing body of knowledge on AI and sustainable development by highlighting the potential of responsible and purposeful AI usage among college students. The findings may support the development of educational programmes that promote digital competence, innovation, ethical awareness, and sustainable thinking among the younger generation.

Keywords: *Artificial Intelligence, AI Usage, Sustainable Development, College Students, Higher Education, Digital Competence*

1. Introduction

Artificial Intelligence (AI) has become an important part of contemporary society. Its applications are increasingly visible in education, healthcare, business, transportation, agriculture, communication, environmental management, and public administration. AI refers broadly to technologies and systems capable of performing tasks that are generally associated with human intelligence, such as learning, reasoning, problem-solving, decision-making,

language processing, and pattern recognition. Recent developments in generative AI and other intelligent technologies have made AI more accessible to students and educators than ever before. Higher education is experiencing significant changes because of the rapid growth of AI-enabled technologies. College students increasingly use AI applications for searching for information, generating ideas, improving writing, analysing data, solving academic problems, developing creative projects, and supporting independent learning. AI can provide personalised learning experiences and enable students to access information and educational support more efficiently. As AI becomes a regular part of students' academic and everyday lives, it is important to understand not only whether students use AI but also the purposes for which they use it. At the same time, the world is facing several major sustainability challenges. Climate change, environmental degradation, poverty, inequality, resource depletion, and social exclusion require innovative and collaborative solutions. Sustainable development emphasises the need to meet present needs while protecting the ability of future generations to meet their own needs. The Sustainable Development Goals (SDGs) provide a global framework for addressing these interconnected challenges.

Artificial Intelligence has the potential to contribute to sustainable development in several ways. AI can support the analysis of large volumes of information, improve decision-making, optimise the use of resources, predict environmental changes, and assist in the development of innovative solutions. AI-based systems can contribute to energy management, smart agriculture, environmental monitoring, healthcare delivery, disaster management, and educational accessibility. However, the relationship between AI and sustainability is not automatically positive. AI technologies may also create challenges related to energy consumption, electronic waste, algorithmic bias, privacy, misinformation, inequality, and unethical use.

Therefore, the responsible use of AI is essential. College students represent an important group in this context because they are future professionals, researchers, educators, administrators, entrepreneurs, and citizens. Their present understanding and usage of AI may influence how these technologies are used in society in the future. Students who are able to use AI critically, creatively, ethically, and responsibly may be better prepared to contribute to sustainable development. The present study, therefore, focuses on Artificial Intelligence Usage for Promoting Sustainable Development among College Students. The study seeks to understand how AI is being used by college students and how such usage may contribute to sustainable thinking, learning, innovation, and problem-solving.

2. Need of the Study

Artificial Intelligence (AI) is increasingly becoming an important part of higher education and offers new opportunities to address social, economic, and environmental challenges related to sustainable development. College students, as future professionals and responsible citizens, need to develop the knowledge and skills to use AI effectively and responsibly. Although AI tools are widely used for learning and academic purposes, there is a need to understand how college students use AI to promote sustainable development. Therefore, the present study was undertaken to examine Artificial Intelligence Usage for Promoting Sustainable Development among College Students and to understand whether selected demographic variables influence

their usage.

3. Review of Related Literature

Kasneci et al. (2023) discussed the opportunities and challenges associated with large language models in education. The authors observed that AI technologies can support learning and educational innovation but may also create concerns regarding academic integrity, bias, misinformation, and overdependence on automated systems. Their work highlights the importance of developing AI literacy among learners.

Tlili et al. (2023) examined the emergence of generative AI in education and discussed both its educational potential and the challenges associated with its rapid adoption. The study suggested that AI can support creativity, personalised learning, and access to information when used responsibly.

Vinuesa et al. (2020) demonstrated that AI can contribute to achieving several Sustainable Development Goals through applications in areas such as health, education, energy, environmental protection, and economic development. At the same time, the researchers noted that AI may negatively affect some sustainability targets if it is developed and used without appropriate governance.

4. Objectives of the Study

The present study has the following objectives:

- To determine the level of Artificial Intelligence usage for promoting sustainable development among college students.
- To find out whether there is any significant difference in Artificial Intelligence usage for promoting sustainable development among college students in respect to their
    - Gender
    - Locality
    - Types of Management

5. Hypotheses of the Study

The following null hypotheses are formulated for the study:

- There is no significant difference between (Gender) male and female College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.
- There is no significant difference between rural and urban (Locality) College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.
- There is no significant difference among type of management (government / government-aided / private) College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.

6. Methodology:

The investigator adopted the survey method of study and selected the stratified random sampling technique. 150 college students were randomly selected from various colleges belongs to government, government-aided and self-financed management. Data were collected using a structured tool designed to assess students' usage of AI in relation to sustainable development. A Personal Data Sheet was also created by the investigator. The formulated

hypotheses and objectives were tested using appropriate statistical technique t-test and F-Test Analysis of Variance (ANOVA).

7. Testing of Hypothesis:

Hypothesis – 1

There is no significant difference between (Gender) male and female College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.

Table 1

Details of t-Test Result for Gender

Variables	Gender	N	Mean	SD	t-Value	LOS
Artificial Intelligence Usage for Promoting Sustainable Development	Male	22	114.82	17.46	0.239	Not Significant
	Female	128	114.98	13.58		

As seen in Table 1, the average score for Men (N= 22) is 114.82 with SD of 17.46 and the mean score for women (N = 128) is 114.98 with SD of 13.58. Based on these findings (t = 0.239 < 1.96), the artificial intelligence usage for promoting sustainable development does not discernible differs between male and female college students based on gender. It can be concluded that null hypothesis 1 is accepted.

Hypothesis – 2

There is no significant difference between rural and urban (Locality) College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.

Table 2

Details of t-Test Result for Locality

Variables	Locality	N	Mean	SD	t-Value	LOS
Artificial Intelligence Usage for Promoting Sustainable Development	Rural	22	49.92	10.26	0.198	Not Significant
	Urban	128	50.05	9.76		

As shown in the Table 2, the mean score for Rural (N= 22) is 49.92 with SD of 10.26 and the mean score for Urban (N=128) is 50.05 with SD of 9.76. Based on these findings (t = 0.198 < 1.96), the Artificial Intelligence Usage for Promoting Sustainable Development does not discernible differs between rural and urban college students based on locality. It can be concluded that null hypothesis 2 is accepted.

Hypothesis – 3

There is no significant difference among type of management (government / government-aided / private) College Students with respect to their Artificial Intelligence Usage for Promoting Sustainable Development.

Table 5						
Details of F-ratio Result for Type of Management						
Variables	**Nature**	**Sum of Squares**	**Df**	**Mean Square**	**F-ratio**	**LOS**
Artificial Intelligence Usage for Promoting Sustainable Development	Between Groups	1469.93	2	325.06	1.092	**Not Significant**
	With in Groups	25216.71	147	103.95		
	Total	26685.64	149			
	Total	**Nature**	**Sum of Squares**	**3.859**		

As shown in Table 3, the obtained value for F is 1.092; At the F- results (1.092) is less than the table value (3.84). Artificial Intelligence Usage for Promoting Sustainable Development does not discernible differs between government, government aided and private college students based on Management Types. It can be concluded that null hypothesis 3 is accepted.

8. Major Findings of the study

The major findings of the study are as follows:

- There is no significant difference between male and female college students in their Artificial Intelligence Usage for Promoting Sustainable Development. The mean scores of male students (114.82) and female students (114.98) were almost similar, and the obtained t-value (0.239) was not significant.
- There is no significant difference between rural and urban college students in their Artificial Intelligence Usage for Promoting Sustainable Development. The obtained t-value (0.198) was not significant, indicating that locality did not influence the students' AI usage for promoting sustainable development.
- There is no significant difference among government, government-aided, and private college students in their Artificial Intelligence Usage for Promoting Sustainable Development. The obtained F-value (1.092) was not significant, indicating that the type of management did not significantly influence AI usage for promoting sustainable development.

9. Discussion of the results

Overall, the results suggest that Artificial Intelligence Usage for Promoting Sustainable Development is becoming increasingly common among college students, irrespective of their gender, locality, or type of institutional management.

10. Educational Implications:

The findings of the study may have several important implications for higher education.

- First, higher education institutions can integrate AI literacy with sustainability education. Students should not only learn how to operate AI tools but also understand how AI can be applied to solve environmental, social, and economic problems.

- Second, educators can design learning activities that encourage students to use AI for addressing real-world sustainability challenges. Project-based learning, problem-solving activities, data analysis, and community-based projects can help students apply AI meaningfully.
- Third, institutions should promote responsible and ethical AI usage. Students require guidance regarding academic integrity, privacy, misinformation, algorithmic bias, intellectual responsibility, and the environmental consequences of digital technologies.
- Fourth, teacher education and professional development programmes can prepare educators to integrate AI and sustainability into teaching and learning. Teachers play a significant role in guiding students towards responsible and purposeful technology use.
- Fifth, policymakers and educational administrators can use the findings to develop guidelines and programmes for responsible AI integration in higher education. Such initiatives can support the development of students as informed, innovative, and socially responsible citizens.
- Finally, the study may encourage further research on the relationship between AI competence, sustainability awareness, innovation, problem-solving, and responsible digital citizenship.

11. Conclusion: The study concludes that college students demonstrate a similar level of Artificial Intelligence usage for promoting sustainable development, irrespective of their gender, locality, and type of institutional management. The findings indicate that these demographic factors do not significantly influence students' use of AI for sustainability-related purposes. The increasing accessibility of AI tools and digital technologies may have provided students with relatively equal opportunities to use AI for learning, problem-solving, innovation, and sustainable development. Therefore, higher education institutions should encourage the responsible and effective use of Artificial Intelligence to develop students' knowledge, skills, and awareness towards promoting sustainable development.

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A STUDY ON ADJUSTMENT ABILITIES OF UNDERGRADUATE STUDENTS OF KALABURAGI DISTRICT IN RELATION TO THEIR INTELLIGENCE AND INTEREST

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Abstract

The present study was undertaken to investigate the adjustment abilities of undergraduate students of Kalaburagi District in relation to their intelligence and interest. Adjustment is an important psychological process that enables students to deal effectively with academic, social, emotional and personal demands. Intelligence may facilitate effective problem-solving and decision-making, while interest influences students' involvement, motivation and adaptation to different activities. The study adopted a descriptive survey research design. A sample of 400 undergraduate students was selected from different colleges of Kalaburagi District by using an appropriate sampling procedure. Gender and locale were considered as demographic variables. Adjustment ability was treated as the dependent variable, whereas intelligence and interest were considered independent variables. Data were proposed to be analysed using mean, standard deviation, t-test, correlation coefficient (r-test) and multiple regression analysis. The study is expected to provide useful information to teachers, counsellors, teacher educators and college administrators for developing suitable programmes to improve students' adjustment abilities.

Keywords: *Adjustment Ability, Intelligence, Interest, Undergraduate Students, Gender, Locale, Kalaburagi District, Correlation, Regression.*

1. Introduction:

Higher education is an important stage in the development of young people. Undergraduate students experience several changes in their academic, social, emotional and personal lives. They are expected to adapt themselves to new learning environments, relationships, responsibilities, academic expectations and future career demands. The ability to adjust successfully is therefore an important determinant of students' academic progress and overall well-being.

Adjustment refers to the process through which an individual modifies his or her behaviour, attitudes and responses to maintain a satisfactory relationship with the environment. A well-adjusted student is generally able to manage academic responsibilities, establish healthy interpersonal relationships, regulate emotions and deal with everyday challenges effectively. Poor adjustment may result in academic difficulties, interpersonal problems, dissatisfaction and lack of motivation.

Intelligence is another important psychological variable associated with

adjustment. Intelligent individuals may be better able to understand situations, analyse problems, select appropriate alternatives and adapt their behaviour according to environmental requirements. However, adjustment is not determined by intelligence alone. Students' interests, motivation and involvement in academic and social activities may also influence their ability to adapt.

Interest refers to a person's relatively enduring inclination or preference towards particular activities, subjects, ideas or experiences. Students who possess appropriate interests may demonstrate greater attention, motivation and involvement in educational activities. Such involvement may contribute to better academic and social adjustment.

Kalaburagi District has a diverse undergraduate student population studying in government, aided and private institutions located in urban and rural areas. Differences in educational environment and socio-cultural conditions may influence students' adjustment. Hence, there is a need to examine the adjustment abilities of undergraduate students and determine the extent to which intelligence and interest are associated with adjustment.

The present study therefore focuses on the adjustment abilities of undergraduate students of Kalaburagi District in relation to their intelligence and interest, with gender and locale as demographic variables.

2. Need and Significance of the Study:

Undergraduate students are passing through a critical period of personal and educational development. Their ability to adjust to college life has implications for academic achievement, interpersonal relationships and future professional development. Understanding the factors associated with adjustment can help educational institutions provide appropriate guidance and counselling.

The present study is significant for the following reasons:

1. It helps to understand the level of adjustment abilities among undergraduate students.
2. It examines whether adjustment differs according to gender.
3. It examines whether adjustment differs according to locale.
4. It determines the relationship between intelligence and adjustment.
5. It determines the relationship between interest and adjustment.
6. It identifies the predictive contribution of intelligence and interest to adjustment.
7. The findings may help teachers and counsellors identify students requiring additional guidance.
8. The study may provide a basis for developing counselling and student-support programmes in undergraduate colleges.

3. Statement of the Problem:

"A STUDY ON ADJUSTMENT ABILITIES OF UNDERGRADUATE STUDENTS OF KALABURAGI DISTRICT IN RELATION TO THEIR INTELLIGENCE AND INTEREST."

4. Objectives of the Study:

The study was undertaken with the following objectives:

1. To study the adjustment abilities of undergraduate students of Kalaburagi District.

2. To find out whether there is a significant difference in adjustment abilities of undergraduate students with respect to gender.
3. To find out whether there is a significant difference in adjustment abilities of undergraduate students with respect to locale.
4. To find out the relationship between intelligence and adjustment abilities of undergraduate students.
5. To find out the relationship between interest and adjustment abilities of undergraduate students.
6. To determine the predictive contribution of intelligence and interest towards adjustment abilities of undergraduate students.

5. Hypotheses of the Study:

The following null hypotheses were formulated:

1) **H_o1:** There is no significant difference in the adjustment abilities of undergraduate students with respect to gender.
2) **H_o2:** There is no significant difference in the adjustment abilities of undergraduate students with respect to locale.
3) **H_o3:** There is no significant relationship between intelligence and adjustment abilities of undergraduate students.
4) **H_o4:** There is no significant relationship between interest and adjustment abilities of undergraduate students.
5) **H_o5:** Intelligence and interest do not significantly predict the adjustment abilities of undergraduate students.

6. Variables of the Study:

1) Dependent Variable: Adjustment abilities
2) Independent Variables: Intelligence and Interest
3) Demographic Variables: Gender and Locale

7. Operational Definitions of Key Terms:

1) **Adjustment Abilities:** Adjustment abilities refer to the capacity of undergraduate students to adapt effectively to academic, emotional, social and personal demands and maintain a satisfactory relationship with their environment.
2) **Intelligence:** Intelligence refers to the general mental ability of an undergraduate student to understand, reason, learn, solve problems and adapt effectively to different situations, as measured by the selected intelligence test.
3) **Interest:** Interest refers to the degree of preference, attraction and involvement of undergraduate students towards educational and other relevant activities, as measured by the selected interest inventory.
4) **Undergraduate Students:** Undergraduate students refer to students pursuing degree-level education in colleges of Kalaburagi District.

8. Research Method:

8.1. Method of the study:

The descriptive survey method was adopted for the present investigation. The method was considered appropriate because the study aimed to determine the existing level of adjustment

abilities and examine their relationship with intelligence and interest among undergraduate students.

8.2. **Population and Sample:**The population of the study consisted of undergraduate students studying in degree colleges of Kalaburagi District. A sample of 400 undergraduate students was selected for the study. The sample included students from both genders and from urban and rural locales. The sample may be selected from different undergraduate colleges representing the urban and rural areas of Kalaburagi District.

8.3. Tools Used for Data Collection:

The following tools may be used for collecting the required data:

Variable	Tool Name	Author And Year
Adjustment Abilities	Adjustment Inventory	Dr. R K Ojha
Intelligence	Test Of General Intelligence	S. K. Pal And K. S. Mishra
Interest	Multiphasic Interest Inventory	Dr. (Mrs.) S. K. Bawa (Bhatinda)

8.4. **Procedure for Data Collection:** The investigator obtained permission from the concerned college authorities before collecting the data. The purpose of the study was explained to the students. Necessary instructions were provided before administering the tools. The adjustment scale, intelligence test and interest inventory were administered systematically. The responses were collected, scored according to the respective manuals and entered into a data sheet for statistical analysis.

8.5. **Statistical Techniques Used:** The following statistical techniques were proposed for analysing the data:

1. **Mean and Standard Deviation** – to understand the general level and variability of scores.
2. **t-test** – to determine differences in adjustment abilities with respect to gender and locale.
3. **Pearson's Product-Moment Correlation (r)** – to determine the relationship between:

1) Intelligence and adjustment
2) Interest and adjustment

4. **Multiple Regression Analysis** – to determine the predictive contribution of intelligence and interest towards adjustment abilities.

The level of significance may be fixed at **0.05**.

9. Analysis and Interpretation of Data based on Objectives:

1) Objective 1: To study the adjustment abilities of undergraduate students

The overall adjustment scores of the 400 undergraduate students has been analysed using mean and standard deviation.

Table-1: The overall adjustment scores of the 400 undergraduate students

Variable	**N**	**Mean**	**SD**
Adjustment Ability	400	142.68	16.42

The hypothetical result indicates that the undergraduate students have a moderate to favourable level of adjustment abilities. The variation in scores indicates individual

differences among students in their capacity to adapt to academic, social, emotional and personal situations.

2) Objective 2: Gender-wise Difference in Adjustment Abilities

Table 2: t-test of Adjustment Abilities by Gender

Gender	N	Mean	SD	t-value	Significance
Male	200	140.92	16.87	2.14	Significant
Female	200	144.44	15.83		

The hypothetical t-value of **2.14** is greater than the critical value at the 0.05 level for the relevant degrees of freedom. Therefore, the null hypothesis is rejected. This indicates a significant difference in adjustment abilities between male and female undergraduate students. Female students have a slightly higher mean adjustment score than male students in the illustrative data.

3) Objective 3: Locale-wise Difference in Adjustment Abilities

Table 3: t-test of Adjustment Abilities by Locale

Locale	N	Mean	SD	t-value	Significance
Urban	200	143.96	16.01	1.62	Not Significant
Rural	200	141.40	16.77		

The hypothetical t-value of **1.62** is lower than the critical value at the 0.05 level. Hence, the null hypothesis is accepted. This indicates that there is no significant difference between urban and rural undergraduate students in their adjustment abilities.

4) Objective-4: To find out the relationship between intelligence and adjustment abilities of undergraduate students.

Table 4: Correlation between Intelligence and Adjustment Abilities

Variables	N	r-value	Significance
Intelligence × Adjustment	400	0.46	Significant

The hypothetical correlation coefficient of r = 0.46 indicates a moderate positive relationship between intelligence and adjustment abilities. This suggests that students with higher intelligence scores tend to demonstrate better adjustment abilities. The relationship is statistically significant at the 0.05 level. Therefore, the null hypothesis is rejected.

5) Objective-5: To find out the relationship between interest and adjustment abilities of undergraduate students.

Table 5: Correlation between Interest and Adjustment Abilities

Variables	N	r-value	Significance
Interest × Adjustment	400	0.52	Significant

The hypothetical correlation coefficient of r = 0.52 indicates a moderate positive relationship between interest and adjustment abilities. This suggests that students with greater interest and involvement tend to have better adjustment abilities. The relationship is statistically significant at the 0.05 level. Therefore, the null hypothesis is rejected.

6) To determine the predictive contribution of intelligence and interest towards adjustment abilities of undergraduate students.

Multiple regression analysis may be used to determine whether intelligence and interest jointly predict adjustment abilities.

Table 6: Multiple Regression of Intelligence and Interest on Adjustment

Predictor	Beta (β)	t-value	Significance
Intelligence	0.31	6.21	Significant
Interest	0.39	7.84	Significant

Multiple R = 0.58

$R^2 = 0.34$

Adjusted $R^2 = 0.33$

The hypothetical regression results indicate that intelligence and interest jointly explain approximately 34% of the variance in adjustment abilities. Both intelligence and interest make significant positive contributions to adjustment. Interest has a somewhat greater standardized beta coefficient than intelligence in the illustrative analysis.

The regression equation may be represented as:

Adjustment Ability = a + 0.31(Intelligence) + 0.39(Interest)

where *a* represents the regression constant. The actual regression equation should be calculated using the obtained raw-score data.

10. Major Findings of the Study:

Based on the illustrative analysis, the major findings are:

1. Undergraduate students demonstrate a moderate to favourable level of adjustment abilities.
2. A significant difference is found between male and female undergraduate students in adjustment abilities.
3. Female students show comparatively higher adjustment scores than male students in the illustrative results.
4. No significant difference is found between urban and rural undergraduate students in adjustment abilities.
5. Intelligence has a significant positive relationship with adjustment abilities.
6. Interest has a significant positive relationship with adjustment abilities.

7. Intelligence and interest jointly make a significant contribution to the prediction of adjustment abilities.
8. Interest appears to be a comparatively stronger predictor of adjustment than intelligence in the illustrative regression analysis.
9. Intelligence and interest together explain approximately 34% of the variance in adjustment abilities in the hypothetical model.

The findings suggest that adjustment among undergraduate students is associated with their intellectual ability and interests. Intelligence may help students understand problems, evaluate alternative solutions and respond appropriately to challenging situations. Students with better intellectual abilities may therefore be able to cope more effectively with academic and environmental demands.

Interest also appears to play an important role in adjustment. Students who are interested in their educational activities are more likely to participate actively, maintain attention and develop positive relationships with teachers and peers. Such involvement may facilitate academic and social adjustment.

The gender difference observed in the illustrative results may be related to differences in social experiences, coping patterns, emotional expression and interpersonal relationships. However, such interpretations should be made cautiously and should be supported by the actual data.

The absence of a significant difference based on locale suggests that urban and rural students may have broadly similar adjustment capabilities when they are provided with comparable educational opportunities and college environments.

The regression findings further indicate that adjustment is a multidimensional phenomenon. Intelligence and interest together explain only part of the variation in adjustment, suggesting that other factors such as emotional intelligence, family environment, social support, personality, academic achievement, self-concept and socioeconomic conditions may also contribute.

11. Educational Implications:

The findings of the study may have several implications for higher education:

1. Student Counselling: Colleges should provide regular counselling services to identify students experiencing adjustment difficulties.
2. Orientation Programmes: Orientation programmes can help new undergraduate students adapt to the college environment.
3. Interest-Based Learning: Teachers may incorporate students' interests into classroom activities to increase participation and motivation.
4. Academic Support: Students with adjustment difficulties may be provided with academic guidance and mentoring.
5. Psychological Guidance: Counselling programmes may focus on emotional regulation, interpersonal skills and coping strategies.
6. Individual Attention: Teachers should identify students who require additional support and provide appropriate guidance.

7. Career Guidance: Interest inventories can be used as a basis for academic and career counselling.
8. Parent–College Collaboration: Where appropriate, communication between parents and educational institutions may support students' adjustment.
9. Life-Skill Education: Colleges can organize programmes on communication skills, decision-making, stress management and problem-solving.
10. Inclusive College Environment: Institutions should create supportive and welcoming environments for students from both urban and rural backgrounds.

12. Conclusion:

Adjustment ability is an important psychological characteristic that enables undergraduate students to respond effectively to academic, social, emotional and personal demands. The present study focuses on the relationship between adjustment abilities, intelligence and interest among undergraduate students of Kalaburagi District. The proposed analysis using t-test, correlation and regression provide a systematic approach to understanding individual differences and predictive relationships.

The illustrative findings suggest that intelligence and interest are positively associated with adjustment abilities and that both variables jointly contribute to the prediction of adjustment. The study highlights the need for higher education institutions to give attention not only to academic achievement but also to students' psychological adjustment, interests and individual needs. Appropriate counselling, mentoring, interest-based educational activities and student-support programmes can contribute to the overall development of undergraduate students.

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PSYCHOLOGICAL WELL-BEING AMONG PROSPECTIVE TEACHERS: AN EMPIRICAL STUDY OF B.ED. TEACHER TRAINEES

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Abstract

The main objective of the study as to find out the Psychological Well-Being among Prospective Teachers: An Empirical Study of B.Ed. Teacher Trainees. The study adopted a survey design, and data were collected from 154 B.Ed. teacher trainees from the researcher's institution. Data were collected using the 50-item Psychological Well-Being Scale developed and standardized by Sisodia and Choudhary. The study used Chi-square test to analysis the distribution of level and its significance of psychological well-being and its dimensions. The study found that, the findings suggest that B.Ed. teacher trainees predominantly exhibit a moderate level of psychological well-being and most of its dimensions.

Key Words: *Well-being, Psychological Well-being, B.Ed Teacher Trainees and Prospective teachers*

Introduction:

A person's entire functionality and quality of life are significantly influenced by their psychological well-being, which includes positive psychological functioning, personal development, meaningful connections, and the capacity to successfully navigate life's obstacles. According to Ryff (1989), psychological well-being is a complex concept which includes positive functioning, self-realization and the ability to cope with the life's challenges. (Wan, Wee, Siau, & Wong, 2025), while well-being is also associated with occupational, psychological, and social accomplishment (Psychology Writing, 2024). The World Health Organization (2021) defines psychological well-being as "a state of mind in which an individual is able to develop their potential, work productively, and creatively, and is able to cope with the normal stresses of life" (Dhanabhakyam & M, 2023), highlighting its importance for productive and balanced functioning. Further, psychological well-being involves nurturing positive emotions and social relationships and developing "a fulfilling sense of purpose and personal growth" rather than merely being free from psychological distress (Morin, 2026). In the teaching profession, teachers' psychological well-being is increasingly recognized as a factor that influences the quality of education, students' academic achievement, professional resilience, and quality of life (Ruza, Briede, Zimele, Kravale-Paulina, & Savicka, 2025). Moreover, "teachers with good psychological wellbeing do better in their profession", as psychological well-being is closely connected with teaching academic subjects, nurturing pupils, developing social values, and performing professional responsibilities effectively (U & Rajendran, 2025). Therefore, it is crucial to assess the psychological well-being of aspiring teachers, especially B.Ed. teacher candidates, in order to better understand their professional and personal readiness and to enhance teacher education

programs that facilitate their successful development as future educators.

Statement of Problem:

The main objective of the study as to find out the Psychological Well-Being among Prospective Teachers: An Empirical Study of B.Ed. Teacher Trainees

Objectives of the study:

- To determine the level of Psychological Well-Being among B.Ed. teacher trainees.
- To determine the level of Satisfaction among B.Ed. teacher trainees.
- To determine the level of Efficiency among B.Ed. teacher trainees.
- To determine the level of Sociability among B.Ed. teacher trainees.
- To determine the level of Mental Health among B.Ed. teacher trainees.
- To determine the level of Interpersonal Relations among B.Ed. teacher trainees.

Hypothesis of the study:

Hypohteis-1: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of psychological well-being.

Hypothesis-2: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Satisfaction.

Hypothesis-3: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Efficiency.

Hypothesis-4: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Sociability.

Hypothesis-4: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Mental Health.

Hypothesis-4: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Interpersonal Relations.

Design of the Study:

The study adopted a survey design, and data were collected from 154 B.Ed. teacher trainees from the researcher's institution.

Tools Used in the Study:

Data were collected using the 50-item Psychological Well-Being Scale developed and standardized by Sisodia and Choudhary, covering five dimensions: Satisfaction, Efficiency, Sociability, Mental Health, and Interpersonal Relations.

Statistical Techniques Used;

The study used Chi-square test to analysis the distribution of level and its significance of psychological well-being and its dimensions.

Analysis and Interpretation of Data:

Hypohteis-1: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of psychological well-being.

Table 1. Psychological Well-Being: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	44	28.57%	9.2078	.010	S ($p<.05$)
Moderate	69	44.81%			
Low	41	26.62%			

Total	154	100.00%			

The above table indicate that 28.57% (44) of B.Ed teacher trainees showed low level of psychological well-being, 44.81% (69) of B.Ed teacher trainees showed moderate level of psychological well-being and 26.62%(41) of B.Ed teacher trainees showed moderate level of psychological well-being. The Chi-square Goodness-of-Fit test value is 9.2078 and p-value is .010. In this case, the p-value is below the significance level of.05. Thus, there is a significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of psychological well-being at .05 level of significance, $X^2 = 9.2078$ $p < .05$. This indicates that the observed distribution of teacher trainees across the low, moderate and high categories of psychological well-being differs significantly from an equal distribution across the three levels.

Hypothesis-2: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Satisfaction.

Table 2. Satisfaction: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	16	10.39%	36.5195	.001	S (p<.05)
Moderate	68	44.16%			
Low	70	45.45%			
Total	154	100.00%			

The above table indicates that 10.39% (16) of B.Ed. teacher trainees showed a low level of Satisfaction, 44.16% (68) showed a moderate level of Satisfaction, and 45.45% (70) showed a high level of Satisfaction. The Chi-square Goodness-of-Fit test value is 36.5195 and the p-value is .001. Thus, there is a significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Satisfaction, $\chi^2 = 36.5195$, $p < .05$. This indicates that the observed distribution of teacher trainees across the low, moderate, and high categories of Satisfaction differs significantly from an equal distribution across the three levels.

Hypothesis-3: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Efficiency.

Table 3. Efficiency: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	58	37.66%	1.4545	.483	S (p>.05)
Moderate	46	29.87%			
Low	50	32.47%			
Total	154	100.00%			

The above table indicates that 37.66% (58) of B.Ed. teacher trainees showed a low level of Efficiency, 29.87% (46) showed a moderate level of Efficiency, and 32.47% (50) showed a high level of Efficiency. The Chi-square Goodness-of-Fit test value is 1.4545 and the p-value is .483. In this case, the p-value is higher the significance level of.05. Thus, there is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Efficiency, $\chi^2 = 1.4545$, $p > .05$. This indicates that the observed distribution of teacher trainees across the low, moderate, and high categories of Efficiency does not differ

significantly from an equal distribution across the three levels.

Hypothesis-4: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Sociability.

Table 4. Sociability: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	40	25.97%	15.0130	.001	S (p<.05)
Moderate	74	48.05%			
Low	40	25.97%			
Total	154	100.00%			

The above table indicates that 25.97% (40) of B.Ed. teacher trainees showed a low level of Sociability, 48.05% (74) showed a moderate level of Sociability, and 25.97% (40) showed a high level of Sociability. The Chi-square Goodness-of-Fit test value is 15.0130 and the p-value is .001. Thus, there is a significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Sociability, $\chi^2 = 15.0130$, $p < .05$. This indicates that the observed distribution of teacher trainees across the low, moderate, and high categories of Sociability differs significantly from an equal distribution across the three levels.

Hypothesis-5: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Mental Health.

Table 5. Mental Health: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	48	31.17%	5.9351	.051	S (p>.05)
Moderate	65	42.21%			
Low	41	26.62%			
Total	154	100.00%			

The above table indicates that 31.17% (48) of B.Ed. teacher trainees showed a low level of Mental Health, 42.21% (65) showed a moderate level of Mental Health, and 26.62% (41) showed a high level of Mental Health. The Chi-square Goodness-of-Fit test value is 5.9351 and the p-value is .051. In this case, the p-value is higher the significance level of.05. Thus, there is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Mental Health, $\chi^2 = 5.9351$, $p > .05$. This indicates that the observed distribution of teacher trainees across the low, moderate, and high categories of Mental Health does not differ significantly from an equal distribution across the three levels.

Hypothesis-6: Hypothesis-5: There is no significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Interpersonal Relations.

Table 6. Interpersonal Relations: Level-wise Distribution

Level	Count	Percentage	X^2 - Value	p-value	S/NS
Low	48	31.17%	17.8182	.002	S (p<.05)
Moderate	65	42.21%			
Low	41	26.62%			
Total	154	100.00%			

The above table indicates that 31.17% (48) of B.Ed. teacher trainees showed a low level of Interpersonal Relations, 42.21% (65) showed a moderate level of Interpersonal Relations, and 26.62% (41) showed a high level of Interpersonal Relations. The Chi-square Goodness-of-Fit test value is 17.8182 and the p-value is .002. Thus, there is a significant difference in the distribution of B.Ed. teacher trainees across the high, moderate, and low levels of Interpersonal Relations, $\chi^2 = 17.8182$, $p < .05$. This indicates that the observed distribution of teacher trainees across the low, moderate, and high categories of Interpersonal Relations differs significantly from an equal distribution across the three levels.

Major Findings:

The major findings indicate that Psychological Well-Being, Satisfaction, Sociability, and Interpersonal Relations showed significant differences in their distribution across low, moderate, and high levels, with the moderate level being predominant. In contrast, Efficiency and Mental Health did not show significant differences in their distribution across the three levels. Overall, the findings suggest that B.Ed. teacher trainees predominantly exhibit a moderate level of psychological well-being and most of its dimensions.

Discussion and Conclusion:

The study found that B.Ed. teacher trainees exhibited a moderate level of psychological well-being, which includes overall well-being and its dimensions: a moderate level of psychological well-being related to overall and its dimensions, namely satisfaction, sociability, and interpersonal relations. Whereas concern pertaining to dimensions of efficiency and mental health was not observed. However, overall, the study observed a balanced or moderate level of psychological well-being and scope for improvement. Thus, teacher education institutions need to encourage supportive environments and opportunities to improve satisfaction, sociability, and interpersonal relation components of psychological well-being.

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ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION: TRANSFORMING TEACHING, LEARNING, ASSESSMENT, AND RESEARCH IN THE GENERATIVE AI ERA

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Abstract

Artificial Intelligence (AI) is rapidly transforming the educational landscape by introducing innovative approaches to teaching, learning, assessment, and educational research. Its integration into Science, Technology, and Mathematics (STM) education is particularly significant because these disciplines emphasize logical reasoning, problem-solving, experimentation, data analysis, computational thinking, creativity, and the application of knowledge to real-world situations. AI-powered educational tools can facilitate personalized learning, intelligent tutoring, adaptive learning, automated assessment, immediate feedback, scientific simulations, virtual laboratories, mathematical problem-solving, data analysis, coding, robotics, and technological design. These applications can make complex and abstract concepts more accessible through interactive, learner-centered, and flexible learning experiences. AI can also support teachers by assisting in the preparation of instructional materials, identifying students' learning difficulties, analysing performance, generating practice activities, and designing differentiated learning experiences. However, the effective integration of AI requires careful consideration of challenges such as accuracy and reliability of AI-generated information, academic integrity, and student data privacy, and algorithmic bias, unequal access to technology, teacher preparedness, and excessive dependence on AI. Teachers therefore have a central role in guiding learners to use AI critically, ethically, creatively, and responsibly. AI should complement rather than replace teachers, practical experiments, classroom interaction, independent thinking, and authentic learning experiences. In the Indian context, the National Education Policy (NEP) 2020 emphasizes technology integration, experiential learning, multidisciplinary education, digital literacy, critical thinking, and skill development, creating a supportive framework for the meaningful use of AI in education. This paper examines the concept, applications, educational benefits, challenges, ethical considerations, and pedagogical implications of AI in Science, Technology, and Mathematics education. It argues that responsible and well-planned integration of AI can enhance the quality and effectiveness of STM education while developing scientifically literate, mathematically competent, technologically skilled, creative, critical-thinking, and future-ready learners.

Keywords: *Artificial Intelligence, Science Education, Technology Education, Mathematics Education, Personalized Learning, Intelligent Tutoring, Digital Literacy, Computational Thinking, AI in Education.*

Introduction

Artificial Intelligence refers to computer systems capable of performing tasks that typically require human intelligence, including learning, reasoning, pattern recognition, language comprehension, and problem-solving. The increasing availability of generative AI, intelligent tutoring systems, adaptive learning platforms, and data-analysis tools has created new opportunities for educational practice.

Science, Technology, and Mathematics education plays a vital role in developing scientific thinking, creativity, logical reasoning, problem-solving abilities, and technological literacy among learners. However, conventional classroom instruction may be constrained by differences in students' learning levels, limited laboratory resources, and the time required for provide individualized feedback. AI can help address some of these challenges by offering adaptive learning experiences and interactive educational environments.

AI can support students in exploring scientific concepts through simulations, understanding mathematical relationships through step-by-step explanations, and developing technological skills through intelligent digital environments. Nevertheless, effective integration requires appropriate teacher guidance, digital literacy, ethical awareness, and careful consideration of issues such as privacy, bias, and unequal access to technology.

Objectives of the paper

The major objectives of this research paper are:

1. To explain the concept of Artificial Intelligence in education.
2. To examine the applications of AI in Science education.
3. To analyze the role of AI in Technology education.
4. To identify the applications of AI in Mathematics education.
5. To evaluate the educational benefits of AI-based learning.
6. To examine the challenges and ethical issues associated with AI in education.
7. To propose strategies for the effective and responsible integration of AI into STM education.

Definitions of Keywords

1. **Artificial Intelligence (AI):**
   Artificial Intelligence is the technology that enables machines and computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, problem-solving, and decision-making.
2. **Science Education:**
   Science Education is the process of developing scientific knowledge, skills, attitudes, inquiry abilities, and understanding through observation, experimentation, and investigation.
3. **Technology Education:**
   Technology Education is the process of developing knowledge and skills to understand, use, design, and apply technology for solving problems and meeting human needs.

4. **Mathematics Education:**
   Mathematics Education is the process of teaching and learning mathematical concepts, reasoning, logical thinking, problem-solving, and the application of mathematics in everyday life.
5. **Personalized Learning:**
   Personalized Learning is an educational approach in which teaching methods, learning materials, pace, and activities are adapted to the individual needs, abilities, interests, and progress of learners.
6. **Intelligent Tutoring:**
   Intelligent Tutoring is an AI-based educational system that provides individualized instruction, guidance, hints, practice, and feedback according to the learner's performance and needs.
7. **Digital Literacy:**
   Digital Literacy is the ability to access, understand, evaluate, create, and communicate information effectively, safely, and responsibly using digital technologies.
8. **Computational Thinking:**
   Computational Thinking is a systematic approach to problem-solving that involves decomposition, pattern recognition, abstraction, logical reasoning, and the development of step-by-step algorithms.
9. **AI in Education:**
   AI in Education refers to the application of Artificial Intelligence technologies to support and improve teaching, learning, assessment, educational management, and research.

AI in Science Education

Science education requires observation, experimentation, inquiry, analysis, and evidence-based reasoning. AI can strengthen these processes in several ways.

- **Intelligent Learning Systems**

AI-based learning systems can identify students' strengths and areas requiring improvement. They can recommend learning materials and activities according to individual learning needs and performance levels.

- **Virtual Laboratories and Simulations**

AI-supported simulations can provide opportunities to explore scientific phenomena that may be difficult, expensive, or unsafe to demonstrate in a physical laboratory. Students can investigate concepts in physics, chemistry, biology, and environmental science through interactive digital environments.

- **Scientific Data Analysis**

Students can use AI tools to organize and analyze large datasets. This can help them identify patterns, relationships, and trends in scientific investigations while developing essential data-literacy skills.

- **AI-Assisted Scientific Inquiry**

AI can support inquiry-based learning by helping learners formulate questions, identify variables, organize information, and compare possible explanations. Teacher supervision

remains essential to ensure that students critically evaluate evidence rather than simply accepting AI-generated responses.

- **Personalized Science Learning**

AI systems can adjust the complexity and pace of learning activities according to individual student performance. Students who require additional practice can receive targeted reinforcement, while advanced learners can be provided with more challenging activities.

AI in Technology Education

Technology education focuses on developing technological knowledge, creativity, digital skills, and problem-solving abilities. AI itself is becoming an increasingly important component of technological literacy.

- **Coding and Programming**

AI-based programming assistants can help students understand programming concepts, identify errors, and explore alternative solutions. Teachers should encourage students to understand the logic underlying generated code rather than merely reproducing it.

- **Robotics and Automation**

AI provides a foundation for learning about robotics, automation, sensors, machine learning, and intelligent systems. Educational robotics activities can foster computational thinking, creativity, and problem-solving skills.

- **Design and Innovation**

AI tools can assist students in generating ideas, comparing designs, and developing prototypes. This can strengthen project-based learning and support innovation-oriented educational practices.

- **Digital Literacy**

The responsible use of AI is increasingly becoming an essential component of digital literacy. Students need to understand the capabilities and limitations of AI, verify information, recognize potential bias, and use digital tools ethically.

- **Career-Oriented Learning**

Exposure to AI and related technologies can help learners develop skills relevant to emerging fields such as data science, robotics, software development, engineering, and computational science.

AI in Mathematics Education

Mathematics education is one of the areas in which AI can provide immediate and individualized support.

- **Intelligent Mathematical Problem-Solving**

AI systems can assist students in solving mathematical problems and explaining alternative approaches. Such systems can provide hints, guidance, and feedback rather than merely presenting final answers.

- **Adaptive Learning**

AI can analyze student responses and provide questions at an appropriate level of difficulty. This enables learners to progress at their own pace while receiving instruction suited to their current level of understanding.

- **Error Diagnosis**

AI can identify common errors in mathematical calculations and reasoning. This can help teachers understand students' misconceptions and provide targeted instructional support.

- **Visualization**

AI, when combined with digital mathematical tools, can help learners visualize graphs, geometrical figures, functions, and complex mathematical relationships.

- **Mathematical Modeling**

AI can be used to introduce students to mathematical modeling by analyzing real-world datasets and identifying relationships between variables.

- **Immediate Feedback**

AI-based systems can provide immediate responses to student work. Timely feedback can help learners recognize errors, revise their approaches, and improve their conceptual understanding.

Integration of AI across Science, Technology, and Mathematics

AI can promote interdisciplinary learning by connecting concepts from different subject areas.

Area	Possible AI Application
Science	Simulations, data analysis, virtual laboratories
Technology	Coding, robotics, automation, and design
Mathematics	Problem-solving, visualization, and adaptive practice
Science + Mathematics	Statistical analysis and mathematical modelling
Science + Technology	Robotics, sensors, and intelligent systems
Mathematics + Technology	Programming, algorithms, and computational thinking
STM integration	AI-based projects addressing real-world problems

For example, students can undertake a project on climate change by collecting environmental data, using mathematics to analyze trends, applying AI to identify patterns, and using technology to present their findings. Such activities promote collaboration, critical thinking, and interdisciplinary problem-solving.

Benefits of AI in STM Education

- **Personalized Learning**

AI can provide learning experiences tailored to individual needs, interests, and performance levels.

- **Improved Engagement**

Interactive simulations, intelligent tutors, and AI-supported activities can make abstract concepts more accessible and engaging.

- **Immediate Feedback**

Students can receive rapid feedback on their work, enabling them to correct errors and improve their learning outcomes.

- **Support for Teachers**

AI can assist teachers in preparing learning materials, generating practice questions, analysing student performance, and designing differentiated activities.

- **Development of Higher-Order Thinking**

When used appropriately, AI can encourage analysis, evaluation, creativity, and problem-solving rather than rote memorization.

- **Inclusive Learning**

AI-based technologies may provide alternative forms of explanation and learning support for students with diverse learning needs.

Challenges of Using AI in STM Education

Despite its potential, the integration of AI presents several challenges.

- **Accuracy and Reliability**

AI systems can generate incorrect or misleading information. Students must therefore verify AI-generated responses using textbooks, reliable sources, experiments, and teacher guidance.

- **Overdependence on AI**

Excessive dependence on AI may weaken students' independent thinking and problem-solving abilities. AI should support learning rather than replace intellectual effort.

- **Academic Integrity**

Students may use generative AI to complete assignments without understanding the underlying content. Teachers therefore need assessment approaches that emphasize reasoning, explanation, practical work, and authentic performance.

- **Data Privacy**

AI systems may process sensitive student information. Educational institutions must ensure the responsible collection, storage, protection, and use of learner data.

- **Digital Divide**

Not all students have equal access to devices, reliable internet connections, or AI tools. Unequal access may exacerbate existing educational inequalities.

- **Teacher Preparedness**

Teachers require professional development to understand AI tools, their limitations, ethical implications, and appropriate pedagogical applications.

- **Bias and Fairness**

AI systems may reflect biases present in their training data or design. Their educational use therefore requires critical evaluation of outputs and ongoing attention to fairness and inclusivity.

AI and Constructivism:

The integration of Artificial Intelligence in Science, Technology, and Mathematics education can be understood through the principles of constructivist learning theory. Constructivism views learners as active participants who construct knowledge through prior experiences, exploration, interaction, problem-solving, and reflection. AI-supported learning environments can facilitate this process by providing personalized tasks, simulations, intelligent feedback, scaffolding, and opportunities for inquiry. In Science education, virtual laboratories and simulations enable learners to investigate scientific phenomena; in Mathematics, AI tools can support exploration of mathematical relationships and problem-solving; and in Technology education, AI can facilitate coding, robotics, design, and project-based learning. In this approach, the teacher acts as a facilitator who guides learners, encourages critical thinking, and helps them evaluate AI-generated information. Thus, AI can strengthen constructivist pedagogy when it is used as a **supportive learning tool rather than as a substitute for the learner's thinking or the teacher's role.**

Role of the Teacher in AI-Supported Education

AI cannot replace the professional, social, and emotional roles of teachers. Teachers remain responsible for designing meaningful learning experiences, exercising professional judgement, and guiding students' intellectual and personal development.

The teacher's role includes:

- Selecting appropriate AI tools.
- Establishing clear learning objectives.
- Verifying the accuracy of AI-generated information.
- Teaching students how to evaluate AI outputs.
- Encouraging independent thinking.
- Protecting student privacy.
- Promoting the ethical use of technology.
- Designing assessments that measure genuine understanding.
- Supporting collaboration and communication.
- Integrating AI with experiments, discussions, and hands-on activities.

Ethical Principles for AI in Education

The responsible use of AI should be guided by the following principles:

1. **Human oversight** – Teachers should remain responsible for educational decisions.
2. **Transparency** – Learners should understand when and how AI is being used.
3. **Privacy** – Student data should be protected.
4. **Fairness** – AI should not discriminate against learners.
5. **Accuracy** – AI-generated information should be critically verified.
6. **Academic integrity** – AI should not be used to facilitate dishonest academic practices.
7. **Accessibility** – AI-supported education should aim to benefit diverse learners.
8. **Digital responsibility** – Students should develop ethical and critical AI literacy.

AI and NEP 2020

The National Education Policy (NEP) 2020 emphasizes technology integration, digital literacy, experiential learning, critical thinking, multidisciplinary education, and the development of 21st-century skills. These priorities create a favourable educational context for the thoughtful use of AI.

AI can support the broader goals of NEP 2020 by facilitating personalized learning, strengthening digital capabilities, supporting multidisciplinary projects, and providing new approaches to assessment and the development of educational resources. However, AI adoption should remain aligned with educational objectives and the development of human values and competencies.

Conclusion

Artificial Intelligence has significant potential to transform Science, Technology, and Mathematics education. It can facilitate personalized learning, intelligent feedback, virtual experimentation, mathematical support, coding assistance, data analysis, and interdisciplinary learning opportunities. AI can make learning more flexible and responsive to individual learner needs.

Therefore, the future of STM education should focus not merely on using AI, but on using AI intelligently, ethically, and pedagogically to develop scientifically literate, mathematically competent, technologically capable, and critically thinking learners.

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ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION: A REVIEW OF EVIDENCE ON ITS EFFECTIVENESS IN HIGH SCHOOL MATHEMATICS INSTRUCTION

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Abstract

Artificial intelligence (AI) is reshaping instructional practice across Science, Technology, Engineering, and Mathematics (STEM) education, offering adaptive, data-driven, and personalized pathways for learners. This paper reviews and synthesizes current empirical and meta-analytic evidence on the effectiveness of AI-supported instruction, with particular emphasis on high school mathematics teaching and learning. Drawing on recent systematic reviews and meta-analyses published between 2023 and 2026, the paper reports a consistent, statistically significant, positive effect of AI-supported instruction on student achievement, with effect sizes ranging from small-to-moderate ($g \approx 0.34$) in mathematics-specific analyses to large ($g \approx 0.67–0.92$) in broader STEM contexts. Moderator analyses across studies indicate that intelligent tutoring systems and adaptive learning platforms yield stronger gains than generic AI tools, and that secondary/high-school-level learners benefit at least as much as, and in some analyses more than, other educational levels. The paper discusses the pedagogical mechanisms underlying these effects — including personalization, immediate feedback, adaptive sequencing, and reduced cognitive load — and considers implications for classroom integration, teacher preparation, and equity. Limitations of the current evidence base, including study heterogeneity and short intervention durations, are also discussed, along with directions for future research.

Keywords: *artificial intelligence, STEM education, mathematics achievement, high school students, intelligent tutoring systems, adaptive learning, meta-analysis*

Introduction

Mathematics achievement at the secondary level remains a persistent concern for educators, policymakers, and parents worldwide, as it underlies students' access to science, engineering, and technology pathways in higher education and the workforce. Traditional classroom instruction, constrained by fixed pacing, limited individualized attention, and one-size-fits-all assessment, often struggles to accommodate the wide variability in learners' prior knowledge, working-memory capacity, and mathematics-related anxiety that characterizes any high school classroom. Over the past decade, artificial intelligence (AI) has emerged as a technological response to this variability, offering tools that can diagnose individual learning gaps, adapt content difficulty in real time, and provide instantaneous, individualized feedback at a scale no human teacher could sustain alone.

The integration of AI into Science, Technology, Engineering, and Mathematics (STEM) education spans a broad range of applications: intelligent tutoring systems (ITS) that

model student knowledge states and adjust problem sequencing; adaptive learning platforms that personalize practice sets; generative AI tools such as large language models that can explain concepts, generate practice problems, and provide conversational scaffolding; and AI-powered analytics dashboards that help teachers identify at-risk students earlier. In mathematics specifically, AI applications have concentrated on procedural skill practice, conceptual explanation, immediate error diagnosis, and, more recently, open-ended problem-solving support through generative AI.

While enthusiasm for AI in education has grown rapidly, questions remain about the actual magnitude of its effect on student learning outcomes, particularly for high school mathematics, and about which forms of AI implementation are most effective. Early qualitative and case-study reports offered promising but fragmented evidence, while claims of transformative impact often outpaced rigorous quantitative verification. The recent emergence of systematic reviews and meta-analyses, several published in 2025 and 2026, now allows for a more statistically grounded assessment of AI's effectiveness across STEM subjects and, within that broader picture, mathematics education specifically.

This paper has three aims. First, it reviews the theoretical rationale for AI-supported mathematics instruction, situating it within established learning theories. Second, it synthesizes recent meta-analytic and statistical evidence on the effectiveness of AI in STEM and mathematics education, with particular attention to high school-level findings and moderating variables such as AI type and intervention duration. Third, it discusses implications for classroom practice, teacher preparation, and future research, while acknowledging current limitations in the evidence base.

Theoretical Foundations of AI-Supported Mathematics Instruction

AI-supported instruction in mathematics draws on several converging theoretical frameworks. Cognitive Load Theory suggests that adaptive systems, which adjust task difficulty to a learner's current knowledge state, can reduce extraneous cognitive load and free working-memory resources for schema construction. Self-efficacy theory predicts that the immediate, non-judgmental feedback typical of AI tutoring systems can reduce mathematics anxiety and build learners' confidence through repeated mastery experiences, particularly for students who are reluctant to seek help from peers or teachers. Universal Design for Learning (UDL) principles further support AI's role in offering multiple means of representation, engagement, and expression, which is especially relevant for high school classrooms containing students with varied learning needs, including learning disabilities. Together, these frameworks provide a coherent rationale for why AI-supported instruction might be expected to improve mathematics achievement beyond what conventional, uniform-pace instruction can achieve.

AI Applications in High School Mathematics Education

Three categories of AI application dominate current high school mathematics practice. Intelligent tutoring systems (ITS) use knowledge-tracing algorithms to estimate a student's mastery of specific skills and select subsequent practice items accordingly; platforms of this kind have the longest research history and the most consistent evidence of effectiveness. Adaptive learning platforms extend this logic across entire courses, adjusting the sequence and

pacing of content delivery based on continuous performance data. Generative AI tools, which have proliferated rapidly since 2023, allow students to request step-by-step explanations, alternative solution strategies, and worked examples in natural language; these tools show particular promise for open-ended problem-solving and conceptual explanation, though their effectiveness appears more sensitive to how they are integrated into instruction than is the case for structured ITS platforms.

Across these categories, the common pedagogical mechanism is personalization: the capacity to match instructional pace, difficulty, and feedback to the individual learner rather than the class average. For high school mathematics, where content builds cumulatively and gaps compound quickly, this capacity for continuous, individualized adjustment is frequently cited as the primary driver of observed achievement gains.

Statistical Analysis of AI's Effectiveness in Mathematics and STEM Education

To quantify the effectiveness of AI-supported instruction, this review draws on effect sizes reported in recent systematic reviews and meta-analyses that used random-effects models to synthesize experimental and quasi-experimental studies. Effect sizes are reported as Hedges' g, interpreted using Cohen's conventional benchmarks (small ≈ 0.2, medium ≈ 0.5, large ≥ 0.8). Table 1 summarizes the key statistical findings from six recent syntheses relevant to STEM and mathematics education, and Figure 1 presents the five numerically reported pooled effect sizes for visual comparison against Cohen's conventional benchmarks.

Study	Focus / Sample	Model	Effect Size (g)	Interpretation
Zhao et al. (2025)	Generative AI & higher-order thinking, 29 studies	Random effects	Moderate (strongest for problem-solving)	Positive, moderate
STEM meta-analysis (2026, Journal of Intelligence)	AI-supported instruction in STEM, 35 studies	Random effects	g = 0.67, 95% CI [0.49, 0.85]	Positive, large; strongest at high-school level
Dong, Tang, & Wang (2025)	AI & academic achievement, 29 studies, n = 2,657	Random effects	g = 0.924 overall; g ≈ 0.47 for mathematics	Positive, large overall; moderate for mathematics
K-12 mathematics meta-analysis (2025, IJSME)	AI & K-12 mathematics achievement, 21 studies / 40 samples	Random effects	g = 0.343	Positive, small-to-moderate
Open Praxis meta-analysis (2025)	AI technology-based teaching, multiple levels	Random effects	g = 0.503 overall; 0.448 (higher ed) / secondary ed. reported separately	Positive, moderate
García-Martínez et al. (2023)	AI & computational sciences on student performance, 25 studies	Systematic review + meta-analysis	Positive impact on achievement, attitude, motivation	Positive, consistent across stages

Table 1. Summary of recent meta-analytic effect sizes for AI-supported instruction in STEM and mathematics education.

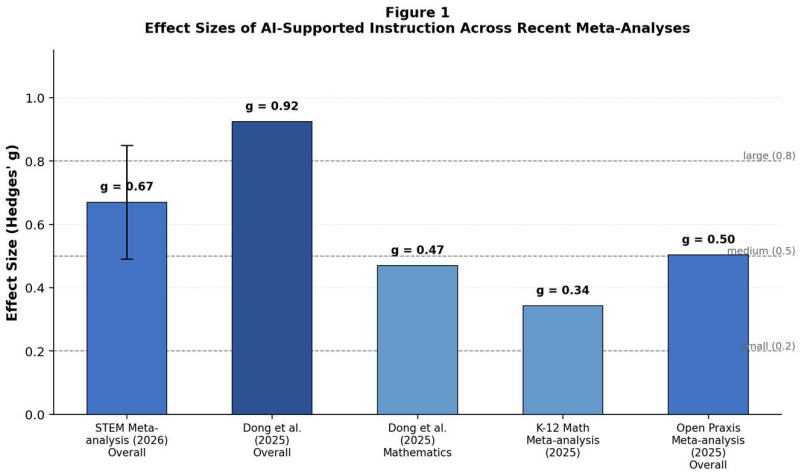

Figure 1. Pooled effect sizes (Hedges' g) for AI-supported instruction reported across five recent meta-analyses. Dashed reference lines mark Cohen's conventional benchmarks for small (0.2), medium (0.5), and large (0.8) effects. Error bars for the STEM meta-analysis (2026) represent the reported 95% confidence interval [0.49, 0.85]; confidence intervals were not available for the remaining studies.

Several statistical patterns emerge from this synthesis. First, every meta-analysis identified a statistically significant, positive overall effect of AI-supported instruction on student achievement, with confidence intervals excluding zero in each case where they were reported; for instance, the 2026 STEM synthesis reported a large effect ($g = 0.67$, 95% CI [0.49, 0.85], $p < .001$) drawn from thirty-five studies. Second, effect sizes for mathematics specifically tend to be somewhat smaller than those for STEM subjects taken together: a 2025 meta-analysis focused exclusively on K-12 mathematics reported a smaller pooled effect ($g = 0.343$) than broader STEM syntheses, while a separate achievement-focused meta-analysis reported a moderate effect for mathematics ($g \approx 0.47$) within a larger overall effect ($g = 0.924$) spanning multiple subjects. This pattern suggests that mathematics, while still benefiting meaningfully from AI-supported instruction, may show more modest gains than subjects such as language learning or nursing education, possibly because mathematical reasoning places heavier demands on conceptual transfer that current AI tools address less directly than procedural practice.

Third, moderator analyses consistently identify AI type as a significant driver of effect-size variation. Structured intelligent tutoring systems and adaptive learning systems produce stronger effects than less-structured or general-purpose AI tools, indicating that the pedagogical design of an AI system, and not merely the presence of AI, determines its instructional value. Fourth, educational level emerges as a relevant moderator: the 2026 STEM meta-analysis found AI interventions to be most effective at the high school level relative to other educational stages, a finding of direct relevance to secondary mathematics instruction and consistent with the theoretical expectation that adolescent learners, who are consolidating abstract mathematical reasoning, may be particularly responsive to individualized scaffolding. Fifth, heterogeneity across studies is consistently high (for example, $I^2 \approx 84\%$ in one synthesis), reflecting wide variation in intervention duration, AI tool

design, sample characteristics, and outcome measures; this heterogeneity means that pooled effect sizes should be interpreted as indicative averages rather than precise, universally applicable estimates.

Taken together, the statistical evidence supports the conclusion that AI-supported instruction produces a real, positive, and replicable effect on mathematics achievement among high school students, with the magnitude of that effect depending substantially on the type of AI tool used and the duration and quality of its classroom implementation.

Discussion and Implications

The convergence of independent meta-analyses on a positive effect of AI-supported instruction offers reasonably strong evidence that AI, when well implemented, can meaningfully improve high school mathematics achievement. For classroom practice, this suggests that structured, adaptive tools (ITS and adaptive learning platforms) should be prioritized over loosely integrated generative AI use, at least until further research clarifies effective pedagogical scaffolding for the latter. For teacher preparation, the findings imply a need for professional development that helps mathematics teachers interpret AI-generated diagnostic data and integrate AI tools purposefully into lesson design, rather than treating them as a stand-alone substitute for instruction. For equity, the finding that AI interventions may be particularly effective at the high school level is encouraging, but it should be read alongside broader concerns about differential access to technology infrastructure, especially in under-resourced schools and rural districts. Where access is unequal, AI-supported gains risk widening rather than narrowing achievement gaps unless deliberately paired with equitable implementation policies. Additionally, most included studies report short-to-moderate intervention durations, and evidence on long-term retention of AI-supported gains remains limited; sustained, multi-year evaluations are needed before strong causal claims about durable achievement gains can be made.

Conclusion

This review synthesizes recent statistical evidence indicating that AI-supported instruction has a consistent, positive, and educationally meaningful effect on student achievement in STEM education generally and mathematics education specifically, with effect sizes ranging from small-to-moderate for mathematics alone to large for STEM subjects combined. High school students appear to benefit at least as much as, and in some analyses more than, learners at other educational levels, and structured, adaptive AI tools consistently outperform less-structured applications. These findings support the continued, thoughtfully designed integration of AI into secondary mathematics classrooms, while underscoring the need for further longitudinal research, attention to equitable access, and teacher preparation that enables purposeful rather than incidental use of these technologies.

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SKILL DEVELOPMENT AND EMPLOYABILITY AMONG HIGHER EDUCATION STUDENTS: BRIDGING THE GAP BETWEEN EDUCATION AND INDUSTRY REQUIREMENTS

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Abstract

The changing nature of the global economy and rapid technological development have significantly influenced the skills required in the workplace. Higher education institutions are expected to prepare students not only with academic knowledge but also with technical, digital, communication, interpersonal, and problem-solving skills. However, a gap continues to exist between the competencies developed through higher education and the expectations of employers. This thematic paper examines the importance of skill development in enhancing employability among higher education students and discusses the major factors responsible for the educationindustry skill gap. The paper focuses on technical skills, soft skills, digital literacy, critical thinking, teamwork, adaptability, practical exposure, and industry interaction. It also highlights the role of higher education institutions in curriculum development, internships, experiential learning, career guidance, and industry-academia collaboration. The paper concludes that a coordinated approach involving educational institutions, industry, students, and policymakers is essential for developing employable and adaptable graduates.

Keywords: *Skill Development, Employability, Higher Education, Industry Requirements, Technical Skills, Soft Skills, Digital Skills*

Introduction

Higher education is an important instrument for developing human resources and preparing students for employment and responsible citizenship. Traditionally, higher education has given greater importance to academic knowledge and theoretical understanding. However, the contemporary employment environment requires graduates to possess a wider range of competencies. Technological advancement, globalization, automation, and changing workplace practices have created new occupational opportunities while simultaneously changing the skills required for existing jobs. Employers increasingly expect graduates to demonstrate practical knowledge, communication skills, teamwork, critical thinking, digital competence, creativity, and adaptability.

A degree provides students with subject knowledge, but employability depends on the ability to apply that knowledge effectively in real-life situations. The difference between what students learn in educational institutions and what employers expect from graduates is commonly described as the education-industry skill gap. Bridging this gap requires higher education institutions to integrate skill development into academic programmes and establish stronger relationships with industry. Students should be provided with opportunities to learn through practical projects, internships, workshops, industry interaction, and experiential learning.

Concept of Skill Development and Employability

Skill development refers to the process of acquiring knowledge, abilities, competencies, and attitudes that enable individuals to perform tasks effectively. In higher education, skill development includes both discipline-specific technical skills and transferable skills. Employability refers to the combination of knowledge, skills, attitudes, and personal attributes that enable an individual to obtain employment, perform effectively, and adapt to changing workplace conditions.

Employability is therefore broader than academic achievement. A student may have good academic performance but still face difficulties in employment if they lack communication, teamwork, practical knowledge, or confidence. Effective employability development requires a balanced combination of academic learning, technical competence, soft skills, and practical experience.

Review of Literature

Yorke (2006) described employability as a combination of achievements, skills, understanding, and personal attributes that increase graduates' chances of obtaining employment and succeeding in their occupations.

Pool and Sewell (2007) developed the CareerEDGE model and emphasized career development learning, work and life experience, degree subject knowledge, generic skills, and emotional intelligence as important components of graduate employability.

Jackson (2015) highlighted the importance of work-integrated learning in developing students' ability to apply academic knowledge in workplace situations.

Tomlinson (2017) noted that graduates require multiple forms of capital and a broad range of skills to succeed in competitive labour markets.

The literature indicates that employability is a multidimensional concept. Academic qualifications alone are insufficient; students also need technical, interpersonal, professional, and transferable skills.

Need and Significance of the Study

The increasing number of higher education graduates has intensified competition for employment. At the same time, employers frequently report difficulties in finding candidates with the combination of technical knowledge and workplace skills required for particular roles. The study is significant because developing employability skills can,

- improve students' preparedness for employment.
- increase confidence and workplace readiness.
- strengthen students' ability to apply theoretical knowledge.
- support career development and progression.
- reduce the education-industry skill gap.
- improve the relevance and quality of higher education.

The issue is particularly important because technological change requires graduates to continuously update their skills throughout their careers.

Statement of the Problem

There exists a considerable difference between the skills acquired by many higher education students and the competencies expected by employers. The problem is not necessarily the absence of education but the limited integration of academic knowledge with practical and industry-oriented skills. Therefore, there is a need to examine how skill development can enhance employability and how higher education institutions can bridge the gap between education and industry requirements.

Objectives of the Study

1. To examine the importance of skill development in enhancing employability among higher education students.
2. To identify major technical and soft skills required by contemporary industries.
3. To examine the gap between skills acquired through higher education and industry expectations.
4. To discuss the role of higher education institutions in developing employability skills.
5. To suggest measures for strengthening industry-oriented skill development.

Hypotheses for Future Empirical Study

Although the present paper is thematic in nature, the following hypotheses may be examined in future empirical research:

H_1: There is a significant relationship between skill development and employability among higher education students.

H_2: Technical skills significantly influence students' employability.

H_3: Soft skills significantly influence students' employability.

H_4: Higher education institutions significantly contribute to students' employability through skill development programmes.

H_5: Employability skills differ significantly based on selected demographic characteristics of students.

Major Skills Required for Employability

- Technical Skills: Technical skills are specific competencies related to a particular academic discipline or occupation. Engineering, information technology, management, healthcare, and other professional fields require students to possess appropriate technical knowledge and practical abilities. Curricula should therefore be regularly updated to reflect technological developments and changing occupational requirements.
- Communication Skills: Communication is one of the most important employability competencies. Graduates should be able to communicate ideas clearly through speaking, writing, presentations, and professional interactions. Good communication contributes to effective teamwork, leadership, customer relations, and workplace performance.
- Critical Thinking and Problem Solving: Modern organisations require employees who can analyse problems and make appropriate decisions. Higher education should encourage students to develop critical thinking through case studies, projects, discussions, research activities, and problem-based learning.

- Teamwork and Leadership: Most professional activities involve collaboration. Students should learn to work effectively with people from different backgrounds, share responsibilities, resolve differences, and contribute to common objectives. Leadership skills are also important for taking initiative and managing responsibilities.
- Digital Literacy: Digital transformation has changed almost every sector. Students require digital competence appropriate to their discipline. Basic digital literacy, information management, data handling, and familiarity with relevant software and technologies can significantly enhance employability.
- Adaptability and Lifelong Learning: The workplace is continuously changing. Graduates must therefore be willing to acquire new knowledge and adapt to changing technologies, roles, and working environments. Lifelong learning is increasingly important for sustainable career development.
- Soft skills: Soft skills are personal habits, social traits, and communication styles that shape how you interact with others and handle daily tasks.

Education-Industry Skill Gap

The education-industry skill gap can arise for several reasons. One major factor is the difference between rapidly changing industry requirements and relatively slow curriculum revision. In some institutions, students may receive extensive theoretical instruction but limited exposure to real workplace situations. Another factor is insufficient interaction between educational institutions and employers. Without regular industry feedback, institutions may find it difficult to identify emerging skills and occupational requirements. Limited internship opportunities, inadequate practical facilities, insufficient career guidance, and excessive dependence on traditional assessment methods can also contribute to the gap. Reducing this gap requires continuous communication between institutions and industry and greater emphasis on practical learning.

Role of Higher Education Institutions

Higher education institutions have a central responsibility in preparing students for employment. They can contribute by integrating employability skills into academic curricula rather than treating them as separate activities. Institutions should encourage:

- practical and project-based learning.
- internships and industry exposure.
- industry-oriented workshops.
- communication and soft-skill training.
- digital and technological skill development.
- entrepreneurship and innovation.
- career counselling and placement preparation and interaction with industry professionals.

Faculty members should also adopt teaching approaches that encourage creativity, independent thinking, collaboration, and application of knowledge.

Role of Industry-Academia Collaboration

Strong collaboration between industry and educational institutions is essential for reducing the skill gap. Industry professionals can participate in curriculum development, guest lectures, workshops, mentoring, internships, industrial visits, and project evaluation. Internships provide students with an opportunity to understand workplace culture and apply classroom learning to practical situations. Industry-based projects can further strengthen students' problem-solving and professional skills. Regular feedback from employers can help institutions identify changing skill requirements and modify their programmes accordingly.

Suggestions for Bridging the Gap

The following measures can help improve graduate employability:

- Update curricula regularly according to changing industry requirements.
- Increase practical learning through projects, laboratory activities, and experiential learning.
- Provide meaningful internships and industry exposure.
- Strengthen soft-skill development, particularly communication, teamwork, leadership and problem solving.
- Improve digital competence across academic disciplines.
- Increase industry participation in curriculum design and student training.
- Strengthen career guidance and placement services.
- Encourage entrepreneurship and innovation among students.
- Provide continuous professional development opportunities.
- Assess employability outcomes regularly to evaluate the effectiveness of institutional programmes.

Conclusion

Skill development is an essential component of graduate employability. In the contemporary employment environment, academic qualifications alone cannot fully meet workplace expectations. Graduates require a combination of technical knowledge, communication skills, digital competence, critical thinking, teamwork, problem-solving ability, adaptability, and practical experience.

The gap between education and industry can be reduced by making higher education more responsive to changing employment requirements. Curriculum revision, internships, practical learning, industry interaction, career guidance, and skill-development programmes can significantly improve students' workplace readiness. Bridging the education-industry gap is a shared responsibility. Higher education institutions must work closely with industry, policymakers, faculty members, and students to create meaningful learning opportunities. Such collaboration can produce graduates who are not only employable but also capable of continuous learning and adapting to the changing demands of the future workplace.

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TEACHING IN THE AGE OF AI: TRANSFORMING TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT

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Abstract

Artificial Intelligence (AI) is reshaping educational landscapes worldwide by enhancing teaching, learning, assessment, and professional growth. The rapid advancement of generative AI, machine learning, intelligent tutoring systems, and predictive analytics has created unprecedented opportunities for teacher education and continuous professional development. This paper examines the transformative role of AI in preparing future teachers and supporting practicing educators. It explores various AI tools and platforms applicable to teacher education, discusses their pedagogical benefits, analyzes associated challenges, and proposes strategies for responsible integration. The study argues that AI should not replace teachers but augment their capabilities, enabling personalized learning, data-informed decision-making, and lifelong professional growth. The paper concludes with recommendations for integrating AI literacy and ethical competencies into teacher education programs.

Keywords: *Artificial Intelligence, Teacher Education, Professional Development, Generative AI, Educational Technology, AI Literacy.*

1. Introduction

The Fourth Industrial Revolution has accelerated the integration of Artificial Intelligence (AI) across multiple sectors, including education. AI technologies have evolved from simple automation tools to sophisticated systems capable of generating content, analyzing data, providing personalized feedback, and supporting complex decision-making processes. Educational institutions are increasingly adopting AI-driven technologies to improve learning outcomes and administrative efficiency.

Teacher education and professional development have become critical areas where AI can produce significant impacts. Future teachers must develop competencies that allow them to effectively integrate AI into pedagogical practices while maintaining human-centered approaches to learning. International organizations such as UNESCO emphasize the need for responsible and ethical implementation of Generative AI in education to protect human agency, equity, and inclusion. This paper explores how AI is transforming teacher preparation and professional development and identifies practical AI tools that can be effectively utilized by educators.

2. Understanding AI in Education

Artificial Intelligence refers to computer systems capable of performing tasks that

typically require human intelligence, including learning, reasoning, problem-solving, language processing, and decision-making.

In education, AI technologies include Generative AI, Machine Learning, Natural Language Processing (NLP), Intelligent Tutoring Systems, Learning Analytics, Adaptive Learning Systems, Chatbots, Virtual Assistants and Automated Assessment Systems. These technologies enable personalized learning experiences, automate routine tasks, and provide actionable insights for teachers and institutions.

3. AI and Teacher Education

3.1 Enhancing Teaching Competencies

Teacher education programs traditionally focus on pedagogy, curriculum design, assessment, and classroom management. AI expands these competencies by enabling future teachers to Design personalized learning experiences, Analyze learner data, create adaptive instructional materials, Develop digital and AI literacy and Foster critical thinking about AI-generated content. AI-powered platforms can simulate classroom scenarios, enabling preservice teachers to practice decision-making in safe virtual environments.

3.2 Personalized Learning for Teacher Trainees

AI systems can assess teacher candidates' strengths and weaknesses and provide customized learning pathways. Adaptive learning platforms recommend resources, activities, and assessments based on individual progress. This benefits Self-paced learning, Continuous feedback, Improved mastery of teaching skills and Individualized professional growth.

3.3 AI-Based Teaching Simulations

Virtual reality and AI-driven teaching simulations provide realistic classroom environments where teacher trainees can practice lesson delivery, Handle behavioral issues, Improve communication skills and Receive instant performance feedback. This will bridge the gap between theory and practice.

4. AI in Professional Development of Teachers

Professional development is no longer confined to workshops and seminars. AI enables continuous, personalized, and data-driven learning opportunities.

4.1 Continuous Learning Support

AI can recommend to search relevant research articles, Professional courses, attend Webinars and workshops and avail Curriculum resources. By this Teachers receive learning opportunities based on their interests and professional needs.

4.2 Automated Feedback and Reflection

AI tools can analyze Lesson plans, Teaching recordings and Student performance data. These analyses help teachers reflect on their instructional strategies and identify areas for improvement.

4.3 Data-Informed Decision Making

Learning analytics platforms collect and analyze student performance data, helping teachers to Identify learning gaps, Monitor progress, Personalize interventions and Improve classroom outcomes.

5. AI Tools for Teacher Education and Professional Development

5.1 ChatGPT (OpenAI), Google Gemini and Microsoft copilot: can be used for Lesson plans, Content generation, Assessment design, Presentation creation, Feedback creation and educational research support. This helps to save preparation time, supports differentiated instruction and enhances creativity

5.2 Canva AI is a user-friendly application used for educational infographics, Presentations, Visual lesson materials and to create educational posters

5.3 MagicSchool AI specifically Designed for educators for Lesson planning, Individualized Education Plans (IEPs), Assessment generation and for Classroom communication. This AI tool reduces the administrative workload of teachers and provides time for teaching.

5.4 Gradescope is an AI tool used for Automated grading, Assessment analytics and for Feedback generation. This tool helps for Faster evaluation and Consistent assessment practices.

5.5 Kahoot! AI and Quizizz AI used for Quiz generation, Formative assessment and Interactive classroom engagement. This improves student participation and to collect the Immediate feedback.

5.6 Turnitin AI Tools used for Academic integrity, Writing evaluation and feedback support. This Encourages responsible AI use and Promotes ethical academic practices.

6. Benefits of AI in Teacher Education and Professional Development

AI automates repetitive administrative tasks, allowing teachers to focus on instruction and student engagement. Which **Improves Teachers Efficiency.** Teachers receive customized recommendations based on their professional goals. It **Enhances Content Creation helps in** generating Lesson plans, Assessments, Case studies and Learning activities. AI tools helps for **Better Student Support.** Data analytics enable early identification of struggling learners and targeted interventions. AI promotes continuous professional growth by offering on-demand learning opportunities cultivates **Lifelong Learning Culture.**

7. Recommendations

To maximize the benefits of AI in teacher education and professional development, institutions should:

7.1 Integrate AI Literacy into Teacher Education

Teacher education curricula should include:

- AI fundamentals, Prompt engineering, Ethical AI usage, Critical evaluation of AI outputs

7.2 Develop Institutional Policies

Universities and schools should establish clear guidelines regarding:

- AI use, Data privacy, Assessment practices, Academic integrity

7.3 Promote Human-AI Collaboration

AI should function as an assistive tool rather than a replacement for teachers.

7.4 Strengthen Professional Development Opportunities

Regular AI-focused training programs should help educators:

- Explore emerging tools, Develop digital competencies, Implement innovative pedagogies

7.5 Encourage Ethical and Responsible Use

Teachers should model responsible AI practices and encourage students to critically engage with AI-generated content.

8. Conclusion

Artificial Intelligence is transforming teacher education and professional development by providing personalized learning opportunities, enhancing instructional design, supporting assessment, and promoting continuous professional growth. AI-powered tools such as ChatGPT, Microsoft Copilot, Gemini, Canva AI, MagicSchool AI, and Gradescope are redefining how educators learn, teach, and develop professionally. However, successful implementation requires careful attention to ethics, privacy, equity, and human agency.

The future of education lies not in replacing teachers with AI but in empowering teachers through AI. Educators who possess AI literacy, pedagogical expertise, and ethical awareness will be better equipped to prepare learners for an increasingly digital and intelligent world.

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A STUDY OF B.ED. TRAINEES' EXPERIENCES IN THE USE OF EDUCATIONAL TECHNOLOGY IN TEACHING PRACTICE

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Abstract

Educational technology is an important component of contemporary teaching and teacher education. Its effective use during teaching practice helps B.Ed. trainees enhance classroom interaction, learner engagement, content presentation, and digital teaching competencies. However, trainees may face challenges related to technological skills, resources, infrastructure, and technical support. The present study aims to examine B.Ed. trainees' experiences and difficulties in using educational technology during teaching practice and to suggest measures for its effective integration. A descriptive survey design will be adopted, and data will be collected from B.Ed. trainees using a structured questionnaire. The findings are expected to provide insights into trainees' technology-use experiences and challenges and help teacher educators and institutions strengthen technology-integrated teaching practice programmes.

Keywords: *B.Ed. trainees, educational technology, teaching practice, digital pedagogy, teacher education, technology integration, classroom teaching*

Introduction

Educational technology has become an essential part of modern teaching and learning. It helps teachers make lessons more interactive, engaging, and effective through digital tools and resources. For B.Ed. trainees, teaching practice provides an opportunity to apply educational technology in real classroom situations.

However, trainees may face difficulties such as lack of resources, poor internet connectivity, technical problems, limited skills, and inadequate support. Therefore, it is important to study their experiences and challenges in using educational technology. The present study focuses on the experiences of B.Ed. trainees, the difficulties they face, and measures to improve the effective use of educational technology during teaching practice.

Need and Significance of the Study

The present study is significant as it helps assess the digital teaching competence of B.Ed. trainees and understand how they apply educational technology during actual classroom practice. It identifies practical challenges such as inadequate infrastructure, connectivity issues, limited access to devices, and technical difficulties, thereby helping teacher education institutions improve training programmes through workshops, demonstrations, and practical activities. The study also promotes innovative and learner-centred pedagogies and supports the preparation of future teachers to meet the growing digital demands of contemporary schools.

Statement of the Problem

A Study of B.Ed. Trainees' Experiences in the Use of Educational Technology in Teaching Practice

Objectives of the Study

- To study the experiences of B.Ed. trainees in using educational technology during teaching practice.
- To study the difficulties faced by B.Ed. trainees while using educational technology during teaching practice.
- To suggest measures for improving the effective use of educational technology in teaching practice programmes.

Methodology

Research Design: A descriptive survey research design adopted for the present study. The design is appropriate because the study aims to examine the experiences, challenges and confidence levels of B.Ed. trainees regarding educational technology.

Sample: A sample of 46 B.Ed. trainees selected from Kumadvathi College of Education, Shikariura.

Research tool: A self-developed Educational Technology Experience Scale for B.Ed. Trainees used. The tool consist of two sections.

- **Section – A:** Experiences in the Use of Educational Technology during Teaching Practice
- **Section – B:** Problems Faced While Using Educational Technology

A five-point Likert scale used: 5 – Strongly Agree, 4 – Agree, 3 – Undecided, 2 – Disagree, 1 – Strongly Disagree

Data Collection Procedure

Data were collected from 46 B.Ed. trainees of Kumadvathi College of Education, Shikaripura, using a structured questionnaire. The questionnaire was administered to the selected trainees to collect information regarding their experiences in using educational technology during teaching practice.

Data Analysis

The collected quantitative data may be analysed using: Percentage

Results and Interpretation

Section – A: Experiences in the Use of Educational Technology During Teaching Practice

Sl. No.	Questions	Response				
		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Educational Technology made my teaching practice more effective.	32	13	1	0	0
		69.57%	28.26%	2.17%	0.00%	0.00%
2	I felt confident while using technological tools in the classroom.	17	25	3	0	1
		36.96%	54.35%	6.52%	0.00%	2.17%

3	Students showed more interest during technology-supported lessons.	28	16	2	0	0
		60.87%	34.78%	4.35%	0.00%	0.00%
4	Multimedia presentations improved students' understanding of concepts.	19	25	2	0	0
		41.30%	54.35%	4.35%	0.00%	0.00%
5	Educational Technology helped me manage the classroom effectively.	21	23	2	0	0
		45.65%	50.00%	4.35%	0.00%	0.00%
6	I was able to prepare digital teaching materials easily.	17	25	4	0	0
		36.96%	54.35%	8.70%	0.00%	0.00%
7	Smart classroom facilities supported my teaching practice.	20	23	3	0	0
		43.48%	50.00%	6.52%	0.00%	0.00%
8	Online resources helped me in lesson planning.	25	21	0	0	0
		54.35%	45.65%	0.00%	0.00%	0.00%
9	Educational Technology increased student participation in learning activities.	25	19	2	0	0
		54.35%	41.30%	4.35%	0.00%	0.00%
10	I enjoyed using technology during teaching practice.	20	21	5	0	0
		43.48%	45.65%	10.87%	0.00%	0.00%
11	Technology-based teaching improved my teaching skills.	20	21	5	0	0
		43.48%	45.65%	10.87%	0.00%	0.00%
12	I received adequate guidance from teacher educators in using Educational Technology.	27	17	2	0	0
		58.70%	36.96%	4.35%	0.00%	0.00%
13	Educational apps and software were useful in classroom teaching.	27	16	3	0	
		58.70%	34.78%	6.52%	0.00%	0.00%
14	Technology helped me explain difficult concepts more clearly.	22	22	2	0	0
		47.83%	47.83%	4.35%	0.00%	0.00%
15	I am motivated to use Educational Technology in my future career.	26	19	1	0	0
		56.52%	41.30%	2.17%	0.00%	0.00%

- **Teaching Effectiveness:** 97.83% of trainees agreed that Educational Technology made their teaching practice more effective.
- **Confidence in Technology Use:** 91.31% of trainees agreed that they felt confident while using technological tools in the classroom.
- **Student Interest:** 95.65% reported that students showed more interest during technology-supported lessons.
- **Improved Understanding:** 95.65% agreed that multimedia presentations improved students' understanding of concepts.
- **Classroom Management:** 95.65% felt that Educational Technology helped them manage the classroom effectively.

- **Digital Teaching Materials:** 91.31% reported that they could prepare digital teaching materials easily.
- **Smart Classroom Facilities:** 93.48% agreed that smart classroom facilities supported their teaching practice.
- **Lesson Planning:** 100% of the trainees agreed that online resources helped them in lesson planning.
- **Student Participation:** 95.65% reported that Educational Technology increased student participation in learning activities.
- **Enjoyment:** 89.13% of trainees enjoyed using technology during teaching practice.
- **Teaching Skills:** 89.13% agreed that technology-based teaching improved their teaching skills.
- **Guidance from Teacher Educators:** 95.66% reported receiving adequate guidance from teacher educators in using Educational Technology.
- **Educational Apps and Software:** 93.48% found educational apps and software useful for classroom teaching.
- **Explanation of Difficult Concepts:** 95.66% agreed that technology helped them explain difficult concepts more clearly.
- **Future Motivation:** 97.82% of trainees were motivated to use Educational Technology in their future teaching career.

Section – B: Problems Faced While Using Educational Technology

Sl. No.	Questions	Response				
		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Lack of infrastructure affected my use of technology.	14	17	4	11	0
		30.43%	36.96%	8.70%	23.91%	0.00%
2	Internet connectivity problems disturbed classroom teaching.	7	24	4	5	6
		15.22%	52.17%	8.70%	10.87%	13.04%
3	I faced technical difficulties while using digital tools.	9	14	11	6	6
		19.57%	30.43%	23.91%	13.04%	13.04%
4	Lack of sufficient training created challenges in using Educational Technology.	10	19	9	4	4
		21.74%	41.30%	19.57%	8.70%	8.70%
5	Limited availability of devices affected teaching effectiveness.	10	22	7	7	0
		21.74%	47.83%	15.22%	15.22%	0.00%
6	Power failure interrupted technology-based teaching.	12	16	7	9	2
		26.09%	34.78%	15.22%	19.57%	4.35%

7	Time limitations reduced effective use of Educational Technology.	6	20	10	5	5
		13.04%	43.48%	21.74%	10.87%	10.87%
8	Some students were not familiar with digital learning tools.	13	21	5	6	1
		28.26%	45.65%	10.87%	13.04%	2.17%
9	I needed more technical support during teaching practice.	15	23	3	3	2
		32.61%	50.00%	6.52%	6.52%	4.35%
10	Excessive use of technology sometimes distracted students.	12	19	5	3	7
		26.09%	41.30%	10.87%	6.52%	15.22%

- **Lack of Infrastructure:** 67.39% of trainees agreed that inadequate infrastructure affected their use of technology.
- **Internet Connectivity:** 67.39% reported that internet connectivity problems disturbed classroom teaching.
- **Technical Difficulties:** 50.00% of trainees faced technical difficulties while using digital tools, while 23.91% remained neutral.
- **Insufficient Training:** 63.04% agreed that lack of sufficient training created challenges in using Educational Technology.
- **Limited Availability of Devices:** 69.57% reported that limited availability of devices affected teaching effectiveness.
- **Power Failure:** 60.87% agreed that power failures interrupted technology-based teaching.
- **Time Limitations:** 56.52% felt that time limitations reduced the effective use of Educational Technology.
- **Students' Digital Familiarity:** 73.91% reported that some students were not familiar with digital learning tools.
- **Need for Technical Support:** 82.61% of trainees indicated that they needed more technical support during teaching practice, representing the **highest reported challenge**.
- **Student Distraction:** 67.39% agreed that excessive use of technology sometimes distracted students.

Major Findings

- The findings indicate that B.Ed. trainees had highly positive experiences with Educational Technology during teaching practice.
- No trainee reported disagreement with any of the 15 statements.
- The highest positive response was for online resources supporting lesson planning (100%).
- The findings suggest that Educational Technology contributes positively to teaching effectiveness, student engagement, classroom management, lesson planning, and development of teaching competencies

- The major challenges identified were lack of technical support (82.61%), students' limited familiarity with digital tools (73.91%), limited availability of devices (69.57%), and infrastructure and internet connectivity problems (67.39% each).
- 50% of trainees experienced technical difficulties, indicating a need for better technical preparation and support.
- Overall, the findings suggest that although trainees use Educational Technology positively, infrastructure, technical support, training, connectivity, and student digital literacy remain important barriers to its effective integration.

Educational Implications

- **Strengthening Digital Competence:** B.Ed. programmes should provide regular practical training to develop trainees' skills and confidence in using Educational Technology.
- **Improving Technical Support:** Adequate technical assistance should be provided during teaching practice to help trainees overcome difficulties while using digital tools.
- **Enhancing Infrastructure:** B.Ed. institutions and practice-teaching schools should ensure adequate availability of smart classrooms, digital devices, internet connectivity, and power backup.
- **Providing Hands-on Training:** Workshops, demonstrations, peer learning, and practical assignments should be organized to improve trainees' ability to integrate technology effectively into lessons.
- **Developing Students' Digital Literacy:** Trainees should be encouraged to provide necessary guidance to school students who have limited familiarity with digital learning tools.
- **Promoting Effective Pedagogy:** Technology should be integrated with appropriate teaching strategies to enhance student engagement, understanding, participation, and classroom interaction.
- **Effective Time Management:** Trainees should be trained to plan technology-supported lessons efficiently so that technical preparation does not reduce instructional time.
- **Balanced Use of Technology:** Trainees should use technology purposefully and appropriately to avoid student distraction and ensure that technology supports, rather than replaces, effective teaching.
- **Strengthening Teacher Education Curriculum:** Findings can be used to strengthen the Educational Technology component of B.Ed. programmes by giving greater emphasis to practical classroom application.
- **Continuous Professional Development:** Teacher educators should encourage continuous learning and updating of digital skills so that future teachers can adapt to emerging technologies and changing educational needs.

Conclusion

The present study concludes that B.Ed. trainees had highly positive experiences with the use of Educational Technology during teaching practice. Technology was found to enhance teaching effectiveness, student participation, interest, understanding, lesson planning, and teaching

competencies. However, challenges such as inadequate technical support, limited digital devices, infrastructure and internet connectivity problems, insufficient training, and students' limited familiarity with digital tools were identified. Therefore, providing adequate infrastructure, technical support, practical training, and continuous professional development is essential for the effective and meaningful integration of Educational Technology in teacher education and school teaching.

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SUSTAINABLE PROFESSIONAL DEVELOPMENT FOR TEACHER EDUCATORS

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Abstract

In order to produce effective, thoughtful, and creative educators who can adapt to the ever-changing demands of education, teacher educators are essential. Teacher educators must participate in ongoing learning to preserve their professional competence in the quickly changing educational landscape of today, which is marked by globalisation, technology breakthroughs, educational reforms, and a variety of learner demands. Throughout their careers, teacher educators can continuously enhance their knowledge, pedagogical skills, research capabilities, leadership attributes, and digital competences through an ongoing, methodical, and collaborative process known as Sustainable Professional Development (SPD). SPD places a greater emphasis on lifelong learning, reflective practice, collaborative inquiry, mentoring, action research, and continual improvement than traditional one-time training programs.

Keywords: *Sustainable Professional Development, Teacher Educators, Continuous Professional Development (CPD), Teacher Education, Reflective Practice, Professional Learning Communities, Artificial Intelligence, Digital Learning, Educational Innovation*

Introduction

The foundation of social, economic, and national progress is universally acknowledged to be education. Teachers are the most important contributors to the quality of education among all educational resources. However, the proficiency and knowledge of teacher educators, who are in charge of training future educators and fostering their professional development, have a significant impact on the calibre of educators. Therefore, enhancing the abilities of teacher educators is crucial to raising the standard of education as a whole. Globalisation, digital technology, competency-based curriculum, inclusive education, and artificial intelligence have all significantly altered educational practices in the twenty-first century. Teacher educators must constantly refresh their instructional expertise, research abilities, technical proficiencies, and professional attitudes in light of these advancements. Professional development is now seen to be a continuous process of learning and professional development rather than a set of discrete workshops. Throughout their careers, educators can enhance their teaching methods, leadership abilities, research capacities, and technical proficiencies through Sustainable Professional Development (SPD), which is defined as ongoing, methodical, and significant professional

learning. It promotes cooperation, introspection, creativity, and evidence-based practice while emphasising long-term development over short-term training. Teaching, curriculum creation, educational research, mentorship, assessment, academic leadership, and community participation are just a few of the many responsibilities demanded of teacher educators. These duties necessitate ongoing professional development as well as adjustment to new technological advancements and educational regulations. Teacher educators can continue to be efficient, adaptable, and creative in carrying out their many duties with the support of sustainable professional development. The National Education Policy (NEP) 2020 in India highlights ongoing professional development as a crucial tactic for raising educational standards. It suggests providing teachers and teacher educators with frequent chances for professional development through seminars, online courses, mentorship programs, research projects, and professional learning communities. Organisations that support lifelong professional learning include the National Council for Teacher Education (NCTE), the University Grants Commission (UGC), DIKSHA, SWAYAM, and PM eVIDYA.

Significance of the Study

- Highlights the importance of continuous professional learning for teacher educators.
- Explains the principles and models of sustainable professional development.
- Examines the role of ICT, AI, and digital technologies in professional learning.
- Reviews national and international policy perspectives on teacher educator development.
- Suggests practical strategies for strengthening professional development systems in teacher education institutions.

Objectives of the Study

- To comprehend the idea of teacher educators' Sustainable Professional Development (SPD).
- To investigate the necessity and significance of ongoing professional development in teacher preparation.
- To determine the tenets and traits of long-term professional growth.
- To investigate the different techniques and strategies for teacher educators' professional development.
- To examine how artificial intelligence (AI) and information and communication technology (ICT) contribute to long-term professional development.
- To examine worldwide and national policies concerning the professional development of teacher educators
- To determine the difficulties in putting sustainable professional growth into practice.
- To make suggestions and tactics for enhancing teacher educators' long-term professional development.

Concept of Sustainable Professional Development

Teachers can increase their teaching effectiveness and educational quality by continuously improving their knowledge, abilities, attitudes, and competences through professional development. Sustainable Professional Development (SPD) encourages lifelong, collaborative,

and reflective learning, going beyond sporadic workshops or training sessions.

Opportunities for ongoing learning that let teacher educators adjust to curriculum modifications, technology advancements, educational reforms, and changing student demands are what define SPD. It motivates teachers to develop into thoughtful professionals who actively participate in research, creativity, and teamwork.

Sustainable professional development is integrated into educators' everyday work lives, in contrast to traditional professional development, which frequently concentrates on discrete training programs. It is continuous, evidence-based, context-specific, and in line with educational policies and institutional objectives.

Definitions of Sustainable Professional Development

Guskey (2002) Professional development refers to systematic efforts that bring about change in teachers' classroom practices, beliefs, attitudes, and student learning outcomes.

Day (1999) Professional development is the process by which educators renew and extend their commitment to teaching and acquire the knowledge, skills, and emotional intelligence necessary for effective professional practice throughout their careers.

Characteristics of Sustainable Professional Development

Effective Sustainable Professional Development possesses several distinctive characteristics.

- **Continuous Process**

  After initial teacher preparation, professional development continues. To maintain their professional competence, teacher educators continue to learn throughout their careers.

- **Lifelong Learning**

  In reaction to societal shifts, technological breakthroughs, and educational reforms, SPD urges educators to constantly refresh their knowledge.

- **Reflective Practice**

  To determine their strengths and opportunities for development, teacher educators routinely assess their own professional practices, teaching, and research.

  Continuous improvement and evidence-based decision-making are encouraged by reflection.

- **Collaborative Learning**

Professional learning becomes more effective when educators collaborate through:

- Professional Learning Communities (PLCs)
- Peer observation
- Team teaching
- Mentoring
- Academic networking

Collaboration encourages knowledge sharing and collective problem-solving.

- **Research-Oriented**

Teacher educators are expected to engage in:

- Action research
- Educational research

- Classroom research
- Innovation projects

Research enables evidence-based improvements in teaching practices.

- **Context-Specific**

  Instead of implementing generic training programs, professional development should meet the real requirements of educators within their institutional and cultural contexts.

- **Technology-Enabled**

Modern professional development integrates digital technologies such as:

- Learning Management Systems (LMS)
- MOOCs
- Artificial Intelligence tools
- Virtual workshops
- Webinars
- Online collaborative platforms

Technology provides flexible access to learning opportunities.

- **Learner-Centred**

  Innovative educational strategies that improve student engagement, critical thinking, creativity, and problem-solving are taught to teacher educators.

- **Evidence-Based**

Effective professional development is based on:

- Educational research
- Classroom evidence
- Student learning outcomes
- Institutional data
- Reflective practice

Sustainable and Long-Term

SPD encourages ongoing professional development that is incorporated into regular professional practice rather than concentrating on discrete seminars.

Principles of Sustainable Professional Development

The effective use of sustainable professional development is guided by a number of principles.

Principle 1: Lifelong Learning

Throughout their careers, teacher educators should keep up with the latest developments in their field.

Principle 2: Reflective Practice

Teachers can enhance the efficacy of their instruction by critically analysing their methods through reflection.

Principle 3: Collaboration

Collaboration, peer coaching, mentoring, and professional learning groups should all be a part of professional learning.

Principle 4: Relevance

The actual demands of teacher educators and educational institutions must be taken into consideration in professional development activities.

Principle 5: Active Participation

Discussions, projects, research, demonstrations, and cooperative problem-solving should all be actively pursued by teacher educators.

Principle 6: Continuous Assessment

Professional growth should be regularly monitored using:

- Self-assessment
- Peer review
- Student feedback
- Performance evaluation
- Reflective journals

Principle 7: Technology Integration

Digital platforms, ICT, and AI should facilitate adaptable, individualised, and ongoing professional development.

Principle 8: Innovation

Innovative teaching techniques, educational technologies, and research-based teaching methodologies should be tested by teacher educators.

Principle 9: Inclusiveness

All teacher educators should have access to professional development programs, regardless of their location, age, gender, or institutional affiliation.

Principle 10: Institutional Support

Successful professional development requires:

- Administrative support
- Financial assistance
- Policy encouragement
- Recognition and incentives
- Leadership commitment

Conclusion: Teacher educators can maintain their professional competence in a continuously evolving educational environment through the lifelong, collaborative, reflective, research-based, and technology-supported process of sustainable professional development. Lifelong learning, cooperation, innovation, inclusivity, relevance, and institutional support are some of the tenets that serve as its compass. These ideas serve as the cornerstone for both successful teacher preparation programs and ongoing enhancements to the standard of education.

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PROFESSIONAL DEVELOPMENT OF TEACHER'S EDUCATION AS, AWARENESS OF ICT, USE OF ICT, WITH TEACHING EFFECTIVENESS OF CLASSROOM SITUATION.

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Introduction

Information and Communication Technology (ICT) is the buzzword today everywhere as the world has entered into an information and communication age. Computers have proliferated, becoming increasingly fast, powerful, small and cheap, so that now there is scarcely a human activity in which they are not to be found, bearing an increasing share of the burden of repetitive information processing activities. Now, information cannot only be stored, retrieved, communicated, and broadcasted in enormous quantities and at phenomenal speeds, but it can also be rearranged, selected and transformed, of the human brain. While creative, judicious, moral, and aesthetic choices are still best left to people, all the tedious and mechanical mental processes can now be relegated to the accurate, fast, and tireless machines. Now a day's, ICT is the most powerful, effective, easy and rapid media in the communication of information. Hence, in the present study an effort has been made to study the relationship of awareness of ICT, use of ICT, attitude toward ICT with teaching effectiveness.

Review :An Overview

In review of the related studies, most of the studies are either related to awareness or use of technology. It can be further stated that most of the studies are specifically related to the computer and internet further looking at a glance to the above studies, it can be revealed that most of the studies were conducted abroad and very few studies were conducted in India. Many of the studies revealed that a great degree of awareness about the ICT of teachers but less usage due to one or other reasons. Further, it was found that there were many studies carried out related to teachers' awareness of technology and teachers use of technologies but only few studies conducted which are related to the teachers need of technologies.

The variables teachers' attitude towards *ICT* and their technology competence are explored vastly and independently in some studies. The investigator feels that there is a need to further explore the influence of these variables in order to improve teaching learning process. The review of related literature presents a glut of researches presently being conducted in field of variables like use of *ICT*, their attitude towards *ICT* and technology competence. Based on the research studies, the researcher felt that there is a need to explore the use of *ICT* by teachers in relation to their attitude towards *ICT* and technology competence in schools that it will help to adjudged the extent of all the variables related to teachers and suggest measures to overcome the

problems of teachers in the application of *ICT* in teaching-learning Process.

Some of studies revealed that 100% ICT awareness of ICT prevailed among the teachers while some other studies revealed moderate or less awareness of teachers about ICT. Most of the studies revealed that the use of technology is more among the young teacher in comparison to the old teachers. Use of technology was found more among teachers in abroad where as less usage of technologies were found among Indian teachers. No study has been conducted so far found with the combination of ICT awareness, use and need of teachers in integration whole. Hence the present study is an attempt in this direction to study the ICT Awareness, use and need of secondary and higher secondary school teachers.

Statement of the Problem

The present study entitled "**Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"**

Variables

Independent Variables

i. Awareness of ICT
ii. Use of ICT

Dependent Variable

i. Teaching Effectiveness

Demographic Variables

i. Gender – Male / Female
ii. Locality – Urban / Rural

Objectives of the Study

Following objectives are formulated for the present study :

1. To investigate the relationship of awareness of ICT, use of ICT, with teaching effectiveness among primary school teachers.
2. To investigate the relationship of awareness of ICT, use of ICT, with teaching effectiveness among male primary school teachers.
3. To investigate the relationship of awareness of ICT, use of ICT with teaching effectiveness among female primary school teachers.
4. To investigate the relationship of awareness of ICT, use of ICT, with teaching effectiveness among urban primary school teachers.
5. To investigate the relationship of awareness of ICT, use of ICT, with teaching effectiveness among rural primary school teachers.

Research Hypotheses

Following hypotheses are formulated to realize the above mentioned objectives :

1. There is a positive and significant relationship between awareness of ICT, use of ICT, attitude toward ICT, with teaching effectiveness among primary school teachers.

2. There is a positive and significant relationship between awareness of ICT, use of ICT, attitude toward ICT with teaching effectiveness among male primary school teachers.
3. There is a positive and significant relationship between awareness of ICT, use of ICT, attitude toward ICT with teaching effectiveness among female primary school teachers.
4. There is a positive and significant relationship between awareness of ICT, use of ICT, attitude toward ICT with teaching effectiveness among urban primary school teachers.
5. There is a positive and significant relationship between awareness of ICT, use of ICT, with teaching effectiveness among rural primary school teachers.

Research Design

Research Method

The present study was a descriptive survey research. The method deals with the relationship between the variables, the testing of hypotheses, and the development of generalizations, principles or theories that have universal validity. Descriptive research has been divided into several types, however, they are all attempting to find generalizable attitudes, and they all deal with present conditions. The study was focus on the investigation of awareness of ICT, use of ICT, attitude towards ICT and their relationship with teaching effectiveness of primary school teachers.

Sample

The list of all the primary schools of Chitradurga district (prepared by DIET of Chitraduraga) was constituted the population for the study. Using stratified random sampling method 50 primary schools were selected. Primary school teachers from each school were selected randomly. In all 548 primary school teachers were involved in the present study.

Tools Used

The following research tools were used to collect the essential data. They are : Awareness of ICT Scale, Use of ICT Scale, Attitude towards ICT Scale, Teaching Effectiveness Scale. The investigator ensured the content and face validity of the present scales since each item was judged by content experts. The investigator used Split Half method to compute the reliability coefficient of Scales.

Collection of Data

Data collection is one of the most important tasks of any research. As far as the problem under study is concerned, the data were collected properly, timely and precisely since it helps in finding the solutions to the problems. For the present study, the required data were collected from the primary school teachers by personally visiting the schools. For this purpose, the investigator personally contacted the school principals and explained the purpose of the study. After that scales were administered to the teachers and the completed tools were collected from the respondents. Self rating scale was used in order to measure the teaching effectiveness of teachers.

Statistical Techniques

The data on variables in the studywas properly coded to suit the computer analysis. The analysis was carried out on the basis of objectives of the study and hypotheses formulated by applying appropriate statistical techniques. In pursuance of the Objectives – 1 to 5 the Pearson's Product-Moment Coefficient of Correlation technique was used to find out the relationship between independent variables and dependent variable.

Analysis :

The relationship between awareness of ICT, use of ICT, with teaching effectiveness is analysed using correlation coefficient.

Entire Sample

Table – 1 "Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"-Entire Sample

Variables	Teaching Effectiveness				
	r-**value**	**df**	**t-value**	**p-value**	**Signi.**
Awareness of ICT	0.7359	547	25.4178	< 0.05	Yes
Use of ICT	0.6009	547	17.5820	< 0.05	Yes

Interpretation

The analysis of the above table reveals the following :

1. Since theobtained 't' value 25.4178 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between awareness of ICT of teachers and their teaching effectiveness.
2. Since theobtained 't' value 17.5820 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between use of ICT of teachers and their teaching effectiveness.
3. Since theobtained 't' value 22.8342 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between attitude towards ICT of teachers and their teaching effectiveness.

Findings

The interpretation of the data reveals the followingfindings :

1. There is a positive and significant relationship between awareness of ICT of primary school teachers and their teaching effectiveness.
2. There is a positive and significant relationship between use of ICT of primary school teachers and their teaching effectiveness.

Male Teachers

Table – 2 "Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"– Male Teachers

Variables	Teaching Effectiveness				
	r-value	**df**	**t-value**	**p-value**	**Signi.**
Awareness of ICT	0.7444	280	18.6543	< 0.05	Yes
Use of ICT	0.6090	280	12.8473	< 0.05	Yes

Interpretation

The analysis of the above table reveals the following :

1. Since theobtained 't' value 18.6543 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between awareness of ICT of male teachers and their teaching effectiveness.
2. Since theobtained 't' value 12.8473 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between use of ICT of male teachers and their teaching effectiveness.

Findings

The interpretation of the data reveals the followingfindings :

1. There is a positive and significant relationship between awareness of ICT of male primary school teachers and their teaching effectiveness.
2. There is a positive and significant relationship between use of ICT of male primary school teachers and their teaching effectiveness.

Female Teachers

Table – 3 "Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"– Female Teachers

Variables	Teaching Effectiveness				
	r-value	**df**	**t-value**	**p-value**	**Signi.**
Awareness of ICT	0.7294	265	17.3587	< 0.05	Yes
Use of ICT	0.5938	265	12.0152	< 0.05	Yes

Interpretation

The analysis of the above table reveals the following :

1. Since theobtained 't' value 17.3587 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between awareness of ICT of female teachers and their teaching effectiveness.

2. Since theobtained 't' value 12.0152 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between use of ICT of female teachers and their teaching effectiveness.

Findings

The interpretation of the data reveals the following findings :

1. There is a positive and significant relationship between awareness of ICT of female primary school teachers and their teaching effectiveness.
2. There is a positive and significant relationship between use of ICT of female primary school teachers and their teaching effectiveness.

Urban Teachers

Table – 4 : "Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"– Urban Teachers

Variables	Teaching Effectiveness				
	r-**value**	**df**	**t-value**	**p-value**	**Signi.**
Awareness of ICT	0.7840	189	17.3635	< 0.05	Yes
Use of ICT	0.5690	189	9.5129	< 0.05	Yes

Interpretation

The analysis of the above table reveals the following :

1. Since theobtained 't' value 17.3635 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between awareness of ICT of urban primary school teachers and their teaching effectiveness.
2. Since theobtained 't' value 9.5129 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between use of ICT of urban primary school teachers and their teaching effectiveness.

Findings

The interpretation of the data reveals the following findings :

1. There is a positive and significant relationship between awareness of ICT of urban primary school teachers and their teaching effectiveness.
2. There is a positive and significant relationship between use of ICT of urban primary school teachers and their teaching effectiveness.

Rural Teachers

Table – 5 : "Professional Development of Teacher's Education As,Awareness of ICT, Use of ICT,with Teaching Effectiveness of Classroom Situation"– Rural Teachers

Variables	Teaching Effectiveness				
	r-**value**	**df**	**t-value**	**p-value**	**Signi.**
Awareness of ICT	0.7083	356	18.9326	< 0.05	Yes
Use of ICT	0.6241	356	15.0714	< 0.05	Yes

Interpretation

The analysis of the above table reveals the following :

1. Since theobtained 't' value 18.9326 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between awareness of ICT of rural primary school teachers and their teaching effectiveness.
2. Since theobtained 't' value 15.0714 is greater than the tabled 't' value 1.96 at 0.05 level, the hypothesis that $r_{pop.}$is zero is rejected. It thus implies that the obtained correlation is a significant. This reveals that there is relationship between use of ICT of rural primary school teachers and their teaching effectiveness.

Findings

The interpretation of the data reveals the following findings :

1. There is a positive and significant relationship between awareness of ICT of rural primary school teachers and their teaching effectiveness.
2. There is a positive and significant relationship between use of ICT of rural primary school teachers and their teaching effectiveness.

Conclusions

1. Awareness of ICT, Use of ICT, of primary school teachers are having positive and significant relationship with their teaching effectiveness.
2. Male primary school teachers' Awareness of ICT, Use of ICT, , are having positive and significant relationship with their teaching effectiveness.
3. Female primary school teachers' Awareness of ICT, Use of ICT, are having positive and significant relationship with their teaching effectiveness.
4. Urban primary school teachers' Awareness of ICT, Use of ICT are having positive and significant relationship with their teaching effectiveness.
5. Rural primary school teachers' Awareness of ICT, Use of ICT, are having positive and significant relationship with their teaching effectiveness.

Discussion

The present study has revealed a positive and significant relationship between teachers' awareness of ICT and its use in classroom teaching and their attitude towards ICT have positive impact on their teaching effectiveness. Even the analyses of data among the sub-samples like

male teachers, female teachers, urban teachers and rural teachers have also revealed the same findings. This implies that selected ICT related variables have positive influence on their teaching effectiveness in the classroom. The research studies conducted earlier on educational innovation suggests that it is important for schools to share a reformed vision of teaching and learning in order to create sustainable change in the classroom. With respect to ICT integration research suggests that it tends to improve learning, motivate and engage learners, promote collaboration, foster enquiry and exploration, and create a new learner centered learning culture. Since ICT provides greater opportunity for both teachers and students to adjust learning and teaching to individual needs it is necessary to improve and promote the integration of ICT in classroom teaching.

ICT enabled education will always support, enhance, and optimise the delivery of information during classroom teaching. Worldwide research has shown that ICT can lead to an improved student learning and better teaching methods. A report made by the National Institute of Multimedia Education in Japan, proved that an increase in the use of ICT in education with integrating technology to the curriculum has a significant and positive impact on students' achievement. The results specifically showed that the students who are continuously exposed to technology through education has better 'knowledge', presentation skills, innovative capabilities, and are ready to take more efforts into learning as compared to their counterparts.

Educational Implications

There is a need of skill training to the school teachers because the findings of the study suggest that computer trained teachers were using more ICT resources than the computer untrained teachers. The finding of the study should be given to the government authority so as to take the necessary steps in this direction.

The variables like Type of school in which teachers are teaching, teaching experience have great impact on ICT awareness, use and need of teachers. For example, private school teachers were using ICT resources more than that of private aided school teachers. It may be due to availability of ICT resources. So Government should increase the school infrastructure in terms of ICT so as to increase and improve the teachers use of ICT.

The most outstanding characteristics of any research is that it must contribute something new to the development of the area concerned. So, an investigator should find out the educational implications of the study. This study has implications for teachers, students in particular and the whole educational system in general. Technology is becoming more and more dominant in our society. Technology is all around us whether we want it to be or not: it is the vehicles we drive. Upgrades are being made and new innovations are being discovered every day in field of information and communication technology *(ICT). ICT* has had a major impact on our school systems and is still impacting it today. ICTenables all students to master more complex subjects via rich interactions with resources outside of classroom walls just as geographically distributed workers create, share, and master knowledge.

Thus, technology is impacting the young mind to a great extent. However, the issue is not whether instructional tools are more efficient at accomplishing current goals of education, but

instead how much is this emerging technology being explored by teachers in their classrooms with high morale, positive attitude and required technology competence, so that it can provide an effective means of reaching essential educational objectives in the technology-driven evolution of a knowledge-based economy.

This research attempted to provide a few recommendations that may help in developing morale, attitude towards ICT and technology competence among primary school teachers. The study revealed that majority of the primary school teachers are at a moderate level of awareness and use of ICT. In order to make teachers reach a higher level of awareness and use of ICT, there is a need to implement more ICT resources and to provide opportunities to them to utilize and integrate ICT to its fullest potential in their classroom teaching.

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THE EDUCATIONAL IMPLICATIONS OF AI - BENEFITS AND CHALLENGES

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Abstract

This paper discusses the educational implications of using AI and focuses on the benefits and challenges faced by education sector in applying AI. The potential of the AI in enhancing the educational environment is prospectively very high. AI is transforming the educational system through offering personalised learning experiences to learners. AI is transforming the traditional class room teaching , colonial era influenced learning practices, and creativity barred learning. AI is hailed because it can allow teachers to spend more time on research, lesson planning , mentoring and counselling slow learners . But the utilizing of AI in educational environment and administration is tagged with significant challenges and constraints along with benefits. The data privacy concerns, algorithms bias, the possibility of reduced critical thinking and lack of ethical standards need strong policy interventions. The AI has been a bone of contention between academicians and researchers for the benefits accrued and the challenges ahead. The over reliance on AI is demanding stringent policy interventions in regulating AI usage. These challenges need to be addressed by appropriate policy interventions.

Keywords: AI, educational implications, benefits and challenges

Introduction: The potential of the AI in enhancing the educational environments has been very promising. AI is making the learning more effective, engaging the learners and creating technological adaptability to young learners. AI is transforming the educational system by offering personalised learning experiences automated grading and streamlined administration

Benefits of AI in education - There are several benefits of AI in education.

1. Typical classrooms run on a traditional curriculum and syllabus schedule are considered out of date. Instead , AI based platforms are put forward as being able to support in analysing students' answers , testing their learning speed , solving any issues in learning complicated lessons and practice problems as per students requirements.
2. AI tutors and chat based learning assistants are giving immediate feedback outside the class hours. They explain concepts, practice questions, summarize chapters and advice students editing. Their answers still need human supervision as generative AI tools can deliver inaccurate and misleading information.
3. The use of AI is steadily expanding in Indian educational environment and in automated repetitive task operations like attendance tracking, test grading, time table marking or handling normal queries about students.

4. The AI automation is recommended in educational sector because AI is viewed as a tool to save time and allows teachers to spend more time on research, lesson planning , mentoring and counselling slow learners. AI supported predictive analytics is being used to pin point students who are slow learners and drop out. By checking their attendance assessments crores and college activity engagement patters which help educational Institutions to counsel student before he fails or drops out of studies.
5. The AI technology also affects core curriculum and syllabus pattern. AI information processing technologies are changing their businesses. The employers are demanding educational institutions to equip students for AI cyber security , data analysis and digital transformation. Syllabus pattern is being remodelled to include AI basics at school level and AI theoretical learning of AI usage at college level.

Core challenges of AI in education

1. **Challenges of data retention**- AI needs to process large amount of student data including academic admission processes, semester wise results, student's behavioural pattern and bio metric data etc. These are the core areas where hacking, misuse, identity thefts can occur. The use of AI in hacking the entire data may lead to mischievous uses. AI can perpetuate data sets which are predominantly biased and there may be social , historical or ethnic bias .
2. **Reduced critical thinking** - AI can increase dependence of the students on AI programmes and make them lazy and lethargic. There are chances students depending on AI for answers rather than solving the problems and getting information. The use of AI can make students lose their creative skills and problem solving skills. Students might rely on AI for finding very simple, easy and straight answers instead of reading, researching and referring. Students may lose interest in visiting libraries and reading rooms. Extra reading , Book referring , sources searching etc might be lost.
3. **Over reliance** – Generative AI facilitates copying from other's work such as writing essays, submitting reports, finalising projects and other tasks. AI provides easier pathways to **cut copy paste** methods. with minimal student efforts students can submit their projects and gradually this becomes a habitual practice among students to rely on AI for every academic work. Traditional task of assessment writing and personal scripting long essayed answers fades away. Largely the task of assignment writing which reflected students writing skills becomes copied through pre prepared formats available through AI. This leaves very less space for students to improve their writing and pedagogic skills. Poor pedagogy leads to sluggish and lethargic student groups with very less confidence in exhibiting their academic skills.
4. **Dehumanising education** - AI cannot offer the support, friendship or social or emotional teacher guidance that human teachers do. IN class rooms teachers often offer personal counselling services and guide the slow learners. They positively motivate the learners to apply diverse learning techniques and learn complicated syllabi with easier methods. But AI is a machine which cannot replace human teaching. Gradually learners might

become addicted to AI use. Overuse of AI leads to dehumanizing education there by reducing opportunities for academic collaboration, peer learning practices and finally dropping the teacher student personalised connection.

5. **Digital divide and inequitable access** – Entire AI applications and AI tools are completely reliant on the internet technology and Internet related gadgets and AI tech assistance. These AI support applications are easily available to urban learners while rural students fail to access upgraded versions of AI tools and fall behind the urban learners. This is a direct influence of learning capacities of urban and rural learners. Rural students will not be able to afford technological advancements needed for upgraded AI use. This creates inequitable opportunities in accessing AI tools and will create digital divide. This also causes void in creation of employability and economic opportunities.
6. **Ethical implementation concerns**- AI in education has several ethical challenges. Top among them is the ethical implementation concerns. Both teachers and students need to be aware of AI's decision making process. Biased algorithms may lead to unjust and unfair outcomes. AI is an automated machinery tool where human emotions and human feelings are out of reach and only AI gadgets are applicable. The loss of ethics is so great that even policy interventions have been not enough to contain the AI. The ethical usage of AI is often widely discussed but few outcomes have become successful. AI has been growing outside it limits and unethical use of AI is increasing.
7. **Fear of Job loss**- Job displacement fears are the most imperative panic among learners. This is hindering the progress of technology as this panic is creating an apprehensive filled atmosphere among higher education students who fear their careers are vanished because of AI usage. Several engineering colleges are fearing the future of several branches of engineering have become completely out of date and AI demands top tech inputs which are not easily affordable by academic institutions . The transformation is also linked with changing demands of organizations. The **World Economic Forum's Future of Jobs Repor**t for 2025 estimates that nearly 40% of the key skills required by workers will change in the next decade. It calls for schools m universities and training providers to rethink their programs to contain AI digital literacy.
8. **Bleak future**- AI tools are developed by private companies who work for profit. The companies in a bid to acquire higher revenues and resources might misuse academic data. The large student data which is restored in AI which is meant for beneficial after use might be used without liability by companies. The appropriate handling of the voluminous data is open to mishandling. Private corporate companies are eyeing on profits fail to check the after use impact of students' data. Very few policy interventions in checking the companies usage formats might lead to exploitation of data. Educational institutions failing to check the authentic motives of AI tools and data usage might lead their students to a bleak future.

Need for AI competency training for AI lacuna and limitations –

The **World Economic Foru**m found that 86% of employers surveyed say **AI Information**

Processing Technologies will change their businesses by 2030. Thus education providers to equip students for AI cyber security , data analysis and digital transformation is needed. AI competency is needed for both students and students in usage of AI. An appropriate hand on training and competency building in all levels of AI tools is needed. Policy makers need to frame targeted initiatives which can support educators and learners to understand the core values of human society. There are very few policy interventions which are strongly addressing the AI misuse and ethical collapse of AI. There is a need for providing educators with the upgrade versions of effective AI use. There is also a dire need for guiding students in recognising AI's limitations. AI can be leveraged to provide multiple language options for content via translation and also provide students with access to content despite language barriers an disabilities of speech recognition. Technology based learning environments such as virtual classrooms and automated support systems can be utilised to provide learning opportunities for areas where qualified teachers are not available. The policies UNESCOs **Ethics of AI Recommendations & AI Act** advocates for transparency human control and fairness ensuring that AI acts as a support system for teachers instead of a replacement.There is a need for bridging access and academic integrity because developing dependable internet connectivity simultaneously with AI resistant evaluations such as oral defences and local projects devices and AI ready platforms ensures schools have equitable access safeguards integrity and stops the digital divide from growing.

Conclusion : The use of AI in education is very promising but there are significant challenges and constraints which need to be addressed by suitable government policy interventions. The privacy concerns algorithms bias the possibility of reduced critical thinking and lack of access to technology needs policy interventions. AI is feared for making students superficially educated. The AI tools can amplify issues surrounding incapable problem solving and give rise to doorstep customers starving for prompt answers or induce them to fall upon erroneous misleading and prejudicial information.

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FROM DIGITAL LITERACY TO AI LITERACY: REIMAGINING TEACHER COMPETENCIES FOR THE FUTURE OF EDUCATION

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Abstract

The rapid advancement of intelligence (AI) is transforming educational practices and redefining the roles and competencies expected of teachers. While digital literacy has become a component of contemporary teaching the emergence of generative AI requires teachers to move beyond the effective use of digital technologies towards a deeper understanding of AI, its capabilities, limitations, ethical implications and pedagogical possibilities. This paper explores the transition from literacy to AI literacy and examines how teacher competencies need to be reimagined in response to the changing educational landscape. It focuses on competencies such as AI knowledge and understanding AI-integrated pedagogical competence, critical thinking, creativity, problem-solving, ethical decision-making, adaptability and reflective practice. Particular emphasis is placed on the need for responsible engagement with AI to prevent overdependence on technology while preserving human values, empathy and meaningful teacher-learner relationships. The paper further highlights the role of teacher education and continuous professional development in preparing educators to evaluate AI-generated content, address issues of bias, privacy and academic integrity and use AI to facilitate personalised, inclusive and innovative learning. The paper proposes a perspective of the AI-literate teacher as a future-ready ethical, reflective and human-centred educator. It concludes that AI literacy should not replace literacy but should extend it towards a more critical creative, ethical and mindful approach, to teaching and learning.

Keywords: *AI literacy, digital literacy, teacher competencies, artificial intelligence, 21st-century skills, mindful technology use, teacher education*

Introduction

Education has always evolved in response to changes in society, culture and technology. The emergence of computers, the internet, smart phones, online learning platforms and digital educational resources has significantly transformed the teaching-learning process. Consequently, digital literacy became an essential competency for teachers and learners. Teachers were expected not only to possess subject and pedagogical knowledge but also to use digital technologies effectively to support communication, collaboration, assessment and learning.

The emergence of artificial intelligence, particularly generative AI, represents another significant transformation. AI systems are increasingly capable of generating text, images, presentations, questions, explanations, lesson plans and other educational resources. These developments have created new opportunities for personalized and innovative learning while simultaneously raising questions regarding accuracy, bias, privacy, academic integrity, teacher autonomy and the future

role of educators.

The central issue is therefore no longer whether teachers should use technology, but whether they possess the knowledge and judgment required to use increasingly intelligent technologies responsibly and meaningfully. A teacher may be digitally competent and still lack the ability to critically evaluate an AI-generated response, identify algorithmic bias, protect student data or determine whether the use of AI is pedagogically appropriate.

This situation necessitates a transition from digital literacy to AI literacy. AI literacy does not mean that every teacher must become an AI programmer or computer scientist. Rather, teachers need sufficient understanding of AI to interact with it critically, ethically, creatively and purposefully.

The changing technological environment also demands a reconsideration of teacher competencies. The future teacher must combine technological knowledge with critical thinking, creativity, ethical awareness, adaptability, emotional intelligence and reflective practice. In this context, human qualities become even more important rather than less important.

This paper therefore examines the transition from digital literacy to AI literacy and discusses the competencies required by teachers to respond effectively to the future of education. It also proposes a conceptual perspective in which the AI-literate teacher is viewed as a future-ready, ethical, reflective, mindful and human-centered educator.

Objectives

- To examine the transition from digital literacy to AI literacy in contemporary education.
- To identify the emerging competencies required by teachers in the AI era.
- To examine the relationship between AI literacy and 21st-century skills.
- To explore the importance of mindfulness, ethics and responsible AI use in teaching.
- To suggest strategies for developing AI-literate and future-ready teachers

From Digital Literacy to AI Literacy

Digital literacy means the ability to access, understand, evaluate, create and communicate information through digital technologies. It contains the ability to effectively use digital platforms, online resources, multimedia tools, communication technologies and digital assessment systems for teachers.

Digital Literacy has been the cornerstone of Education with the help of Technology. But AI adds a whole new level as AI systems are not only able to store or present information but also create information, detect patterns and even suggest recommendations.

Thus, there is a need for a higher level of technological literacy for AI literacy. An AI-literate teacher should have a basic understanding of AI concepts, be aware of its capabilities and limitations, and evaluate the quality of AI-generated content and use AI responsibly.

The transition can be represented as:

Digital Literacy → AI Literacy → AI-Pedagogical Competence → Ethical and Mindful AI Integration

Importantly, AI literacy should not be viewed as a replacement for digital literacy. Instead, it is to expand digital competence to a space where technology is increasingly involved in the

creation of knowledge. The digitally literate teacher can search the web, make digital resources and lead the virtual classes. An AI-literate teacher needs to also inquire about the accuracy, reliability, bias or appropriateness of information produced by AI.

The Changing Role of the Teacher in the AI Era

Teachers need to know how to utilize AI in teaching as it has become an integral part of the learning landscape. With the rise of AI in the field of education, it is becoming more crucial than ever for teachers to be familiar with AI literacy. AI can be used to assist in lesson planning, content creation, assessment, feedback, content translation, differentiation, and admin tasks.

But using AI tools is not sufficient for effective educational practice. It will be the job of teachers to make professional judgment decisions about when, how, and when not to use AI.The information created by AI can sometimes be incorrect or misleading. For teachers, it is crucial to be able to verify information and compare AI outputs to trusted sources.

Additionally, AI literacy is crucial for personalized learning. AI can be used to create various learning material versions based on students' needs, abilities and learning levels. But the use of such resources should be pedagogically and culturally suitable, teachers' work should be done. This suggests that the future teacher should not be understood simply as an AI user. Rather, the teacher should become a pedagogical decision-maker who works with AI.

Reimagining Teacher Competencies

Effective teacher competence needs to be rethought in light of the emergence of artificial intelligence (AI). The age of AI requires a new educational technology that connects and transcends the traditional focus on subject knowledge and school-based pedagogical knowledge, digital skills, and learner responsibility, to include technological expertise, pedagogical judgement, ethical responsibility, and human agency. The UNESCO AI Competency Framework for Teachers (Miao & Cukurova, 2024) defines the following competencies in five areas: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning.

Awareness of AI Knowledge and Understanding: Teachers should have a basic understanding of generative AI, algorithms, data and machine learning, as well as what they can and cannot do. This allows for using AI tools, not relying on their output. AI-Pedagogical Competence: The teacher should use AI in a meaningful way, relating to learning goals, teaching and assessment. AI can aid differentiated activities and explanations, formative assessment and feedback, but teachers are responsible for accuracy, appropriateness and alignment with learning outcomes. Critical-Evaluative Competence: AI can produce inaccurate, biased or fabricated information, teachers need strong verification and evidence-based judgement. Students can also be prompted to examine and problematize AI's answers, to check accuracy, evidence and argumentation, and to defend what they think is right, all of which enhances the development of higher-order thinking skills. Ethical and Responsible Competence: Concerns with privacy, data protection, bias, copyright, transparency, academic integrity and equity exist in the use of AI. For UNESCO (2023), generative AI is about safe, equitable, meaning and human centred use. Teachers need to develop ethical discernment in using AI when, why, and how.

Creative and Adaptive Competence: Teach and provide with creativity, contextualisation and personalisation; AI can provide opportunities for generating examples, activities, and learning resources. Teachers need to experiment, reflect, evaluate and adapt their teaching in the rapidly changing landscape of AI. According to UNESCO (2024), AI for professional learning is one of the dimensions of competency. Finally, the teaching in an AI era is still human-centred teaching. While AI can aid in information processing and repetitive tasks, empathy, motivation, relationships and understanding learners are still very human things.

AI Literacy as a Catalyst for 21st-Century Skills

AI literacy should not be treated as an isolated technological skill. When used for its educational value, it has a greater significance when it helps build 21st century skills. This is where critical thinking is crucial, as learners need to assess AI-generated content and not take it for granted. AIgenerated errors can be leveraged by teachers for analysis, fact-checking and argumentation.AI can be used for brainstorming and exploring ideas, which can help enhance creativity. Students should be encouraged, however, to add their own ideas to AI ideas, challenge them, and develop them into their own work. Communication remains fundamental. While students can interact with an AI system, it is important to maintain human communication in the form of discussion, presentation, debate and dialogue in education. Cooperation, too, is a uniquely human ability. While AI can offer information or suggestions, learners must still negotiate, listen, cooperate, and make decisions with others. To reinforce problem-solving skills, have students compare the AI-designed solutions to the problems and discuss the potential for failures as well as building new solutions. The need for adaptability grows more critical as technology is constantly evolving. A teacher's ability to learn throughout life can inspire confidence in the students to learn and adapt throughout their lives. So, the goal of AI literacy should not be to render learners dependent on AI. Instead, it should enable them to become more critical, creative, adaptive and responsible users of technology.

From AI Use to Mindful AI Literacy

Teachers and students have more access to information, creation of content, and all-day school tasks as AI is more widely adopted in education. But having access to an AI tool doesn't mean someone is AI literate. Real proficiency is knowing when to use AI and understanding its limitations and making informed choices about it. The most important learning-related issue is not whether AI can do something, but can it do something that is useful for learning?

This paper advocates for adding mindful AI literacy to AI literacy. It is the intentional, thoughtful and deliberate use of AI, where educators reflect on the learning goal, benefits, constraints and unintended consequences of AI use. That is consistent with the Human-centered approach to Generative AI that focuses on meaning, agency, safety and ethical responsibility (Miao & Holmes, 2023).

It is especially crucial to use AI mindfully, as convenience can sometimes detract from learning. Giving students instant answers might diminish the time they have for thinking, making errors, solving problems on their own, and creating their own explanations. Further evidence of the need for careful use of generative AI (Kasneci et al., 2023) comes from concerns about over-reliance,

accuracy and independent thinking. Teachers should thus differentiate the tasks in which artificial intelligence can contribute to the educational process and those in which students should act independently. AI can create variations of mathematical problems or ideas for activities, for instance. Students can then compare and contrast the solutions created by the AI and propose areas for improvement or mistakes over copying answers. In this way, AI is not a replacement for thought, but a tool that stimulates thoughts. A critical evaluation is also required for mindful AI-literacy. AI-generated answers might be convincing but include inaccuracies, omissions or biased assumptions. Important information must be checked by the teachers as well as other reliable sources and textbooks, and the students must be encouraged to do the same.

Human-Centered and Ethical AI Integration

The question is not whether or not AI should be used in education but what kind of education should AI help to create. UNESCO believes in a human-centred approach, where AI should empower, not replace, human agency, intellectual growth, inclusiveness and social relationships. Teachers need to understand this principle very well. Education is not just about the transfer of information, it is about motivation, empathy, emotional support, values, social interaction and development of individual potential. Thus, the future teacher must not be against the use of AI or just a recipient of AI-generated material. The teacher needs to be a human-AI team member who decides on the value of technology for meaningful educational outcomes. Equity needs to be considered in a human-centered approach. AI should not exacerbate inequalities, as it should be able to help all learners and institutions, not just those with more access to technology. Therefore, teacher education must take into account the accessibility, the inclusion, the cultural and linguistic diversity and the needs of learners with disabilities.

Preparing Teachers through Continuous Professional Development

Creating teachers who are AI literate is not a simple matter of providing one-off training sessions or exposing them to AI tools. It can't be delivered in a single day and needs ongoing professional learning. Development of teacher education programmes to include AI literacy in the pre-service training, and continuing professional development for practising teachers. Training should incorporate conceptual, hands on, pedagogical and ethical reflection. Professional development might involve reviewing AI-generated lesson plans, creating AI-enable learning activities, examining the AI responses to biased prompts, reviewing AI-assisted assessment, and discussing policies in the classroom. Teacher learning communities can be important as well. The teachers can exchange experiences, discuss practices, and jointly analyse the educational impact of AI. Most importantly, professional development should be on principles, not specific platforms. Individual AI tools may change rapidly, but the ability to evaluate accuracy, protect privacy, make ethical decisions, and select appropriate pedagogical uses remains relevant.

Conclusion and Implications

The rapid emergence of artificial intelligence, particularly generative AI, is transforming the educational landscape and creating a need to rethink the competencies expected of teachers. The transition from digital literacy to AI literacy should not be viewed as a replacement of digital literacy, but as an extension of digital competence towards a more critical, creative, ethical and

mindful engagement with technology. An AI-literate teacher requires more than the ability to operate AI tools; teachers need to understand the capabilities and limitations of AI, critically evaluate AI-generated information, and exercise appropriate pedagogical judgement in deciding when, how and when not to use AI. The paper highlights the importance of developing a broad range of teacher competencies, including AI knowledge and understanding, AI-pedagogical competence, critical-evaluative competence, ethical and responsible competence, and creative and adaptive competence. These competencies are closely connected with 21st-century skills such as critical thinking, creativity, communication, collaboration, problem-solving and adaptability. AI can support the development of these skills when learners are encouraged to question, verify, compare and improve AIgenerated responses rather than simply accept or copy them. A key implication of the paper is the need for mindful AI literacy. The educational value of AI should be determined not merely by what AI can do, but by whether its use contributes meaningfully to learning. Excessive dependence on AI may reduce opportunities for independent thinking, creativity, problem-solving and reflection. Therefore, teachers should make intentional decisions about the appropriate use of AI and create learning experiences where AI stimulates thinking rather than replaces it. The paper also has important implications for teacher education and professional development. Pre-service teacher education programmes and continuous professional development should incorporate AI literacy through conceptual understanding, hands-on practice, pedagogical application and ethical reflection. Teachers should be prepared to address concerns related to accuracy, bias, privacy, copyright, academic integrity, accessibility and equity. Professional learning communities can further support teachers in sharing experiences and reflecting on responsible AI practices. Ultimately, the future-ready teacher should be viewed not simply as an AI user, but as a critical, ethical, reflective, adaptive, mindful and human-centred educator. AI should empower teachers and learners while preserving human agency, meaningful interaction, empathy and teacher–learner relationships. Thus, the goal of AI integration in education should be to achieve meaningful human–AI collaboration in which technology enhances learning without replacing human judgement, creativity and connection.

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INTEGRATING GREEN NANOTECHNOLOGY AND ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE AGRICULTURE: ADVANCES IN NANO PRIMING AND STRESS MANAGEMENT

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Abstract

Agriculture is currently challenged by climate change, land degradation, water scarcity, and increased food demands. These issues promote the search for new ways to improve agriculture and ensure food security. Nanotechnology is a promising solution, providing nanoparticles (NPs) with an extended range of physicochemical properties that can improve nutrient uptake, germination, plant growth, and stress resistance. Seed nano-priming is an emerging technology that can optimize seed germination and plant seedling growth under stress conditions and improve crop productivity. Green synthesis of nanoparticles using botanical resources is a sustainable and environmentally friendly approach that can replace conventional methods of NP production. It produces biologically synthesized nanoparticles (BSNsPs) that can increase water uptake, nutrient contents, and plant resistance to stress. The efficiency of BSNP application depends on the element type, particle size, and plant species, and can be optimized to improve crop productivity while reducing environmental risks. Artificial intelligence can be used in combination with machine learning to study and understand biologically mediated NP production processes and improve their application in agriculture. This technology can be used for computer modelling of the germination process to predict its outcome, control the NP production process, and optimize the measurement of different traits in plant biology. By combining green nanotechnology and artificial intelligence, precision nano-priming and sustainable ways to improve crop production can be developed. The role of green synthesis of nanoparticles, nano-priming, stress resistance, and antioxidant activity, with a specific emphasis on the application of artificial intelligence in agricultural science, will contribute to improved and sustainable crop production.

Keywords: *Nanoparticles, nano-priming, green nanotechnology, eco-friendly artificial intelligence (AI)*

1. INTRODUCTION

Agriculture is experiencing transformative changes aimed at boosting food production while minimizing environmental harm, particularly in light of climate change and resource limitations. Conventional farming methods, relying on fertilizers and pesticides, can lead to nutrient losses and environmental damage. Factors such as drought and high soil salinity impede crop yields, highlighting the need for innovative agricultural technologies that align with environmental sustainability. Seed quality plays a crucial role in crop yields, with techniques like seed priming and nanopriming shown to enhance germination and stress resilience. *(*Ntshalintshali et a*l., 2025)*Nanotechnology offers promising advancements by modifying fertilizers at the nanoscale, though nanoparticle effectiveness varies by type and concentration. Green synthesis of nanoparticles using plant extracts is emerging as an eco-friendly method for agricultural applications. *(*Ying et *al., 2022)*Additionally, artificial intelligence (AI) is becoming a vital tool in agriculture, enhancing precision farming through data analysis and robotic tasks. The integration of green nanotechnology, plant science, and AI holds the potential to create efficient agricultural systems, although challenges in data availability and computational complexity remain. This innovative framework could optimize seed priming strategies, improving crop production and understanding the biochemical factors influencing germination.(Javaid et al., 2023)

1.1 Green Synthesis of Agricultural Nanoparticles. The sustainable synthesis of nanomaterials with minimum use of toxic reagents and waste is the main objective of green nanotechnology. There are several methods of synthesizing nanoparticles (NPs), such as chemical, physical and biological methods. The biological methods are environment-friendly, low-cost techniques using plant extracts and microorganisms. Plants contain phytochemicals that help in NP synthesis and are antioxidants.(Edo et al., 2025) Plant-derived NPs enhance crop protection and nutrition, and other functional applications in agriculture. Some widely used NPs in agriculture are silver, zinc oxide, and copper, and their effectiveness depends on their size, shape, and charge.(Altaf et al., 2026) Standardization and concerns of biosafety in agriculture restrict the use of green synthesis for the production of these bioactive compounds; characterization through techniques such as TEM and SEM is essential, and green synthesis is an economical and environmentally friendly approach**.**(Irshad et al., 2021)

2. Applications of Nanoparticles in Sustainable Agriculture

Agricultural nanotechnology includes a wide range of approaches from nutrient management and crop protection to seed treatment, plant growth promotion and environmental restoration. Nanoparticles can improve the efficiency of agricultural inputs due to their unique physicochemical characteristics at the nanoscale.*(Bouhadi et al., 2025)*

2.1 Nano fertilizers and nutrient delivery

One of the key issues in agricultural nanotechnology is nano fertilizers, which are designed to enhance nutrient delivery and controlled release for better utilization of fertilizers. They solve

problems of leaching and volatilization occurring with conventional fertilizers. (Yadav et al., 2023)Nano-based carriers are suitable carriers for the delivery of essential minerals like zinc and iron, which are important for the establishment and health of plants. The efficacy of nanoparticle formulations is dependent on the type of plant, the type of formulation and the application method.(Mim et al., 2025)

2.2 Nano pesticides and antimicrobials

Some nanoparticles are intrinsically antimicrobial due to their surface properties, mechanism of action, and interaction with microorganisms. Silver- and copper-based nanoparticles, in particular, have received considerable attention for their ability to disrupt cell membrane integrity and function, as well as induce oxidative damage in target bacteria and fungi. *(*Ameh et al., *2022)*Nanoparticle-based crop protection products have gained traction due to their multifunctionality and broad-spectrum activity.(Martin et al., 2026)

However, antimicrobial activity is also a double-edged sword, where non-target bacteria and fungi may also be impacted. Notably, the soils harbour a wealth of bacteria and other microorganisms that play a vital role in nutrient cycling and overall plant health.

2.3 Plant growth promotion

Nanoparticles can enhance seedling development and crop productivity by influencing nutrient metabolism, enzyme activity, photosynthesis, and other physiological processes. Ideally, the use of nanoparticles with growth-promoting attributes can enhance root and shoot development, biomass production, chlorophyll content, and several other related traits. Most studies report a concentration-dependent response, where increasing nanoparticle concentrations can have variable physiological effects on the targeted plant species. Notably, the recent literature on nano priming makes it clear that the choice of nanoparticles and their physicochemical properties are also critical determinants of plant growth and development.(Rasheed et al., 2022)

2.4 Stress management

Nanoparticles are being explored for their role in improving stress tolerance mechanisms in plants to help combat drought, salinity, extreme temperatures and heavy metal toxicity. Although recent studies are encouraging, studies are needed to understand their mechanisms and risks. While the use of nanoparticles in agriculture has the potential to enhance nutrient use efficiency and stress management, it has yet to be fully understood what can happen if such technologies are used on a large scale.(Yang et al., 2025)

3. Nanopriming and Seed Germination

Seed germination is an energetically demanding process that is dependent on the food energy stored in the seed. A pre-conditioning technique that involves water or solutions for an extended period of time to improve uniformity and seedling establishment without radicle emergence is known as priming. The use of nano priming with nanoparticles can further enhance this by altering the membrane potentials, enzyme activation, nutrient availability and water absorption, which results in increased germination percentage, speed and seed viability.(Ochoa-Chaparro et

al., 2025) It also helps with water uptake, which is essential for starting seed metabolism, influences aquaporin activity and antioxidant defence, leading to improved germination success. Parameters of plant growth, such as root and shoot length, increase; however, the effects of the nanoparticles are dependent on their properties and their concentration. Although the results obtained in controlled studies were excellent, in the variable field conditions the application of green nanopriming was limited.*(*Santás-Miguel et *al., 2023)*

4. Nanoparticles and Seedling Growth

The biological effects of nanoparticles are significant and impact the growth of seedlings, especially in the development of their roots and shoots. These features include primary root length, lateral root emergence and biomass, essential for anchorage and nutrient uptake. Nanoparticles have the ability to increase shoot length and leaf growth, which leads to greater biomass production by providing essential nutrients and promoting increased enzyme activity. (Meng et al., 2025)The treatment effects are provided by fresh and dry biomass, whereas the photosynthetic potential is provided by chlorophyll content, which, though in some treatments may be increased by nanoparticles, could actually be reduced at high concentrations. Nutrient uptake is affected by the type of nanoparticles (ZnO and Fe2O3). Enzyme activities are correlated with physiological changes in germination. One interesting thing about nanoparticle treatments is that they have "hermetic" properties; low doses promote growth and high doses are inhibitory.

5. Nanoparticles in Abiotic Stress Management

Abiotic stresses are some of the most devastating challenges to plant productivity. These stresses greatly impact germination, plant growth, and crop production. Climate change is projected to augment the occurrence and severity of some abiotic stresses. Therefore, it is critical to explore methods that improve plant tolerance to these stresses.(Dilnawaz et al., 2023)

5.1 Drought stress

Drought is one of the most damaging abiotic stresses affecting crop production. Drought stress causes cellular dehydration, thereby limiting photosynthesis, nutrient uptake, and growth. It also increases the production of reactive oxygen species (ROS), which damages cellular components. Nanoparticle treatments could improve drought tolerance by promoting root development, enhancing antioxidant enzyme activity, and modulating osmotic potential.(Al-Khayri et al., 2023)

5.2 Salinity stress

Soil salinity is a serious threat to agricultural production. Salinity causes both osmotic and ionic stress, which limits nutrient uptake and causes cellular toxicity. Nanoparticle treatments could improve salinity tolerance by modulating antioxidant enzyme activity and osmotic potential. Recent review studies have shown that salinity is one of the most promising areas for nano priming research.(Jamei et al., 2026)

5.3 Temperature stress

High and low temperatures could be damaging to plants. High temperatures could impair membrane fluidity, enzyme activity, and photosynthesis. On the other hand, low temperatures could also inhibit enzyme activity and cellular processes. Nanoparticle treatments could improve temperature stress tolerance by modulating antioxidant enzyme activity.(Kumari et al., 2024)

5.4 Heavy-metal stress

Heavy metals are some of the most dangerous soil contaminants because they could accumulate in plant tissues, impairing physiological processes. Nanoparticle treatments could improve heavy-metal tolerance by modulating metal availability and uptake. However, caution should be exercised when using nanoparticles in heavy-metal-contaminated soils as nanoparticles could also mobilize heavy metals.(Faizan et al., 2023)

5.5 Oxidative stress

In plant cells, the production of ROS is a response to abiotic stresses and can damage cell components. The antioxidant enzymes eliminate ROS; nanoparticles treatments could potentially increase enzyme activity to further eliminate ROS in plants. Review studies show that nanotechnology can trigger the plant's reactions to abiotic stresses; the effect will be different depending on the induced physiological and biochemical changes. All these parameters must be combined to evaluate the effects of nanoparticles on stress tolerance. Recent studies indicate that nano priming may affect the expression of genes, water transport and antioxidant enzyme activities, which may also lead to an enhanced tolerance towards abiotic stress factors.(Kumari et al., 2024)

6. Antioxidant and Biochemical Mechanisms

ROS are produced as a result of plant metabolism, mainly in chloroplasts and mitochondria and can cause damage to cells under stress. To combat this damage, plants have developed antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), and ascorbate peroxidase (APX) that help to neutralize the presence of ROS like superoxide radicals and hydrogen peroxide. There are also non-enzymatic antioxidants such as ascorbic acid and flavonoids that are protective. Proline and glycine betaine are osmolytes which stabilize cellular structures under stress. Nanoparticle therapies can increase antioxidant activity, but also may result in overproduction of ROS with a higher dosage. Machine learning can be used to predict plant stress responses from various physiological parameters, which can be used for further research on biochemical effects on plant growth and development with nanoparticles.(Batool et al., 2026)

7. The application of Artificial Intelligence in Green-Synthesized Nanoparticles and Sustainable Agriculture.

By bringing together complex data throughout the research process, Artificial Intelligence (AI) can greatly improve the development and application of green-synthesized nanoparticles in agriculture. In the process of synthesising nanoparticles, AI can examine various factors,

including the concentration of plant extracts, the concentration of precursors, pH, temperature and duration of the reaction, to determine the conditions required for the synthesis of nanoparticles with desired properties.(Koduri et al., 2026) AI can also be used to interpret data from UV-Vis, FTIR, XRD, SEM and TEM. This includes nanoparticle size and morphology.(Asghari & Naderi, 2024)For nanopriming, machine-learning models can combine the type of nanoparticles, concentration, particle properties and the duration of nanopriming on the one hand, and the variety of seeds on the other hand, to predict germination percentage, germination rate, root and shoot length, and seedling vigour. Based on computer vision, seed/seedling image analysis can be automated to minimize manual measurements. Physiological and biochemical parameters like chlorophyll, SOD, CAT, POD, APX, Proline, and ROS can also be added to the list of parameters for integration with AI to identify those associated with increased stress tolerance, including drought and salinity.(Sharmin et al., 2024)Therefore, the continuous prediction-experiment-optimisation cycle can be realized by using AI, which can optimize nanoparticle synthesis and application. While laboratory characterization and biological validation will not be replaced by AI, the use of AI in combination with green nanotechnology can help to minimize trial-and-error experiments and facilitate the development of accurate, repeatable and sustainable nanopriming practices for future precision agriculture.(Yazdani et al., 2026)

CONCLUSION

Green **synthesis** of nanoparticles is the process of producing nanomaterials using plants and microorganisms instead of using traditional processes that rely on toxic chemicals. This can improve food security, plant growth, plant protection and stress management. Nanopriming targeting early life stages of plants can be used to modulate physiological processes, enhance resistance to abiotic stresses and improve germination. But optimization is required to prevent phytotoxicity. The use of AI, machine learning, and computer vision can enhance the use of nanoparticles in agriculture, with the potential to predict germination patterns and analyse phenotyping data. This is a multidisciplinary approach with emphasis on education in biology, mathematics and computer science. Overall, the integration of green nanotechnology, artificial intelligence and interdisciplinary education has great potential to help ensure food security in the future, which requires standardization of practices and environmental safety assessment. Such innovations are designed to work alongside, not instead of, conventional agriculture, resulting in sustainable agriculture solutions.

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EFFECTIVENESS OF CONTENT BASED DRAMATIZATION TEACHING TECHNIQUE ON SKILL AND ACADEMIC ACHIEVEMENT IN SOCIAL SCIENCE SUBJECT AMONG HIGHER PRIMARY SCHOOL STUDENTS

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Abstract

Dramatization is a learner-centered pedagogical technique in which curricular content is converted into role-play, mime and enactment so that learners experience concepts instead of merely receiving them. The present study examined the effectiveness of the dramatization teaching technique on the Skill and Academic Achievement of higher primary school students in the Social Science subject. An experimental method was adopted, and sixty 6th Standard students of a Government Higher Primary School, Navalur, Dharwad district, Karnataka, constituted the sample, selected through purposive sampling. The sample was divided into a Control Group of 30 students (Section 6th A) taught through the conventional method and an Experimental Group of 30 students (Section 6th B) taught Social Science through dramatization for a period of four weeks. Skill was assessed using a self-constructed rating scale and compared between the Control and Experimental groups using an independent-samples 't' test. Academic Achievement was assessed through a Pre-test and a Post-test administered to the Experimental Group, and the gain was analyzed using a paired-samples 't' test. Results showed that the Experimental Group's mean Skill score ($M = 79.5667$, $SD = 4.71010$) was significantly higher than that of the Control Group ($M = 52.1667$, $SD = 5.48404$), $t = -20.760$, $p < 0.001$. Similarly, the Post-test Academic Achievement scores of the Experimental Group ($M = 17.8000$, $SD = 1.27035$) were significantly higher than their Pre-test scores ($M = 11.0667$, $SD = 1.83704$), $t = -18.140$, $p < 0.001$. The findings affirm that the dramatization teaching technique is effective in enhancing both the Skill and the Academic Achievement of higher primary school students in Social Science, and the paper offers suggestions for its wider classroom use.

Keywords: Dramatization Technique, Skill Development, Academic Achievement, Higher Primary Students, Experimental Method, Social Science Subject.

Introduction: Education at the primary stage lays the foundation for a child's cognitive, psychomotor and affective growth. However, in a large number of government primary schools, teaching continues to be dominated by verbal exposition and rote memorization, which offer the learner few opportunities to actively participate, express, or apply what is being taught. Such a teacher-centered approach tends to leave the child's skills under-developed and limits the extent to which classroom instruction translates into measurable academic gains. There is, therefore, a growing recognition among educationists that primary-level teaching must move away from passive listening towards activity-based, child-centered methods that engage the learner physically, cognitively and socially. Dramatization, also referred to as educational or creative drama, is one such activity-based technique. It involves the re-enactment of a life situation, story, or curricular concept by one or more learners through role play, mime, dialogue and improvisation (Dima et al., 2020). Rooted in the philosophy of "learning by doing", dramatization transforms the classroom into a space of lived experience rather than mere instruction, allowing the child to internalize knowledge through action, imagination and social interaction. Because it simultaneously calls upon the learner's body, voice, emotion and intellect, dramatization is widely regarded as a multi-dimensional pedagogic tool that influences learners emotionally, cognitively, socially, linguistically and kinesthetically (Yıldırım, 2022).

Need and Importance of the Study: Government higher primary schools, particularly those situated in semi-urban and rural belts, often function with limited teaching aids and large, heterogeneous classrooms, which makes it difficult for teachers to sustain learners' attention and translate instruction into durable learning gains through lecture-based teaching alone. In such settings, techniques that are low-cost, require no special equipment, and actively involve the learner assume special significance. Dramatization satisfies these conditions, as it primarily draws upon the learners' own bodies, voices and imagination rather than on expensive material resources. Although a fair amount of research has examined the effect of drama-based instruction on language and speaking skills (Kauts & Monika, 2013) and on higher-order thinking abilities such as critical thinking (Dima et al., 2020), comparatively little empirical work has looked jointly at Skill and Academic Achievement as twin outcomes of dramatization at the higher primary stage in the Social Science subject, and still less has been conducted within the Government school system of Karnataka. Examining both a psychomotor outcome (Skill), compared between a Control and an Experimental group, and a measurable learning outcome (Academic Achievement), tracked from Pre-test to Post-test within the Experimental group, allows the present study to offer a more complete picture of how dramatization influences the learner. Moreover, findings generated from a Government Higher Primary School in Navalur, Dharwad, provide field-level, context-specific evidence that can guide teachers, teacher educators and curriculum planners in deciding whether dramatization deserves a more prominent place in the higher primary Social Science classroom.

Review of Related Studies:

Yildirim (2022) pooled the results of 57 experimental studies (67 effect sizes) on the effect of the drama method on academic achievement and 23 experimental studies (25 effect sizes) on its effect on attitude, conducted at the pre-school and primary levels. The analysis revealed a strong positive effect of the drama method on academic achievement (d = 1.157), and the accompanying meta-synthesis indicated that drama influences learners emotionally, cognitively, socially, linguistically and kinesthetically. This review lends strong cumulative support to the proposition that drama-based techniques enhance both skill-related and achievement-related outcomes, which is precisely the dual focus of the present study.

Dima et al. (2020) evaluated educational drama as an innovative method for cultivating critical thinking skills among 400 primary school students aged 8 to 10 years, drawn from six schools in Greece. Using a semi-experimental pre-test post-test design built around fifteen drama-based theatrical workshops, and triangulating quantitative and qualitative data, the study found that learners' performance on five critical thinking skills improved significantly after the drama-based intervention, confirming that structured dramatization strengthens learners' practical reasoning skills in addition to engaging them meaningfully in the learning process.

Objectives of the Study:

1. To study the significant difference in Skill between the 6th Standard Section A (Control Group) and Section B (Experimental Group).
2. To study the difference between Pre-test and Post-test scores of Academic Achievement of 6th Standard students in the Experimental Group.

Hypotheses:

1. There is no significant difference in Skill between the 6th Standard Section A (Control Group) and Section B (Experimental Group).
2. There is no significant difference between Pre-test and Post-test scores of Academic Achievement of 6th Standard students in the Experimental Group.

Methodology:

Research Method: A **Experimental Method** was adopted. Skill was examined using a control-group comparison design, in which the Experimental Group (taught through dramatization) was compared with the Control Group (taught through the conventional method). Academic Achievement was examined using a one-group Pre-test Post-test design, in which the same 30 students of the Experimental Group were tested before and after the dramatization-based instruction.

Population: The population of the study comprised all the higher primary school students studying at the **Government Higher Primary School, Navalur, Dharwad district, Karnataka**.

Sample and Sampling Technique: A sample of 60 sixth-standard students was selected from the population by purposive sampling technique, Section 6th A and Section 6th B being the two intact sections available at the school. The sample was divided into two equal groups of 30

students each. Section 6th B was designated as the Experimental Group (15 male and 15 female students) and was taught Social Science through the dramatization technique, while Section 6th A was designated as the Control Group (15 male and 15 female students) and was taught the same Social Science content through the conventional lecture method.

Tools Used: Skill was measured using a **self-constructed** rating scale with a maximum score of 90, developed by the investigator for higher primary school students. Academic Achievement in Social Science was measured using an achievement test with a maximum score of 20, administered as a Pre-test before the instructional treatment and as a Post-test after its completion.

Procedure: The Experimental Group was taught selected lessons from the Social Science subject of the 6th Standard Karnataka State Syllabus through dramatization for a period of four weeks, wherein students enacted roles, situations and concepts drawn from the lessons under the teacher's guidance. The Control Group was taught the identical Social Science content through the traditional lecture-cum-demonstration method for the same duration of four weeks. The Academic Achievement test was administered to the Experimental Group before the four-week treatment began (Pre-test) and again immediately after its completion (Post-test). On completion of the four-week instructional period, the Skill of both groups was assessed using the Skill rating scale, and all scores obtained were statistically analyzed.

Statistical Technique: An **Independent-Samples 't' Test** was used to compare the Skill scores of the Control and Experimental groups. A paired-samples 't' test was used to compare the Pre-test and Post-test Academic Achievement scores within the Experimental group. Both null hypotheses were tested at the 0.001 level of significance.

Data Analysis and Interpretation:

Table 1: Mean, Standard Deviation and Independent-Samples’t’ value of Skill between the Control Group (6th A) and the Experimental Group (6th B)

Group	N	Mean	S.D.	't' value
6th Control Group	30	52.1667	5.48404	-20.760***
6th Experimental Group	30	79.5667	4.71010	

**** Significant at the 0.001 level (2-tailed); Independent-Samples 't' test, df = 58.*

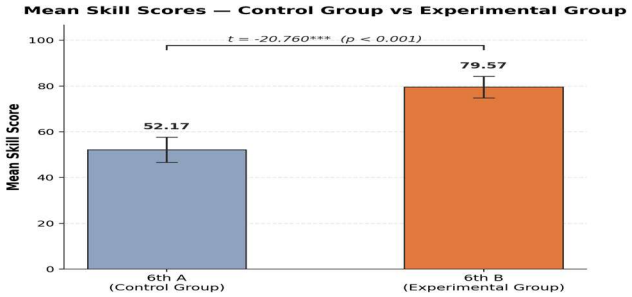

Figure 1: Mean Skill Scores of the Control Group and the Experimental Group

Interpretation – Skill: Table 1 shows that the Control Group (6th A) obtained a mean Skill score of 52.1667 with a standard deviation of 5.48404, whereas the Experimental Group (6th B) obtained a considerably higher mean Skill score of 79.5667 with a standard deviation of 4.71010. The obtained independent-samples 't' value of -20.760 (df = 58) is significant at the 0.001 level (2-tailed). Hence, the null hypothesis H0(1) is rejected, indicating that there is a significant difference in Skill between the Control and Experimental groups. This finding suggests that the dramatization technique, which requires learners to enact, perform and physically engage with the Social Science content, produced a marked improvement in Skill as compared to the conventional lecture method, a pattern consistent with the significant skill-related gains reported for drama-based instruction by Kauts and Monika (2013) and Dima et al. (2020).

Table 2: Mean, Standard Deviation and Paired-Samples 't' value of Pre-test and Post-test Academic Achievement of the Experimental Group (6th B)

Test	N	Mean	S.D.	't' value
Pre-test	30	11.0667	1.83704	-18.140***
Post-test	30	17.8000	1.27035	

*** *Significant at the 0.001 level (2-tailed); Paired-Samples 't' test, df = 29, N = 30.*

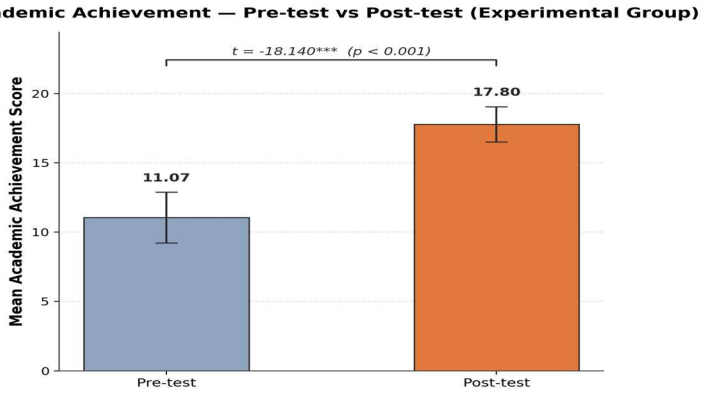

Figure 2: Mean Academic Achievement Scores — Pre-test vs Post-test (Experimental Group)

Interpretation – Academic Achievement:

Table 2 shows that the Experimental Group (6th B) obtained a mean Pre-test Academic Achievement score of 11.0667 (SD = 1.83704), which rose to a mean Post-test score of 17.8000 (SD = 1.27035) after the four-week dramatization-based instruction. The obtained paired-samples 't' value of -18.140 (df = 29) is significant at the 0.001 level (2-tailed). Hence, the null hypothesis H0(2) is rejected, confirming a significant difference between the Pre-test and Post-test Academic Achievement scores of the Experimental Group. This finding indicates that teaching Social Science through dramatization produced a substantial and statistically significant gain in learners' academic achievement, consistent with the strong overall effect of the drama method on academic achievement reported in the meta-analytic review by Yıldırım (2022).

Findings of the Study:

- The mean Skill score of the Experimental Group (79.5667) was significantly higher than that of the Control Group (52.1667).
- The difference between the Control and Experimental groups on Skill was statistically significant ($t = -20.760$, $df = 58$, $p < 0.001$); hence H0(1) was rejected.
- The mean Post-test Academic Achievement score of the Experimental Group (17.8000) was significantly higher than its mean Pre-test score (11.0667).
- The difference between the Pre-test and Post-test Academic Achievement scores of the Experimental Group was statistically significant ($t = -18.140$, $df = 29$, $p < 0.001$); hence H0(2) was rejected.
- Both findings together indicate that the dramatization teaching technique produced measurable gains in a psychomotor outcome (Skill, assessed between groups) as well as a cognitive learning outcome (Academic Achievement, assessed within the Experimental group over time).

Suggestions:

- Dramatization may be incorporated as a regular pedagogic technique for teaching Social Science and other content-heavy subjects at the higher primary stage.
- In-service teacher training programmes should orient primary teachers to simple, low-cost dramatization strategies such as role play, mime and story enactment.
- School authorities may allocate a small block of time each week for drama-based activities within the existing timetable, without requiring additional infrastructure.
- Periodic Skill assessment and formative achievement testing may be built into dramatization-based lesson plans to track learner progress over time.
- Further studies may be undertaken with larger and more diverse samples, across different subjects and grade levels, and using a control-group Pre-test Post-test design for Academic Achievement, to strengthen the generalizability of the present findings.

Results and Discussion:

The results of the present study demonstrate that higher primary school students taught Social Science through the dramatization technique achieved significantly higher Skill scores than those taught through the conventional method, and that the Experimental Group's Academic Achievement improved significantly from Pre-test to Post-test following the dramatization-based intervention. This pattern of gains is consistent with the broader literature on drama-based pedagogy, which has repeatedly shown improvements in performance-related outcomes such as speaking skill and achievement (Kauts & Monika, 2013), in practical skills such as critical thinking (Dima et al., 2020), and in achievement when examined cumulatively across a large body of studies (Yıldırım, 2022). Taken together, the findings support the conclusion that dramatization is not merely an entertaining classroom activity but a pedagogically sound technique capable of producing measurable gains in both what learners can do (Skill) and what

they come to know (Academic Achievement).

Conclusion:

The present study set out to examine the effectiveness of the dramatization teaching technique on the Skill and Academic Achievement of higher primary school students studying Social Science at a Government Higher Primary School in Navalur, Dharwad district, Karnataka. The Experimental Group, taught through dramatization, achieved significantly higher Skill scores than the Control Group taught through the conventional method, and showed a significant gain in Academic Achievement from Pre-test to Post-test. Both null hypotheses framed for the study were rejected. These findings reaffirm the value of activity-based, learner-centered techniques in government primary schools and indicate that dramatization, being low-cost and easily implementable, can be meaningfully integrated into everyday Social Science teaching to strengthen learners' practical skills as well as their academic performance.

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ARTIFICIAL INTELLIGENCE ENABLED TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: PREPARING SMART TEACHERS FOR A SMART FUTURE

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Abstract

By impacting curriculum development, teaching, learning, assessment, and educational administration, artificial intelligence (AI) is drastically changing education. Although the use of AI to enhance student learning has received a lot of attention, more focus should be placed on the role that educators play in the ethical and successful incorporation of Artificial Intelligence. Teachers are today required to have more than just subject-matter expertise and pedagogical abilities; they also need to be AI literate, ethically conscious, digitally competent, data literate, and capable of critically analyzing material generated by Artificial Intelligence. In addition to discussing how AI-enabled professional learning can help create intelligent, capable, and future-ready teachers, this article explores the role of Artificial Intelligence in teacher education and professional development. In particular, UNESCO's AI (Artificial Intelligence) Competency Framework for Teachers and other contemporary literature and international policy frameworks serve as the foundation for the paper's conceptual approach. Human-centred Artificial Intelligence competency, Artificial Intelligence (AI) ethics, AI foundations and applications, AI pedagogy, and AI-supported professional learning are the five main topics of discussion. Opportunities including individualized professional development, AI-assisted lesson planning, intelligent feedback, automated administrative support, collaborative learning, and reflective professional practice are also highlighted in the report. Concerns like privacy, bias, digital inequality, academic integrity, excessive reliance on technology, and teacher readiness are all taken into account. Based on the concepts of comprehending, utilizing, assessing, and producing with AI, the paper suggests a framework for teacher professional development facilitated by Artificial Intelligence. It concludes that AI (Artificial Intelligence) should enhance teachers' professional judgment, creativity, empathy, and decision-making rather than replace them. Therefore, ongoing, moral, human-centered, and context-sensitive professional development is necessary to produce smart teachers.

Keywords: *Artificial Intelligence (AI), Professional Development, AI Pedagogy, AI Literacy, Teacher Education, Future-Ready Teachers, Smart Teachers.*

Introduction

One of the most important technologies influencing modern education is artificial intelligence. Personalized learning, automated assessment, learning analytics, content creation, tutoring, feedback, and administrative assistance are all using AI-powered systems more and more. The potential for innovative teaching has been greatly enlarged by the quick development of generative Artificial Intelligence. But technology can't change education on its own. The expertise, abilities, discretion, and ethical awareness of educators have a major

role in how well AI (Artificial Intelligence) works in the classroom. The way that educators and technology interact is changing dramatically. In the past, most people thought of educational technology as a tool that teachers might use to enhance instruction in the classroom. The interaction has grown more complicated as generative AI and intelligent educational systems have developed, resulting in what UNESCO refers to as a teacher-AI-student dynamic. Teachers must comprehend not only how AI tools work but also when, why, and under what circumstances they should be employed. Human-centred mentality, AI ethics, AI foundations and applications, AI pedagogy, and AI for professional learning are the five characteristics that comprise the competencies identified by UNESCO's AI Competency Framework for Teachers. Acquire, Deepen, and Create are the three levels into which the framework further divides teacher development. Institutions that provide teacher education will be significantly impacted by this development. While in-service teachers need ongoing professional development to adjust to quickly evolving AI technology, pre-service teachers need opportunities to acquire AI literacy prior to entering the field. As a result, comprehensive Artificial Intelligence competency must replace basic digital literacy in teacher education. In order to train smart teachers for a smart future, this paper investigates how AI might be included in professional development and teacher education.

Need for Artificial Intelligence Enabled Teacher Education

Education systems have both opportunities and challenges as a result of AI's rapid growth. It is becoming more and more expected of educators to use digital tools while retaining their professional independence and making sure they are used for instructional objectives. Research has concentrated more on AI applications in education than on AI's function in professional development, according to a recent systematic assessment of 95 publications looking at Artificial Intelligence (AI) in teaching and teacher professional development. Just 35% of the studies focused on AI for teacher professional development, whereas about 65% of the studies looked at AI applications in education. This disparity suggests that teachers' professional development needs need to be given far more consideration. In a similar vein, a 2024 scoping evaluation of AI (Artificial Intelligence) literacy in teacher education concluded that while it is still relatively undeveloped, AI literacy is an emerging field of study. The review highlights the significance of integrating professional judgment, practical skill, and theoretical knowledge. As a result, teacher education should equip educators to critically comprehend, assess, and pedagogically incorporate Artificial Intelligence (AI) in addition to teaching them how to use AI tools.

Artificial Intelligence and the Changing Role of Teachers

Future educators will probably serve in both of these roles at the same time:

- Subject matter expert
- A facilitator of learning
- Pedagogical designer with AI integration
- A critical assessor of data produced by AI
- A moral decision-maker
- Interpreting learning data
- Emotional support and mentor
- A lifelong student
- The creator of inclusive education
- AI-human cooperation

Lesson plans, learning materials, questions, rubrics, and feedback can be produced by AI; nevertheless, teachers are still in charge of deciding whether these materials are accurate,

culturally relevant, instructional, and suited for specific students.

AI Competencies Required for Smart Teachers

A thorough competency framework is necessary for the development of intelligent teachers. An essential global foundation for this goal is provided by UNESCO's AI Competency Framework for Teachers.

➲ **A Human-Centered Perspective**

Teachers need to be aware that AI is meant to support human education. Teacher autonomy, student agency, interpersonal ties, and educational principles should all be safeguarded by AI integration. Thus, an astute educator ought to inquire:

• Does learning get better with this AI tool?
• Does it enhance human relationships rather than take their place?
• Is it suitable for the learners' age and needs?
• Does it encourage self-reliance among students?
• Does it protect the professional judgment of teachers?

➲ **Artificial Intelligence Ethics**

The application of AI in education presents serious ethical issues, such as:

- Privacy of data
- Algorithmic prejudice
- Openness
- Responsibility
- Intellectual property
- Honesty in academia
- False information
- Monitoring
- Inequality in digital

The significance of a human-centered, moral, secure, and significant approach to AI application in education is emphasized in UNESCO's guidelines on generative AI. Therefore, rather than treating AI ethics as an elective, teacher education programs ought to incorporate it as a fundamental component.

➲ **AI Foundations and Applications**

Becoming a computer scientist is not a requirement for educators. Nonetheless, they must have enough fundamental understanding to comprehend:

- The definition of AI
- The fundamentals of machine learning
- The definition of generative AI
- The conceptual operation of big language models
- The capabilities and limitations of AI
- How material or forecasts are produced by AI systems
- The reasons why AI systems might generate false information
- How to assess AI tools

Teachers can become knowledgeable users of technology instead of just passive consumers thanks to this understanding.

➲ **AI Pedagogy**

AI proficiency needs to be linked to pedagogy. Teachers need to understand how AI can help:

- Planning lessons
- Differentiated education
- Tailored education
- Evaluation
- Comments
- Content creation
- Collaborative education
- Learning through projects

- Learning through inquiry
- Inclusive education
- Acquiring knowledge about analytics

The UNESCO framework highlights teachers' capacity to critically analyze AI's impact on teaching, learning, and assessment and explicitly names AI pedagogy as a key competency area.

AI for Professional Learning

AI has the potential to become a tool for professional growth. AI-supported systems can be used by educators to:

- ★ Determine what needs to be improved professionally.
- ★ Create educational resources for professionals.
- ★ Create instructional materials
- ★ Examine your lesson plans.
- ★ Investigate different teaching approaches
- ★ Get input
- ★ Create evaluation resources
- ★ Take part in customized learning programs
- ★ Participate in professional learning communities.

This results in a significant change from recurring training courses to ongoing professional learning aided by AI.

AI-Enabled Professional Development Model

Four successive stages make up the AI-Enabled Teacher Professional Development Model proposed in this paper.

Stage 1: Recognize Teachers acquire a basic understanding of AI.

Emphasis:

- ◆ Comprehending AI
- ◆ Recognizing uses of AI
- ◆ Recognizing advantages and restrictions
- ◆ Acquiring a basic understanding of AI terminology

Step 2: Submit an application

Teachers are starting to utilise AI tools in their work.

For instance:

- ◆ Planning lessons
- ◆ The creation of questions
- ◆ Development of educational materials
- ◆ Formative evaluation
- ◆ Differentiation

Stage 3: Assess Teachers' critical analysis of AI outcomes.

They assess:

- ◆ Precision
- ◆ Prejudice
- ◆ Significance
- ◆ Cultural sensitivity
- ◆ Availability
- ◆ Implications for ethics
- ◆ Educational value

Stage 4: Develop Teachers become AI-informed innovators in education, going beyond the use of current instruments.

They can:

- Co-create educational activities with AI support.
- Create creative teaching methods
- Produce individualized educational materials
- Create exams with AI enhancements
- Take part in communities for professional learning
- Create context-specific AI apps.

In general, this pattern aligns with UNESCO's focus on the Acquire, Deepen, and Create levels of teacher competency development.

Opportunities of AI for Teacher Professional Development

- **Personalized Professional Education**

All teachers receive the same training through traditional professional development. AI can facilitate customized professional learning according to competency levels, instructional circumstances, and individual needs. An AI-powered platform might, for instance, determine that one instructor needs help with evaluation while another needs help creating digital content.

- **AI-Powered Lesson Planning**

AI can be used by educators to provide differentiated resources, exercises, questions, and preliminary lesson ideas. Teacher validation is still crucial, though.

- **Constant Feedback**

Teachers can participate in ongoing professional reflection by using AI-supported systems to offer input on class planning, instructional materials, and assessment methods.

- **Cutting Down on Administrative Work**

Repetitive chores that AI can help with include:

- Organizing data
- Report drafting
- Making rubrics for assessments
- Getting worksheets ready
- Condensing professional, non-sensitive materials

Teachers may be able to dedicate more time to pedagogical planning and student interaction by reducing their regular workload.

- **Favour of inclusive education**

Accessibility can be enhanced by AI by:

- Text-to-voice
- Conversation-to-text
- Translating
- Learning that adapts
- Individualized materials
- Assistive technology.

With a focus on human rights and privacy, UNESCO's teacher competency framework particularly emphasizes the potential of AI to serve students with disabilities and special

educational needs.

Challenges in AI (Artificial Intelligence) Enabled Teacher Professional Development

AI integration is not always advantageous, despite its potential.

- **Insufficient Artificial Intelligence (AI) Proficiency**

Many educators may be unconfident when utilizing AI technologies and have little grasp of the technology.

- **Concerns about Ethics**

Instructors require advice on copyright, bias, data protection, privacy, and responsible AI use.

- **Digital Divide**

Inequalities in education can be exacerbated by unequal access to devices, connectivity, and AI-enabled platforms.

- **Over-reliance on AI**

Teachers' capacity for independent thought, creativity, and professional judgment may be diminished by an over-reliance on AI-generated content.

- **Precision and Delusions**

Information produced by generative AI systems may be false or inaccurate. As a result, teachers need to have good critical evaluation abilities.

- **Academic Integrity**

Plagiarism, authorship, assessment validity, and student learning are all called into doubt by AI-generated content.

- **Cultural and Linguistic Significance**

AI-generated instructional content may not necessarily reflect local cultural contexts, regional languages or learners' life experiences.

- **Resistance from Teachers**

Because of worries about workload, job security, inadequate training, or uncertainty about technological development, educators may be reluctant to accept AI. According to UNESCO's guidelines, human potential and group efforts are still essential for improving education, and generative AI should not be seen as a panacea for all educational issues.

Consequences for Institutions of Teacher Education

In light of the development of AI, teacher education institutions ought to reevaluate their curricula.

For Pre-Service Teacher Education

AI-related skills should be incorporated into teacher education programs for pre-service teachers by:

- Courses on AI literacy
- Pedagogy using AI integration
- Workshops on practical AI
- Case studies on ethics
- AI-assisted instruction
- Development of digital portfolios
- AI-powered instructional design
- Activities for critical evaluation

For Teachers in Service

Instead of being restricted to one-time workshops, professional development ought to be ongoing.

Potential strategies consist of:

- Online courses for AI certification

- ➲ Professional learning communities for AI
- ➲ Mentoring by peers
- ➲ Classrooms for demonstrations
- ➲ AI instructional labs
- ➲ Micro-credential initiatives
- ➲ Reflective AI portfolios
- ➲ Action research conducted in schools

Professional development needs more emphasis in the AI-in-education research agenda, according to the systematic-review evidence.

Indian Setting

India's varied educational contexts, languages, socioeconomic circumstances, and technology ecosystems make it especially crucial for educators to develop AI competencies. The **National Education Policy (NEP) 2020** asks for technology to assist teaching-learning, assessment, teacher training, and professional development. It acknowledges the significance of emerging technologies, such as artificial intelligence and machine learning. Additionally, NEP 2020 highlights the use of technology for teacher professional development and lists platforms like DIKSHA as crucial tools for professional development. Thus, in India, AI-enabled teacher training ought to be:

- ✪ Multilingual
- ✪ Comprehensive
- ✪ Inexpensive
- ✪ Sensitive to context
- ✪ Based on ethics
- ✪ Both rural and urban educators can use it.
- ✪ Compliant with Indian curriculum
- ✪ Aware of cultural and geographical diversity

The objective for India should be to develop professionally capable, morally upright, and socially conscious educators rather than only technologically sophisticated educators.

Proposed Framework: Smart Teacher for a Smart Future

The following conceptual framework is suggested in the paper:

- ⇒ AI-Enabled Teacher Education
- ⇒ AI Literacy + Digital Literacy + Data Literacy
- ⇒ Human-Centred AI Competence
- ⇒ AI Ethics and Responsible Use
- ⇒ AI-Integrated Pedagogy
- ⇒ AI-Supported Professional Learning
- ⇒ Critical Reflection and Professional Judgment
- ⇒ Innovative, Inclusive, and Future-Ready Teaching

SMART TEACHER

Therefore, a smart teacher is more than just a teacher who is proficient with AI tools. A clever teacher can comprehend artificial intelligence (AI), use it effectively, assess it critically, incorporate it pedagogically, and make moral decisions about AI while maintaining human relationships in the classroom.

Suggestions

The following suggestions are put out in light of the conversation:

- ➔ Pre-service teacher education programs ought to include AI (Artificial Intelligence) literacy.
- ➔ Multilingual and culturally sensitive instruction should be supported by Artificial Intelligence (AI) tools used in teacher education.
- ➔ Pedagogy should be prioritized in teacher preparation programs rather than only technology.
- ➔ Teachers should be supplemented by Artificial Intelligence, not replaced.
- ➔ Artificial Intelligence proficiency ought to be a crucial part of ongoing professional growth.
- ➔ From fundamental comprehension to sophisticated creation and innovation, professional growth should adhere to growing competency levels.
- ➔ Academic integrity, privacy, bias, and Artificial Intelligence ethics ought to be required elements of professional growth.
- ➔ Teachers' ought to receive training on how to assess AI-generated content critically.
- ➔ Action research on AI-assisted teaching methods should be promoted to educators. Teachers in remote, rural, and resource-constrained environments should have access to AI training.
- ➔ To facilitate experimentation and group learning, teacher education institutes ought to set up AI labs or innovation centers.
- ➔ Clear rules for the ethical use of AI should be established by educational institutions.

Conclusion

Artificial intelligence is transforming education and setting new standards for educators. Teacher education must advance beyond traditional digital literacy to full AI competency in light of the rise of generative Artificial Intelligence, intelligent learning systems, and AI-supported educational platforms. Developing teachers' ability to comprehend, apply, assess, and creatively employ AI is just as important as giving them access to AI (Artificial Intelligence) tools in order to create smart teachers for a smart future. By highlighting human-centeredness, ethics, AI foundations and applications, AI pedagogy, and AI-supported professional learning, UNESCO's Artificial Intelligence (AI) Competency Framework for Teachers offers a significant global foundation. Teachers can receive individualized learning, instructional support, feedback, resource development, and chances for ongoing professional development through AI-enabled professional development. However, these advantages are only possible if Artificial Intelligence is used responsibly and educators maintain their professional independence and discretion. Therefore, it is inappropriate to define the future of education as "AI versus teachers." It is better to think of it as "AI with teachers." The most effective educational systems will be those that integrate AI's analytical powers with teachers' human connections, creativity, empathy, and ethical

judgment. Therefore, the goal of AI-enabled teacher education should be to develop educators who are not just technologically proficient but also intelligent, moral, introspective, inclusive, and prepared for the future.

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ARTIFICIAL INTELLIGENCE AND PUBLIC GOVERNANCE: TOWARDS HUMAN-CENTRED AND CITIZEN-CENTRED ADMINISTRATION

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Abstract

Artificial Intelligence (AI) is increasingly transforming public administration by enabling governments to process large volumes of information, automate routine tasks, support decision-making and improve public-service delivery. However, the use of AI in government is not merely a technological development. It also raises important questions concerning administrative discretion, transparency, accountability, equality, privacy, democratic legitimacy and public trust. This article examines the relationship between Artificial Intelligence and public governance from a Political Science perspective. It adopts a qualitative and conceptual approach based on a review of scholarly literature and major international policy frameworks. The article argues that AI can strengthen state capacity and citizen-centred administration only when technological efficiency is balanced with democratic values and institutional accountability. Particular attention is given to the relationship between AI, administrative decision-making, public values and citizen trust. The article also considers the relevance of these issues to India, where linguistic, socioeconomic and digital diversity makes inclusive AI governance especially important. Based on the analysis, the article proposes a Human-Centred Public AI Governance Framework based on six principles: human oversight, transparency and explainability, institutional accountability, fairness and inclusion, citizen participation, and redress and remedy. The article concludes that AI-enabled governance should be assessed not only by efficiency and automation but also by its contribution to public value, democratic legitimacy, responsiveness and citizen trust.

Keywords: *Artificial Intelligence, Public Governance, Public Administration, State Capacity, Democratic Accountability, Citizen-Centred Governance, Public Trust, Responsible AI, India*

1. Introduction

Artificial Intelligence has become an important component of contemporary digital governance. Governments are increasingly exploring AI for public-service delivery, information processing, fraud detection, and administrative decision support and citizen interaction. The OECD's 2025 study of government AI use identifies significant potential for automation, tailored services, improved decision-making and enhanced administrative capacity, while simultaneously highlighting risks related to biased data, transparency,

overreliance, digital divides and public trust.

The significance of AI for Political Science extends beyond technological efficiency because public administration is one of the principal means through which state authority is exercised. Administrative decisions affect citizens' access to welfare, education, healthcare, employment and other public services. When AI becomes part of these processes, technology increasingly influences how public authority is exercised.

Existing literature recognises both opportunities and risks. Zuiderwijk, Chen and Salem's systematic review identified the need for stronger theoretical and multidisciplinary approaches to understanding AI's implications for public governance. More recent research has focused on automated administrative decision-making, public values, good governance and citizen trust.

However, an important question remains: How can governments use AI to strengthen administrative capacity without weakening democratic accountability, public values and citizen agency? This article argues that AI should strengthen the capacity of democratic institutions rather than replace human judgement, institutional responsibility or citizen participation.

2. Objectives and Methodology

The study has four objectives:

1. To examine the implications of AI for public governance and state capacity.
2. To analyse AI's influence on administrative decision-making, accountability and public values.
3. To examine the relationship between AI, citizen-centred administration and public trust.
4. To propose a Human-Centred Public AI Governance Framework with relevance to India.

The article adopts a qualitative, conceptual and analytical methodology. It draws upon peer-reviewed academic literature and major international policy and ethical frameworks concerning AI, public administration and governance. The study does not claim original survey, interview or statistical findings. Its purpose is to synthesise existing literature and develop a conceptual framework for responsible AI-enabled governance.

3. AI, State Capacity and Public Administration

AI can strengthen state capacity by enabling governments to process information more rapidly, identify patterns, support administrative decisions and automate repetitive processes. The OECD reports that 57% of the government AI use cases it examined were aimed at automating, streamlining or tailoring processes and services.

These capabilities can potentially improve:

- administrative efficiency;
- information management;
- resource allocation;

- service responsiveness;
- fraud and risk detection; and
- Decision support.

Yet technological capacity and state capacity are not identical.State capacity involves not only what government can technically do, but also its ability to exercise public authority effectively, lawfully and fairly. Therefore, AI can increase administrative capability, but institutions must determine how that capability should be used and what safeguards should govern it. The central concern is consequently not whether AI can make government faster, but whether it can make government more capable without making it less accountable.

4. AI, Administrative Decision-Making and Public Values

One of the most significant consequences of AI adoption is its growing role in administrative decision-making. AI systems may classify applications, identify risks, prioritise cases or provide recommendations to officials. Such systems can improve consistency and reduce routine workloads. However, automated decision-making can also create tensions between efficiency and other values of good governance.

Roehl and Hansen's systematic review of automated administrative decision-making identifies relationships with nine governance values: accountability, efficiency, equality, fairness, resilience, responsiveness, privacy, rule of law and transparency. Their analysis demonstrates that AI-enabled administrative decision-making can create both synergies and trade-offs, particularly as the degree of automation increases.

This leads to an important distinction between AI-assisted administration and administration controlled by AI. AI should therefore function primarily as a tool that supports public officials, while responsibility for significant administrative decisions remains identifiable and reviewable.

A useful principle is: The greater the impact of an AI-assisted decision on a citizen, the stronger the requirement for human oversight and accountability. This approach is consistent with the broader principle of responsible AI governance, which emphasises human responsibility, transparency and mechanisms for review and remedy.

5. AI, Accountability, Transparency and Trust

Accountability is fundamental to democratic public administration. AI can complicate conventional accountability because a decision may involve a government department, public official, technology provider, data source and algorithmic system.

Technological complexity, however, cannot eliminate public responsibility.

Citizens should be able to know:

- whether AI influenced an important decision;
- which institution is responsible;
- what role the system played;
- how the decision can be reviewed; and
- Where a complaint or appeal can be submitted.

Transparency therefore needs to be meaningful rather than merely technical.

Public trust is equally important. If citizens perceive AI systems as opaque, discriminatory or impossible to challenge, technological efficiency may fail to produce legitimate governance. The OECD specifically warns that lack of transparency can weaken accountability, while overreliance on AI can propagate errors, widen digital divides and reduce citizen trust. Thus, responsible public AI governance requires a combination of: transparency + human oversight + institutional accountability + privacy + accessible remedy.

6. AI, Equality, Inclusion and Public Value

AI can potentially make public services more accessible and responsive. However, it can also reproduce inequalities contained in data or embedded in existing institutions. Citizens differ in digital literacy, internet access, education, language, disability and socioeconomic circumstances. These differences are particularly significant in large and diverse democracies. Consequently, digital transformation should not become digital exclusion.

Recent scholarship on good governance of public-sector AI emphasises that AI should operate within a democratic and rule-of-law framework while also protecting the just treatment and wellbeing of citizens. Mišić, van EST and Kool identify seven core values for public-sector AI governance, including responsiveness, effectiveness, procedural justice, resilience, counterbalance, wellbeing and social justice. This provides an important basis for evaluating AI through the broader concept of public value. AI-enabled governance should therefore be assessed not only by: How fast can government act? But also by: How fairly, transparently, inclusively and accountably does government act?

7. The Indian Context

India provides an important context for examining AI-enabled public governance because of the scale and diversity of its administrative system. AI can potentially support public-service delivery, information management, grievance handling, administrative coordination and citizen communication. At the same time, India faces considerable diversity in language, geography, socioeconomic conditions and digital access. This means that AI systems designed without sufficient attention to inclusion may produce unequal outcomes.

Indian public-sector AI therefore requires:

1. multilingual accessibility
2. human assistance
3. alternative service channels
4. privacy protection
5. transparent decision-making
6. accessible grievance mechanisms
7. Continuous monitoring for bias and exclusion.

The Indian context demonstrates that responsible AI governance must be designed around citizen's diverse needs rather than technological capability alone.

8. Human-Centred Public AI Governance Framework

Based on the preceding analysis, this article proposes a Human-Centred Public AI Governance Framework consisting of six principles.

1. Human Oversight: AI should support public officials rather than eliminate human responsibility. Decisions with significant consequences for citizens should remain subject to meaningful human review.

2. Transparency and Explainability: Citizens should know when AI substantially influences an important administrative decision and should receive an understandable explanation appropriate to the significance of that decision.

3. Institutional Accountability: Responsibility for AI systems must remain clearly attributable to identifiable public institutions and officials.

4. Fairness and Inclusion: AI systems should be assessed for discriminatory outcomes and barriers affecting disadvantaged and digitally excluded groups.

5. Citizen Participation: Citizens, civil society and affected communities should have opportunities to participate in discussions concerning significant public-sector AI applications.

6. Redress and Remedy: Citizens must have accessible mechanisms to question, review, correct and appeal AI-assisted decisions.

The contribution of this framework is not the claim that each principle is individually new. Rather, it integrates these principles into a Political Science-oriented model connecting technological capacity with democratic legitimacy and citizen trust.

9. Policy Implications

The analysis suggests several priorities for governments.

1. Public institutions should establish clear AI-governance policies defining permissible uses, responsibilities and monitoring mechanisms.
2. High-impact AI systems should undergo assessment for potential effects on equality, privacy, transparency and public trust.
3. Meaningful human review should remain available for decisions with significant consequences for citizens.
4. Public officials require AI literacy so that they understand both the capabilities and limitations of AI systems.
5. Accountability chains should clearly identify responsibility for procurement, implementation, monitoring and correction.
6. Essential public services should retain accessible alternatives for citizens who cannot effectively use digital systems.

Finally, government should evaluate AI not only through technical performance but also through citizen experience, fairness, accessibility and trust.

10. Conclusion

Artificial Intelligence is transforming public governance by creating new possibilities

for administrative efficiency, information processing, and decision support and public-service delivery. Yet its importance extends beyond technology because AI increasingly participates in processes through which public authority is exercised.

The central challenge is therefore not whether governments should use AI, but how AI should be governed within democratic institutions.

AI can strengthen state capacity, but state capacity without accountability may weaken democratic governance. Automation can improve efficiency, but efficiency without fairness can undermine public value. Data can improve decision-making, but data-driven administration without appropriate safeguards can threaten privacy and equality. Digital services can increase convenience, but convenience without inclusion can deepen existing inequalities.

This article therefore proposes a Human-Centred Public AI Governance Framework based on human oversight, transparency and explainability, institutional accountability, fairness and inclusion, citizen participation, and redress and remedy. For India, these principles are particularly significant because AI-enabled administration must operate within a socially, economically and linguistically diverse democracy.

The future of public administration should not be understood as government by algorithms. It should be understood as democratic government strengthened by responsible technology. Ultimately, the success of AI in public governance should not be measured only by how efficiently governments automate administrative processes. It should be measured by whether AI helps governments become more responsive, fair, inclusive, transparent, accountable and worthy of citizen trust.

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AI-ENABLED NEXT-GENERATION DIGITAL DEVICES: TRANSFORMING COMPUTING SPEED, CONNECTIVITY AND THE FUTURE OF PHYSICAL EDUCATION AND SPORTS DEVELOPMENT

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Abstract

The rapid development of Artificial Intelligence (AI), advanced processors, wearable sensors, Internet of Things (IoT), cloud and edge computing, augmented reality (AR), virtual reality (VR), and high-speed wireless connectivity is transforming education, exercise, training, and sports. Next-generation digital devices are evolving from conventional computers and smartphones into intelligent, interconnected systems capable of sensing, processing, analysing, and communicating information in real time. These technologies have important applications in Physical Education (PE) and sports development.

This paper examines the role of AI-enabled digital devices in improving computing speed, connectivity, Physical Education pedagogy, fitness assessment, sports training, performance analysis, injury-risk management, and athlete development. Wearable devices can collect information related to movement, heart rate, speed, distance, workload, and activity levels, while AI-based systems can analyse these data and provide personalized feedback. The paper adopts a narrative review approach based on literature related to AI, wearable technology, digital devices, physical activity monitoring, and sports technology. The review identifies major benefits such as individualized learning, real-time feedback, objective assessment, improved performance monitoring, and data-informed coaching. It also identifies challenges including digital inequality, data privacy, cybersecurity, measurement accuracy, cost, excessive dependence on technology, and the need for teacher and coach training. The paper proposes a human-centred approach in which technology supports, rather than replaces, the professional judgement of Physical Education teachers, coaches, and sports scientists.

Keywords: *Artificial Intelligence, Next-Generation Digital Devices, Wearable Technology, Physical Education, Sports Development, IoT, High-Speed Computing, Connectivity, Sports Analytics, Digital Transformation*

INTRODUCTION

Digital technology has become an important part of modern education and sport. The rapid growth of Artificial Intelligence, high-speed computing, sensors, cloud services, edge computing, and connected devices has created new opportunities for monitoring and improving physical activity and sports performance. Unlike traditional digital devices, next-

generation systems can collect data, process information, identify patterns, and provide feedback with minimal delay.

Physical Education and sports are particularly suitable for digital innovation because physical activity produces measurable information. Speed, distance, acceleration, heart rate, exercise duration, movement patterns, workload, and activity intensity can be recorded through wearable devices and sensors. Such information can help teachers and coaches understand individual performance and provide more appropriate training and learning experiences.

The importance of physical activity for health and holistic development is widely recognized. Therefore, the effective use of digital technology can help make Physical Education more engaging, individualized, measurable, and data-informed. However, technology should not become a substitute for human interaction, professional judgement, teamwork, or actual participation in physical activity.

NEXT-GENERATION DIGITAL DEVICES IN PHYSICAL EDUCATION AND SPORTS

Next-generation digital devices include smartwatches, fitness trackers, GPS devices, heart-rate monitors, smart clothing, motion sensors, AI-enabled cameras, smart sports equipment, AR/VR devices, smartphones, tablets, and IoT-connected systems.

These devices generally perform four major functions:

1. **Sensing** – collecting physical, physiological, and movement data.
2. **Connectivity** – transmitting data through Bluetooth, Wi-Fi, cellular networks, or IoT.
3. **Computing** – processing information through device, edge, or cloud computing.
4. **Intelligence** – using AI to analyse information and generate meaningful insights.

The combination of these functions creates a connected digital sports ecosystem in which information can move from the athlete to the device, smartphone, AI platform, teacher, coach, or sports scientist.

TRANSFORMATION OF COMPUTING SPEED AND CONNECTIVITY

High-speed computing has an important role in modern sports technology. Traditional systems often depend on centralized processing, whereas next-generation systems distribute computing across devices, edge systems, cloud platforms, and specialized AI processors.

This is valuable in Physical Education and sport because many activities require immediate feedback. AI-enabled systems can potentially analyse movement during exercise and provide feedback within seconds. Edge computing can also reduce delay by processing selected information close to the user.

High-speed computing can support:

- Real-time movement analysis
- Exercise technique assessment
- Repetition counting
- Running-speed measurement

- Jump and posture analysis
- Reaction-time measurement
- Fitness assessment
- Personalized exercise recommendations

Connectivity further strengthens these applications. A modern sports system can be represented as:

Wearable Device → Smartphone/Tablet → Edge Computing → Cloud Platform → AI Analysis → Teacher/Coach/Athlete

Such connectivity allows information to be collected and reviewed during or after training. It also creates opportunities for continuous monitoring and digital record keeping.

INJURY PREVENTION AND ATHLETE SAFETY

One promising application of AI and wearable technology is injury-risk management. Training load, movement patterns, recovery indicators, and changes in performance can be monitored over time. AI may help identify unusual patterns that require attention. Potential applications include workload monitoring, movement-asymmetry analysis, recovery monitoring, rehabilitation support, and return-to-play decision support. However, AI-generated information should never be treated as a medical diagnosis. Coaches, physiotherapists, sports physicians, and other qualified professionals must remain responsible for safety-related decisions.

Challenges and Limitations

Despite its potential, digital transformation in Physical Education and sports faces several challenges.

Digital Divide

Not all schools, colleges, and students have equal access to advanced devices, reliable internet, or technical infrastructure.

Data Privacy and Cybersecurity

Wearable devices can collect personal and physiological information. Institutions need clear policies relating to data collection, storage, access, sharing, and deletion.

Accuracy and Reliability

Measurements obtained from different devices may not always be identical. Proper validation and appropriate interpretation are necessary.

Teacher and Coach Training

Physical educators need digital literacy and professional development to understand AI systems, wearable technologies, and sports analytics.

Excessive Dependence

Technology should not reduce direct human interaction, outdoor activity, teamwork, and practical participation.

Cost

Purchasing devices, maintaining equipment, upgrading systems, and providing technical

support can be difficult for educational institutions.

PROPOSED HUMAN-CENTERED DIGITAL MODEL

For successful implementation, a human-centred model is recommended. Six principles are particularly important:

1. **Human-Centered:** Teachers and coaches remain the primary decision-makers.
2. **Evidence-Based:** Technology should be selected according to demonstrated educational and sporting value.
3. **Inclusive:** Digital innovation should be accessible to students from different economic backgrounds.
4. **Secure:** Personal and performance-related information must be protected.
5. **Sustainable:** Institutions should choose affordable and maintainable technologies.
6. **Purpose-Driven:** Every device should have a clear educational, health, or performance objective.

FUTURE SCOPE

The future of Physical Education and sports is likely to involve greater integration of AI, wearables, IoT, high-speed connectivity, AR/VR, and intelligent analytics. Emerging applications may include AI fitness assistants, smart sports grounds, intelligent sports equipment, real-time biomechanical analysis, digital athlete profiles, personalized virtual coaching, smart rehabilitation, AI-assisted PE assessment, and digital sports laboratories. The future direction should not focus merely on collecting more data. The real objective is to convert data into meaningful, ethical, and practical action that improves physical literacy, health, participation, and sporting performance.

RECOMMENDATIONS

1. Physical Education institutions should gradually adopt suitable digital technologies.
2. Teachers and coaches should receive regular training in AI and sports analytics.
3. Institutions should establish strong data-protection and cybersecurity policies.
4. Technology should supplement, not replace, professional observation.
5. Affordable technologies should be prioritized to reduce the digital divide.
6. Digital devices should be scientifically evaluated before large-scale implementation.
7. Students should be educated about responsible use of digital technology.
8. AI-generated recommendations should be reviewed by qualified professionals.
9. Institutions should encourage research on the long-term impact of digital PE.
10. Collaboration among Physical Education departments, technology experts, and sports scientists should be strengthened.

CONCLUSION

AI-enabled next-generation digital devices are creating significant opportunities for the transformation of computing, connectivity, Physical Education, and sports development. The integration of AI, wearable sensors, IoT, cloud and edge computing, AR/VR, and high-speed communication can create more personalized, connected, and data-informed learning

and training environments. In Physical Education, these technologies can support individualized learning, real-time feedback, objective assessment, motivation, and inclusive participation. In sports, they can contribute to performance analysis, workload monitoring, skill development, recovery management, and athlete development. At the same time, technological innovation must be balanced with privacy, equity, accuracy, affordability, professional judgement, and human interaction. The future should therefore not be understood as **"technology replacing the teacher or coach,"** but as **"technology empowering the teacher, coach, and athlete."** A successful smart Physical Education and sports ecosystem will combine the speed of modern computing, the intelligence of AI, the connectivity of digital networks, and the experience of human professionals. The ultimate purpose should remain the holistic development of individuals through health, physical fitness, physical literacy, participation, and sporting excellence.

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ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCE AND HUMANITIES

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Abstract

Artificial Intelligence (AI) is increasingly influencing the ways knowledge is created, interpreted, communicated and shared across Social Science and Humanities education and research. This paper examines the emerging role of AI in disciplines such as history, sociology, political science, economics, psychology, languages, literature, philosophy and cultural studies. AI-based tools can assist learners and researchers in organizing large collections of information, identifying patterns in texts and datasets, translating languages, generating summaries, supporting qualitative and quantitative analysis, and creating interactive learning experiences. In humanities, AI can contribute to the study of historical documents, literature, languages, cultural materials and digital archives. In social sciences, it can support survey analysis, data interpretation, social trend analysis and the exploration of complex social issues. These possibilities can make learning more accessible, flexible and engaging. However, the use of AI also introduces important concerns, including inaccurate or fabricated information, algorithmic bias, privacy risks, plagiarism, loss of originality and excessive dependence on automated systems. AI may reproduce existing social and cultural biases present in the data on which it is trained. Therefore, critical evaluation and human judgment remain essential. The paper argues that AI should function as a supportive instrument rather than a replacement for human interpretation, creativity and ethical reasoning. Appropriate AI literacy, teacher preparation, responsible use, source verification and clear academic guidelines are necessary for meaningful integration. When thoughtfully employed, AI can enrich Social Science and Humanities education while preserving the importance of human values, cultural understanding, critical thinking and independent scholarship.

Keywords: Artificial Intelligence, Social Sciences, Humanities, AI in Education, Digital Humanities, Social Science Research, Critical Thinking, AI Literacy, Cultural Studies, Ethical Use of AI.

1. Introduction

Artificial Intelligence has become an important part of contemporary digital development. Its applications are expanding beyond scientific and technological fields and are increasingly entering areas concerned with people, society, culture, language and human thought. Social Science and Humanities disciplines are particularly concerned with understanding human behavior, social relationships, historical developments, values, beliefs and cultural expression. AI offers new possibilities for studying these areas while also creating questions about the relationship between technology and human judgment.

Social Science includes disciplines such as sociology, economics, political science, psychology, geography and education. Humanities includes history, literature, philosophy, languages, cultural studies and related fields. These disciplines traditionally depend on reading, observation, interpretation, discussion, evidence and critical reflection. AI can support many of these activities by helping students and researchers process information more efficiently.

However, human experiences cannot always be reduced to patterns in data. Meaning, emotion, culture and historical context often require careful human interpretation. Therefore, the educational use of AI in Social Science and Humanities requires a balanced approach in which technological assistance is combined with human reasoning.

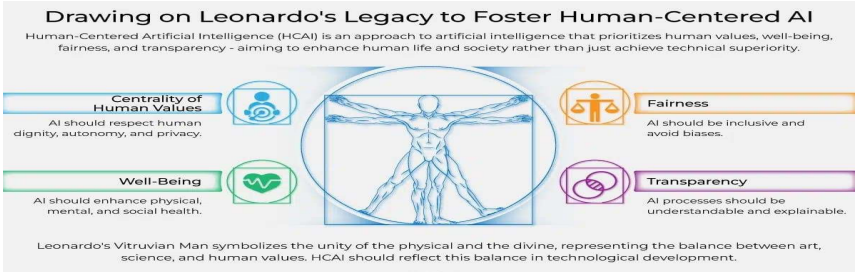
2. Objectives of the Study

The study aims:

1. To examine the role of AI in Social Science and Humanities.
2. To identify the educational applications of AI in these disciplines.

3. To explore how AI can support teaching, learning and research.
4. To examine the benefits of AI-assisted learning.
5. To identify the challenges and ethical concerns associated with AI.
6. To understand the importance of human judgment in AI-supported education.
7. To suggest strategies for the responsible integration of AI in Social Science and Humanities.

3. AI in Social Science



Social Sciences involve the systematic study of individuals, groups, institutions and societies. AI can support both classroom learning and research in several ways.

3.1 Sociology

AI can help students examine social patterns using large datasets. It may assist in identifying relationships between different social variables and organizing information obtained from surveys or digital sources. Students can use AI-supported activities to explore topics such as population change, social inequality, migration and changing social behaviour.

3.2 Economics

Economic education increasingly involves the interpretation of data. AI can assist in organizing economic information, identifying trends and explaining relationships among economic variables. Students can explore concepts such as inflation, employment, consumption and economic growth through data-based activities.

However, AI-generated economic interpretations need to be examined carefully because economic outcomes are influenced by social, political and historical circumstances.

3.3 Political Science

AI can help learners examine political documents, speeches, policies and public information. Text-analysis tools may assist in identifying themes and patterns within large collections of documents.

At the same time, political information can be sensitive and context-dependent. Students should therefore learn to identify bias, distinguish evidence from opinion and verify information using reliable sources.

3.4 Psychology

AI can assist psychology education through data organization, behavioral pattern analysis and simulation-based learning. Students may explore psychological concepts using hypothetical situations and structured datasets.

Nevertheless, human behavior is complex. AI-based interpretations should not be treated as substitutes for professional psychological judgment or direct human interaction.

4. AI in Humanities



The Humanities focus on human thought, language, history, creativity and culture. AI is opening new possibilities for studying and preserving these areas.

4.1 History

AI can assist in organizing and searching historical documents, photographs, manuscripts and digital archives. Optical character recognition and language-processing technologies can make historical materials more accessible. Students can use digital tools to compare historical

documents and identify themes. However, historical interpretation requires attention to context, authorship, chronology and evidence. AI-generated historical information must therefore be verified.

4.2 Literature

AI can assist students in exploring literary texts by identifying recurring themes, characters, language patterns and stylistic features. Large collections of texts can be examined more quickly with computational methods. However, literary interpretation involves imagination, emotion, symbolism and cultural context. An AI system may identify patterns but cannot replace the reader's personal and critical interpretation.

4.3 Language Education

AI-powered language tools can support translation, vocabulary development, grammar practice, pronunciation and writing assistance. Students can receive immediate feedback and practise communication skills. At the same time, learners should understand that automated translation may not always preserve cultural meanings, idioms or contextual nuances.

4.4 Philosophy

AI provides opportunities to discuss questions concerning intelligence, consciousness, knowledge, ethics and human identity. Students can use AI-generated arguments as starting points for debate and critical examination. Rather than accepting AI responses as philosophical conclusions, learners should evaluate assumptions, identify weaknesses and construct their own arguments.

4.5 Cultural Studies

AI can assist in organizing cultural materials and examining patterns across texts, images and historical records. It can contribute to digital preservation and make cultural resources more accessible. However, cultural materials are closely connected to identity, history and community.

Responsible use requires sensitivity toward cultural context and representation.

5. Role of AI in Teaching and Learning

AI can support teachers and students in several ways.

Personalized learning: AI can provide different explanations and learning activities according to students' needs.

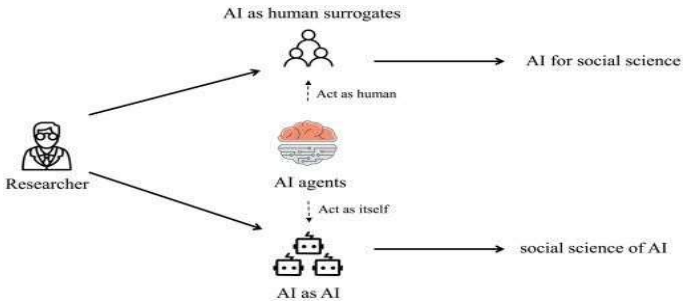
Information organization: Large amounts of information can be organized into manageable categories.

Interactive learning: AI can support simulations, question-answer activities, discussions and educational scenarios.

Writing assistance: Students can receive help with language, structure and preliminary ideas while retaining responsibility for the final work.

Research support: AI can assist with preliminary organization of information and identification of themes. Assessment: AI may support certain forms of formative assessment and feedback. Despite these advantages, teacher supervision is essential. Students should understand that AI-generated content is a starting point for learning and not automatically a reliable source.

6. Benefits of AI in Social Science and Humanities



The appropriate use of AI may provide the following benefits:

- Makes learning more interactive and flexible.
- Provides rapid access to explanations and learning materials.
- Supports analysis of large amounts of information.
- Encourages interdisciplinary learning.
- Helps students explore different perspectives.
- Supports language learning and translation.
- Assists researchers in organizing information.
- Provides opportunities for personalized learning.
- Encourages digital and AI literacy.
- Supports preservation and exploration of cultural and historical materials.

7. Challenges and Ethical Concerns

The use of AI also creates significant challenges.

7.1 Accuracy and Misinformation

AI systems may generate information that appears convincing but is incorrect. Students must therefore verify important information.

7.2 Literature

AI can assist students in exploring literary texts by identifying recurring themes, characters, language patterns and stylistic features. Large collections of texts can be examined more quickly with computational methods.

However, literary interpretation involves imagination, emotion, symbolism and cultural context. An AI system may identify patterns but cannot replace the reader's personal and critical interpretation.

7.3 Loss of Originality

Excessive use of AI for writing may reduce students' opportunities to develop their own ideas and voices.

7.4 Academic Integrity

Students may use AI to complete assignments without understanding the subject.

Educational institutions therefore need clear guidelines regarding acceptable AI use.

7.5 Privacy

AI tools may process personal or sensitive information. Teachers and students should avoid sharing unnecessary personal data.

7.6 Cultural Representation

AI-generated interpretations may oversimplify cultures or present dominant perspectives while overlooking local knowledge and less-represented communities.

7.7 Dependence on Technology

Overdependence may weaken independent reading, reasoning, writing and interpretation. Human intellectual skills should remain central to education.

8. Role of the Teacher

Teachers have an important role in ensuring that AI is used meaningfully. They should help students understand both the capabilities and limitations of AI.

Teachers can design activities in which students compare AI-generated responses with textbooks, original documents and scholarly sources. They can ask students to identify errors, biases and missing perspectives. This transforms AI from an answer-producing tool into an object of critical investigation.

Teachers should also encourage discussion, debate, independent writing and interpretation. These activities ensure that technology complements rather than replaces human learning.

9. Strategies for Responsible Use

The following strategies can improve the use of AI:

1. Use AI according to clearly defined learning objectives.
2. Teach students to verify AI-generated information.
3. Encourage independent thinking before using AI.
4. Compare AI responses with primary and reliable secondary sources.
5. Discuss bias, privacy and ethical issues.
6. Establish clear institutional guidelines for academic AI use.
7. Encourage students to acknowledge AI assistance when required.
8. Protect personal and confidential information.
9. Include discussions, presentations and oral activities to assess genuine understanding.
10. Provide teachers with appropriate AI-literacy training.

10. Educational Implications

AI integration requires changes in curriculum and teacher preparation. Students need AI literacy alongside traditional literacy. They should know how AI systems work at a basic level, how to formulate effective questions, how to evaluate generated information and how to recognize possible bias. Social Science and Humanities education should continue to emphasize reading, writing, interpretation, argumentation, empathy and cultural understanding. AI should provide additional tools for these activities rather than replacing them. Teacher education programs should include practical training in responsible AI use.

Educational institutions should also develop policies addressing privacy, academic integrity, transparency and appropriate use of AI-generated content.

11. Conclusion

Artificial Intelligence has considerable potential to enrich Social Science and Humanities education. It can help learners explore large collections of information, analyse texts and data, practice languages, examine historical materials and engage with complex social questions. It can also support teachers and researchers by reducing some routine information-processing tasks. However, the unique value of Social Science and Humanities lies in human interpretation, ethical reasoning, creativity, empathy and understanding of context. These qualities cannot simply be replaced by automated systems. AI can produce information, but learners must determine its meaning, reliability and relevance. Therefore, the future of AI in Social Science and Humanities should be based on human-centered and responsible integration. Students should learn not merely how to use AI but how to question it, verify it and use it ethically. When AI is combined with critical thinking, independent scholarship and human values, it can become a powerful support for deeper learning and research.

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EFFECT OF STEM-BASED ATAL TINKERING LAB ACTIVITIES ON CREATIVITY, INNOVATIVE THINKING AND ENTREPRENEURSHIP AMONG SECONDARY SCHOOL STUDENTS: A QUASI-EXPERIMENTAL STUDY

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Abstract

STEM education has emerged as an important approach for preparing school students to address complex problems through interdisciplinary knowledge, creativity, critical thinking, collaboration and technological competence. In India, the Atal Tinkering Lab (ATL) initiative of the Atal Innovation Mission provides school students with opportunities to engage in hands-on experimentation, design thinking, robotics, electronics, 3D printing, computational thinking and problem-solving activities. The present research article examines the potential of STEM education through ATL activities in enhancing creativity, innovative ideas and entrepreneurship among secondary school students. The article proposes a structured STEM–ATL intervention based on problem identification, ideation, design thinking, prototyping, testing, modification and entrepreneurial presentation. The proposed study may employ a quasi-experimental pre-test–post-test control-group design involving secondary school students of Dharwad city. Creativity, innovative thinking and entrepreneurship was assessed using appropriate validated tools. The conceptual framework suggests that regular participation in ATL activities can provide students with authentic opportunities to transform scientific knowledge into practical solutions. The official ATL framework itself emphasizes curiosity, creativity, imagination, design thinking, computational thinking and hands-on learning, while the ATL curriculum also includes business pitching and entrepreneurship-related modules. The article concludes that effective integration of STEM pedagogy with ATL activities can contribute in developing a generation of creative problem-solvers, innovators and potential young entrepreneurs.

Keywords: *STEM Education, Atal Tinkering Lab, Creativity, Innovation, Innovative Thinking, Entrepreneurship, Secondary School Students, Design Thinking, Problem Solving, Experiential Learning.*

1. Introduction

The rapid development of science and technology has transformed the nature of education, employment and social life. Contemporary education therefore needs to move beyond the transmission of factual knowledge and provide learners with opportunities to apply knowledge to real-life problems. STEM education—integrating **Science, Technology, Engineering and Mathematics**—provides an interdisciplinary framework through which students can understand concepts, investigate problems, design solutions and develop technological products.

At the secondary-school level, STEM education is particularly important because

students begin to develop abstract reasoning, independent thinking, problem-solving abilities and career aspirations. However, conventional classroom teaching may sometimes provide limited opportunities for students to experiment, construct, fail, redesign and test their own ideas.

The **Atal Tinkering Lab (ATL)** initiative of the Atal Innovation Mission was established to create innovation-oriented spaces in schools. The official ATL framework describes these laboratories as workspaces where young people can develop ideas through hands-on, do-it-yourself activities and learn STEM concepts using tools such as electronics, robotics, sensors, open-source microcontrollers, 3D printers and computers.

ATL's objectives explicitly include developing creativity, innovation, critical thinking, design thinking, computational thinking and collaboration among young people. Thus, ATL activities provide a natural environment for implementing STEM education through experiential and project-based learning.

2. Background of the Study

The Atal Innovation Mission (AIM), under NITI Aayog, has developed ATL as a school-level innovation initiative for students broadly covering Grades 6–12. AIM describes ATLs as spaces designed to stimulate curiosity and innovation through technologies including IoT, 3D printing, rapid prototyping, robotics, electronics and do-it-yourself kits.

According to the current AIM ATL overview, the programme reports **10,000 ATLs across 35 States/Union Territories and 722 districts**, with more than **1.1 crore students actively engaged** and more than **6,200 Mentors of Change**.

3. Need and Significance of the Study

The world of work increasingly requires individuals who can identify problems, generate alternatives, collaborate with others and develop innovative solutions. Therefore, schools need to cultivate not only academic achievement but also **creative confidence, innovation capability and entrepreneurial thinking**.

4. Statement of the Problem

“Effect of STEM-Based Atal Tinkering Lab Activities on Creativity, Innovative Thinking and Entrepreneurship among Secondary School Students: A Quasi-Experimental Study”

5. Objectives of the Study

General Objective

To examine the effectiveness of STEM education through Atal Tinkering Lab activities in enhancing creativity, innovative thinking and entrepreneurship among secondary school students.

Specific Objectives

1. To assess the level of creativity among secondary school students before and after exposure to STEM-based ATL activities.

2. To examine the effect of STEM-based ATL activities on students' ability to generate innovative ideas.
3. To determine the effect of ATL activities on students' entrepreneurship.
4. To compare the creativity of students exposed to STEM–ATL activities with that of students receiving conventional instructional experiences.
5. To compare the innovative thinking of students in the experimental and control groups.
6. To compare entrepreneurship between students exposed to STEM–ATL activities and students in the control group.
7. To examine the relationship among creativity, innovative thinking and entrepreneurship among secondary school students.

7. Hypotheses

The following null hypotheses were formulated:

H_o1: There is no significant difference between the pre-test and post-test creativity scores of students exposed to STEM-based ATL activities.

H_o2: There is no significant difference between the post-test creativity scores of the experimental and control groups.

H_o3: There is no significant difference between the post-test innovative-thinking scores of the experimental and control groups.

H_o4: There is no significant difference between the post-test entrepreneurial-orientation scores of the experimental and control groups.

H_o5: There is no significant relationship between creativity and innovative thinking among secondary school students.

H_o6: There is no significant relationship between innovative thinking and entrepreneurship among secondary school students.

8. Research Methodology

- **Research Approach:** A **quantitative research approach** was adopted by following a mixed-method component to understand students' experiences and perceptions.
- **Research Design:** A **quasi-experimental pre-test–post-test control-group design** was followed.

Group	Pre-test	Intervention	Post-test
Experimental	O_1	STEM–ATL Programme	O_2
Control	O_3	Conventional teaching	O_4

Where: **O_1/O_3** = Pre-test, **O_2/O_4** = Post-test, **X** = STEM–ATL intervention

9. Population, Sample and Sampling Technique

The population was consisted of students studying in **Classes VIII–X** in secondary schools having access to an ATL or comparable STEM laboratory facilities at selected government, aided and unaided secondary schools of Dharwad district.

Sample: A sample consisted of **120 secondary school students of Dharwad City as** Experimental group – 60 and Control group – 60

A purposive sampling procedure was used for school selection, followed by random

assignment of eligible students where feasible. The final sample size was ideally established through **a priori power analysis** based on the expected effect size, significance level and statistical power.

10. Variables of the Study

Independent Variable: STEM education through Atal Tinkering Lab activities

Dependent Variables: Creativity, Innovative idea generation, Entrepreneurship

Moderate Variables: Age, Gender, Grade, Previous academic achievement, Previous exposure to ATL/STEM activities, Socio-economic background and School type.

11. Tools used for Data Collection: The researcher used combination of standardized and researcher-developed tools.

Tool 1: Creativity Test: A validated creativity measure assessing dimensions such as Fluency, Flexibility, Originality and Elaboration.

Tool 2: Innovative Idea Generation Rubric: A researcher-developed rubric to assess Problem identification, Novelty, Relevance, Feasibility, Technical application, social usefulness, Prototype quality and Improvement based on feedback.

Tool 3: Entrepreneurship Scale: Dimensions include Opportunity recognition, Initiative, Risk-taking, Creativity, Persistence, Self-confidence, Innovation orientation, Problem-solving, Leadership and Value creation.

12. Findings: The study demonstrated that systematic participation in STEM-based ATL activities can contribute to:

- Higher levels of creativity.
- Greater fluency and flexibility in generating ideas.
- Greater originality in proposed solutions.
- Improved problem-solving ability.
- Greater confidence in experimentation.
- Increased interest in STEM subjects.
- Improved collaborative learning.
- Greater ability to develop prototypes.
- Improved understanding of real-world applications of science and technology.
- Greater entrepreneurship.

ATLs reported that ATLs encouraged students to explore, experiment and apply knowledge practically, while also supporting critical thinking, collaboration, interdisciplinary learning, creativity and entrepreneurial thinking. A study specifically examining ATL participation also investigated creative self-efficacy, problem-solving confidence and STEM interest, indicating the growing research interest in these outcomes.

13. Discussion

The educational value of ATL-based STEM education lies in its movement from **"learning about" technology to "learning by creating with" technology**. Traditional STEM instruction may provide students with conceptual knowledge, whereas ATL activities can provide opportunities to apply that knowledge to authentic problems.

The design-thinking cycle further promotes a culture in which failure is regarded as a component of learning. Students can test a prototype, identify its limitations, redesign it and test it again. Such processes are particularly relevant to creativity and innovation because students are encouraged to generate alternatives rather than search for one predetermined answer.

Entrepreneurial learning becomes particularly meaningful when students move from **"Can we make it?"** to **"Whom does it help, and how can it create value?"** The official ATL ecosystem has expanded beyond technical tinkering to include intellectual property, business pitching and entrepreneurship-oriented modules. Thus, ATL can serve as a bridge connecting **STEM knowledge → Creativity → Innovation → Prototype → Value creation → Entrepreneurship.**

14. Educational Implications

For Teachers: Teachers should function as **facilitators, mentors and problem-solving coaches** rather than merely transmitters of information.

For Schools: Schools should integrate ATL activities with the regular curriculum rather than treating the laboratory as an extracurricular facility.

For Teacher Education: B.Ed. and M.Ed. programmes should prepare teachers in STEM pedagogy, Design thinking, Robotics, Computational thinking, Project-based learning, Innovation assessment and Entrepreneurship education.

For Students: Students should be encouraged to Ask questions, identify local problems, Experiment, accept failure, Collaborate, build prototypes, Present ideas, Improve designs.

For Educational Administrators: ATL effectiveness should be evaluated not merely by laboratory availability but by **student participation, quality of projects, innovation outcomes, mentorship and integration with classroom learning**.

15. Conclusion

STEM education through Atal Tinkering Lab activities represents an important opportunity to transform secondary education from predominantly content-oriented learning toward **experiential, problem-centred and innovation-oriented learning**. The ATL framework provides students with access to technologies and learning experiences involving design thinking, computational thinking, physical computing, prototyping and innovation.

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ASSESSMENT, EVALUATION AND LEARNING ANALYTICS THROUGH ARTIFICIAL INTELLIGENCE: TRANSFORMING EVIDENCE-BASED EDUCATIONAL DECISION-MAKING

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Abstract

Artificial Intelligence (AI) is transforming educational assessment, evaluation, and learning analytics through continuous, personalized, predictive, and data-driven approaches. This thematic paper examines the use of machine learning, natural language processing, automated and adaptive assessment, predictive analytics, intelligent feedback, and learning dashboards in education. It highlights AI's potential to improve the efficiency, scalability, personalization, validity, and responsiveness of assessment while emphasizing concerns related to algorithmic bias, data privacy, transparency, digital inequality, academic integrity, and explain ability. The paper proposes an integrated framework linking AI-enabled assessment, learning analytics, human judgment, and continuous improvement. It concludes that AI should augment rather than replace teachers and educational evaluators, supporting informed, ethical, and learner-centered decision-making.

Keywords: *Artificial Intelligence, educational assessment, evaluation, learning analytics, machine learning, adaptive assessment, predictive analytics, automated feedback, educational technology.*

INTRODUCTION

Assessment and evaluation constitute fundamental components of the educational process. They provide evidence about learners' knowledge, skills, competencies, attitudes, progress, and learning needs while also supporting decisions concerning teaching, curriculum, educational programmers, and institutional effectiveness. Traditionally, assessment has relied heavily on examinations, assignments, teacher observations, portfolios, projects, and standardized tests. Although these approaches continue to be important, contemporary educational environments generate increasingly large and diverse volumes of digital learning data. The emergence of Artificial Intelligence has created new possibilities for transforming these processes. AI systems can analyze structured and unstructured educational data, identify patterns, generate predictions, provide automated feedback, support adaptive assessment, and assist educators in making evidence-informed decisions. Learning Management Systems, online learning platforms, digital assessment systems, educational applications, intelligent tutoring systems, and virtual learning environments continuously generate information about learners' interactions and performance. The development of

learning analytics has further strengthened this transformation. Learning analytics involves the measurement, collection, analysis, and reporting of data about learners and their contexts for understanding and optimizing learning and the environments in which learning occurs. AI extends these capabilities by enabling automated pattern recognition, predictive modeling, natural language processing, recommendation systems, and intelligent interventions. However, technological capability does not automatically guarantee educational validity. An algorithm may identify a statistical pattern without adequately understanding the learner's social, emotional, cultural, linguistic, or contextual circumstances. Therefore, the integration of AI into assessment and evaluation requires a balance between technological efficiency and human educational judgment.

CONCEPTUALIZING ARTIFICIAL INTELLIGENCE IN EDUCATION

Artificial Intelligence refers broadly to computational systems capable of performing tasks that traditionally require human cognitive capabilities, such as learning, reasoning, prediction, language processing, pattern recognition, and decision support. Within education, AI can be understood as a collection of technologies that support teaching, learning, assessment, administration, and educational decision-making.

Important AI technologies relevant to assessment and learning analytics include:

- Machine learning
- Deep learning
- Natural language processing
- Generative AI
- Computer vision
- Knowledge-based systems
- Predictive analytics
- Recommendation systems
- Intelligent tutoring systems
- Automated feedback systems

The educational value of these technologies depends not merely on their computational capacity but on their alignment with pedagogical objectives, assessment principles, institutional requirements, and ethical standards.

AI IN EDUCATIONAL ASSESSMENT

AI is changing assessment from predominantly periodic measurement toward more continuous and adaptive forms of evidence collection.

Automated Assessment

AI can support the automated scoring of objective questions and, increasingly, constructed responses. Natural language processing can analyse written responses for linguistic characteristics, organization, and selected dimensions of content. Automated assessment can reduce teachers' routine workload and provide rapid results. However, automated scoring should be carefully validated because complex human responses may contain contextual,

creative, cultural, and disciplinary characteristics that algorithms may not adequately recognize.

Adaptive Assessment

AI-supported adaptive assessment modifies the difficulty, sequence, or type of questions according to learners' previous responses.For example, if a learner demonstrates mastery of basic mathematical concepts, the system may provide more challenging questions. If the learner experiences difficulty, the system may provide additional foundational items or learning resources. Adaptive assessment can therefore move assessment toward individualized measurement rather than applying identical assessment experiences to all learners.

Intelligent Feedback

One of the most significant contributions of AI is the capacity to generate immediate feedback. Traditional assessment frequently separates performance from feedback because learners may receive results days or weeks after completing an activity. AI-enabled systems can provide immediate indications of errors, explanations, suggestions, and learning resources. Effective feedback should not simply identify whether an answer is correct or incorrect. It should support learners in understanding:

- What they have achieved
- Where they have made an error
- Why the error occurred
- How they can improve
- What they should learn next

AI IN EDUCATIONAL EVALUATION

Educational evaluation extends beyond individual learner assessment. It includes the systematic examination of curricula, programmers, teaching effectiveness, institutional performance, educational interventions, and learning outcomes.AI can support evaluation through large-scale data analysis.

Programme Evaluation

AI-based analytics can examine data from multiple sources to identify patterns in programme participation, achievement, retention, completion, and learner satisfaction.

Teacher and Teaching Evaluation

Learning analytics can provide evidence concerning student engagement, participation, assessment performance, and learning progression. Such information can potentially contribute to reflective teaching practices. However, AI-generated indicators should not be treated as definitive measures of teacher quality. Teaching effectiveness is multidimensional and includes relationships, classroom climate, inclusion, creativity, professional judgment, and contextual responsiveness.

Institutional Evaluation

Educational institutions can use analytics to monitor:

- Student retention
- Course completion
- Academic achievement
- Attendance
- Engagement
- Resource utilization
- Progression
- Student satisfaction

AI can help identify patterns that may otherwise remain difficult to detect manually.

AI AND LEARNING ANALYTICS

Learning analytics provides the data foundation through which AI can support educational decision-making. A simplified AI-enabled learning analytics cycle can be represented as:

Data Collection → Data Integration → Data Processing → Pattern Identification → Prediction → Interpretation → Intervention → Evaluation.

Data Collection

Educational data may originate from:

- Learning Management Systems
- Online assessments
- Digital classrooms
- Learning applications
- Student information systems
- Discussion forums
- Digital libraries
- E-portfolios
- Attendance systems.

Descriptive Analytics

Descriptive analytics examines what has happened.

- Examples include:
- Number of learning activities completed
- Assessment scores
- Attendance patterns
- Time spent on learning activities
- Assignment submission patterns

Diagnostic Analytics

Diagnostic analytics attempts to identify why a particular learning pattern has occurred. For example, an analytics system may identify that students who repeatedly fail a particular concept also show difficulty with prerequisite concepts.

Predictive Analytics

Predictive analytics estimates possible future outcomes.AI models can potentially identify learners who may be at risk of:

- Academic failure
- Course withdrawal
- Low engagement
- Delayed completion

Such predictions should be used to provide support rather than to label or stigmatize learners.

Prescriptive Analytics

Prescriptive analytics goes beyond predicting an outcome and recommends possible actions. For example, an AI system may recommend:

- Remedial instruction
- Additional practice
- Alternative learning resources
- Individualized learning activities
- Teacher intervention
- Peer-supported learning

PERSONALIZED ASSESSMENT THROUGH AI

One of the major promises of AI is personalization is Learners differ in their prior knowledge, learning pace, interests, cognitive characteristics, language backgrounds, and learning needs. A standardized assessment system may not adequately capture these differences.AI can analyse learner data and support individualized assessment pathways. A personalized assessment system may:

Assess → Diagnose → Adapt → Provide Feedback → Reassess

This creates a continuous learning-assessment cycle.

Personalized assessment can potentially improve learner engagement because learners receive activities that are more closely aligned with their current level of understanding.

Predictive Learning Analytics

Predictive learning analytics represents an important application of AI. For example, a system may analyse combinations of:

- Previous assessment performance
- Attendance
- Learning activity
- Assignment submission
- Interaction frequency
- Assessment attempts
- Course progression

To estimate the likelihood of future academic difficulties. However, predictive analytics should be regarded as an early-warning mechanism rather than an unquestionable prediction of an individual's future. A learner classified as “at risk” may improve substantially after

receiving appropriate support. Consequently, predictive information should trigger human intervention rather than determine educational outcomes automatically.

AI-GENERATED ASSESSMENT AND GENERATIVE AI

Generative AI has introduced new possibilities for assessment design. It can assist teachers in generating:

- Multiple-choice questions
- Short-answer questions
- Case studies
- Problem-based tasks
- Scenario-based questions
- Rubrics
- Feedback
- Differentiated assessment materials

Generative AI can also support the creation of formative assessment activities tailored to different levels of learner proficiency. Nevertheless, human review remains essential because AI-generated content may contain factual inaccuracies, inappropriate assumptions, biased representations, or poorly aligned assessment objectives.

AI, ACADEMIC INTEGRITY AND ASSESSMENT SECURITY

The emergence of generative AI has also created new challenges for conventional assessment. If students can use AI systems to generate essays, solve problems, summarize sources, or produce assignments, institutions need to reconsider what assessment should measure. Instead of relying exclusively on product-oriented assessment, educational institutions may increasingly emphasize:

- Oral examinations
- Viva voce
- Project-based assessment
- Performance tasks
- Reflective journals
- Process portfolios
- Authentic assessment
- Classroom-based activities
- Application-oriented tasks

The objective should not simply be to detect AI use but to redesign assessment so that it measures meaningful human learning, reasoning, creativity, reflection, and application.

ETHICAL ISSUES IN AI-BASED ASSESSMENT AND LEARNING ANALYTICS

Data Privacy

Educational data may include sensitive information concerning learners' performance, behavior, interactions, and educational history. Institutions must therefore establish clear policies regarding:

- Data collection
- Data storage
- Data access
- Data sharing
- Data retention
- Data deletion
- Consent

Algorithmic Bias

AI systems learn from data. If historical data contain inequalities or biases, algorithms may reproduce or amplify them. Bias may emerge through:

- Language
- Socioeconomic background
- Gender
- Disability
- Cultural differences
- Digital access
- Geographic location

Therefore, AI assessment systems require continuous auditing and validation.

Transparency and Explain ability

Teachers and learners should have reasonable understanding of how significant AI-supported decisions are generated. A system that produces a risk score without explaining the relevant evidence may undermine trust.

Human Oversight

Educational decisions should not be completely delegated to algorithms. Human educators should remain responsible for interpreting AI-generated evidence and considering contextual information that may not be visible in digital data.

Digital Inequality and Inclusion

AI-enabled assessment can potentially improve accessibility, but it can also create new forms of inequality. Learners may differ in their access to:

- Reliable internet
- Digital devices
- AI tools
- Assistive technologies
- Digital literacy
- Learning platforms

Therefore, AI implementation should be accompanied by policies addressing the digital divide.

Inclusive AI assessment should consider learners with disabilities and provide appropriate

accessibility features such as:

- Screen-reader compatibility
- Alternative formats
- Speech-based interaction
- Adjustable presentation
- Multilingual support
- Assistive technologies.

TEACHER'S ROLE IN AI-ENABLED ASSESSMENT

AI should be conceptualized as a tool for teacher augmentation rather than teacher replacement.

Teachers contribute dimensions of educational judgment that AI cannot fully reproduce, including:

- Understanding learners' contexts
- Recognizing emotional and social factors
- Interpreting unexpected responses
- Providing empathetic support
- Designing meaningful learning experiences
- Making professional judgments

The future teacher therefore requires not only pedagogical competence but also AI literacy and data literacy.

Teachers should be able to:

- Understand basic AI concepts.
- Interpret analytics responsibly.
- Evaluate AI-generated feedback.
- Identify potential algorithmic bias.
- Protect learner data.
- Verify AI-generated content.
- Integrate AI with pedagogical objectives.
- Maintain meaningful human interaction.

BENEFITS OF AI IN ASSESSMENT, EVALUATION AND LEARNING ANALYTICS

For Learners

- Immediate feedback
- Personalized learning pathways
- Adaptive assessment
- Identification of learning gaps
- Increased opportunities for practice
- Greater learner autonomy

For Teachers

- Reduced routine assessment workload
- Faster analysis of learner performance

- Early identification of learning difficulties
- Data-informed instructional planning
- Individualized feedback support

For Institutions

- Evidence-based decision-making
- Monitoring of student progression
- Improved programme evaluation
- Early-warning systems
- More efficient use of educational resources

For Researchers

- Large-scale educational data analysis
- Identification of learning patterns
- Development of predictive models
- Evaluation of educational interventions
- New opportunities for longitudinal research.

CHALLENGES AND LIMITATIONS

1. AI systems depend heavily on the quality and representativeness of available data. Poor-quality data can produce unreliable conclusions.
2. Educational learning is multidimensional. Not every important aspect of learning can be reduced to measurable digital indicators.
3. Predictive models can create self-fulfilling effects if teachers treat predictions as fixed outcomes.
4. , excessive dependence on AI may reduce professional autonomy and critical judgment.
5. Implementation requires infrastructure, technical expertise, teacher training, financial investment, and institutional governance.

Therefore, successful implementation requires an ecosystem rather than merely the adoption of an AI application.

IMPLICATIONS FOR TEACHER EDUCATION

Teacher education institutions should incorporate AI and learning analytics into pre-service and in-service teacher education. Teacher education programmes should develop competencies in:

- AI literacy
- Data literacy
- Digital assessment
- Ethical use of learner data
- AI-assisted feedback
- Adaptive assessment
- Learning analytics interpretation
- AI-supported instructional design
- Critical evaluation of AI tools

Teacher educators should also emphasize the limitations and risks of AI rather than presenting technology exclusively as a solution to educational challenges.

IMPLICATIONS FOR EDUCATIONAL POLICY

Policymakers should establish comprehensive frameworks for responsible AI use in education.

Policy priorities should include:

- Data protection and privacy.
- Transparency and accountability.
- Algorithmic fairness.
- Accessibility and inclusion.
- Human oversight.
- Teacher professional development.
- AI literacy.
- Institutional governance.
- Digital infrastructure.
- Ethical standards for educational AI.

AI policy should focus not only on technological innovation but also on educational quality, learner rights, equity, and human development.

CONCLUSION

AI is transforming educational assessment by making it continuous, personalized, adaptive, and data-driven. It helps teachers identify learning gaps, provide quick feedback, and support individual learning. However, AI should support, not replace, teachers, because education requires human judgment and understanding. The effective use of AI in assessment should focus on integration of Accuracy, Personalization, Equity and Human Oversight. Thus, AI and teachers should work together to improve learning, assessment, and educational quality.

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DIGITAL WELL-BEING AND PRE-SERVICE TEACHER READINESS FOR 21ST-CENTURY CLASSROOMS: DEVELOPMENT OF THE DIGITAL WELL-BEING AND PRE-SERVICE TEACHER READINESS MODEL

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Abstract

The digital transformation of education has expanded teachers' responsibilities from basic technology use to digital content creation, technology-integrated teaching, online collaboration, digital assessment, information evaluation, and responsible engagement with emerging technologies. Consequently, preparing pre-service teachers for digitally transformed classrooms requires more than developing operational digital skills. Recent evidence indicates that pre-service teachers may demonstrate basic digital competence while experiencing challenges in pedagogical integration, digital safety, critical engagement, psychological preparedness, and the practical application of technology. Readiness is also shaped by institutional support, infrastructure, cultural contexts, and opportunities for authentic practice. Against this background, this paper develops the Digital Well-being and Pre-Service Teacher Readiness (DWPTR) Model through a literature-based conceptual synthesis. Relevant theoretical frameworks and recent empirical studies were examined to identify recurring concepts related to digital competence, pedagogy, psychological readiness, intercultural competence, institutional support, digital well-being, and teacher readiness. The synthesis resulted in five foundational inputs, namely digital competence, pedagogical knowledge, psychological readiness, intercultural competence, and institutional and infrastructural support. These inputs are conceptualized as contributing to pre-service teacher readiness, which is expressed through digital self-regulation, digital resilience, ethical awareness, critical engagement, and professional boundaries. These digital well-being processes are subsequently connected with teacher readiness outcomes, including effective technology integration, meaningful digital teaching, critical thinking, collaboration, innovation, problem-solving, inclusive digital pedagogy, ethical practice, intercultural communication, adaptability, and sustainable professional practice. The model is proposed as a conceptual framework rather than a validated causal model and provides a basis for future empirical testing across diverse educational contexts.

Keywords: *digital well-being, pre-service teachers, digital competence, teacher readiness, digital resilience, digital pedagogy, intercultural competence, teacher education*

1.0.0 Introduction

Digital technologies have transformed contemporary education through learning management systems, online assessment, educational applications, digital content, virtual collaboration, artificial intelligence, and other emerging technologies. Teachers are consequently expected not only to operate digital tools but also to select, evaluate, adapt, create, and integrate them according to instructional purposes and learner needs (European Commission, 2022; UNESCO, 2018). Teacher education must therefore prepare pre-service teachers for technological as well as pedagogical, psychological, ethical, cultural, and professional demands. However, digital competence cannot be equated with teacher readiness. Digital competence concerns the knowledge, skills, and attitudes required to use digital technologies, whereas readiness concerns the preparedness to translate these capabilities into appropriate professional teaching practice. Alnasib (2023), for example, found that among the five DigComp areas (identifying information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving) examined, digital safety represented the weakest area for the participating pre-service teachers. Maghfiroh et al. (2024) similarly reported variation in prospective teachers' levels of digital competence, with only some participants expressing readiness to integrate a variety of digital technologies into classroom teaching. A recent systematic review by Zeng et al. (2025) further identified training and curriculum support, psychological and environmental support, policy and resource environments, legal and ethical considerations, and individual characteristics as important influences on pre-service teachers' digital competence. Zhang et al. (2026) likewise indicate that digital competence is increasingly considered in relation to sustainable educational practice rather than technology operation alone. Pedagogical integration represents another important challenge. TPACK emphasizes that meaningful educational technology use requires the interaction of technological, pedagogical, and content knowledge (Koehler et al., 2013). Tomczyk's (2024) global study involving 35 experts from 33 countries highlighted areas including digital content creation, ICT integration, media literacy, data protection, e-risks, and classroom interaction as important concerns for pre-service teacher preparation. Kınık (2025) also examined pre-service teachers' digital capabilities and readiness for digital pedagogies. More recent intervention evidence from Shogbesan et al. (2026) indicates that structured digital-age teaching experiences can improve digital literacy, instructional planning, collaborative learning, and technology integration. Readiness is additionally shaped by context. Aridan et al. (2025) examined 6,113 pre-service language teachers across five Asian countries and identified differences in technological, pedagogical, and affective readiness, demonstrating that readiness cannot be separated from institutional and educational environments. Zulaiha (2025) similarly found that Papuan preservice teachers developed adaptive, "offline-first" practices while facing constraints involving internet access, electricity, devices, and professional training. These findings point to an important conceptual issue. Existing literature provides substantial knowledge about digital competence,

technology integration, teacher readiness, psychological factors, ethical technology use, and contextual support, but these elements are often discussed separately. What is needed is a framework that explains how different foundational conditions come together to constitute pre-service teacher readiness and how this readiness is translated into healthy, ethical, critical, and sustainable technology engagement. Digital well-being provides a useful perspective for addressing this issue. For teachers, digital well-being is not simply the absence of digital stress or reduced screen time. It concerns the ability to engage with technology in ways that support purposeful, safe, ethical, critical, socially appropriate, and sustainable professional functioning. Accordingly, the purpose of this paper is to develop and theoretically justify the Digital Wellbeing and Pre-Service Teacher Readiness (DWPTR) Model through a synthesis of relevant literature. The paper addresses two questions:

RQ1. What factors and concepts in the literature are relevant to digital well-being and digital readiness among pre-service teachers?

RQ2. How can these factors and concepts be integrated into a conceptual model explaining pre-service teacher readiness and sustainable digital teaching practice?

2.0.0 Approach to Digital Well-being and Pre-Service Teacher Readiness Model (DWPTR) Development

This is a conceptual/model-development paper based on literature synthesis, rather than an empirical study, systematic review, meta-analysis, or statistical model-validation study. The purpose was to identify recurring concepts in relevant theoretical frameworks and empirical research and then integrate those concepts into a coherent conceptual structure. The modeldevelopment process follows the logic specified in the study plan, that is, literature identification → concept extraction → thematic grouping → theoretical integration → identification of relationships → conceptual model construction → conceptual refinement → propositions. The literature supplied for this paper was examined around recurring areas of digital competence, pedagogical integration, psychological readiness, digital well-being, ethics and safety, intercultural competence, institutional support, infrastructure, resilience, and teacher readiness. Established frameworks were used to provide theoretical grounding, while recent empirical studies were used to identify contemporary evidence and contextual variation. The process did not assume that any one existing framework adequately represented the complete construct of pre-service teacher readiness. Instead, recurring concepts were compared and grouped according to their conceptual role. Concepts representing knowledge, skills, psychological resources, cultural capacity, and environmental conditions were grouped as foundational inputs. Concepts concerned with regulating and sustaining technology engagement were grouped as the digital well-being process. Finally, concepts representing professional manifestations of readiness were grouped as teacher readiness outcomes. Thus, the DWPTR Model is an author-developed conceptual synthesis rather than an existing model adopted unchanged from a single theory.

3.0.0 Literature Foundations of the Digital Well-being and Pre-Service Teacher Readiness (DWPTR) Model

3.1.0 Foundational input

3.1.1 Digital competence

Digital competence provides the technological foundation for participation in contemporary education. DigComp identifies information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving as important areas of digital competence (European Commission, 2022). The UNESCO ICT Competency Framework for Teachers similarly connects ICT competence with teaching, learning, professional development, and educational transformation (UNESCO, 2018).

However, the evidence suggests that competence is necessary but insufficient. Alnasib (2023) demonstrated that although pre-service teachers possessed competencies across several digital areas, digital safety remained comparatively weak. Zeng et al. (2025) found that many preservice teachers possess fundamental digital competencies while challenges remain in ethical awareness, pedagogical integration, and critical thinking. These findings provide the rationale for positioning digital competence as the first foundational input, rather than treating it as equivalent to complete teacher readiness.

3.1.2 Pedagogical knowledge

Digital technology becomes educationally meaningful when it is integrated with pedagogy and content. TPACK explains this integration through the interaction of technological, pedagogical, and content knowledge (Koehler et al., 2013). Therefore, knowing how to operate a digital platform does not necessarily mean knowing whether it is appropriate for a particular learning objective, subject, learner group, or assessment context.

Tomczyk (2024) identified ICT integration with subject content, digital content creation, classroom interaction, media literacy, and other pedagogically relevant areas as important concerns for future teacher education. Shogbesan et al. (2026) further found positive effects of a structured digital-age teaching intervention on digital literacy, instructional planning, collaborative learning, and technology integration.

Consequently, pedagogical knowledge was included as a second foundational input. It represents instructional design, assessment, learner engagement, classroom management, and subject-specific pedagogy. Its inclusion reflects the principle that technology should serve teaching and learning purposes rather than become an end in itself.

3.1.3 Psychological readiness

Technology integration also involves psychological resources. Self-Determination Theory identifies autonomy, competence, and relatedness as important psychological needs associated with motivation and well-being (Ryan & Deci, 2020). In teacher education,

autonomy can involve making informed choices about technology; competence can involve confidence in using digital tools effectively; and relatedness can involve support from peers, mentors, teacher educators, and professional communities.

Zeng et al. (2025) identified psychological and environmental support as important influences on pre-service teachers' digital competence. Aridan et al. (2025) also included affective readiness alongside technological and pedagogical readiness in their cross-regional investigation. Therefore, psychological readiness—including self-efficacy, motivation, confidence, adaptability, and resilience—is positioned as a foundational input to readiness.

3.1.4 Intercultural competence

Digital teaching occurs in culturally and linguistically diverse environments. Learners differ in language, cultural experience, socioeconomic circumstances, access to technology, and educational expectations. Therefore, technology-integrated teaching cannot be understood as culturally neutral.

Aridan et al. (2025) provide cross-regional evidence that technological, pedagogical, and affective readiness varies across educational contexts. Tomczyk (2024), drawing on expert perspectives from 33 countries, likewise demonstrates the global and socially situated nature of digital competence. These findings support the inclusion of intercultural competence as a foundational input involving cultural awareness, intercultural communication, sensitivity to diverse learners, and critical interpretation of digital content.

The purpose is not to rank cultures according to digital capability but to recognize that appropriate digital teaching must respond to cultural and educational context.

3.1.5 Institutional and infrastructural support

Individual capability cannot always be translated into classroom practice without adequate environmental conditions. Devices, connectivity, technical assistance, mentoring, professional development, curriculum support, and institutional policies can influence the opportunities available to pre-service teachers.

Zeng et al. (2025) identified policy systems, resource environments, training, curriculum support, and psychological and environmental support as major influences on digital competence. Zulaiha (2025) provides a particularly clear contextual example: Papuan preservice teachers demonstrated resilience and offline-first approaches while their digital practices were constrained by inadequate connectivity, electricity, devices, and professional development.

Accordingly, institutional and infrastructural support constitutes the fifth foundational input in the DWPTR Model.

From Foundational Inputs to Pre-Service Teacher Readiness

The synthesis of the literature indicates that the five inputs should not be understood as isolated variables. Rather, together they contribute conceptually to a broader state of pre-service teacher readiness.

A digitally competent teacher may know how to use a platform but may lack pedagogical

knowledge about its appropriate use. A teacher with pedagogical knowledge may struggle to implement digital teaching without confidence or motivation. A technically and pedagogically capable teacher may encounter difficulties when working with culturally diverse learners. Similarly, individual competence may not translate into practice where connectivity, devices, mentoring, or institutional support are inadequate.

The central oval in the DWPTR Model therefore represents Pre-Service Teacher Readiness as the point at which these foundational capacities come together. In the present model, a ready pre-service teacher is conceptualized as:

- digitally competent;
- ethically grounded;
- culturally responsive;
- well-being oriented; and
- prepared for future teaching demands.

This positioning is important because it distinguishes readiness from competence. Readiness represents a broader preparedness to use digital technologies within professional teaching contexts, while competence represents one important foundation of that preparedness.

4.0.0 Digital Well-being Process

The next conceptual step in the model is the Digital Well-being Process. Digital well-being is treated here as a process rather than simply as an outcome. It concerns how a digitally prepared teacher regulates, evaluates, and sustains technology engagement.

Five processes were derived for the present model.

Digital self-regulation

Digital self-regulation refers to the ability to manage attention, time, technology use, digital habits, and technology-related behavior purposefully. It is important because effective digital teaching requires intentional use rather than continuous or unnecessary technology engagement.

Digital resilience

Digital resilience refers to the capacity to adapt when technologies change, fail, become unavailable, or create unexpected challenges. Zulaiha's (2025) evidence of offline-first practices illustrates why resilience should be understood in relation to actual technological environments rather than solely as an individual characteristic.

Ethical awareness

Teachers increasingly interact with learner information, digital assessment, online communication, digital content, and artificial intelligence. Ethical awareness therefore includes privacy, cybersecurity, copyright, responsible AI use, digital identity, and appropriate professional conduct. Alnasib (2023) and Zeng et al. (2025) reinforce the importance of safety and ethical dimensions within digital competence.

Critical engagement

Critical engagement involves evaluating digital information, online content, misinformation,

algorithms, AI-generated outputs, and the educational consequences of technology. This process extends digital competence beyond operational skill toward informed professional judgment.

Professional boundaries

Professional boundaries concern appropriate relationships between teachers, learners, colleagues, and digital technologies. They include managing digital workload, online communication, professional identity, and the boundary between professional and personal digital engagement.

Taken together, these five processes explain how readiness is enacted through a healthy, ethical, critical, and sustainable relationship with technology.

5.0.0 Teacher Readiness Outcomes

The final component of the model consists of Teacher Readiness Outcomes. These outcomes represent the professional expression of readiness in digitally transformed classrooms.

The literature supports several interconnected outcomes. Pedagogically meaningful digital teaching and effective technology integration follow from combining digital competence with pedagogical knowledge (Koehler et al., 2013). Critical thinking and ethical practice are supported by critical digital literacy, safety, privacy, and responsible engagement (Alnasib, 2023; Tomczyk, 2024). Collaboration and innovation are connected with the social and pedagogical dimensions of digital teaching, while problem-solving and adaptability are important for responding to technological change (Kınık, 2025; Shogbesan et al., 2026).

The model therefore identifies the following outcomes: effective technology integration; pedagogically meaningful digital teaching; critical thinking; collaborative learning; innovation; problem-solving; inclusive digital pedagogy; ethical practice; intercultural communication; adaptability; and sustainable professional practice.

These outcomes distinguish a teacher who can simply operate digital tools from one who can use technology purposefully and responsibly to support teaching and learning over time.

6.0.0 Digital well-being and Pre-Service Teacher Readiness (DWPTR) Model

The literature synthesis can now be expressed as a clear model-development sequence.

First, digital competence research demonstrated that teachers require knowledge and skills for digital participation, but competence alone is insufficient.

Second, TPACK demonstrated the importance of connecting technological knowledge with pedagogy and content, leading to the inclusion of pedagogical knowledge.

Third, psychological perspectives demonstrated the importance of confidence, motivation, autonomy, resilience, and support, leading to psychological readiness.

Fourth, cross-cultural research demonstrated that readiness is influenced by linguistic, cultural, institutional, and educational contexts, supporting intercultural competence.

Fifth, research on digital competence and digital divides demonstrated that infrastructure, resources, mentoring, and institutional support influence whether individual capability can be translated into practice.

Sixth, the literature on digital well-being indicates that sustainable technology engagement requires self-regulation, resilience, ethical awareness, critical engagement, and appropriate professional boundaries.

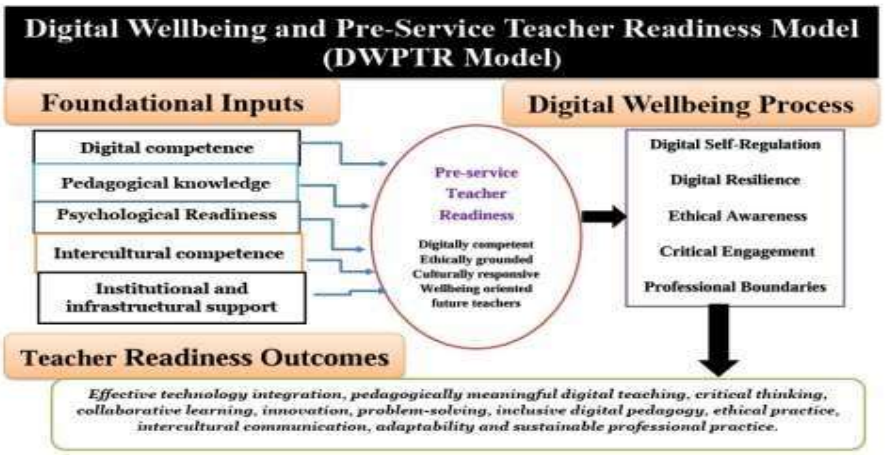
Finally, the literature on technology-integrated teaching identifies professional outcomes such as meaningful technology integration, collaboration, innovation, critical thinking, adaptability, and sustainable practice.

These findings led to the conceptual sequence:

Foundational Inputs → *Pre-Service Teacher Readiness* → Digital well-being Process → Teacher Readiness Outcomes**.**

This is the conceptual logic represented in the DWPTR Model.

Figure 1: Digital well-being and Pre-Service Teacher Readiness (DWPTR) Model



Developed by: Shruthi, Vilma D'Souza, & Dr Flosy C R D'Souza

Note: The arrows represent proposed conceptual relationships derived from the literature and do not represent statistically tested causal pathways.

The model should not be interpreted as strictly linear. The arrows indicate the conceptual direction proposed by the synthesis, while the relationships may be dynamic and mutually reinforcing. For example, greater readiness may strengthen self-regulation and confidence, while effective digital well-being processes may support the sustainability of readiness.

7.0.0 Conceptual Propositions

Based on the literature-to-model synthesis, the following propositions are advanced for future empirical examination:

Proposition 1: Digital competence provides an essential foundation for pre-service teacher readiness but does not by itself constitute complete digital teaching readiness.

Proposition 2: Pedagogical knowledge enables pre-service teachers to translate digital capabilities into purposeful and meaningful instructional practice.

Proposition 3: Psychological readiness supports pre-service teachers' capacity to adapt to technological change and sustain digital engagement.

Proposition 4: Intercultural competence supports culturally responsive and inclusive digital teaching practice.

Proposition 5: Institutional and infrastructural support influences the extent to which individual digital capabilities can be translated into professional practice.

Proposition 6: Pre-service teacher readiness may support digital self-regulation, resilience, ethical awareness, critical engagement, and appropriate professional boundaries.

Proposition 7: Digital well-being processes may contribute to effective, ethical, inclusive, adaptable, and sustainable technology-integrated teaching.

Proposition 8: Cultural and contextual conditions may shape the expression of both digital well-being and teacher readiness across educational settings.

These propositions are not tested hypotheses. They provide directions for subsequent empirical research.

8.0.0 Implications for Teacher Education

The DWPTR Model has several implications for teacher education.

First, programs should move beyond tool-centered training toward integrated digitalpedagogical preparation. Pre-service teachers should learn not only how technologies operate but also when and why they should be used for particular instructional purposes (Koehler et al., 2013; Tomczyk, 2024). Second, digital well-being should be explicitly addressed through activities related to selfregulation, digital stress, ethical technology use, cybersecurity, privacy, critical engagement, professional boundaries, and responsible AI. Third, teacher education should provide authentic opportunities for practice, including digital microteaching, technology-integrated lesson planning, online assessment, collaborative digital projects, and reflective practice. Evidence from Shogbesan et al. (2026) supports the value of structured digital-age teaching interventions. Fourth, institutions need to provide adequate infrastructure and support, including connectivity, devices, technical assistance, mentoring, and professional development. Finally, digital preparation should be contextually and culturally responsive. Where infrastructure is limited, offline-first resources, downloadable content, low-bandwidth platforms, and locally relevant digital materials may be more appropriate than technology models dependent on continuous connectivity. Zulaiha (2025) provides evidence for the importance of such contextual adaptation.

9.0.0 Limitations and Future Research

The DWPTR Model is a conceptual model and has not been empirically validated. The relationships represented by the arrows are therefore theoretical propositions rather than established causal relationships. The five foundational inputs, five digital well-being processes, and proposed outcomes represent a synthesis of the literature rather than a universal taxonomy. Future studies should operationalize the constructs and develop valid measurement instruments. Exploratory and confirmatory factor analyses can examine the underlying structure, while structural equation modelling can test the proposed relationships. Longitudinal studies could examine whether digital well-being processes contribute to the sustainability of teacher readiness over time. Intervention studies could evaluate whether teacher education programmes designed around the model improve readiness outcomes. Cross-cultural and qualitative research is also needed to determine how the model operates across different linguistic, cultural, institutional, and infrastructural settings.

10.0.0 Conclusion

The rapid digital transformation of education requires teacher preparation to move beyond a narrow understanding of technological competence. The literature reviewed in this paper indicates that pre-service teacher readiness is shaped by technological capability, pedagogical knowledge, psychological resources, intercultural competence, and institutional and infrastructural conditions. At the same time, sustainable technology use requires teachers to regulate their digital engagement, demonstrate resilience, act ethically, engage critically, and maintain appropriate professional boundaries. The central contribution of the DWPTR Model is therefore its integration of digital capability, teacher readiness, and digital well-being within a single conceptual structure. Rather than viewing a digitally ready teacher simply as someone who can operate technology, the model conceptualizes readiness as the capacity to use technology competently, pedagogically, ethically, critically, culturally responsively, and sustainably. The model remains a theoretical proposition and requires empirical validation. Nevertheless, it provides a structured basis for future research and for redesigning teacher education programs around the broader goal of developing future teachers who are not merely technologically capable, but digitally competent, ethically grounded, culturally responsive, well-beingoriented, and prepared for sustainable professional practice.

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A STUDY ON ARTIFICIAL INTELLIGENCE IN COMMERCE EDUCATION PEDAGOGY: CHALLENGES AND OPPORTUNITIES

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Abstract

Artificial Intelligence (AI) is becoming an increasingly important part of the educational environment and is influencing the way teaching, learning, assessment and educational resources are developed. The emergence of generative AI has further expanded these possibilities by enabling users to create text, explanations, questions, examples and other learning materials. These developments have important implications for teacher education because future teachers need to develop not only subject and pedagogical knowledge but also the ability to use emerging technologies critically and responsibly.Commerce education provides considerable scope for the application of AI because disciplines such as Accountancy, Business Studies, Economics, Entrepreneurship and related subjects involve problem-solving, interpretation, decision-making and the application of concepts to practical situations. For B.Ed. student-teachers specialising in Commerce, AI can support lesson preparation, development of teaching-learning materials, case-based learning, assessment and personalised learning. However, its integration also raises concerns relating to accuracy, academic integrity, privacy, ethical use, digital inequality and excessive dependence on technology.The present paper examines the role of Artificial Intelligence in Commerce education pedagogy, the opportunities and challenges associated with its integration, and emerging trends in pre-service teacher education, with particular reference to Karnataka. The study adopts a descriptive and analytical approach based on secondary data. Information was drawn from relevant policy documents, reports, scholarly literature, and other published sources related to AI, education, teacher education, and Commerce pedagogy. The paper argues that effective AI integration requires more than technological access. It requires appropriate curriculum integration, AI literacy, pedagogical competence, ethical awareness, and continuous professional development among student-teachers and teacher educators. The study concludes that a human-centered and pedagogically appropriate approach to AI can strengthen the preparation of future Commerce teachers in Karnataka.

Keywords: *Artificial Intelligence, Commerce Education, Commerce Pedagogy, Pre-service Teachers, B.Ed., Teacher Education, AI Literacy, Karnataka*

1. Introduction

Education has always responded to changes in society, technology and the nature of work. In recent years, Artificial Intelligence has emerged as one of the most significant

technological developments affecting education. Unlike earlier digital technologies that primarily provided access to information or supported its presentation, contemporary AI systems can generate content, analyse information, respond to questions and assist users in performing a variety of intellectual tasks.

The emergence of generative AI has made these developments more visible in educational settings. Students can use AI systems to obtain explanations and examples, while teachers can use them to prepare learning resources, questions, activities and other instructional materials. UNESCO has highlighted both the opportunities and risks associated with generative AI in education, particularly in relation to human agency, equity, privacy, ethics and responsible use.

The development of AI has important implications for teacher education. Future teachers are likely to work in classrooms where learners have increasing access to AI-enabled technologies. Therefore, teacher education cannot limit itself to traditional pedagogical knowledge and basic digital literacy. Student-teachers need to understand the possibilities and limitations of AI and learn to make informed decisions regarding its educational use.

The issue is particularly relevant to Commerce education. Commerce is a dynamic field connected with business, finance, economics, entrepreneurship, accounting and management. Effective Commerce teaching requires students to understand concepts as well as apply them to practical and changing situations. AI can potentially support this process by providing examples, business cases, simulations, problem-solving activities, assessment questions and differentiated learning resources.

In the context of Karnataka, these developments have implications for B.Ed. programmes and the preparation of Commerce student-teachers. The National Education Policy (NEP) 2020 emphasises the appropriate use of technology in education, including teaching-learning, assessment, teacher preparation and professional development. Consequently, there is a need to consider how emerging AI technologies can be meaningfully connected with Commerce pedagogy and pre-service teacher education.

The present paper therefore focuses on the role of AI in Commerce education pedagogy and examines its opportunities, challenges and emerging trends in pre-service teacher education, with particular reference to Karnataka.

2. Need and Significance of the Study

The increasing presence of AI in education creates a need to reconsider the competencies expected from future teachers. Traditional teacher education generally gives importance to subject knowledge, pedagogical knowledge, classroom management, assessment, and educational technology. The development of AI introduces another dimension to these competencies.

For Commerce student-teachers, the issue is particularly important because Commerce education involves subjects that are closely connected with data, business decisions, financial information, economic developments and changing commercial practices.

AI may provide useful support in presenting these concepts in more practical and interactive ways. At the same time, the availability of AI tools can create problems if student-teachers use them without adequate understanding. AI-generated information may be inaccurate, and excessive dependence on AI may reduce opportunities for independent thinking and professional decision-making. Questions relating to academic integrity, privacy and responsible use are also becoming increasingly relevant.

Therefore, the importance of the present study lies in examining AI not simply as a technological innovation but as an emerging issue in Commerce teacher preparation and pedagogy.

The study is also relevant to the broader context of the user's research area concerning Commerce student-teachers, B.Ed. pedagogy and teacher education in Karnataka. It provides a contemporary perspective on how technological developments may influence the competencies expected from future Commerce teachers.

3. Review of Related Literature

The following literature has been reviewed:

Tulimelli et al. (2026). This study looks at the effects of AI adoption on learning outcomes and student satisfaction among students studying management and commerce. It emphasises how AI may increase accessibility, broaden educational options, and offer immediate feedback. However, its application may be limited by issues including data privacy, a lack of technological know-how, expensive expenses, and opposition to change. The results imply that, when used properly, AI can improve learning efficacy; nevertheless, institutional and student ICT preparedness is necessary for successful adoption. AI will probably change how business is taught in the future and increase the analytical, interactive, and contentious nature of teacher education.

Kiran et al. (2026). The impact of artificial intelligence (AI) on commerce education in higher education is examined in this systematic review. Studies published between 2020 and 2026 were examined in accordance with PRISMA 2020 principles to determine the advantages, difficulties, and possibilities of AI. The results demonstrate how personalised learning, student engagement, research productivity, and digital skills can all be enhanced by generative AI, intelligent tutoring systems, and adaptive learning tools. But issues with bias, privacy, academic integrity, staff preparedness, and an excessive dependence on AI still exist. The report emphasises the necessity of institutional support, ethical principles, faculty training, and responsible AI governance.

V et al. (2026). This paper analyses the advantages, difficulties, and long-term effects of AI on commerce education. The study concludes that AI improves conceptual understanding, facilitates adaptive learning, and equips students for technology-driven corporate contexts based on secondary data gathered from academic publications, research articles, and educational reports. But obstacles including data privacy issues, high implementation costs, the digital divide, and a lack of technological know-how continue to be major obstacles. The

study comes to the conclusion that although AI cannot take the position of human teachers, it can be a very helpful tool in making commerce education more adaptable, skill-oriented, and in line with the demands of contemporary business.

Kalyani et al. (2025). This study examines how 100 sixth-semester ITEP students' self-efficacy and reflective practice are affected by AI-based evaluation tools. It discovered that both regions significantly improved following the intervention using a pre-test and post-test design. While B.Sc. B.Ed. students improved marginally more than B.A. B.Ed. students, perhaps as a result of their science-focused curriculum, female students shown stronger advances in reflective practice. The results demonstrate how AI may enhance critical professional competencies and equip upcoming educators for classrooms in the twenty-first century by using subject-specific and gender-sensitive methods.

Dhotre et al. (2025). The perspectives and preparedness of commerce faculty members to employ AI in institutions around Chhatrapati Sambhajinagar City are investigated in this study. Of the 56 responders, 80% were new to AI, and 89% want training to enhance instruction. The most popular tool (61%) was ChatGPT. Preferences for AI tools did not significantly correlate with teaching experience. Faculty expressed concerns about data security, authenticity, abuse, and potential job loss, even while they valued AI for administration, research, content development, lesson planning, and personalised learning. All things considered, AI has a great deal of potential to change commerce education.

B N and N S (2025). This study used a validated, researcher-developed scale (Cronbach's alpha = 0.93) to evaluate the AI literacy of 357 B.Ed. teacher candidates from five districts in the Southern Zone of Karnataka. The general level of AI literacy was mediocre, suggesting room for development. While urban trainees showed more literacy than their rural counterparts, male trainees expressed more confidence in AI's technical features. Additionally, second-year trainees performed better than first-year trainees, and literacy differed by pedagogical speciality. Stronger institutional support, curriculum change, and skill-development programs are suggested by the study to enhance trainees' digital preparedness and efficient application of AI in the classroom.

Appa Rao, D. Ch., & Brahmaiah, C. (2025). This study looks at how the attitudes and abilities of teachers affect the use of AI in commerce education. The results demonstrate that while digital skills alone are insufficient, teachers' cognitive, practical, and educational management competences are greatly enhanced by positive views about AI. Collaborative learning, ongoing professional growth, and robust institutional support are necessary for the successful deployment of AI. Limited technological resources, worries about equity and bias, and opposition brought on by a lack of pedagogical preparedness and AI awareness are some of the main obstacles. To prepare commerce educators for an AI-driven future, the report suggests more frequent training, improved digital infrastructure, and more robust business relationships.

Kalniņa et al. (2024). The University of Latvia's pre-service teachers' perspectives on the

usage of AI in higher education, as well as their future teaching responsibilities, are examined in this study. Less than half of the 240 students who participated in the poll regularly utilise AI, according to the results. Many participants were concerned about plagiarism and diminished critical thinking, even if they appreciated its support for language learning, accessibility, and global knowledge. Few had actually deployed AI, despite their recognition of its potential to assist inclusive education. The report emphasises the need for improved AI integration into teacher preparation programs and increased AI literacy.

Jamal (2023). The purpose of this study is to examine AI's possible advantages, disadvantages, and difficulties in teacher education. The study looks at how AI may boost instructors' abilities, support individualised learning, and raise the standard of teacher education. The study also emphasises how AI in teacher education has ethical, social, and cultural ramifications. The study comes to the conclusion that while AI has the potential to revolutionise teacher education, its application must be done carefully and ethical issues must be taken into account.

Kuleto et al. (2021). This study aims to examine, through a survey of current research and policy literature, this article investigates the potential and difficulties of artificial intelligence (AI) in education. The results demonstrate how AI can increase data-driven decision-making, assist personalised learning, boost evaluation, and improve educational quality. Data privacy, algorithmic bias, teacher preparedness, unequal access to technology, and lax policies are still major issues, though. The article emphasises that AI is a socio-technical evolution that calls for careful pedagogical, ethical, and policy choices rather than just a technology fix. AI can contribute to the development of more inclusive, adaptable, and human-centered education when used responsibly.

4. Objectives of the Study

The present study has been undertaken with the following objectives:

1. To study the role of Artificial Intelligence in Commerce education pedagogy.
2. To identify the opportunities offered by Artificial Intelligence for teaching and learning in pre-service Commerce teacher education.
3. To know the major challenges and ethical concerns associated with the integration of Artificial Intelligence in Commerce pedagogy.
4. To recommend appropriate measures for strengthening AI-integrated pedagogical competencies among Commerce student-teachers in Karnataka.

5. Research Methodology

5.1 Research Design

The present study is descriptive in nature and is based entirely on secondary data. The study does not involve the collection of primary data from B.Ed. student-teachers or teacher educators.

5.2 Sources of Data

The study draws information from secondary sources such as:

Books and edited books, Research articles published in academic journals, Government policy documents, Reports of national and international organizations, Teacher education frameworks, Reports and publications concerning Artificial Intelligence in education, Relevant educational and institutional publications, published literature relating to Commerce education and pedagogy. Particular attention is given to policy and framework documents concerning AI, teacher education and educational technology.

5.3 Method of Analysis

The available literature was studied thematically. The analysis was organized around three major areas corresponding to the objectives of the study:

1. Role of AI in Commerce pedagogy
2. Opportunities in pre-service Commerce teacher education
3. Challenges and ethical concerns

6. Artificial Intelligence in Commerce Education Pedagogy

Artificial Intelligence can be understood as a group of technologies that enable computer systems to perform tasks involving activities such as analysing information, identifying patterns, generating content, and providing responses.

In Commerce education, the relevance of AI extends beyond simply presenting information. It can potentially support different stages of the teaching-learning process.

6.1 AI and Lesson Planning: AI tools can assist student-teachers in preparing preliminary lesson plans, identifying possible learning activities and developing questions. For example, a Commerce student-teacher preparing a lesson on entrepreneurship may use AI to generate possible business situations for classroom discussion.

However, AI-generated lesson plans require modification by the teacher according to the prescribed curriculum, learning objectives, learner characteristics, and classroom conditions.

6.2 AI and Teaching-Learning Materials: Preparing appropriate teaching-learning materials can be time-consuming for student-teachers. AI can assist in developing examples, case studies, questions, worksheets and discussion activities.

This can be particularly useful in Commerce education because many concepts can be connected with real-world business and economic situations.

6.3 AI and Case-Based Learning: Case-based learning is particularly appropriate for Commerce subjects. AI can help student-teachers construct hypothetical business situations involving marketing, entrepreneurship, finance, management or consumer behaviour.

Such activities can encourage learners to analyse situations rather than simply memorise concepts.

6.4 AI and Assessment: AI can support the preparation of formative assessment questions, quizzes and practice exercises. It can also provide preliminary feedback in certain learning environments.

Nevertheless, assessment should continue to involve professional teacher judgement,

particularly when evaluating creativity, critical thinking, communication and practical understanding.

7. Opportunities of Artificial Intelligence in Commerce Education Pedagogy

The integration of Artificial Intelligence into Commerce education provides several opportunities for improving teaching and learning. Commerce is a practical and application-oriented area of study that includes Accountancy, Business Studies, Economics, Entrepreneurship, Finance and Management. These subjects require learners to understand concepts, analyse information, solve problems and relate theoretical knowledge to real-life business situations. AI can provide additional support to teachers and student-teachers in addressing these requirements.

7.1 Opportunity for Innovative Teaching Practices: AI provides opportunities for student-teachers to move beyond conventional teaching practices. Instead of depending primarily on lecture and explanation methods, Commerce student-teachers can use AI-supported activities such as case-based learning, problem-solving exercises, simulations, discussions and inquiry-based learning.

For example, while teaching entrepreneurship, a student-teacher can develop a hypothetical business situation and ask learners to identify problems, analyse alternatives and suggest suitable solutions. Such activities can make Commerce learning more practical and participatory.

7.2 Support for Lesson Planning: Lesson planning is an important part of pre-service teacher education. AI can assist student-teachers in developing initial ideas for learning objectives, teaching activities, examples, questions and assessment tasks. This can reduce some of the routine workload involved in preparing a lesson.

However, AI-generated lesson plans should not be adopted without modification. Student-teachers need to examine whether the proposed content is consistent with the prescribed curriculum and appropriate for the learners.

7.3 Development of Teaching-Learning Materials: Preparing appropriate teaching-learning materials is often a demanding task for student-teachers during their teaching practice. AI can support the development of worksheets, examples, case studies, questions, classroom activities and other learning resources.

In Commerce education, such materials can be connected with contemporary business situations, entrepreneurship, markets, financial decisions and consumer behaviour. This can help bridge the gap between theoretical knowledge and practical application.

7.4 Personalised Learning Opportunities: Learners differ in their level of understanding, learning pace and educational needs. AI-supported systems can provide alternative explanations, examples and learning activities according to individual requirements.

For Commerce student-teachers, this creates an opportunity to prepare differentiated learning experiences. A difficult concept in Accountancy or Economics, for instance, can be explained in simpler language or through additional examples for learners who require further

support.

7.5 Improvement of Assessment Practices: AI can assist student-teachers in preparing formative assessment activities. Different types of questions, including objective questions, short-answer questions, case-based questions and problem-solving activities, can be generated and adapted.

This can help student-teachers provide more varied assessment opportunities. However, assessment should continue to involve teacher judgement, particularly when evaluating critical thinking, creativity, communication and application of knowledge.

7.6 Development of Digital and AI Literacy: Exposure to AI during B.Ed. can help Commerce student-teachers develop digital competencies that may become increasingly important in their future professional lives.

AI literacy involves more than knowing how to use an AI application. It includes understanding its capabilities, recognising its limitations, evaluating its responses and using it responsibly.

7.7 Opportunities for Practical and Experiential Learning: Commerce education is closely connected with real-world business activities. AI can support the creation of simulated business environments in which learners can explore situations related to marketing, entrepreneurship, financial management and business decision-making.

Such experiences can help students understand how Commerce concepts operate beyond the textbook.

7.8 Support for Professional Development: AI can also provide opportunities for continuous professional learning. Student-teachers can use AI as one of several resources to explore new pedagogical strategies, teaching methods, educational concepts and developments in Commerce.

This may contribute to the development of a habit of continuous learning among future teachers.

8. Challenges of Artificial Intelligence in Commerce Education Pedagogy:

Although AI offers considerable educational possibilities, its integration also presents several challenges. These challenges need to be considered carefully when AI is introduced into B.Ed. and Commerce pedagogy programmes.

8.1 Accuracy and Reliability of Information: One of the major concerns associated with AI is the possibility of inaccurate or incomplete information. AI-generated responses may appear convincing even when they contain factual or conceptual errors.

This is particularly important in Commerce education. Incorrect explanations relating to accounting principles, financial concepts, economic theories or business practices can lead to misconceptions among learners.

Therefore, student-teachers must develop the ability to verify AI-generated information using reliable academic and official sources.

8.2 Lack of Adequate AI Competency: Not all student-teachers may have the same level of familiarity with AI. Some may have considerable experience with digital technologies, while others may have limited exposure.

Without systematic training, AI may be used only for simple tasks such as generating text rather than for meaningful pedagogical purposes. Teacher education programmes therefore need to provide structured opportunities for developing AI competency.

8.3 Excessive Dependence on Artificial Intelligence: There is a risk that student-teachers may become overly dependent on AI for lesson plans, teaching materials, explanations and assignments.

Such dependence may limit the development of independent thinking, creativity and professional judgement. Teacher education should therefore encourage student-teachers to use AI as an assisting resource while retaining responsibility for pedagogical decisions.

8.4 Academic Integrity: Generative AI has created new challenges for academic integrity. Students can use AI to prepare assignments, reports and other academic work without demonstrating their own understanding.

This creates difficulties for teacher educators in determining whether submitted work genuinely represents the student's learning.

Teacher education institutions therefore need clear policies regarding acceptable and unacceptable uses of AI.

8.5 Privacy and Data Protection: The use of AI tools may involve entering personal, academic or institutional information into digital systems. This raises concerns about privacy and the responsible handling of data.

Student-teachers need to understand what information should and should not be entered into AI systems and should develop responsible digital practices.

8.6 Bias and Ethical Concerns: AI systems may sometimes produce biased or inappropriate information. If student-teachers accept AI-generated responses without critical examination, such biases may enter classroom teaching materials.

Therefore, ethical awareness should be an essential part of AI education.

8.7 Digital Divide and Unequal Access: The benefits of AI cannot be equally experienced when students and institutions have different levels of access to devices, internet connectivity and digital resources.

In Karnataka, differences may exist between institutions in terms of technological infrastructure and digital capacity. AI integration should therefore consider issues of accessibility and equity.

8.8 Copyright and Intellectual Property: The use of AI-generated and digitally available educational materials raises questions concerning copyright and intellectual property. Student-teachers should understand the importance of respecting sources and using educational materials responsibly.

8.9 Preparedness of Teacher Educators: AI integration cannot be successful if only student-teachers are trained. Teacher educators also need to understand AI technologies, their educational applications and their limitations.

Continuous professional development is therefore required for teacher educators.

8.10 Changing Nature of Teacher Competencies: The emergence of AI may change the competencies expected from future teachers. In addition to subject knowledge and pedagogical skills, teachers may increasingly need AI literacy, digital ethics, information verification skills and the ability to design human-AI learning environments.

9. Recommendations for Strengthening AI-Integrated Commerce Pedagogy:

In view of the opportunities and challenges identified above, the following recommendations are proposed for strengthening AI-integrated pedagogical competencies among Commerce student-teachers in Karnataka.

9.1 Integrate AI Literacy into B.Ed. Curriculum: AI literacy should be systematically included in teacher education programmes. Student-teachers should be introduced to the basic concepts, applications, limitations and ethical dimensions of Artificial Intelligence.

Rather than treating AI as a separate technological topic, it should be connected with educational technology and subject pedagogy.

9.2 Integrate AI with Commerce Pedagogy: AI training should be directly related to the teaching of Commerce subjects. B.Ed. Commerce student-teachers should receive practical guidance on how AI can support the teaching of Accountancy, Business Studies, Economics, Entrepreneurship, Finance, and Business Communication

This subject-specific approach can make AI training more meaningful and useful.

9.3 Provide Hands-on Training: Teacher education institutions should provide practical opportunities for student-teachers to use AI in realistic teaching situations.

Activities may include preparing AI-assisted lesson plans, creating case studies, developing assessment questions, designing classroom activities and evaluating AI-generated teaching materials.

9.4 Develop Information Verification Skills: Student-teachers should be trained to verify AI-generated information before using it in classrooms.

They should learn to compare AI outputs with textbooks, peer-reviewed research, government publications, official educational resources and other reliable sources.

9.5 Establish Ethical Guidelines for AI Use: B.Ed. institutions should develop clear guidelines regarding responsible use of AI in teaching, assignments, research and assessment.

These guidelines should address academic integrity, privacy, copyright, bias, transparency and appropriate attribution.

9.6 Strengthen Teacher Educator Competencies: Regular professional development programmes should be organised for teacher educators. Such programmes can focus on AI applications in education, prompt formulation, evaluation of AI-generated content, AI ethics and AI-supported pedagogy.

Teacher educators should be able to demonstrate appropriate use of AI rather than merely explaining its theoretical aspects.

9.7 Encourage Reflective AI Practice: Student-teachers should be encouraged to reflect on their use of AI during teaching practice.

For example, they can document why AI was used and what educational purpose it served. Whether the generated information was accurate, how the material was modified, what limitations were identified, and whether the learning objective was achieved.

Reflective practice can help student-teachers develop professional judgement.

9.8 Promote Human-Centered Use of AI: AI should be used to support teachers rather than replace them. The teacher should remain responsible for understanding learners, selecting appropriate teaching methods, evaluating information and maintaining meaningful classroom interaction.

A human-centered approach can ensure that technology contributes to education without reducing the importance of human relationships and professional judgement.

9.9 Improve Digital Infrastructure: Teacher education institutions should make efforts to provide adequate digital infrastructure, including reliable internet connectivity, appropriate devices and access to relevant educational technologies.

Equal access is important to ensure that AI integration does not create further educational inequalities.

9.10 Encourage Research on AI and Commerce Teacher Education: Higher education institutions and teacher education departments should encourage research on the use of AI in Commerce pedagogy.

Future studies can examine the AI awareness, attitudes, competencies and preparedness of Commerce student-teachers and teacher educators. Such empirical studies would provide evidence for curriculum development and policy decisions in Karnataka.

10. Conclusion:

Artificial Intelligence is gradually becoming an important part of the educational environment, and its influence is likely to increase in the coming years. Commerce education, with its emphasis on business, economics, accounting, finance and entrepreneurship, provides several opportunities for meaningful AI-supported teaching and learning.

This secondary-data-based study shows that AI can support Commerce student-teachers in lesson preparation, developing teaching-learning materials, case-based learning, assessment, and differentiated learning. These possibilities can contribute to more innovative and flexible pedagogical practices.

At the same time, AI cannot be considered a solution to all educational challenges. Problems relating to inaccurate information, academic integrity, privacy, bias, digital inequality and excessive dependence need careful consideration. These challenges make AI literacy and ethical awareness essential components of contemporary teacher education.

For Karnataka, integrating AI into B.Ed. Commerce teacher education provides an

opportunity to prepare future teachers for an increasingly technology-oriented educational environment. However, the objective should not simply be to make student-teachers familiar with AI applications. They should develop the ability to select, evaluate, adapt and use AI according to specific pedagogical requirements.

Teacher educators also have an important role in this process. Their professional development is necessary for creating meaningful learning experiences in which student-teachers can explore AI while maintaining academic and professional standards.

The future direction of Commerce teacher education should therefore be based on a balanced relationship between technology and human expertise. AI can support teachers, but it cannot replace the teacher's responsibility for understanding learners, exercising professional judgement, fostering critical thinking and creating meaningful human interaction.

Thus, the most appropriate approach to AI in Commerce teacher education is not AI replacing teachers, but professionally prepared teachers using AI responsibly to enrich teaching and learning.

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MINDFUL DIGITAL LEARNING: EXPLORING THE PATHWAYS TO ACADEMIC WELL-BEING AMONG STUDENTS

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Abstract

Digital technology has entered the education system quickly, altering the way pupils learn, communicate, seek information and engage in educational activities, as well as offering flexibility, accessibility, collaborative learning, personalisation and opportunities outside of the classroom. But the overuse and misuse of digital interaction may lead to distraction, information overload, multitasking, reduced attention, academic stress, and unhealthy technology use, as studies suggest that distractors can disrupt students from being focused and have a negative impact on academic performance and the learning processes (Martin et al., 2025). Likewise, studies about media multitasking have revealed problems in terms of student attention, understanding, self-regulation, and academic achievement (May & Elder, 2018). Mindful digital learning inspires students to be purposeful, attentive, and reflective in their digital use. It draws on attention regulation and present moment awareness (Bishop et al., 2004) and will need to be mediated by how learners interact with the digital tools in the context of their education (Nkomo et al., 2021). This thematic paper is a synthesis of literature on key components such as mindful attention, self-regulation, distraction reduction, information management, academic engagement, healthy habits, teacher roles, and well-being. Overall, digital mindfulness is integrated into education and helps in focused learning, responsible technology use, emotional balance, and overall student well-being (Alrashdi et al., 2024).

Keywords: *Digital Mindfulness, Mindful Digital Learning, Academic Engagement, Student Well-being, Digital Learning, Self-Regulation, Digital Distraction*

1. Introduction

This article presents findings of a systematic thematic literature review on the connection between mindful digital learning, academic engagement and well-being of students. A total of nine key scholarly studies were cited for this review on the topics of mindfulness, digital distraction, media multitasking, student engagement with digital technology, online mindfulness-based interventions, and IT mindfulness in learning. Literature was collected mainly from peer reviewed scientific articles in the educational, psychological, educational technology, and education and digital learning fields, such as systematic reviews and conceptual studies, as well as from empirical research. This review of the above studies aims to bring together what is already known about the impact of mindful use of digital technology

on students' attention, self-regulated learning, learning engagement, and wellbeing. The article aims to communicate the importance of students being aware of how, why, when, and for what purpose they use technology for effective digital learning, in addition to the access to technology. The review thus aims to support the use of digital mindfulness practice in the classroom as a tool to enhance effective learning, healthy use of technology, academic engagement, and student well-being.

2. Mindful Digital Learning

The intentional, thoughtful and reflective application of digital tools in learning activities is referred to as mindful digital learning, drawing on the two-component model of mindfulness proposed by Bishop et al. (2004). It is an open and/or curious awareness to present thoughts, feelings, and digital experiences, along with paying attention to them. This method allows students to become aware of the impact that digital environments have on their attention and emotions, and to move from automatic to purposeful and conscious technology use. A conscious digital learner considers: Does technology promote learning objectives, what distracts them, and how to take a break from digital. Therefore, digital mindfulness is not about ditching technology, but it is a learning of a new and healthy way to engage with technology, where technology is used to help with meaningful and focused learning, not as a distraction or cause of academic stress (Bishop et al., 2004).

3.The need for Mindful Digital Learning

Therefore, in today's digital age, the importance of mindful digital learning becomes more relevant to education as digital technologies are becoming more dependent on today's society, and high exposure to digital stimuli can interfere with focused learning and divert students' attention from learning activities. One of the big challenges, however, reveals the need for mindful digital learning when students are cut from distractions like notifications, social media, messaging apps, entertainment and other online content that hampers their focus and learning.

3.1 Digital distraction

Digital distraction refers to a high occurrence of being distracted from academic work by notifications, social media, messaging or off task web browsing. Martin et al. (2025) noted that these technology distractions were among the main reasons for the loss of focus among students, affecting students' performance and the effectiveness of instruction. The fight against this is addressed through the development of self-awareness in mindful digital learning: Rather than responding automatically to digital stimuli, students learn to identify shifts in attention, take a break before responding, and intentionally shift their attention back to the learning task to support sustained and intentional learning behaviours.

3.2 Information Overload and Multitasking

Digital learning offers students access to vast amounts of information, but too much digital information can lead to the problem of information overload and finding relevant information. Meanwhile, students can be distracted between assignments, social media,

messages and activities with digital media, which leads to multitasking. These actions may lead to having less attention to pay, more cognitive burden, and less understanding and school performance. Mindful digital learning is a combination of four elements: identifying unnecessary digital activities, evaluating information carefully, focusing on one digital activity at a time, and using digital resources purposefully (May & Elder, 2018).

3.3 Academic Stress and Reduced Self-Regulation

Academic stress can arise from the constant connectivity to digital devices by having to be available, respond to messages and complete online work. It may also be difficult for students to manage their digital behaviour in the case of using the same device for academic and non-academic purposes. Mindful Digital Learning supports students to become aware of their digital habits, their attention and how to regulate it, how to set healthy boundaries, when to take purposeful breaks, and how to regulate technology use. These practices can help ensure a balanced digital engagement, alleviate stress, and foster academic well-being.

4. Key Dimensions of Mindful Digital Learning

Mindful digital learning consists of several interconnected dimensions that help students use digital technology in a conscious, purposeful, and balanced manner. These dimensions move beyond simply accessing digital tools and focus on how students direct their attention, regulate their digital behaviour, engage in learning, manage their emotional well-being, and develop healthy technology habits**.** Together, these dimensions provide a framework for understanding how mindful use of technology can support meaningful learning and academic well-being.

4.1 Mindful Attention and Focused Learning

Students are encouraged to focus on the learning task in the present moment, and to be mindful of what they are learning, which helps them to stay focused despite digital distractions. It helps students to pay attention to what is important, to observe when their attention is wandering and to make a conscious effort to come back to the learning task. Deeper understanding, meaningful information processing and effective academic performance come from focused digital learning (Bishop et al., 2004).

4.2Digital Self-Regulation and Distraction Reduction

Self-regulation through technology involves students' deliberate engagement with technology in relation to their learning targets. Students can manage notifications, prevent excessive app switching, prevent off-task browsing and have purposeful digital breaks. The practices have the positive effect of minimizing electronic distractions and supporting learners to focus attention and purposefully engage with academics (May & Elder, 2018; Martin et al., 2025).

4.3 Academic engagement

Academic engagement is defined as students' behavioural, emotional, cognitive and agentic involvement in learning (Fredricks et al., 2004; Reeve & Tseng, 2011). Mindful digital learning fosters sustained attention, intentional engagement, sustained effort, and intentional reflection on the use of technology, which in turn can facilitate meaningful engagement in

digital learning activities (Nkomo et al., 2021).

4.4 Emotional and Academic Well-Being

Mindful digital learning can support students' emotional and academic well-being by helping them manage digital stress, maintain emotional balance, and develop healthier boundaries between academic and personal technology use. Mindfulness-based digital interventions have been associated with reduced psychological distress and improved well-being among university students (Alrashdi et al., 2024).

4.5 Healthy Digital Habits

Healthy digital habits involve using technology intentionally, responsibly, and in ways that support learning and well-being. Practices such as single-tasking, planned breaks, limiting unnecessary notifications, maintaining digital boundaries, and regularly reflecting on technology use can help students develop balanced and sustainable digital learning behaviours. Thus, the quality and purpose of digital engagement are more important than screen time alone (Firth et al., 2024).

5. Pathways from Mindful Digital Learning to Academic Well-Being

The concept of Mindful Digital Learning can help students' academic well-being in a series of interrelated processes. It starts with the mindful attention, to be aware of thoughts, feelings and digital behaviours as they learn. This awareness leads to increased digital self-regulation, allowing students to regulate notifications, not to be overwhelmed by multitasking, to control their off-task technology usage, and to use digital tools intentionally. Digital distraction is reduced, and students can sustain their attention, focus, and engage in meaningful learning when they are better equipped to regulate their digital devices. Deeper understanding, effective task completion and meaningful academic engagement in turn are fostered through focused learning. Through greater participation in the classroom and healthier technology dynamics and use, students' academic well-being can be improved. The pathway is therefore conceptualised as Mindful Digital Learning to Mindful Attention to Digital Self-Regulation to lessened Digital Distraction, to Focused Learning, to Academic Engagement, to Academic Well-Being (Bishop et al., 2004; Fredricks et al., 2004; Martin et al., 2025; Alrashdi et al., 2024).

6. Theoretical Perspectives

6.1 Two-Component Model of Mindfulness: The two-component model proposed by Bishop et al. (2004) provides a foundational framework for understanding mindful digital learning. It explains mindfulness through two key components: self-regulation of attention and an orientation toward present-moment experience characterized by curiosity, openness, and acceptance. In digital learning environments, this perspective helps students consciously direct their attention toward academic tasks while becoming aware of distracting thoughts, emotions, notifications, and online activities. Thus, students can move from automatic and reactive technology use toward purposeful and reflective digital engagement.

6.2 Langer's Socio-Cognitive Perspective: Langer's (1989) perspective views mindfulness as an active process of noticing new information, recognizing different perspectives, and avoiding automatic ways of thinking. Applied to digital learning, this perspective encourages students to critically examine online information rather than passively accepting everything they encounter. It supports curiosity, flexible thinking, critical evaluation, and awareness of alternative viewpoints, thereby helping students make more thoughtful and informed decisions while using digital resources for learning.

6.3 Self-Regulated Learning Perspective: Self-regulated learning provides an important theoretical foundation for understanding how students manage their learning in digital environments. It involves processes such as planning, monitoring, controlling, and evaluating one's learning behaviour. In mindful digital learning, students can set learning goals, monitor their attention and digital habits, identify distractions, regulate technology use, and reflect on their learning outcomes. Such self-regulatory processes help learners become more independent, purposeful, and responsible users of digital technology.

6.4 Student Engagement Theory: Student engagement theory explains students' active involvement in learning through behavioural, emotional, cognitive, and agentic dimensions (Fredricks et al., 2004; Reeve & Tseng, 2011). Mindful digital learning can strengthen these dimensions by helping students maintain attention, participate actively, regulate emotions, persist with academic tasks, and make purposeful contributions to their learning environment. Therefore, mindful and intentional use of digital technologies can transform digital learning from passive screen consumption into meaningful academic engagement, which may ultimately support students' academic well-being.

7. Educational institutions can implement the following expanded practical strategies to support mindful digital practices:

- Digital **Intention Setting:** Before starting a session, students record a specific learning goal. Pre-defining purpose anchors focus, establishes a clear benchmark to detect off-task browsing, and minimizes passive media consumption.
- **Notification-Free Learning:** Silencing non-essential alerts during study blocks eliminates external interruptions and frequent task-switching, preserving cognitive capacity for sustained deep work.
- **Digital Pause:** Inserting a brief metacognitive pause before opening new tabs or apps prompts students to evaluate if the action serves their goal, weakening automatic distraction triggers and strengthening self-regulation.
- **One-Task Learning:** Committing to single-tasking and closing irrelevant applications protects working memory, speeds up task completion, and improves overall academic output quality.
- **Mindful Breathing:** Integrating 1–2-minute breathing exercises before study sessions or during transitions resets focus, lowers physiological stress, and mitigates screen-induced cognitive fatigue.
- **Reflective Digital Diary:** Tracking screen habits, triggers, emotional states, and focus duration in weekly logs builds self-awareness—shifting technology management from external rules to internal self-regulation.
- **Scheduled Digital Breaks:** Incorporating structured offline breaks (e.g., physical movement or eye rest) between study periods prevents mental exhaustion, restores attentional resources, and sustains productivity.
- **Digital Environment Organization:** Systematically organizing desktops, cloud storage, bookmarks, and open tabs removes visual clutter, reducing unnecessary cognitive load to foster calm, structured learning.

8. Educational Implications

The implications of mindful digital learning are great in developing a healthy, focused, and meaningful digital learning environment. It argues that schools should not create policies that allow students to access digital technologies, but also enable them to use these technologies in a responsible and purposeful way.

On the student level, mindful digital learning can foster awareness around students' digital behaviours, help students pay attention and focus, enhance self-regulation, minimize unnecessary multiple tasks and distraction, and encourage students to use technology in a healthy way. Pupils are able to establish learning goals, limit notifications, take planned breaks and pause to review the impact of digital tasks on their learning and feelings.

The teacher's side of the book focuses on the significance of creating well-organised and intentional digital learning experiences. By using explicit instructions, engaging in single task learning, setting clear expectations for technology use and adding brief reflection activities, teachers can minimize unnecessary digital distractions. Learning through modeling by teachers is also important in using technology mindfully.

In teacher education, digital mindfulness can be integrated into teacher training programmes as preparation for the future teachers to manage the digital learning environments effectively. Pre-service teachers can be educated about digital distraction, information overload, self-regulation, digital well-being, and create strategies for their classrooms to promote mindful use of technology for learners.

Educational institutions can host awareness sessions and workshops, and digital well-being initiatives in schools and colleges. To create guidelines for technology use that are responsible, to foster a balance between online and offline learning, and to create supportive learning environments that eliminate unnecessary digital stress on students are some strategies institutions may use.

When creating a curriculum, digital learning resources should be purposeful, well organized, interactive, and not too information packed, but rather manageable. Learning activities can involve opportunities for reflection, focus, collaboration and off-line interaction.

Digital well-being should be considered alongside digital access and digital literacy, and be given more attention by educational policy and researchers. Comparisons can be made of the relationship between digital mindfulness and academic engagement, self-regulated learning, attention, cognitive flexibility, academic learning outcomes, and general well-being of children. The educational implication of mindful digital learning is that technology should be used more consciously, purposefully and responsibly, rather than being used more. Mindful digital practices can be incorporated into the learning and teaching process to develop learners who are academically engaged, digitally responsible, emotionally balanced and better equipped to handle the demands of today's digital education.

9. Conclusion

While digital technology expands flexible and collaborative learning, unmanaged usage, continuous connectivity, and information overload frequently cause divided attention, elevated stress, and reduced academic engagement (Martin et al., 2025; May & Elder, 2018). Synthesizing current literature reveals that digital mindfulness offers a vital paradigm shift from technology-centric models toward conscious, self-regulated engagement. Meta-analytic evidence confirms that online mindfulness practices significantly reduce psychological distress while enhancing student well-being (Alrashdi et al., 2024; Bishop et al., 2004).

Addressing digital distraction requires more than restricting screen time; it demands building attentional awareness, critical information evaluation, and intentional habits. Integrating mindfulness, self-regulation, and engagement frameworks empowers educational institutions to develop academically capable, digitally literate, and emotionally balanced learners.

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ARTIFICIAL INTELLIGENCE AND COMPUTER VISION FOR EDUCATIONAL ASSESSMENT: A STRUCTURED REVIEW OF AUTOMATED EVALUATION, FEEDBACK, AND LEARNING ANALYTICS

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Abstract

Artificial Intelligence (AI) is increasingly transforming educational assessment through automated grading, intelligent feedback, learning analytics, and personalized learning. Computer Vision (CV) is particularly relevant because educational assessment frequently involves visual information such as handwritten answers, examination scripts, mathematical expressions, diagrams, laboratory records, and other learning artefacts. The integration of computer vision with machine learning, deep learning, Optical Character Recognition (OCR), Natural Language Processing (NLP), and learning analytics enables assessment systems to move beyond simple score generation toward automated analysis and formative feedback. This paper presents a structured review of recent research on AI and computer vision in educational assessment. The review examines developments in automated grading, text and handwriting recognition, computer-vision-based assessment, personalized feedback, multimodal assessment, and human-centred AI. Recent studies indicate that AI-supported assessment can improve assessment efficiency, scalability, feedback timeliness, and data-driven decisionmaking. However, challenges remain concerning recognition errors, dataset bias, explainability, privacy, fairness, academic integrity, and excessive dependence on automated decisions. Based on the reviewed literature, a conceptual framework is proposed in which visual student responses are acquired, pre-processed, recognized, evaluated, and converted into feedback and learning analytics, with teacher validation retained as an essential stage. The review concludes that the most appropriate future direction is human-AI collaboration, in which AI performs computationally intensive assessment tasks while educators retain pedagogical judgement and responsibility.

Keywords: *Artificial Intelligence, Computer Vision, Educational Assessment, Automated Grading, Deep Learning, Handwriting Recognition, Optical Character Recognition, Learning Analytics, Personalized Feedback, Human-Centred AI.*

1. Introduction

Assessment is an essential component of education because it provides evidence of students' knowledge, skills, conceptual understanding, and learning progress. Written examinations, assignments, laboratory records, projects, and other forms of assessment are traditionally evaluated by teachers. Although human assessment provides contextual and pedagogical judgement, evaluating a large number of responses can be time-consuming and may be affected by workload, fatigue, and variation in judgement. The rapid development of Artificial Intelligence (AI) has created new possibilities for addressing some of these limitations. AI in education includes machine learning, deep learning, Natural Language Processing (NLP), Computer Vision (CV), intelligent tutoring systems, recommender systems, and learning analytics. A systematic review by Wang et al. demonstrated that AI in education has developed into a broad research field involving assessment, prediction, learning support, and intelligent educational systems [1]. Educational assessment has become an important application area. AI can support automated scoring, response classification, error identification, feedback generation, performance prediction, and personalized learning. A recent review of AI-powered grading and tailored feedback analysed 77 studies and reported potential benefits including improved efficiency, scalability, rapid feedback, and personalized support. However, it also identified bias, privacy, transparency, and human oversight as continuing concerns [2]. Computer Vision is particularly important because educational information is not limited to machine-readable text. Examination papers, handwritten responses, diagrams, graphs, mathematical expressions, circuit diagrams, and laboratory observations contain valuable visual information. CV techniques can convert such information into computational representations that can subsequently be analysed using AI. Therefore, this review examines the development of AI and computer vision in educational assessment, identifies major applications and benefits, discusses current limitations, and highlights future directions for intelligent and human-centred assessment. This study adopts a structured narrative review rather than a systematic meta-analysis. Recent literature, primarily from 2023–2026, was considered, with earlier studies included where necessary to establish important technological foundations. Literature was identified using combinations of terms including artificial intelligence, educational assessment, computer vision, automated grading, handwriting recognition, optical character recognition, personalized feedback, learning analytics, and human-centred AI. Priority was given to peer-reviewed journal articles, systematic reviews, conference publications, and authoritative educational reports.

The review focused on five major themes:

1. AI supported educational assessment;
2. automated text and handwriting assessment;
3. computer-vision-based assessment;
4. AI-supported feedback and learning analytics; and

5. Human centred and multimodal assessment.

The objective was to synthesize the findings of previous studies and identify the technological and research gaps that influence the development of future AI-based assessment systems.

2. Literature Review

2.1 Artificial Intelligence in Educational Assessment

AI-supported educational assessment has expanded from simple automated scoring to broader systems that analyse student performance and support learning decisions. Wang et al. [1] identified assessment as one of the major application areas of AI in education and emphasized the increasing diversity of AI technologies and educational contexts. Mustafa et al. [2], through a systematic review of existing AI-in-education literature reviews, similarly highlighted the rapid development of the field and the need for future research to address educational effectiveness, ethics, implementation, and pedagogical alignment rather than focusing only on technical performance. Recent research specifically examining AI-supported online assessment confirms these developments. Üstün et al. reviewed 98 studies published between 2018 and 2025 and reported that AI-supported assessment can provide personalized feedback, improve assessment efficiency, and support data-driven decision-making. At the same time, technical limitations, algorithmic bias, data-management problems, security, academic-integrity concerns, and limited empirical evidence remain important challenges [4].

2.2 Automated Assessment of Text-Based Responses

Automatic evaluation of open-ended responses is one of the major applications of AI in education. Manual evaluation of descriptive answers is particularly demanding in large classes. NLP and machine-learning approaches have therefore been developed to evaluate response content, relevance, semantic similarity, and quality. Gao et al. conducted a systematic review of automatic assessment of text-based responses in post-secondary education. Their review screened 838 records and synthesized 93 studies, demonstrating substantial research activity in automated assessment of open-ended responses
[6]. The study indicates that AI and NLP can support rapid assessment and feedback, particularly in large-scale educational environments. However, text-based assessment has an important limitation: it assumes that the student's response is already available in digital text form. In conventional examinations, students frequently provide handwritten responses. Furthermore, answers may include diagrams, equations, symbols, tables, and graphical representations. Consequently, text-based AI alone cannot provide a complete solution for many educational assessment environments.

This limitation creates an important role for computer vision.

2.3 Computer Vision in Educational Assessment

Computer Vision enables educational systems to process information contained in images and video. Its applications include examination-script processing, handwriting recognition,

answersheet analysis, diagram interpretation, laboratory-image analysis, and classroom activity assessment. Jocovic et al. investigated automated assessment of pen-and-paper tests using computer vision. Their study demonstrated the feasibility of processing scanned examination material and automatically recognizing responses, illustrating how conventional paper-based assessment can be incorporated into digital assessment workflows [6].

A typical computer-vision-based assessment process can be represented as:



Figure 1. Conceptual pipeline for AI- and computer-vision-based educational assessment.

In this pipeline, image acquisition captures the student's response using a scanner, camera, or digital device. Pre-processing improves image quality through operations such as denoising, normalization, contrast enhancement, and geometric correction. Segmentation separates relevant regions such as text, diagrams, or answer areas. Feature representation and deeplearning models then extract meaningful visual information. Recognition converts the visual information into machine-readable representations, after which AI-based evaluation estimates correctness, quality, or performance. The resulting information can be used to generate feedback and learning analytics. The significance of this pipeline is that computer vision can serve as the bridge between physical student responses and digital AI-based assessment.

2.4 Handwriting Recognition and OCR

Handwritten-response assessment is an important application of computer vision because handwritten examinations and assignments remain common in education. OCR and Handwritten Text Recognition (HTR) techniques can convert handwritten material into machine-readable information. However, handwriting recognition is considerably more challenging than printed-text recognition. Variations in handwriting style, character shape, spacing, writing pressure, orientation, image quality, and language can affect recognition performance. Errors introduced during OCR can subsequently influence the accuracy of the assessment model. Recent research has demonstrated the integration of OCR with large language models for handwritten assessment. Such systems illustrate a developing multimodal approach in which computer vision first extracts information from the physical

response and language-based AI subsequently evaluates the extracted content. This demonstrates an important principle: computer vision and NLP are complementary technologies rather than competing approaches. CV provides visual understanding, whereas NLP provides semantic interpretation.

2.5 Deep Learning and Visual Assessment

The development of deep learning has significantly improved visual recognition. Convolutional Neural Networks (CNNs), transfer-learning architectures, and object-detection models can learn hierarchical representations from educational images.

Potential applications include recognition of handwritten characters, mathematical symbols, diagrams, circuit diagrams, graphs, scientific images, and laboratory observations. Deeplearning models can reduce dependence on manually engineered visual features and may provide high recognition performance when adequate training data are available. Nevertheless, model performance depends strongly on dataset quality and diversity. A model trained on a narrow set of handwriting styles or educational contexts may not generalize effectively to other student populations. Therefore, educational datasets should represent differences in handwriting, language, educational level, response format, and image acquisition conditions. Furthermore, technical accuracy alone is insufficient for educational assessment. Assessment systems must also be evaluated in terms of reliability, fairness, interpretability, and educational validity.

2.6 AI-Based Grading, Feedback and Learning Analytics

An important development in AI-supported assessment is the transition from automated scoring to personalized feedback. A score indicates performance, but feedback provides information that can help students improve. The literature indicates that AI can identify performance patterns, detect weaknesses, and provide individualized feedback. Deepshikha's review of 77 studies identified personalized feedback as one of the important applications of AI-powered grading systems [3].

When assessment results are combined with learning analytics, AI systems can identify recurring errors, changes in performance, and areas requiring intervention. Alfredo et al. reviewed 108 studies on human-centred learning analytics and AI in education and emphasized the importance of human control, reliability, safety, trustworthiness, and stakeholder involvement [8].

2.7 Synthesis of the Reviewed Literature and Conceptual Framework

The reviewed literature indicates a progressive transition from conventional score-based assessment toward intelligent, continuous, and learner-centred assessment. Traditional assessment primarily maps a student response to a score, whereas AI-supported assessment can integrate response analysis, diagnosis of errors and weaknesses, teacher validation, personalized feedback, learning intervention, and reassessment.

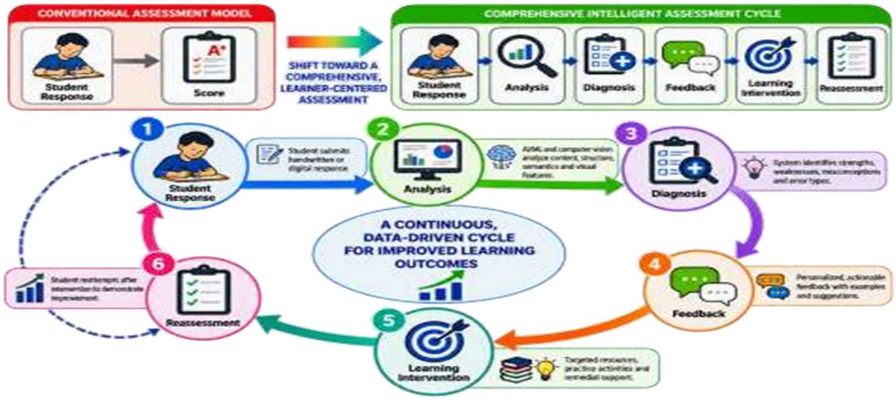

Figure 2: Conceptual transition from conventional

Based on the synthesis of the reviewed studies, this transition is conceptualized as a continuous humancentred assessment cycle, as illustrated in Figure 2.

Table 1. Synthesis of Recent Research on AI and Computer Vision in Educational Assessment

Study	Technology/approach	Assessment application	Major contribution	Key limitation/issue
Wang et al. (2024) [1]	AI/ML literature synthesis	AI in education	Maps major AIED research areas	Broad scope
Mustafa et al. (2024) [2]	Review-ofreviews	AIED research agenda	Identifies research gaps and future directions	Not CV-specific
Alfredo et al. (2024) [8]	Human-centred AI/learning analytics	Assessment and learning support	Emphasizes human control, reliability and trust	Limited enduser involvement
Gao et al. (2024) [6]	AI/NLP	Open-ended response assessment	Synthesizes 93 studies	Mainly textbased assessment
Memarian & Doleck (2024) [5]	AI + Assessment for Learning	Formative assessment	Links AI with feedback and learning	Heterogeneity of evidence
Jocovic et al. (2024) [7]	Computer vision	Pen-and-paper tests	Automated answer recognition	Structured test formats
Study	**Technology/approach**	**Assessment application**	**Major contribution**	**Key limitation/issue**
Deepshikha (2025) [3]	ML, NLP, CV	Automated grading	Synthesizes 77 studies	Bias, privacy and explainability

Liang et al. (2025) [9]	AI in higher education	Curriculum, instruction and assessment	Reviews early AI impact	Rapidly evolving technology
Flores et al. (2024) [6]	OCR + LLM	Handwritten essays	Automated handwritten assessment	Recognition and model dependence
Ncube et al. (2026) [10]	AI assessment review	Academic assessment	Highlights integrity challenges	Strong focus on GenAI
Üstün et al. (2026) [4]	AI-supported assessment	Online higher education	SWOT-based assessment synthesis	Onlineassessment focus
Linwei et al. (2026) [11]	Emerging technologies	Educational measurement	Reviews 933 empirical studies	Broad technology scope

The reviewed studies demonstrate substantial progress in AI-supported educational assessment, including automated grading, open-ended response evaluation, computer vision, OCR, personalized feedback, and learning analytics. However, the literature remains fragmented across individual modalities and assessment functions. These limitations indicate the need for integrated systems that combine visual analysis, text recognition, semantic evaluation, teacher validation, feedback, and learning intervention within a continuous assessment cycle.

3. Multimodal and Human-Centred Assessment

A major limitation of existing AI assessment systems is that many focus on a single information modality. Text-based systems analyse written language, while computer-vision systems analyse visual information. However, students often communicate knowledge through multiple modalities.

For example, a student may provide a written explanation together with a circuit diagram. A mathematics student may combine handwritten equations with graphs, while a science student may use text, labelled diagrams, and experimental observations.

Future assessment systems can therefore integrate:

- Computer Vision for visual and handwriting analysis,
- OCR/HTR for text extraction,
- NLP and large language models for semantic analysis,
- deep learning for visual representation and classification,
- machine learning for prediction and scoring, and
- Learning analytics for longitudinal performance analysis.

Such multimodal assessment can potentially provide richer evidence of student learning than systems restricted to text or images alone.

However, increased automation also creates ethical and pedagogical concerns. AI assessment may produce incorrect decisions because of recognition errors, biased training data,

inadequate explainability, or inappropriate assessment criteria. Student data may also contain personally identifiable information requiring secure management.

Human oversight is therefore essential. Alfredo et al. found that although human-centred principles are increasingly discussed in AI and learning analytics research, actual end-user involvement remains limited [8].

UNESCO's AI Competency Framework for Teachers similarly emphasizes human-centred thinking, AI ethics, AI foundations, and professional learning. The framework stresses the importance of maintaining human agency when AI is introduced into education [12].

Thus, AI should function as an assessment assistant, rather than an autonomous replacement for educators.

4. Research Gap and Future Directions

The literature demonstrates considerable progress, but several gaps remain.

Modality fragmentation remains a limitation. Many systems focus either on text or visual information. More research is needed on integrated systems capable of analysing handwritten text, diagrams, mathematical symbols, and other visual representations simultaneously.

Technical accuracy is often emphasized over educational validity. Future studies should evaluate not only accuracy, precision, recall, and F1-score but also reliability, fairness, interpretability, student acceptance, teacher workload, and learning outcomes.

Diverse datasets are required. Assessment systems should be evaluated across different handwriting styles, languages, educational levels, and demographic groups to minimize bias and improve generalizability.

Explainability requires greater attention. AI systems used for consequential educational decisions should provide evidence for their predictions rather than producing unexplained scores.

Human-AI collaboration requires further investigation. Future systems should explicitly define when AI recommendations should be accepted, reviewed, corrected, or rejected by teachers.

Based on these gaps, a future intelligent assessment system can be conceptualized as:

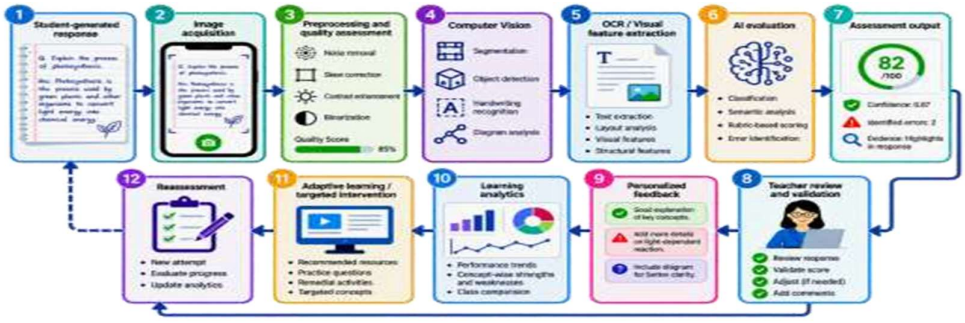

Figure 3. Multimodal AI Framework for Human-Centred Educational Assessment

This framework places teacher validation between automated evaluation and educational intervention, thereby maintaining human oversight while allowing AI to perform repetitive

computational tasks.

5. Conclusion

Artificial Intelligence and Computer Vision are creating significant opportunities for transforming educational assessment. AI can support automated grading, performance analysis, personalized feedback, and learning analytics, while computer vision extends these capabilities to handwritten responses, examination scripts, diagrams, mathematical expressions, and other visual learning materials. Recent literature indicates that AI-supported assessment can improve efficiency, scalability, feedback timeliness, and data-driven decision-making. However, important limitations remain, including recognition errors, dataset bias, privacy, explainability, fairness, academic integrity, and the risk of excessive reliance on automated decisions. The review demonstrates that the future of educational assessment should move beyond isolated automated grading systems toward multimodal and human-centred assessment frameworks. Computer vision, OCR, deep learning, NLP, and learning analytics can be integrated to transform physical and digital student responses into meaningful assessment evidence. Most importantly, AI should not be viewed as a replacement for teachers. Its most appropriate role is to automate repetitive and data-intensive tasks, identify patterns, provide preliminary assessments, and generate actionable feedback, while educators retain responsibility for interpretation, contextual judgement, and consequential decisions. Such human-AI collaboration can contribute to assessment systems that are more efficient, scalable, timely, personalized, and educationally meaningful.

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ARTIFICIAL INTELLIGENCE IN SCIENCE, TECHNOLOGY AND IN MATHEMATICS EDUCATION

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Abstract

Artificial Intelligence (AI) has become a game-changing technology that is changing science, technology, and mathematics (STM) education. Intelligent tutoring systems, adaptive learning platforms, virtual laboratories, and automated assessment systems are examples of AI-powered solutions that facilitate individualized learning, raise student engagement, and increase problem-solving abilities. AI is used in science education to enable virtual experiments, data analysis, and simulations that enhance conceptual comprehension. AI in technology education prepares students for future employment by exposing them to robots, programming, machine learning, and digital innovation. AI supports adaptive practice, immediate feedback, and individualized instruction in mathematics education, all of which enhance mathematical achievement and thinking. Although integrating AI has many advantages, there are drawbacks as well, including issues with data privacy, ethics, digital inequality, and the requirement for teacher preparation. This article explores the uses, advantages, difficulties, and potential applications of artificial intelligence in the teaching of science, technology, and mathematics. It finds that ethical technology use, balanced educational policy, and ongoing professional development for teachers are necessary for the successful application of AI.

Keywords: *adaptive practice, digital innovation and professional development*

Introduction

The ability of computer systems to carry out tasks that often require human intelligence, such as learning, reasoning, problem-solving, decision-making, speech recognition, and natural language understanding, is known as artificial intelligence (AI). AI has developed quickly over the past ten years and is now one of the most important advancements affecting education globally. The basis for scientific literacy, creativity, and technological advancement is science, technology, and mathematics (STM) education. Conventional teaching approaches frequently fail to address students' varied learning demands. AI solves this problem by developing intelligent learning environments that support teachers and students in areas where students actively interact with digital tools, simulations, virtual laboratories, and intelligent tutoring systems. These environments can also adapt to individual learners and offer immediate feedback. AI is anticipated to become a crucial part of education in the future as educational institutions embrace digital change. Students are actively interacting with digital tools, simulations, virtual laboratories, and intelligent tutoring systems in classrooms as a result of the use of AI. AI is predicted to become a crucial part of

education in the future as educational institutions embrace digital transformation more and more.

Importance of Artificial Intelligence (AI) in Science Education

Artificial intelligence (AI) contributes significantly to raising the standard of science education by enhancing the effectiveness, interactivity, and learner-centeredness of instruction. It supports educators in creating lesson plans, encourages scientific inquiry and creativity, and aids students in comprehending difficult scientific ideas. The following points provide a detailed explanation of the significance of AI in science education.

1. Individualized Education

By customizing instruction to each student's learning style, aptitude, and interests, AI offers individualized learning experiences. It ensures that every student gets the assistance they require by identifying each student's unique strengths and shortcomings and suggesting relevant educational resources.

2. Improves Understanding of Concepts

Many scientific ideas are hard to visualize, including genetics, atomic structure, chemical reactions, and astronomical occurrences. Through interactive and visual learning, AI-powered animations, virtual models, and simulations aid students in comprehending these abstract ideas.

3. Encourages Research-Based Education

Observation, experimentation, inquiry, and investigation are all stressed in science education. By enabling students to investigate scientific issues, carry out virtual experiments, evaluate outcomes, and hone their scientific reasoning abilities, artificial intelligence promotes inquiry-based learning.

4. Virtual Laboratory Experiences

Without the need for costly equipment or dangerous chemicals, students may conduct experiments safely and repeatedly in AI-powered virtual laboratories. This is particularly helpful for schools that don't have many labs.

5. Provides Quick Input

Instant feedback on tests, assignments, and lab exercises is offered by AI systems. Without having to wait for a manual assessment, immediate feedback enables students to see errors, clear up misunderstandings, and enhance their comprehension.

6. Enhances Scientific Problem-Solving Abilities

AI takes students through the process of solving real-world scientific challenges. This improves the ability to think critically, reason logically, be creative, and make decisions.

7. Facilitates Data Analysis

Modern science relies heavily on data analysis. AI helps students organize, interpret, and visualize large datasets, making it easier to identify patterns, test hypotheses, and draw scientific conclusions.

8. Assists Teachers

AI reduces teachers' workload by automating routine tasks such as grading assignments, tracking student progress, preparing assessments, and generating performance reports. This allows teachers to devote more time to mentoring and interactive teaching.

9. Increases Student Engagement

Interactive AI applications, educational games, virtual reality environments, and intelligent tutoring systems make science learning more enjoyable and motivating. Increased engagement often leads to better participation and academic achievement.

10. Encourages Independent Learning

AI enables students to learn anytime and anywhere through online platforms and intelligent tutoring systems. Students can review lessons, practice experiments, and explore additional resources independently, fostering lifelong learning habits.

11. Supports Scientific Research

AI assists students and researchers in searching scientific literature, analyzing experimental data, identifying trends, and generating insights. This strengthens research skills and encourages evidence-based learning.

12. Promotes Innovation and Creativity

AI encourages students to design projects, solve scientific challenges, and develop innovative solutions to real-world problems. It fosters creativity by allowing learners to explore multiple approaches to scientific inquiry.

Roles of Teachers in AI-Based Science Education

1. Facilitator of Learning

- Guide students in using AI applications.
- Encourage inquiry-based learning.
- Support collaborative learning activities.
- Help students interpret AI-generated information.

2. Designer of Personalized Learning

- Analyze AI-generated learning reports.
- Modify lesson plans based on student performance.
- Provide additional support to struggling learners.
- Offer enrichment activities for advanced students.

3. Integrator of AI Technology

- Using virtual laboratories during chemistry lessons.
- Employing AI simulations to explain physics concepts.
- Utilizing adaptive learning software for biology topics.
- Using AI-powered quizzes for assessment.

4. Promoter of Scientific Inquiry

- Form hypotheses.
- Design experiments.
- Analyze scientific data.
- Draw conclusions based on evidence.
- Verify AI-generated information using reliable scientific sources.

5. Ethical Guide

- Teach responsible AI use.
- Discuss data privacy and security.
- Explain algorithmic bias.
- Encourage academic honesty.
- Promote critical evaluation of AI-generated content.

6. Developer of Critical Thinking Skills

- Analyze evidence critically.
- Compare multiple sources.
- Evaluate scientific claims.
- Identify misinformation.
- Develop logical reasoning skills.

7. Assessment and Evaluation

- Interpret AI-generated assessment data.
- Provide constructive feedback.
- Evaluate laboratory skills.
- Assess scientific investigations and research projects.
- Monitor overall student development.

8. Mentor and Motivator

- Encourage scientific exploration.
- Build students' confidence.
- Support emotional well-being.
- Motivate students to overcome learning challenges.

Challenges in AI-Based Science Education

1. Lack of Digital Infrastructure
2. High Cost of Implementation
3. Insufficient Teacher Training
4. Data Privacy and Security
5. Algorithmic Bias
6. Digital Divide
7. Overdependence on Technology
8. Reduced Hands-on Laboratory Experience
9. Ethical Issues
10. Accuracy and Reliability of AI

Conclusion: AI integration fosters critical thinking, creativity, problem-solving, scientific inquiry, and digital literacy, equipping students for the quickly changing scientific and technology landscape. Additionally, it improves accessibility by offering tailored assistance to students with a range of needs and expanding chances for both self-directed and group learning. However, the successful implementation of AI in science education depends on addressing several challenges, including inadequate digital infrastructure, high implementation costs, teacher preparedness, data privacy and security, algorithmic bias, ethical concerns, and the digital divide. AI should not replace teachers; instead, it should complement their expertise by automating routine tasks and enabling them to focus on mentoring, fostering curiosity, and developing higher-order thinking skills.

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TEACHER TRAINING FOR UBIQUITOUS LEARNING IN INDIA: CHALLENGES AND OPPORTUNITIES IN DIGITAL EDUCATION

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Abstract

Ubiquitous learning (u-learning) is changing education in India by allowing students and teachers to access learning materials anytime, anywhere through digital platforms. However, for u-learning to be effective, teachers need proper training to use technology in their teaching. Many educators face challenges like limited digital skills, resistance to new teaching methods, lack of internet and devices, and difficulty in adapting traditional lessons to digital formats. The Indian government has introduced various programs, such as DIKSHA, NISHTHA, PM eVidya, and SWAYAM, to support teacher training in digital education. Initiatives like ICT training under Samagra Shiksha and blended learning strategies in CBSE and state boards have helped, but accessibility remains a major issue, especially in rural areas. New approaches like AI-driven personalized training, gamified micro learning, and mobile-based teacher education are making digital training more engaging and inclusive. This article explores the challenges, government initiatives, new trends, and solutions in teacher training for digital education. It highlights successful examples like Kerala's ICT@Schools program, WhatsApp-based teacher training in Maharashtra, and Delhi's blended learning approach. To ensure that teachers across India can effectively use digital tools, we need strong public-private partnerships, more localized digital content, and continuous professional development programs. By building a well-structured teacher training system, India can make u-learning accessible and effective for all, ensuring equal educational opportunities for students across the country.

Keywords: *Ubiquitous Learning, Digital Education, Teacher Training in India.*

1. Introduction

Ubiquitous learning (u-learning) is revolutionizing education in India by enabling anytime, anywhere access to digital educational resources. The rise of AI, cloud computing, and mobile technologies has made learning more personalized and flexible (Kumar & Sharma, 2021; Mishra, 2020). However, its successful implementation depends on well-trained teachers who can integrate digital tools into their teaching. Many educators, especially in rural areas, face challenges such as digital illiteracy, resistance to technology, and lack of resources (NCERT, 2022; Gupta & Singh, 2023). The Indian government has launched initiatives like DIKSHA, NISHTHA, PM eVidya, and SWAYAM to enhance teachers' digital competencies (Ministry of Education, 2021). Despite these efforts, challenges such as limited internet access and inadequate infrastructure persist (Raj & Patel, 2022). Teachers

require ongoing training, structured support, and interactive learning experiences to transition effectively to digital education (Banerjee et al., 2023). A sustainable teacher training ecosystem, integrating public-private partnerships, localized digital content, and continuous professional development (CPD) programs, is essential for the successful adoption of u-learning (Sharma & Kapoor, 2023). Strengthening these aspects will create an inclusive, technology-driven educational environment in India.

1.1 Key Features of U-Learning

U-learning offers several unique characteristics that differentiate it from conventional teaching methods:

1. Accessibility – Learners can access educational resources from any location using mobile devices, tablets, or computers connected to the internet. This feature is particularly beneficial for students in rural and remote areas, where physical access to quality education is limited (Raj & Patel, 2022).
2. Personalization – AI-driven learning platforms adapt to individual learning needs and preferences, offering customized study plans, real-time feedback, and adaptive assessments (Das, 2022).
3. Interactivity – The integration of virtual simulations, gamification, and AI-based tutors makes learning more engaging and immersive. Interactive tools help in better retention of concepts and provide hands-on experience (Reddy & Thomas, 2023).
4. Seamless Learning – U-learning promotes a blend of formal and informal learning, allowing students to learn across multiple platforms without disruption. Whether in a classroom, at home, or on the move, learners can switch between devices and continue their education effortlessly (Gupta & Singh, 2023).

With India's diverse and expansive education system, integrating u-learning into classrooms requires well-trained teachers who can effectively implement digital learning strategies. However, despite its advantages, several challenges hinder the widespread adoption of u-learning among teachers in India.

2. Challenges in Implementing U-Learning for Teachers

Despite the potential of u-learning, its successful implementation in Indian schools is hindered by multiple challenges. These challenges stem from limited teacher digital literacy, resistance to change, infrastructure constraints, lack of training, and assessment difficulties (NCERT, 2022).

2.1 Limited Digital Literacy among Teachers

Many educators, particularly in rural and government schools, lack adequate digital skills to integrate technology into their teaching. A significant number of teachers struggle with using Learning Management Systems (LMS), AI-based teaching tools, and interactive digital resources (Sharma & Kapoor, 2023). Research indicates that less than 40% of teachers in India feel confident using digital teaching tools (Ministry of Education, 2021). Without proper training and exposure, teachers struggle to navigate online platforms, design digital

lessons, or effectively engage students in a virtual environment.

2.2 Resistance to Technological Change

Teachers who have spent years using traditional chalk-and-talk methods often resist adopting digital tools. Many educators perceive technology as an added burden rather than an enabler of learning (Banerjee et al., 2023). Moreover, fears of job displacement due to increasing automation in education discourage teachers from actively engaging in digital training programs (Mishra, 2020). Resistance is particularly high among older educators, who may be reluctant to transition from conventional teaching styles to technology-driven pedagogy (Kumar & Sharma, 2021).

2.3 Infrastructure and Connectivity Issues

One of the most significant barriers to implementing u-learning in India is the lack of adequate digital infrastructure. Many rural and remote schools suffer from unreliable internet connectivity, a shortage of digital devices, and frequent power outages (Gupta & Singh, 2023). According to the Ministry of Education (2021), only 30% of rural schools have access to high-speed internet, and a large percentage of students and teachers lack personal devices for online learning. The urban-rural digital divide significantly impacts teachers' ability to integrate technology into their classrooms effectively.

2.4 Lack of Training in Digital Pedagogy

Although the Indian government has launched multiple digital training programs like DIKSHA, NISHTHA, and SWAYAM, many teachers remain unaware of these resources or lack proper guidance on how to use them (Raj & Patel, 2022). Existing teacher training programs focus primarily on subject knowledge and general pedagogy, rather than developing digital competencies. As a result, many educators struggle to incorporate multimedia content, virtual labs, and AI-based learning assistants into their lessons (Sharma & Kapoor, 2023). To address this, structured, hands-on training workshops that provide practical exposure to digital teaching methods are required. Training programs should focus on blended learning strategies, digital assessment techniques, and real-world case studies to help teachers feel more confident in using technology (Das, 2022).

2.5 Assessment and Evaluation Challenges

Another major challenge in the adoption of u-learning is assessing and evaluating student performance in digital classrooms. Traditional assessment methods, such as pen-and-paper exams, classroom observations, and face-to-face feedback, do not translate effectively into online learning environments (Banerjee et al., 2023). Many teachers struggle with monitoring student progress, engagement, and participation in virtual classrooms. Furthermore, plagiarism and cheating in online assessments remain significant concerns (Reddy & Thomas, 2023). To overcome these challenges, advanced digital assessment tools that use AI-based analytics, real-time student engagement tracking, and automated grading systems must be introduced. Platforms like SWAYAM and DIKSHA offer online quizzes, competency-based assessments, and gamified learning tools, but teachers require proper training to use these features effectively (Ministry of Education, 2021). While u-learning has the potential to

transform education in India, its widespread adoption is hindered by multiple challenges related to teacher preparedness, digital infrastructure, and assessment methods. Addressing these issues requires a multi-pronged approach, including targeted teacher training programs, infrastructure development, and policy support. Government initiatives such as DIKSHA and NISHTHA, along with private-sector collaborations, can help bridge the digital divide and empower teachers with the skills necessary to integrate u-learning effectively. As technology continues to evolve, it is crucial to equip teachers with the right tools and knowledge to ensure that digital education is accessible, engaging, and impactful for all students in India.

3. Government Initiatives for Teacher Training in Digital Pedagogy

To tackle the challenges associated with digital pedagogy, the Government of India has introduced several initiatives aimed at enhancing teacher training and promoting technology-driven education. These programs focus on capacity building, skill development, and accessibility, ensuring that educators across the country, including those in rural and underprivileged areas, can effectively integrate digital tools into their teaching (NCERT, 2022). The DIKSHA platform, launched by the Ministry of Education, serves as a national digital repository offering online courses, interactive lesson plans, e-books, digital teaching resources, including videos, quizzes, and assessment tools. It also provides multilingual content to ensure inclusivity, enabling teachers from different linguistic backgrounds to benefit from the platform (Mishra, 2021). DIKSHA has been widely adopted across various states, integrating state board curricula and providing QR-coded textbooks to enhance digital learning experiences (Ministry of Education, 2021). Similarly, NISHTHA (National Initiative for School Heads and Teachers' Holistic Advancement) is a nationwide teacher training program designed to build digital competencies and pedagogical skills among school educators. It offers structured training modules on digital pedagogy, ICT integration, and innovative teaching strategies. Additionally, NISHTHA provides capacity-building workshops for teachers and school heads to promote leadership skills in digital education. Since its launch, NISHTHA has trained millions of teachers across India, with a strong emphasis on blended learning and ICT-enabled education (Sharma & Kapoor, 2023).

The PM eVidya initiative, introduced under Atmanirbhar Bharat, is a comprehensive digital education program aimed at supporting both teachers and students. It integrates multiple e-learning platforms like DIKSHA and SWAYAM under the "One Nation, One Digital Platform" model. Additionally, it includes TV-based and radio-based educational programs, such as the Swayam Prabha DTH channel, to support learners in low-internet regions. The initiative also makes e-content available across platforms such as the National Institute of Open Schooling (NIOS) and NCERT digital libraries (Ministry of Education, 2021). Another key initiative, SWAYAM (Study Webs of Active Learning for Young Aspiring Minds), is an open-access e-learning platform providing Massive Open Online Courses (MOOCs) developed by premier institutions like IITs, NITs, and NCERT. It offers certified teacher training programs covering digital pedagogy, subject-specific content, and assessment techniques, along with interactive multimedia courses that include videos, quizzes, and

discussion forums (Das, 2022). With over 2,000 courses available, SWAYAM plays a key role in upskilling teachers and preparing them for the digital transformation of education (Reddy & Thomas, 2023). Additionally, the Samagra Shiksha Abhiyan (SSA) promotes ICT-enabled learning and teacher training by providing ICT labs, organizing teacher training workshops, and supporting the development of e-content and digital training modules. SSA ensures that both urban and rural educators have access to quality digital education infrastructure (NCERT, 2022). These government initiatives collectively aim to bridge the digital divide and equip educators with the necessary technological skills to implement ubiquitous learning in India. However, the landscape of teacher training in digital pedagogy is constantly evolving, with new trends emerging to make learning more effective and engaging.

4. Emerging Trends in Teacher Training for U-Learning

As the digital education ecosystem expands, new advancements in technology-driven teacher training are emerging. These innovations focus on making learning more interactive, personalized, and accessible (Kumar & Sharma, 2021). One such trend is AI-driven adaptive training, where AI-powered platforms provide personalized learning dashboards, real-time feedback, and performance analytics to help teachers identify areas for improvement and adjust their teaching strategies accordingly. AI-based EdTech chatbots assist in lesson planning and content delivery, ensuring that teachers receive continuous, individualized learning experiences (Gupta & Singh, 2023). Another important development is gamified microlearning, where interactive, bite-sized training modules are designed to enhance engagement. Features such as points, badges, leaderboards, and short video-based lessons are widely used by EdTech platforms like BYJU'S and Toppr to make teacher training more effective and enjoyable. Microlearning enhances knowledge retention and promotes continuous skill development in an engaging manner (Banerjee et al., 2023). With smartphone penetration increasing in rural India, mobile-based training for educators is gaining traction. WhatsApp-based training programs allow teachers to receive daily learning materials and discussion prompts, while SMS-based micro-courses offer short lessons and assessments for those with limited internet access. Offline learning apps further enable teachers to download and access training content anytime, overcoming connectivity challenges (Reddy & Thomas, 2023). The integration of Augmented Reality (AR) and Virtual Reality (VR) in teacher training is another emerging trend. AR and VR provide hands-on simulations for subjects such as science and mathematics, enabling educators to visualize complex concepts better. Virtual classroom environments allow teachers to practice digital teaching strategies before implementing them in real classrooms, making training more immersive and practical (Raj & Patel, 2022). Given India's linguistic diversity, the development of localized vernacular digital content is crucial. Many EdTech initiatives now focus on creating teacher training materials in regional languages, supported by AI-powered translation tools. This ensures that language barriers do not hinder access to digital pedagogy training. Community-based digital learning platforms are also being developed, where educators can collaborate and share best practices in their native languages (Mishra, 2021). These emerging trends are making teacher training more accessible and efficient, ensuring that teachers across India, including those in rural and marginalized communities, are

equipped with the necessary skills to integrate digital pedagogy effectively.

5. Scalable Solutions for Effective Teacher Training

Addressing the challenges of digital pedagogy in India requires scalable, sustainable, and inclusive teacher training solutions. By leveraging technology, policy reforms, and collaborative efforts, effective training programs can be implemented at scale.

5.1 Strengthening Public-Private Partnerships

Public-private partnerships (PPPs) can play a crucial role in enhancing teacher training programs. EdTech companies like BYJU'S, Vedantu, and Khan Academy have extensive experience in designing interactive digital learning resources. Collaborations between these EdTech firms and government institutions can lead to the development of customized training modules that align with the needs of teachers across India. Additionally, corporate social responsibility (CSR) initiatives from private companies can fund teacher training programs in under-resourced schools, helping bridge the digital divide.

5.2 Continuous Professional Development (CPD) Programs

Incorporating mandatory refresher courses as part of a Continuous Professional Development (CPD) framework can ensure that teachers remain updated with the latest advancements in digital pedagogy. Online platforms like DIKSHA and SWAYAM can host periodic training programs on topics such as AI-driven education, gamification, and blended learning models. The integration of certification-based training programs can further motivate teachers to participate actively in ongoing professional development.

5.3 Creating Community Learning Networks

Peer-learning communities and teacher mentorship programs can help foster collaborative knowledge-sharing environments. By establishing online forums, WhatsApp groups, and local learning hubs, teachers can exchange best practices, discuss challenges, and co-develop innovative teaching strategies. Government-backed platforms like ShikshaLokam and DIKSHA's discussion forums can facilitate the creation of nationwide teacher networks, ensuring continuous learning beyond structured training sessions.

5.4 Affordable Digital Infrastructure for Rural Schools

Ensuring access to digital tools is essential for the success of teacher training programs. Government initiatives must focus on distributing low-cost tablets, setting up solar-powered digital classrooms, and improving internet accessibility in rural areas. Programs like Samagra Shiksha Abhiyan (SSA) have already initiated ICT-based interventions, but expanding these efforts with additional funding and technology-driven solutions is crucial. Additionally, satellite-based internet solutions and mobile-based learning platforms can help overcome connectivity challenges in remote and tribal areas.

6. Case Studies of Successful Teacher Training Models in India

Several state-level initiatives in India have demonstrated the successful implementation of digital teacher training. These models can be replicated and scaled across the country to improve the overall teacher training ecosystem.

6.1 Kerala's ICT@Schools Initiative

Kerala has been a pioneer in integrating ICT-based teacher training. Under the ICT@Schools initiative, over 2 lakh teachers were trained in digital pedagogy, interactive whiteboards, and e-learning tools. The initiative focused on blended learning strategies, digital content development, and capacity building, making Kerala one of the leading states in teacher digital literacy.

6.2 WhatsApp University in Maharashtra

Maharashtra introduced WhatsApp-based microlearning modules to train 40,000+ teachers in rural areas. The WhatsApp University model used short, engaging training videos and quizzes to provide teachers with bite-sized learning resources. This model was cost-effective, scalable, and accessible, proving to be an ideal solution for teacher training in low-resource settings.

6.3 Delhi Government's Teacher Capacity Building Program

Delhi's education department launched a blended learning training program to enhance teachers' skills in digital pedagogy. By integrating EdTech tools, AI-driven assessments, and interactive learning strategies, this program provided continuous professional development (CPD) opportunities for teachers. The initiative also included regular feedback mechanisms and AI-powered analytics to monitor teacher progress and engagement.

7. Conclusion

For India to fully realize the potential of ubiquitous learning (u-learning), it is essential to equip teachers with strong digital skills and pedagogical expertise. While initiatives like DIKSHA, NISHTHA, and SWAYAM have laid a strong foundation, challenges related to infrastructure, accessibility, and teacher engagement still persist. To address these issues, emerging technologies, innovative training models, and policy-driven approaches must be adopted. Public-private partnerships, localized digital resources, and structured CPD programs can help scale teacher training efforts effectively. Additionally, state-level success stories, such as Kerala's ICT@Schools initiative and Maharashtra's WhatsApp-based training, provide valuable insights into how digital training models can be expanded across different regions. By bridging the digital divide, strengthening digital infrastructure, and fostering an inclusive teacher training ecosystem, India can ensure the successful implementation of u-learning. This transformation will not only empower teachers but also enhance the overall quality of education, making learning more engaging, personalized, and accessible for students across the country.

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ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS FOR TEACHING KANNADA AT SECONDARY LEVEL EDUCATION

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Abstract

Artificial Intelligence (AI) is expanding as a disruptive technology in education offering new opportunities to improve the processes of teaching and learning. AI in language education supports personalisation, interactive activities, content creation, language practice, assessment, feedback and student engagement. These possibilities are particularly relevant in the teaching of Kannada in secondary schools where students have to learn reading, writing, speaking, listening, vocabulary, grammar, literary appreciation and creative writing. Moreover, artificial intelligence assists teachers in producing different way of learning materials, generating questions and exercises, providing instant feedback, helping with conversation practice and meeting individual learning needs. It also lightens the burden of rote instruction and lesson planning, allowing teachers to spend more time on meaningful in-class engagement and student growth. However, implementing effective AI in Kannada education are calls for careful attention to linguistic accuracy, cultural relevance, curriculum alignment, ethical use, digital accessibility and teacher readiness. Human review and contextualization might be needed for content produced by AI, especially for regional languages, literature and culturally relevant learning materials. Hence AI should be seen as a learning tool rather than a replacement of the teacher. This paper is a conceptual paper that explores the prospects of AI and pedagogical advancement in teaching Kannada at the secondary school level. In this article, we propose a teacher-guided human-centered approach for AI integration. The research findings suggest that proper application of artificial intelligence makes to learning of Kannada language more personalised, interactive, inclusive, engaging and responsive to the different needs of the learners with a significant role of the teacher in leading, evaluating and improving the learning experience.

Keywords: *Artificial Intelligence, Kannada Language Teaching, Pedagogical Innovations, Secondary Education.*

1. INTRODUCTION

The rapid development of digital technologies has a profound impact on contemporary education. Artificial Intelligence (AI) has become more relevant as an emerging technology due to its ability to generate material, analyse information, provide feedback, personalise learning and assist in instructional decision-making. AI-based educational applications are intelligent tutoring systems, adaptive learning platforms,

automated assessments, learning analytics, conversational systems and generative AI tools.

The use of AI is a breakthrough in technology and education. AI has the potential to change the way of teachers prepare lessons, students interact with learning resources and learning is assessed. Research has shown that AI-supported systems hold the potential to provide personalised learning experiences through the changing of information and activities to the specific requirements and learning progress of students (Luckin *et al.* 2016). Recent research with middle and high school children has also found a positive association between students' learning motivation and AI use for learning, although the correlational nature of the findings prevents causal inferences (Yavich & Davidovitch, 2026).Language instruction is a significant problem for AI since modern artificial intelligence systems are becoming better at handling and producing natural language. These features provide opportunities for language practice, writing support, vocabulary expansion, conversational engagement, feedback and adaptive learning.

But, the integration of AI in teaching Kannada language needs to be more contextualised. Kannada is not only a medium of communication but a mirror of rich linguistic and cultural heritage in Karnataka. AI-powered Kannada education should therefore encompass language correctness, literary traditions, cultural contexts, regional diversity and students' life experiences. Recent research has been particularly enriched by evidence from Karnataka. Dennison *et al.* (2025) explored Shiksha Copilot, an AI-assisted lesson preparation system for government schools in Karnataka. The system helped teachers in preparing lesson plans for grades 5-10 and had materials in English and Kannada. The study shows how artificial intelligence helps to reduce the workload of preparation for instructors, while still allowing teachers to review and customise the content generated by AI. Hence the main point of this study is that AI should be used to complement the Kannada instructor and not replace her. Success of AI based education in Kannada depends on the combination of technology skills with the linguistic knowledge, pedagogical expertise, cultural awareness and professional judgement of instructors.

2. NEED FOR AI IN KANNADA LANGUAGE TEACHING

Kannada teaching at the secondary education level encompasses several competencies, including:

- listening and comprehension;
- speaking and communication;
- reading comprehension;
- vocabulary development;
- grammar;
- writing;
- creative expression;
- literary appreciation;
- critical interpretation; and

- cultural understanding.

Students in the same classroom may have very different language competencies, prior knowledge, learning pace, interests and needs for learning. Traditional teaching methods have difficulty in providing personalised practice for individual learners. It also enables personalised training through the generation of learning exercises of different complexity and the provision of rapid feedback. Artificial intelligence powered adaptive systems creates the personalised learning paths and adapt learning experiences based on student success (Luckin *et al.*, 2016). In addition, recent studies have shown that AI-supported learning is associated with higher levels of student engagement and learning independence (Anshori & Aquino, 2026).

The potential importance of AI is further compounded by the fact that teaching Kannada in the classroom with students with varying levels of linguistic competency. The same lecture's basic, intermediate and advanced tasks are created by the teacher using artificial intelligence. This way the teachers have one educational goal but provide different learning experiences. AI therefore, has the potential to help transform Kannada pedagogy from a one-size-fits-all model to personalised, adaptable, interactive and learner-centred approaches.

3. AI AND PEDAGOGICAL INNOVATION

AI-based pedagogical innovation is about the deliberate application of artificial intelligence (AI) tools to improve teaching and learning, not just adding technology on top of traditional teaching methods. Thus, the use of AI should start with instructional goals, not the technological potential. First, the teacher has to decide the learning outcome and then decide if artificial intelligence meaningfully contributes to achieve it.

The Technological Pedagogical Content Knowledge (TPACK) framework provides a useful theoretical foundation to understand this incorporation. Mishra and Koehler (2006) showed that the interaction of technological knowledge, pedagogical knowledge and content knowledge is required for successful technology integration.

In Kannada education, this is conceptualized as:

"Kannada Content Knowledge + Kannada Pedagogical Knowledge + AI/Technological Knowledge = AI-Supported Kannada Pedagogy"

So, the Kannada teacher should be more than the technical knowledge of artificial intelligence. The teacher should have knowledge of the Kannada language & literature, developmental characteristics of secondary school students, sufficient language-teaching methodologies and an ability to critically examine AI-generated material. Studies on teacher preparedness show that successful AI integration depends significantly on teacher competencies, confidence, training and understanding of AI's pedagogical and ethical considerations (Balraj, 2025).

4. MAJOR AI-BASED PEDAGOGICAL INNOVATIONS FOR KANNADA TEACHING

4.1 AI-Assisted Lesson Planning

AI supports the teachers in preparing:

- lesson objectives;
- introductory activities;
- examples;
- vocabulary exercises;
- grammar activities;
- comprehension questions;
- discussion activities;
- writing prompts;
- classroom activities; and
- formative assessments.

This saves the teacher's time from redundant educational information. The case for this is made out very clearly in the Shiksha Copilot research in Karnataka. The technology were aimed at helping teachers in designing lesson plans aligned to the curriculum and then modify them to the classroom needs (Dennison *et al.*, 2025). Before we implements AI-generated Kannada lesson plans, they need to be linguistically accurate, culturally appropriate, curriculum-aligned and developmentally appropriate.

4.2 Personalized Kannada Learning

One of the major pedagogical advantages of AI is personalization. AI generates different learning activities according to students' proficiency levels.

Namely:

- Basic level: vocabulary, sentence formation, simple comprehension.
- Intermediate level: paragraph writing, contextual grammar, interpretation.
- Advanced Level: Advanced topics include literary analysis, critical reaction, creative writing & argumentation.

In managing learner heterogeneity, differentiated instruction helps to teachers without requiring them to develop fully separate learning programs themselves.

The research on AI-supported learning indicates that personalised learning environments improves the student autonomy and motivation by offering personalised feedback and self-paced learning opportunities (Anshori & Aquino, 2026; Luckin *et al.*, 2016).

4.3 AI-Assisted Vocabulary Learning

AI is also used to create vocabulary activities namely:

- synonyms and antonyms;
- word meanings;
- contextual sentences;
- word associations;
- fill-in-the-blank exercises;
- vocabulary quizzes;

- matching activities; and
- revision exercises.

For instance, after teaching a lesson in Kannada prose, the teacher gets AI to generate vocabulary exercises of varying difficulty and then select and edit pertinent things. This could transform vocabulary learning from a one-dimensional task of memorization into a contextualized and participatory learning experience.

4.4 AI-Supported Grammar Teaching

AI assists in developing grammar exercises according to students' learning needs. Activities may include:

- sentence construction;
- error identification;
- sentence correction;
- contextual grammar;
- sentence transformation;
- word-form exercises; and
- punctuation activities.

Moreover, AI has the potential to generate additional practice questions and make clarifications for grammar errors. The instructors have to verify the grammatical explanations produced by the AI. Generative artificial intelligence systems dream information that may be contextually irrelevant or wrong. So AI should be a help in learning grammar, not an unquestioned authority.

5. AI-SUPPORTED READING COMPREHENSION

AI assists to Kannada teachers in developing reading-comprehension questions at different cognitive levels. Like:

Recall

What happened in the passage?

Understanding

Explain the central idea in your own words.

Application

How can the situation in the passage be related to everyday life?

Analysis

Why did the character behave in this manner?

Evaluation

Do you agree with the character's decision? Give reasons.

Creation

Create an alternative ending to the story.

Questions like these takes Kannada reading education from rote learning to analysis, evaluation, interpretation and creative thinking. Therefore, artificial intelligence helps to teachers to develop higher order questions and reduce the repetitive task of making question

banks.

6. AI-SUPPORTED KANNADA WRITING

Writing in Kannada is a crucial part of Secondary Education. AI is able to support students in brainstorming, outlining, catching language errors, editing manuscripts and receiving feedback. But students shouldn't just ask AI to write entire compositions and turn them in as their own work. Such practices are detrimental to progress in writing and academic integrity. A more appropriate pedagogical model is:

"Student writes → AI provides feedback → Student evaluates the feedback → Student revises → Teacher reviews"

This approach maintains student authorship and employs AI as a formative learning device. Therefore, AI-supported writing should be focused on learning through revision, not outsourcing writing to AI.

7. TEACHER–AI COLLABORATION

The use of AI should not be understood as a substitute for teachers. Instead, it should pave the way for a new sort of teacher-AI partnership. One such example is the Karnataka Shiksha Copilot program, where AI assists in generating instructional materials that are then analysed and customised by teachers and human curators (Dennison *et al.*, 2025).

The teacher contributes:

- subject expertise;
- pedagogical knowledge;
- knowledge of individual students;
- cultural understanding;
- ethical judgment;
- classroom management; and
- professional decision-making.

AI contributes:

- rapid content generation;
- personalization;
- activity generation;
- question generation;
- feedback;
- resource organization; and
- assistance with repetitive planning tasks.

Thus, the preferred model is:

Teacher → AI → Teacher → Student rather than AI → Student

This human-centred approach is consistent with the broader recommendation that AI should support human teaching and learning rather than eliminate the teacher's role (U.S. Department of Education, 2023).

8. CHALLENGES OF AI-BASED KANNADA TEACHING

8.1 **Accuracy:** Content produced by AI may include factual or linguistic inaccuracies. Therefore, teachers are required to screen all educational materials prior to using them in the classroom.

8.2 **Limited Linguistic Resources for Kannada:** Artificial intelligence systems have different capabilities in different languages. Improved Kannada datasets and resources are needed for educational applications in Kannada.

8.3 **Importance of Culture:** Illustrations produced by AI could not authentically represent students' regional experiences. Educators need to put the results of artificial intelligence into context.

8.4 **Reliance on others:** Over-dependence on AI could hamper independent thinking, innovation and critical analysis. Balraj (2025) expressed similar concerns about over-reliance on AI and implications for analytical thinking and creativity.

8.5 **Teachers' Readiness:** Educators need to be AI literate, technologically skilled, pedagogically skilled and ethically aware. There was a considerable interest among B.Ed. students in professional development concerning AI integration (Balraj, 2025).

8.6 **Digital Gap:** Learners may have varying access to devices, internet connectivity and digital resources. AI should be deployed in a holistic manner.

8.7 **Confidentiality and Ethics:** Concerns about privacy, bias, transparency, academic integrity and ethical use arise with the use of AI combined with student data. UNESCO (2021) and U.S. Department of Education (2023) highlight the significance of applying ethical and human-centered AI in educational contexts.

9. PROPOSED AI-ENABLED KANNADA PEDAGOGICAL FRAMEWORK

Based on the reviewed literature, the following conceptual framework proposed for secondary-level Kannada teaching:

Stage 1: Curriculum Alignment

Identify Kannada learning outcomes, competencies and curricular requirements.

↓

Stage 2: Teacher Planning

Teacher identifies students' needs and selects an appropriate AI tool.

↓

Stage 3: AI-Assisted Resource Development

AI assists in preparing lesson plans, examples, activities, questions, vocabulary exercises, grammar tasks and writing prompts.

↓

Stage 4: Human Validation

Teacher verifies language, factual accuracy, cultural relevance, age appropriateness and curriculum alignment.

↓

Stage 5: Personalized Learning

Students receive differentiated learning activities according to their needs and proficiency.

↓

Stage 6: Interactive Language Learning

AI supports reading, writing, vocabulary, grammar, speaking, conversation and creative activities.

↓

Stage 7: Formative Assessment

AI assists in generating questions and providing preliminary feedback.

↓

Stage 8: Critical Reflection

Students evaluate AI-generated information and learn to identify errors, bias and limitations.

↓

Stage 9: Teacher Evaluation

Teacher evaluates actual student learning and provides professional judgment.

↓

Stage 10: Ethical and Inclusive Practice

Ensure privacy, accessibility, responsible AI use, academic integrity and meaningful human interaction.

This framework places the teacher at the centre of AI-supported pedagogy while using AI to extend the teacher's capabilities.

10. IMPLICATIONS FOR KANNADA TEACHERS

AI integration has more implications for Kannada teachers.

10.1 **Artificial Intelligence Literacy:** Teachers need to understand the capabilities and limitations of AI and to critically assess what AI produces.

10.2 **Competency in Prompt Engineering:** Teachers should learn to create relevant prompts that define Consider: Level of class, learning objectives, needs of Kannada language, challenge, cognitive level, cultural context, assessment needs.

10.3 **Content Confirmation.** The AI-generated Kannada content should be validated by the teachers before being used in the classroom.

10.4 **Cultural Contextualisation:** Teachers should modify content produced by AI to include Kannada literature, Karnataka culture, local examples and students' personal experiences.

10.5 **Creation of Content in Kannada language:** Educational institutions should encourage the development of good quality of digital and AI-friendly educational resources in Kannada.

10.6 **Teacher Training:** Teacher education programs and in-service training should incorporate AI literacy, AI-supported pedagogy, prompt design, ethical use, digital citizenship and evaluation of content produced by AI.

11. CONCLUSION

Artificial intelligence (AI) has a lot of potential to improve secondary level Kannada education. It helps to teachers plan lessons, differentiate instruction, build vocabulary, practice grammar, improve reading comprehension, organise writing activities, conduct conversation practice, assess students and give individualised feedback. Also, AI-supported learning enhances the students' engagement, motivation and autonomous learning (Anshori & Aquino, 2026; Yavich & Davidovitch, 2026). But the use of AI in Kannada education should not be considered as a mere technological tool. AI produced material needs close vetting and updating by educators due to the close connection of Kannada to language, literature, culture and region. The research of Shiksha Copilot in Karnataka shows that artificial intelligence assists the teachers in creating and adapting educational content while keeping them actively involved (Dennison *et al.*, 2025). AI should therefore supplement, not supplant, Kannada teachers. Teachers should remain responsible for their teaching decisions, language precision, cultural relevance, assessment and fostering students' critical thinking. The key objective of implementing AI should be to make Kannada learning more personalised, interactive, relevant, inclusive and learner-centred.

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VISION OF NEP ON TEACHER EDUCATION

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Introduction

In order to raise the standard of education in any nation, teacher education is essential. Because they mould the character, knowledge, and abilities of future generations, teachers are the foundation of the educational system. The National Education Policy 2020 brought about a number of changes to teacher education in India in recognition of the significance of teacher training. In order to satisfy the demands of a contemporary, inclusive educational system, the strategy seeks to develop a professional, skilled, and driven teaching workforce. Through robust training programs, improved institutional structures, and ongoing professional growth, NEP 2020 aims to guarantee high-quality teacher education.

Objectives of NEP 2020 in Teacher Education

The vision of NEP 2020 focuses on improving teacher education by achieving the following objectives:

- Enhancing the quality of teacher preparation programmes.
- Developing competent, motivated, and professionally trained teachers.
- Integrating theory with practical teaching experience.
- Promoting research and innovation in teacher education.
- Ensuring continuous professional development for teachers.

Major Provisions of NEP 2020 for Teacher Education

1. Four-Year Integrated B.Ed Programme

One of the key reforms proposed by NEP 2020 is the introduction of a **four-year integrated Bachelor of Education (B.Ed) programme** as the minimum qualification for school teachers. This programme integrates subject knowledge, pedagogy, and practical teaching experience.

The four-year integrated B.Ed programme aims to:

- Provide strong subject knowledge.
- Develop effective teaching skills.
- Offer extensive school-based training and internships.

2. Multidisciplinary Institutions for Teacher Education

NEP 2020 recommends that teacher education programmes should be offered only in **multidisciplinary higher education institutions**. Stand-alone teacher training institutions will gradually be transformed into multidisciplinary institutions by 2030.

This will help in:

- Improving academic quality.
- Promoting interdisciplinary learning.
- Enhancing research and innovation.

3. National Professional Standards for Teachers (NPST)

NEP 2020 proposes the development of **National Professional Standards for Teachers** to guide teacher performance and professional growth.

These standards focus on:

- Teacher competencies
- Professional ethics
- Classroom practices
- Continuous professional development

4. Strengthening Teacher Education Curriculum

The policy emphasizes modernizing the teacher education curriculum to include:

- Inclusive education
- Educational technology
- Child psychology and development
- Multilingual education
- Value-based education
- Experiential learning methods

5. Emphasis on Practical Training and Internship

NEP 2020 stresses the importance of practical training in real classroom situations. Teacher education programmes should include **extensive teaching internships in schools** to provide hands-on experience.

6. Continuous Professional Development (CPD)

Teachers are expected to participate in **continuous professional development programmes** to update their knowledge and skills. NEP recommends that teachers engage in at least **50 hours of professional development training every year**.

7. Use of Technology in Teacher Education

NEP 2020 promotes the use of digital tools and online learning platforms to enhance teacher training.

Teachers will be trained in:

- Digital pedagogy
- Online teaching methods
- Educational technology tools

8. Merit-Based Recruitment and Career Progression

The policy emphasizes transparent and merit-based recruitment of teachers. It also proposes a **clear career progression system** that rewards good teaching performance and professional development.

Impact of NEP Vision on Teacher Education

- Improvement in the quality of teachers.
- Better classroom teaching and learning outcomes.
- Greater professional status for teachers.
- Promotion of innovative teaching methods.
- Development of inclusive and learner-centred classrooms.

Challenges in Implementing NEP Vision

- Lack of infrastructure in some teacher education institutions.
- Need for well-trained teacher educators.
- Financial and administrative constraints.
- Need for coordination between institutions and regulatory bodies.

Suggestions for Effective Implementation

- Strengthen teacher education institutions.
- Provide adequate funding and resources.
- Train teacher educators in modern teaching methods.
- Encourage research and innovation in teacher education.
- Promote collaboration between universities and schools.

Conclusion

The vision of teacher education under the **National Education Policy 2020** focuses on improving the quality, professionalism, and effectiveness of teachers in India. By introducing the four-year integrated B.Ed programme, promoting multidisciplinary institutions, strengthening teacher training, and encouraging continuous professional development, NEP 2020 aims to build a strong and competent teaching workforce. Successful implementation of these reforms will contribute significantly to improving the overall quality of education and achieving national development goals.

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SCIENTIFIC ATTITUDE AND AWARENESS OF GAMIFICATION TEACHING TECHNIQUE AMONG PRE-SERVICE TEACHERS IN THE ERA OF ARTIFICIAL INTELLIGENCE

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Abstract

The quick progress of Artificial Intelligence (AI) is altering the educational field and is opening up new possibilities for innovative methods of teaching and learning. Gamification as one of the emerging teaching technique, has attracted a great deal of attention since it has the potential to increase the learner engagement, motivation, participation, and feedback. This study aims to assess the level of Scientific Attitude and Awareness of Gmaification Teaching Technique, is there any difference in Scientific Attitude and Awareness of Gmaification Teaching Technique, with respect to gender, stream and to find correlation between Scientific Attitude and Awareness of Gmaification Teaching Technique among pre-service teachers. Survey method was adopted to the study. 116 B.Ed students from Mysore district was selected as the sample of the study. Shailaja Bhagawath Scientific attitude scale and Gamification Teaching Technique Awareness Test (GTTAT) were used to collect the data. Pearson product moment correlation was employed to find out the correlation't' test was employed to find the difference between the different categories. Finding shows that these is no significant difference in scientific attitude with respect to gender and stream but there is a significant difference in Stream awareness of Gmaification Teaching Technique. There is a positive high correlation between the Scientific Attitude and Gmaification Teaching Technique.

Keywords: *Artificial Intelligence, Gamification Teaching Technique, Scientific Attitude, Pre-Service Teachers.*

Introduction

Education is experiencing a major change as a result of quick advancement of digital technologies and Artificial Intelligence (AI). Applications based on AI are being used more and more for lesson planning, generating content, assessment and providing feedback, offering personalized learning, carrying out learning analytics and giving instructional support. Since these technologies are appearing teachers are being required to acquire new skills that go beyond traditional pedagogical knowledge. UNESCO's AI Competency Framework for Teachers emphasizes a human centered mindset, ethics of AI, AI foundations and applications, AI pedagogy and AI for professional learning. This indicates that teachers

need not only technical knowledge but also the ability to use AI critically, ethically and pedagogically. Students are nowadays coming into contact with digital games and interactive technologies more and more. As a result, there is a raising interest in teaching that is based on gamification. This kind of teaching makes use of various features of games such as points, badges, challenges, levels, rewards, leader-boards, progress indicators, narratives, and immediate feedback in situations which are not games.

Gamification has the potential to turn traditional classroom activities into engaging learning experiences. However, the mere addition of game elements is not sufficient for effective learning. The educational value of gamification depends on appropriate instructional designs, learner characteristics, learning objectives, context and implication. This problem becomes exceptionally essential in the context of the teacher education. Teacher to-be, pre-service educators, will address learners who will be exposed to a world increasingly driven by AI technologies. Thus, pre-service teachers needs to know how to use gamification, when and why to use it, how to assess its impact, and how to incorporate it into their pedagogical activities based on AI technologies. Scientific attitude is a specific behavior that is especially relevant in the context of technology.

Gamification and Artificial Intelligence

AI expand the possibilities of gamification by making gamified learning environments high adaptive and personalized. Traditional gamification might provide the same challenge to all learner.

AI supported gamification potentially follow this process:

Student performance → AI analysis → Difficulty adjustment → Personalized challenge → Feedback → New learning activity

Awareness of Gamification teaching technique among pre- service teachers

Awareness should be considered multidimensional rather than simply knowing the definition of gamification.

- ❖ Conceptual awareness
- ❖ Pedagogical awareness
- ❖ Technological Awareness
- ❖ Critical Awareness
- ❖ Ethical Awareness
- ❖ Creative Awareness:

Need and importance of the study

The combination of AI and gamification can lead to the development of novel approaches to individualization and interactivity in education. Using AI, it becomes possible to create questions, grade them, and design challenges, offer recommendations and evaluate a student's performance. The successful integration of gamification requires teachers to have the necessary pedagogical knowledge, technological awareness, critical thinking and scientific attitude. Therefore, pre-service teachers must gain the necessary skills to critically

analyze emerging technologies instead of adopting new development just because they are available. Pre-service teachers can be considered future educators who will have to operate in conditions of widespread digital and AI-driven technologies. As such, these students need to gain awareness about gamification and didactical use, as well as critically evaluate its effectiveness. The concept of scientific attitude is highly relevant in this respect since it implies curiosity, objectivity, open-mindedness, critical thinking, rationality and openness to new ideas and evidence. By employing this qualities future teachers will be able to define the genuine benefits of using gamification and AI in education and distinguish them from technological novelties that may appear in the future. The study is of significance to pre-service teachers. Teacher educators, teacher education institutions, curriculum designers and researchers.

The findings of the study offers implications for understanding the readiness of future teachers for gamification and AI enhanced pedagogy and can help design the necessary training courses, workshops and curriculum interventions, moreover, it makes a contribution to the area of education by supporting the designs of effective, evidence-based, ethical, learner centered, and innovative educational practices in the age of Artificial Intelligence.

Objectives of the study:

1. To assess the level of Scientific Attitude among Pre-Service teachers.
2. To assess the level of awareness of Gamification Teaching Technique among Pre-Service teachers.
3. To study whether there is a significant difference in Scientific Attitude among male and female Pre-Service teachers.
4. To study whether there is a significant difference in awareness of Gamification Teaching Technique among male and female Pre-Service teachers.
5. To study whether there is a significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.
6. To study whether there is a significant difference in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.
7. To study whether there is a significant correlation between Scientific Attitude and awareness of Gamification Teaching Technique among Pre-Service teachers.

Hypotheses of the study

1. There is no significant difference in Scientific Attitude among male and female Pre-Service teachers.
2. There is no significant difference in awareness of Gamification Teaching Technique among male and female Pre-Service teachers.
3. There is no significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.

4. There is no a significant difference in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.

5. There is no a significant correlation between Scientific Attitude and awareness of Gamification Teaching Technique among Pre-Service teachers.

Variables of the study

Main Variables

- Scientific Attitude
- Awareness of Gamification Technique teaching

Background Variables

- Gender
- Stream

Study method

Descriptive survey method has been adopted to the present study.

Sample of the study

For the present study, 116 pre-service teachers of different B.Ed Colleges in Mysore city were selected in the sample

Tools used to collect the data

1. Shailaja Bhagwat Scientific Attitude Scale (SBSAS) - Shailaja Bhagwat\
2. Gamification Teaching Technique Scale (AGTTS)- Researcher

Statistical techniques to analyse the data:

Table No: 1 Table Showing, Statistical techniques to analyse the data

S.N	Statistical techniques	Objectives/ Hypotheses
01	Percentage analysis	Objective 1and 2
02	t-Test	Hypotheses 3 , 4 and 5
03	Pearson's product moment	Hypotheses 6

Analysis and interpretation of data:

1. **Objective - (1):** To assess the level of Scientific Attitude among Pre-Service teachers.

Table No: 2 Table Showing, Percentage of teachers having different levels of Scientific Attitude among Pre-Service teachers.

S.N	Variable	Range	Frequency	Percentage
1	Scientific Attitude	Above average (M+S D)(82 and above)	17	14.65
2		Average(M+S D to M-S D) (81 to 70)	84	72.41
3		Below average (M-S D)(below 69)	15	12.94
Total			**116**	**100**

According to table -2, majority of the pre-service teachers (72.41%) having average level of Scientific Attitude, (14.65%) are having above average level of Scientific Attitude and (12.94%) possess below average level Scientific Attitude respectively.

Objective - (2): To assess the level of awareness of Gamification Teaching Technique among Pre-Service teachers.

Table No: 3 Table Showing, Percentage of teachers having different levels of Gamification Teaching Technique among Pre-Service teachers.

S.N	Variable	Range	Frequency	Percentage
1	Gamification Teaching Technique	Above average (M+S D)(20 and above)	16	13.80
2		Average (M+S D to M-S D) (19 to 10)	64	55.17
3		Below average (M-S D) (below 9)	36	31.03
Total			**116**	**100**

According to table -3, majority of the pre-service teachers (55.17%) having average level awareness of Gamification Teaching Technique, (13.80%) having above average level awareness of Gamification Teaching Technique and (31.03%) are having below average level awareness of Gamification Teaching Technique respectively.

Hypothesis- (Ho1): There is no significant difference in Scientific Attitude among male and female Pre-Service teachers.

Table No: 4 Table Showing, in Scientific Attitude among male and female Pre-Service teachers.

Gender	N	Mean	SD	df	t-value	Level of significance
Male	44	75.71	5.317			
Female	72	75.91	6.749	114	0.133	Accepted *

Table 4, revels that, obtained t-value (0.133) is lesser than the table value (1.660) at the 0.05 level of significance. The null hypothesis accepted. Hence There is no significant difference in Scientific Attitude among male and female Pre-Service teachers.

Hypothesis- (Ho2): There is no significant difference in awareness of Gamification Teaching Technique among male and female Pre-Service teachers.

Table No:5 Table Showing, difference in awareness of Gamification Teaching Technique among male and female Pre-Service teachers.

Gender	N	Mean	SD	df	t-value	Level of significance
Male	44	15.73	4.066			
Female	72	16.10	3.428	114	0.525	Accepted *

Table 5, revels that, obtained t-value (0.525) is lesser than the table value (1.660) at the 0.05 level of significance. The null hypothesis accepted. Hence there is a significant difference in awareness of Gamification Teaching Technique among male and female Pre-Service teachers.

Hypothesis- (Ho3): There is no significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.

Table No: 6 Table Showing, in significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.

Stream	N	Mean	SD	df	t-value	Level of significance
Arts	69	75.54	6.116			
Science	47	76.21	6.416	114	0.573	Accepted *

Table 6, revels that, obtained t-value (0.573) is lesser than the table value (1.660) at the 0.05 level of significance. The null hypothesis accepted. Hence There is no significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.

Hypothesis- (Ho4): There is no a significant difference in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.

Table No: 7 Table Showing, difference in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.

Stream	N	Mean	SD	df	t-value	Level of significance
Arts	69	15.48	3.555			
Science	47	16.66	3.761	114	2.716	Rejected

Table 7, revels that, obtained t-value (2.716) is grater than the table value (1.660) at the 0.05 level of significance. The null hypothesis rejected. Hence there is a significance difference between in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.

Hypothesis- (Ho5): There is no a significant correlation between Scientific Attitude and awareness of Gamification Teaching Technique among Pre-Service teachers.

Table No: 8 Table Showing correlation between Scientific Attitude and awareness of Gamification Teaching Technique among Pre-Service teachers.

Variables	r- value	Correlation
Scientific Attitude		
Awareness of Gamification Teaching Technique	0.715	**Positive high correlation**

Table 8, shows that the obtained 'r' value is 0.715, between Scientific Attitude and awareness of Gamification teaching Technique is found that positive high correlation. The null hypothesis is rejected. Hence there is a significant high positive correlation between Scientific Attitude and awareness of Gamification teaching Technique.

Findings of the Study:

- Majority of the pre-service teachers (72.41%) having average level of Scientific Attitude, (14.65%) are having above average level of Scientific Attitude and (12.94%) possess below average level Scientific Attitude respectively.
- Majority of the pre-service teachers (55.17%) having average level awareness of Gamification Teaching Technique, (13.80%) having above average level awareness of

Gamification Teaching Technique and (31.03%) are having below average level awareness of Gamification Teaching Technique respectively.

- There is no significant difference in Scientific Attitude and Gamification Teaching Technique among male and female Pre-Service teachers.
- There is no significant difference in Scientific Attitude among arts and science subject Pre-Service teachers.
- There is a significance difference between in awareness of Gamification Teaching Technique among arts and science subject Pre-Service teachers.
- There is a significant high positive correlation between Scientific Attitude and awareness of Gamification teaching Technique.

Implications:

The result have significant implication for the pre- service teachers. The fact that an average level of gamification teaching technique awareness has been found among trainee teachers. They need a systematic training via, workshops, demonstration, micro-teaching and practical excise and should be encouraged to design and carryout gamified learning activities that make use of digital games, quizzes, challenges rewards etc. since there is a significant difference between those with an arts and science background pre-service teachers, although the strong positive correlation suggests that Scientific attitude, gamification and AI-assisted teaching methods should incorporated into teacher education.

Conclusion:

Artificial intelligence and gamification are important trends influence current education. The combination of these trends will provide engaging, adaptive, interactive and personalized learning process. Study claims that scientific attitude is a vital prerequisite for using gamification methods of teaching in the era of AI. Future teacher must possess curiosity to investigate new technologies, openness to use the innovative approach in education.

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SYNECTICS MODEL OF TEACHING FOR DEVELOPING SKILLS AND ENHANCING EMPLOYABILITY

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Abstract

Employers keep telling the same thing: graduates know their subjects but struggle to think flexibly, communicate with ease and solve problems that come without a marking scheme. Classrooms, meanwhile, remain largely organised around delivering content and reproducing it in examinations. This paper examines the Synectics model of teaching, developed by William J. J. Gordon and adapted for schools by Joyce, Weil and Calhoun, as a practical way of building employability skills. The model uses direct analogy, personal analogy and compressed conflict to loosen habitual thinking before learners return to the task at hand. The paper first clarifies what employability means and groups its main skills under six headings: creative problem-solving, communication, collaboration, adaptability, empathy and reflective judgement. It then describes the model and reviews three recent empirical studies, carried out in junior high schools, government schools and a Malaysian university design programme. These studies report encouraging gains in creative thinking, metacognition and problem identification. They also reveal small samples, short interventions and, in one case, statistically unconvincing results, and none of them measures employment outcomes. Building on this evidence and on learning theory, the paper proposes a framework that links each Synectics phase to specific employability skills, illustrates it with a classroom example, and suggests ways of assessing the thinking behind a final answer as well as the answer itself. The discussion is deliberately balanced, because teachers and institutions need an honest account of what is known as much as they need new ideas, and the paper is written for teachers, trainers and curriculum designers. Practical obstacles, including time pressure, teacher confidence and the fragility of transfer, are discussed candidly. The paper concludes that Synectics is a promising but under-tested method that deserves systematic investigation, and it calls for larger, well-controlled studies that follow learners into the workplace.

Keywords: Synectics, models of teaching, employability skills, creativity, analogical thinking, teacher education

1. Introduction

Employers, if asked, what they look for in a new recruit and subject knowledge seldom comes first. They talk about people who pick things up quickly, explain themselves clearly, get along with colleagues, and keep going when the textbook answer turns out not to fit. The World Economic Forum (2023) found that employers expect analytical thinking and creative

thinking to grow most in importance over the next five years, with resilience, flexibility and curiosity close behind. Yet most classrooms are still built around delivering content and then testing how much of it students can reproduce.

Teachers know this gap exists. What they often lack is a method that fits inside an ordinary timetable and builds these skills while students are learning the subject, instead of in a separate workshop. This paper looks at one such method, the Synectics model of teaching. Gordon (1961) first described the approach, and Joyce, Weil and Calhoun (2015) adapted it for classrooms. Learners work through analogies, imagine themselves inside a problem and coin short paradoxical phrases, and only then return to the task they started with, usually seeing it differently. The paper has four aims. It clarifies what employability involves, describes the model clearly enough for a teacher to try it, reviews the empirical studies that have tested it, and proposes a framework linking each phase of the model to particular employability skills. It is a conceptual paper with an evidence review, and it reports no new data. Where the evidence is thin, it is said so.

2. Employability and the Skills Behind It

Employability is about more than the chance of landing a job. Yorke (2006) described it as a set of achievements, understandings and personal attributes that make graduates more likely to find work and do well in it. The emphasis moves from a job outcome to a bundle of capabilities: a graduate can be out of work in a poor labour market and still be highly employable. Dacre Pool and Sewell (2007) added that these capabilities draw on subject knowledge, generic skills, emotional intelligence, career-development learning and work experience, and that they rest on reflection, self-efficacy and confidence. Seen this way, employability is not a module a student completes. It builds slowly, through repeated experience. Employer surveys and academic frameworks differ in detail, but a stable cluster of skills keeps turning up. For this paper it is grouped under six headings: creative problem-solving, communication, collaboration, adaptability and resilience, empathy and perspective-taking, and reflective judgement. The categories overlap, but they give us something to map a teaching model against. Conventional teaching does not develop these skills very well. When every task has one right answer and one approved route to it, students get good at finding the expected answer. They get little practice at generating alternatives, imagining another person's position, or sitting with not knowing, and they are unlikely to feel at ease doing any of it at work. A teacher who wants to change this needs a routine that puts learners in unfamiliar thinking territory with enough structure that they do not simply flounder.

3. The Synectics Model of Teaching

The name comes from a Greek word meaning the joining together of different and apparently unrelated things. Gordon (1961) developed the approach by watching how groups of inventors and designers actually solved problems. Breakthroughs seldom came from steady, step-by-step reasoning. They came when someone borrowed an image from another field, imagined being the object under study, or held two ideas that seemed incompatible until

something gave way. Two assumptions run through his work: creativity can be taught and practised, and emotion matters as much as logic. Joyce et al. (2015) describe two classroom strategies. In *creating something new*, learners look at a familiar problem afresh in order to produce an original solution. In *making the familiar strange*, they approach unfamiliar material by comparing it with what they already know, so that new concepts begin to mean something. Both strategies rely on three kinds of analogy. A *direct analogy* compares two things from different domains, such as a supply chain and a river system. A *personal analogy* asks learners to become the object or concept and say what it feels, wants or fears. A *compressed conflict* is a two-word phrase that holds opposites together, such as "gentle firmness". A lesson in the first strategy moves through six phases. Learners describe the situation as they see it, propose direct analogies, take a personal analogy, form compressed conflicts, build a new direct analogy from the conflict they like best, and finally re-examine the original task. There are good reasons to expect this to help. People solve unfamiliar problems more readily when they map a known case onto the new one, but they rarely do it unprompted (Gick & Holyoak, 1980). Synectics supplies the prompt, again and again. The sequence also follows Kolb's (1984) experiential cycle quite closely: concrete experience in the personal analogy, reflection in the discussion that follows, abstraction in the compressed conflict, and experimentation when learners return to the task. Along the way, learners also get repeated practice at stating an idea aloud and defending it, which is exactly what meetings and interviews demand.

4. Empirical Evidence

Most published research on Synectics measures creativity or achievement. Very little of it looks at employability directly. Three recent studies, from different countries and levels of education, still tell us something useful about the skills that matter here. In Indonesia, Suratno et al. (2019) used a quasi-experimental, one-group pretest–posttest design with 242 seventh-grade students from three junior high schools. Over four weeks of science lessons on ecosystems, students worked through a five-step Synectics sequence: substantive input, direct analogies, personal analogy, exploration and new analogies. Creative thinking, scored on fluency, flexibility and originality, rose from a mean of 66.68 to 68.14, and self-reported metacognition rose from 69.86 to 72.48. The correlation between the two grew from .718 before the lessons to .873 afterwards. The authors concluded that the model supported both skills. Their interviews suggest that some students found imagining themselves as an object easy but struggled to think of new analogies. The gains are modest in absolute terms, and with no comparison group they cannot be credited to the method alone. The tighter link between creativity and metacognition is still interesting for reflective judgement, although it is a correlation and not proof of cause.

Sahoo et al. (2025) combined Synectics with dialogue-based teaching in a nonequivalent control-group quasi-experiment with 80 seventh-grade students from two government schools. The experimental group was taught with the hybrid model, and the control group by

its regular teacher using traditional methods. The authors report that creative thinking improved more in the experimental group. Having a comparison group makes this study stronger than the first, and its emphasis on classroom talk suggests that Synectics could also serve communication and collaboration, although the study did not test that. The sample is small, the intervention short, and only one skill was measured. The investigator also taught the experimental group while the control group stayed with its regular teacher, which makes it harder to separate the method from the enthusiasm of the person delivering it.The study closest to employability is by Ong and Tan (2025), who worked with 26 diploma students of industrial design at a Malaysian university. Motivated by concern about graduates' creative problem-solving, they built both Synectics strategies into the early problem-identification stage of a studio project. An experimental group was compared with a conventionally taught control group, using a sequential explanatory mixed-methods design. The experimental group scored higher on average in creative problem-solving, but the statistical evidence was not convincing. In interviews, however, students said they were better at identifying users' problems, and the authors advised introducing the model gradually from the start of a programme. A mixed result like this is probably more typical of real classrooms than a clean success story. Their students were a small group in a single programme, so the findings are suggestive at best.

Taken together, the studies point the same way, but not strongly. Each reports some benefit for creativity-related outcomes, across different subjects and levels. Each is also small or short, and the designs range from a single group with no comparison to a posttest-only comparison. None follows learners into employment, and none measures communication, collaboration or empathy directly. The fair conclusion is that Synectics is a promising but under-tested route to employability skills, and the framework that follows is built on that understanding.

5. Framework Linking Synectics to Employability

The framework rests on a simple observation. Each phase of a Synectics lesson asks learners to do something that matches a recognised employability skill. Table 1 sets out the links.

Table 1. **Synectics phases and the employability skills they exercise**

Phase	What learners do	Employability skills
1. Describe the situation	State the problem in their own words; separate what is known from what is puzzling.	Problem framing; clear communication; listening
2. Direct analogy	Offer comparisons from unrelated fields; select one to explore.	Divergent thinking; transfer of learning; flexibility
3. Personal analogy	Become the element and describe its feelings, needs and constraints.	Empathy; perspective-taking
4. Compressed conflict	Condense insights into a two-word paradox.	Synthesis; tolerance of ambiguity; precise language
5. New direct analogy	Build a fresh analogy from the paradox.	Persistence; building on others' ideas

6. Re-examine the task	Return to the original problem, apply what emerged and justify choices.	Decision-making; reflective judgement; presentation

Three features deserve comment. First, the sequence moves from the concrete to the abstract and back again. Many employability programmes stay at the abstract end ("show initiative") and leave students unsure what to actually do, whereas Synectics specifies moves that can be performed, observed and discussed. Second, collaboration is built in, not added on. Analogies are shared and developed by the group, and a learner who brushes off a classmate's comparison soon finds that the session stalls. Third, reflection is a normal closing step. When learners return to the original task they are, in effect, asked what has changed in how they see it, and why. The sequence also gives quieter students a way in, because offering an analogy feels less exposing than offering a finished answer, which may help build the confidence that Dacre Pool and Sewell (2007) place at the centre of employability.

The evidence reviewed above fits this picture in places. The stronger link between creativity and metacognition in Suratno et al. (2019) fits the reflective phases, and the better problem identification reported by Ong and Tan (2025) fits the first phase, where the problem is described and framed. The remaining links, particularly those for empathy and communication, are hypotheses that still await direct testing.

6. Classroom Application and Assessment

Take a first-year business-communication class asked to write to a customer whose order has been delayed for the second time. In pairs, students list what the customer probably feels and what the company can and cannot promise. The class then suggests comparable situations, such as a pilot announcing a delay or a doctor giving unwelcome news, and votes for "the pilot". Each student writes a short first-person paragraph as the pilot: what do I know, what do I fear, what do the passengers need from my voice? Groups then look through these paragraphs for compressed conflicts such as "honest comfort" or "calm urgency" and choose one. From it they build a new analogy, perhaps a lighthouse or a sturdy bridge in fog, and discuss what it suggests about tone. Finally, each student drafts the message and swaps it with a partner, who underlines the sentence that best carries the chosen phrase. A full session like this takes about seventy-five minutes.

The same structure travels well. A science teacher might ask students to imagine being a water molecule at a membrane, and a vocational instructor might use it to prepare learners for a difficult client. The subject changes the examples, but not the sequence. What matters is the atmosphere around it: some playfulness, a willingness to hold back judgement, and a teacher who shows curiosity instead of authority. The most common mistake is to hurry through the personal analogy because it feels like a detour. In practice it is the detour that gives the later phases their substance.

Assessment should capture the thinking as well as the product. Three approaches work well together: a short learning log of analogies, personal paragraphs and compressed conflicts;

teacher or peer observation against a simple rubric covering the range of analogies, perspective-taking, building on others' ideas and reflective judgement; and a three-sentence written reflection at the end of each session. Over a term, the reflections also show how a learner's strategies and confidence change, which is useful material for a portfolio or a job interview.

7. Challenges and Limitations

Time is the first obstacle. A full six-phase session can take well over an hour, which is hard to find under examination pressure, and sessions rarely run to the clock the first time. Teachers can use the shorter strategy, keep full sessions for the hardest topics, or treat Synectics as one tool among several instead of a replacement for direct instruction. Ong and Tan's (2025) advice to introduce the model gradually is sensible.

Teacher confidence is the second. The model asks teachers to loosen control and respond to contributions they cannot predict, and without preparation a lesson can slide into a game with no clear link to the learning goals. Where students are used to being either right or silent, playfulness can also feel risky, so early sessions work best with low-stakes topics and a teacher who openly values unusual ideas. Shallow analogies are a third risk. Comparing the heart to a pump adds little when students already know it. The teacher has to push towards comparisons whose structure can be explored and whose limits can be tested.

The most serious limitation concerns evidence and transfer. As Section 4 shows, the studies are few, small and short, and none tracks employment outcomes. Even if students become more fluent with analogies in class, transfer to the workplace is notoriously fragile. It is more likely when learners are told what the skill is called and are given chances to use it in varied settings (Gick & Holyoak, 1980). The same caution applies to the claims made for any teaching method, including this one. A programme that never names the skills it is building would waste much of its potential.

8. Conclusion

Employability depends on a cluster of skills that conventional teaching does not reliably develop, and those skills grow through repeated practice in situations where the answer is not handed over. The Synectics model creates such situations in a structured form that teachers can learn. By asking learners to compare, imagine, hold a contradiction and then return to the task, it exercises problem-solving, communication, collaboration, empathy, adaptability and reflection in a single compact sequence.

The empirical evidence is encouraging but thin. Larger controlled studies, using validated measures of communication, collaboration and empathy and following learners into the workplace, are needed before strong claims can be made. Until then, a teacher who runs even one well-designed Synectics session a month is giving students a chance to be inventive on purpose, and to find out that they can be.

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A STUDY ON THE USE OF ARTIFICIAL INTELLIGENCE FOR THE DEVELOPMENT OF PERSONALIZED LEARNING IN THE EDUCATION SYSTEM

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1. Introduction

Education systems across the world are undergoing a significant transformation due to rapid advancements in digital technologies. Among these, Artificial Intelligence (AI) has emerged as a powerful tool with the potential to reshape teaching–learning processes. Traditional education systems largely follow a one-size-fits-all approach, which often fails to address individual differences in learners' abilities, interests, learning pace, and cognitive styles. This limitation has created an urgent need for personalized learning, where instruction is tailored to the specific needs of each learner. Artificial Intelligence enables the collection, analysis, and interpretation of large volumes of learner data to design adaptive and individualized learning pathways. AI-driven systems such as intelligent tutoring systems, adaptive learning platforms, learning analytics tools, chatbots, and recommendation engines can dynamically adjust content, pedagogy, and assessment according to learner performance. As a result, AI-supported personalized learning has the potential to improve learner engagement, academic achievement, retention, and lifelong learning skills. In the Indian and global education context, personalized learning supported by AI is gaining attention in schools, higher education institutions, and online learning platforms. National education policies and global frameworks emphasize technology integration to enhance equity, quality, and inclusiveness in education. However, despite the growing adoption of AI-based tools, there is limited systematic research on how AI is actually being used for personalized learning, its effectiveness, challenges, ethical concerns, and future prospects. The present study seeks to examine the role of Artificial Intelligence in the development of personalized learning within the education system. It aims to analyze existing AI applications, evaluate their impact on teaching–learning processes, identify challenges faced by educators and learners, and propose a framework for effective and ethical implementation of AI-driven personalized learning.

2. Background of the Study

Personalized learning is rooted in constructivist and learner-centered theories of education, which emphasize that learners actively construct knowledge based on prior experiences, abilities, and motivations. Educational psychologists such as Piaget, Vygotsky, and Bruner highlighted the importance of individual differences, scaffolding, and adaptive instruction.

However, large class sizes and rigid curricula have historically limited the practical implementation of personalized learning.

The emergence of Artificial Intelligence has provided new opportunities to operationalize personalized learning at scale. AI technologies such as machine learning, natural language processing, datamining, and predictive analytics allow educational systems to continuously monitor learner behavior, diagnose learning gaps, and provide customized feedback and learning resources. Globally, AI-powered platforms like adaptive learning systems, intelligent tutoring systems, MOOCs with personalized pathways, and AI-driven assessment tools are being integrated into education. In India, initiatives related to digital education, online learning platforms, and educational technology startups have begun experimenting with AI-based personalization. Despite this progress, concerns related to data privacy, algorithmic bias, teacher preparedness, infrastructure, and ethical use of AI remain significant.

This background highlights the need for an in-depth academic investigation into how AI supports personalized learning, how stakeholders perceive its effectiveness, and what strategies can ensure its responsible and inclusive adoption.

3. Review of Related Literature

Indian Literature

Agarwal (2019) examined the scope of artificial intelligence within the Indian education system, focusing on both its opportunities and challenges. The study highlighted how AI technologies such as intelligent tutoring systems, automated assessment, and learning analytics can enhance efficiency and personalization in teaching–learning processes. Agarwal emphasized that AI has the potential to address issues like large classroom sizes, diverse learner needs, and uneven teacher–student ratios prevalent in India. However, the study also identified significant challenges, including lack of digital infrastructure, insufficient teacher training, data privacy concerns, and resistance to technological change. The author argued that without proper policy frameworks and capacity building, AI adoption may widen educational inequalities rather than reduce them. This study is relevant to the present research as it provides a foundational understanding of the Indian context and underscores the need for responsible and inclusive implementation of AI-driven personalized learning.

Bansal (2021) focused on the role of artificial intelligence in promoting personalized learning in higher education institutions. The study discussed how AI-powered adaptive learning platforms analyze learner data to customize content, learning pace, and assessment strategies. Findings indicated that personalized learning supported by AI improves learner engagement, self- directed learning, and academic performance. Bansal also highlighted the importance of aligning AI tools with pedagogical goals rather than treating them

as mere technological add-ons. The study emphasized faculty readiness as a crucial factor for successful implementation, noting that teachers require training to effectively integrate AI into instructional practices. This research contributes to the present study by offering insights

into how AI-based personalization functions in higher education and by stressing the role of teachers in maximizing its educational benefits.

Choudhary (2020) explored the transformative role of artificial intelligence in teaching–learning processes. The study analyzed how AI tools such as virtual learning assistants, automated grading systems, and predictive analytics support individualized instruction and continuous assessment. Choudhary argued that AI enables a shift from teacher-centered to learner-centered education by facilitating timely feedback and adaptive learning experiences. However, the study also cautioned that overdependence on technology may reduce human interaction if not balanced carefully. The author emphasized the complementary role of teachers in guiding and mentoring learners in AI-supported environments. This study is significant for the present research as it reinforces the pedagogical value of AI in personalization while acknowledging the need for human oversight.

Gupta (2022) examined the use of artificial intelligence and adaptive learning systems in Indian classrooms. The study discussed how adaptive systems adjust instructional content based on learners' performance and learning styles. Gupta found that such systems can enhance conceptual understanding and accommodate diverse learners, especially in mixed-ability classrooms. The author also highlighted implementation challenges such as limited access to technology in rural areas and the absence of standardized guidelines for AI use in schools. The study recommended policy-level interventions and institutional support to scale adaptive learning solutions effectively. This research is relevant to the present study as it provides practical insights into classroom-level application of AI for personalized learning in the Indian school context.

Jha (2018) discussed technology-enabled personalized learning from an Indian perspective, emphasizing the role of digital tools in catering to individual learner needs. The study highlighted that personalization through technology promotes learner autonomy, motivation, and differentiated instruction. Jha argued that AI- driven systems could further strengthen personalized learning by offering real- time feedback and adaptive content. However, the study noted that successful implementation depends on teacher preparedness and institutional readiness. This work is relevant to the present research as it establishes a conceptual foundation for personalized learning in India and supports the integration of AI as an advanced technological enabler.

Kumar (2023) analyzed the implications of artificial intelligence for teachers and learners in educational settings. The study emphasized that AI can support teachers by automating routine tasks such as grading and attendance, allowing them to focus on higher-order instructional activities. For learners, AI enables personalized learning paths and continuous assessment. Kumar also highlighted concerns related to job insecurity among teachers and ethical use of learner data. The study concluded that AI should be viewed as a supportive tool rather than a replacement for teachers. This research is important for the present study as it

addresses stakeholder perceptions and the evolving role of teachers in AI-based personalized learning environments.

Mishra (2020) focused on educational data analytics as a foundation for personalized learning. The study discussed how data collected from learners' interactions can be analyzed using AI techniques to identify learning gaps and predict performance. Mishra emphasized that data-driven personalization enhances instructional decision-making and learner support. However, the study also raised concerns regarding data accuracy, privacy, and ethical usage. This research contributes to the present study by highlighting the central role of data analytics in AI-driven personalized learning systems.

Pandey (2024) investigated AI-driven personalized learning and its impact on student engagement in digital environments. The study found that AI-based personalization increases learner motivation, participation, and satisfaction by aligning learning materials with individual preferences and abilities. Pandey also noted that interactive features such as adaptive quizzes and personalized feedback foster deeper engagement. The study recommended integrating AI tools with sound pedagogical practices to sustain engagement. This research supports the present study by providing empirical evidence on the positive relationship between AI-based personalization and learner engagement.

Patel (2021) examined issues of equity and ethics in AI-based learning personalization. The study highlighted risks such as algorithmic bias, unequal access to technology, and misuse of learner data. Patel argued that without ethical safeguards, AI may reinforce existing educational inequalities. The study emphasized the need for transparent algorithms, inclusive design, and strong data protection policies. This research is highly relevant to the present study as it addresses ethical challenges that must be considered in implementing AI-driven personalized learning.

Roy (2019) explored emerging trends of artificial intelligence in the Indian education system. The study discussed applications such as adaptive learning platforms, smart classrooms, and AI-based assessment tools. Roy highlighted the growing role of private ed-tech initiatives in promoting AI adoption. However, the study also pointed out gaps in policy support and teacher training. This research contributes to the present study by outlining broader trends and contextual factors influencing AI adoption in Indian education.

Sharma (2022) examined personalized learning models supported by artificial intelligence. The study proposed models that integrate adaptive content delivery, continuous assessment, and learner analytics. Sharma found that AI-supported models enhance learning efficiency and accommodate individual differences.

The study also emphasized the importance of aligning technological models with curriculum objectives. This work informs the present research by providing conceptual models for AI-based personalized learning.

Singh (2023) studied the role of adaptive learning platforms in improving learning outcomes. The findings indicated that students using AI-driven platforms performed better academically

than those in traditional settings. Singh attributed this improvement to personalized feedback and self-paced learning opportunities. The study supports the present research by empirically validating the effectiveness of AI-based personalized learning.

Srivastava (2020) discussed artificial intelligence in learner-centered education. The study emphasized that AI supports individualized instruction and promotes active learning. Srivastava argued that learner-centered approaches are strengthened when AI tools are used to address individual needs. This research aligns with the present study's focus on personalization.

Verma (2024) examined the use of artificial intelligence for personalized instruction at the secondary education level. The study found that AI tools help teachers identify learner difficulties and design targeted interventions. Verma also noted challenges related to infrastructure and teacher training. This research is relevant to the present study as it extends AI-based personalization to school education.

Yadav (2025) analyzed challenges and future directions of artificial intelligence in personalized learning within Indian education. The study emphasized policy alignment, ethical use, and capacity building as future priorities. Yadav concluded that AI has strong potential to support personalized learning if implemented strategically. This study directly supports the rationale of the present research.

Abroad Literature

Baker and Inventado (2014) provided a foundational discussion on educational data mining and learning analytics, emphasizing their role in understanding learner behavior and improving instructional decision-making. The authors explained how large-scale educational data generated from digital learning environments can be systematically analyzed to identify learning patterns, predict student performance, and detect learning difficulties at an early stage. The study highlighted that data-driven insights support personalized learning by enabling adaptive content delivery and timely feedback tailored to individual learners' needs. Although the study predates recent advances in generative AI, it established the conceptual and methodological groundwork for AI-driven personalization in education. The authors also emphasized ethical considerations, such as responsible data use and learner privacy. This work is highly relevant to the present study as it underscores the importance of data analytics as the backbone of AI-based personalized learning systems and informs the analytical framework of learner modeling.

Bates (2019) explored the pedagogical implications of digital technologies in education, offering comprehensive guidelines for designing effective teaching and learning in a digital age. The author emphasized learner-centered approaches, flexibility, and the thoughtful integration of technology to enhance learning outcomes. Although not exclusively focused on artificial intelligence, the book provided a strong pedagogical foundation for understanding how AI can support personalized learning when aligned with instructional design principles. Bates argued that technology should be used to address diverse learner needs, promote self-

paced learning, and enhance engagement rather than simply automate instruction. The work also stressed the changing role of teachers as facilitators and designers of learning experiences in technology-rich environments. This study is relevant to the present research as it contextualizes AI-based personalized learning with in broader digital pedagogy and highlights the necessity of aligning AI tools with sound educational practices

Holmes, Bialik, and Fadel (2019) examined the promises and implications of artificial intelligence in education, emphasizing its potential to transform teaching and learning practices. The authors argued that AI can support personalized learning by providing adaptive pathways, real-time feedback, and individualized assessment. The study also highlighted how AI can assist teachers by reducing administrative workload and enabling data-informed instructional decisions. However, the authors raised critical concerns regarding ethics, equity, and transparency, cautioning that unregulated AI use may exacerbate existing educational inequalities. The report advocated for a human-centered approach to AI integration, where technology complements rather than replaces teachers. This work is particularly relevant to the present study as it balances the opportunities and risks of AI-based personalization and underscores the importance of ethical and policy considerations in educational AI implementation.

Chen, Chen, and Lin (2020) conducted a comprehensive review of artificial intelligence applications in education, focusing on intelligent tutoring systems, adaptive learning environments, and learning analytics. The study highlighted how AI technologies enable personalized learning by dynamically adjusting instructional content, feedback, and assessment based on learner performance. The authors reported that AI-driven systems enhance learner engagement, academic achievement, and learning efficiency. Additionally, the study discussed challenges such as data privacy, algorithmic bias, and the lack of teacher readiness, which may hinder effective implementation. The review emphasized the need for interdisciplinary collaboration between educators, technologists, and policymakers to ensure responsible AI adoption. This study is significant for the present research as it offers an updated and holistic understanding of AI's role in education and provides empirical support for the effectiveness of AI-based personalized learning approaches

Kaurand Kaur (2021) investigated the role of artificial intelligence in facilitating personalized learning across educational settings. The study focused on how AI- powered systems use learner data to customize instructional content, learning pace, and assessment methods. The findings indicated that AI-based personalized learning enhances student motivation, engagement, and academic performance. The authors also highlighted the importance of adaptive feedback in supporting self-regulated learning. However, the study noted challenges related to infrastructure, teacher training, and acceptance of AI technologies. The authors emphasized the need for professional development programs to equip educators with the skills required to integrate AI effectively. This study contributes to the present

research by providing empirical evidence on the effectiveness of AI- driven personalized learning and reinforcing the importance of teacher preparedness and institutional support.

Research Gap

Despite the growing body of literature on Artificial Intelligence in education, several critical research gaps remain, particularly in relation to the development of personalized learning. Existing studies largely focus on the technological capabilities of AI tools, such as adaptive learning systems and learning analytics, while giving limited attention to their pedagogical integration within real classroom settings. Many studies are conceptual or descriptive in nature, with a shortage of empirical, context-specific research examining the actual impact of AI-driven personalized learning on students' learning outcomes, engagement, and equity, especially in developing education systems. Additionally, insufficient research addresses teachers' preparedness, perceptions, and professional challenges in using AI-based personalized learning tools. Ethical concerns such as data privacy, algorithmic bias, and accessibility are often acknowledged but not systematically investigated.

Therefore, there is a clear need for comprehensive research that integrates technological, pedagogical, and ethical dimensions of AI-enabled personalized learning, which the present study aims to address.

4. Statement of the Problem

Although Artificial Intelligence is increasingly being promoted as a transformative force in education, its actual use for personalized learning remains uneven and insufficiently researched. Many educational institutions adopt AI- based tools without a clear understanding of their pedagogical implications, effectiveness, and limitations.

There is a lack of empirical studies that systematically examine:

- The extent to which AI is used for personalized learning in the education system
- The impact of AI-driven personalized learning on students' academic performance and engagement
- Teachers' awareness, attitudes, and readiness to use AI tools
- Challenges related to infrastructure, ethics, data security, and equity

Therefore, the problem addressed in this study is to critically examine the use of Artificial Intelligence for the development of personalized learning in the education system and to identify ways to enhance its effectiveness and sustainability.

5. Significance of the Study

The significance of the present study lies in its potential to contribute meaningfully to the understanding and effective integration of Artificial Intelligence in the development of personalized learning within the education system. By examining how AI-driven tools support individualized instruction, adaptive assessment, and learner engagement, the study will provide valuable insights for improving teaching–learning processes. The findings will benefit educators by clarifying the changing role of teachers in AI-supported learning environments and identifying professional development needs. For students, the study

highlights opportunities for self-paced, learner-centered education that addresses individual differences. Educational institutions and policymakers may use the outcomes to design informed strategies, guidelines, and policies for ethical and inclusive AI adoption. Furthermore, the study will enrich existing academic literature by bridging technological and pedagogical perspectives, thereby supporting future research and innovation in AI-based personalized learning.

6. Objectives of the Study

The objectives of the study are:

1. To examine the concept and components of Artificial Intelligence in education.
2. To analyze the role of AI in the development of personalized learning.
3. To study the extent of use of AI-based tools for personalized learning in the education system.
4. To assess the impact of AI-driven personalized learning on students' learning outcomes.
5. To exploreteachers' perceptions and readiness towards AI-based personalized learning.
6. To identify challenges and ethical issues associated with the use of AI in personalized learning.
7. To suggest strategies and a framework for effective implementation of AI in personalized learning.

7. Research Questions

1. How is Artificial Intelligence being used in the education system for personalized learning?
2. What types of AI tools and technologies support personalized learning?
3. What is the impact of AI-driven personalized learning on students' academic achievement and engagement?
4. What are teachers' perceptions and attitudes towards the use of AI in personalized learning?
5. What challenges and ethical concerns arise in the use of AI for personalized learning?

8. Hypotheses

1. There is a significant difference in learning outcomes between students exposed to AI-based personalized learning and those taught through traditional methods.
2. Teachers' positive attitudes towards AI significantly influence the effective use of personalized learning tools.
3. AI-based personalized learning has a significant impact on students' engagement and motivation.

9. Research Methodology

Research Design

The study will adopt a descriptive and analytical research design, using both quantitative and qualitative approaches.

Population and Sample

- Population: Teachers and students from selected secondary and higher education institutions.
- Sample: A representative samples elected through stratified random sampling.

Tools for Data Collection

- Questionnaire for teachers
- Questionnaire for students

Methods of Data Analysis

- Quantitative data will be analyzed using statistical techniques such as mean, standard deviation, t-test, and ANOVA.
- Qualitative data will be analyzed through the matic analysis.

10. Ethical Considerations

The study will ensure informed consent, confidentiality of data, voluntary participation, and responsible use of collected information. Ethical guidelines related to AI, data privacy, and research integrity will be strictly followed.

11. Expected Outcomes of the Study

- Better understanding of AI applications in personalized learning
- Identification of benefits and limitations of AI-based learning systems
- Practical recommendations for educators and policy makers
- A proposed framework for ethical and effective AI-driven personalized learning

12. Chapterization Scheme

1. Introduction
2. Conceptual Framework of Artificial Intelligence and Personalized Learning
3. Review of Related Literature
4. Research Methodology
5. Data Analysis and Interpretation
6. Findings, Conclusions, and Recommendations

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SMART COMMERCE FOR SMART LEARNERS: ASSESSING RURAL GRADUATE STUDENTS' KNOWLEDGE, PERCEIVED VALUE, AND PURCHASE INTENTION TOWARD AI-DRIVEN E-COMMERCE PLATFORMS

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Abstract

The rapid diffusion of internet access and artificial intelligence (AI) features -- recommendation engines, chatbots, voice and image search, and personalised filters -- has begun to reshape how rural populations in India engage with online commerce. While national data show that rural India now accounts for the majority of the country's active internet users and is adopting AI-enabled digital tools at a fast pace, rural graduate students remain an under-examined consumer segment in the e-commerce literature. This paper synthesises secondary data drawn from national digital-usage reports, industry surveys, and prior peer-reviewed studies to examine three linked constructs among rural graduate students: their knowledge of e-commerce and its AI-driven features, their perceived value of such platforms, and their resulting purchase (adoption) inclination. Building on the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB), the paper argues that knowledge and digital literacy function as antecedents of perceived usefulness and perceived value, which in turn drive purchase intention, but that this pathway is moderated in rural contexts by infrastructure, trust, language, and device-access constraints. The paper also situates these findings within the conference theme, arguing that closing the rural knowledge gap in AI-enabled commerce is itself an educational challenge, and that "smart teachers" -- equipped to build AI and digital-commerce literacy -- are central to translating rural digital access into informed, confident consumer participation. The paper concludes with implications for educators, policymakers, and e-commerce platforms, and outlines directions for future primary research.

Keywords: *Artificial Intelligence, E-Commerce, Rural Graduate Students, Perceived Value, Purchase Intention, Digital Literacy, Secondary Data, Smart Education*

1. Introduction

India's digital landscape has undergone a structural shift over the past decade, with internet access and online commerce expanding fastest not in metropolitan India but in its villages and small towns. According to the Internet in India Report 2025, released by the Internet and Mobile Association of India (IAMAI) in collaboration with Kantar, India crossed 958 million active internet users in 2025, of whom rural India accounted for roughly 57 percent -- around 548 million users -- with rural adoption growing at nearly four times the pace of urban India

(IAMAI, 2025). The same report found that AI-enabled features such as voice search, image search, chatbots, and personalised filters are now used by a sizeable share of India's internet population, with usage concentrated among younger age cohorts (IAMAI, 2025).

This growth in access, however, does not automatically translate into informed or confident participation in online commerce. Rural users disproportionately rely on shared devices, cash-on-delivery payment, and low-bandwidth connections, and continue to report lower digital literacy than their urban counterparts (IAMAI, 2025; RedSeer, 2022, as cited in secondary industry sources). Rural graduate students occupy a distinctive position within this landscape: as students, they are typically more digitally exposed than the general rural population, yet as members of rural households they remain subject to the same infrastructural, economic, and socio-cultural constraints that limit e-commerce adoption more broadly. Understanding what this specific segment knows about e-commerce platforms, how much value they perceive in using them -- particularly AI-driven features such as recommendations, chat-based assistance, and personalised search -- and how these perceptions translate into purchase inclination is therefore both an economic and an educational question.

This paper addresses that question using secondary data. Rather than administering a fresh survey, it draws together findings already published in national digital-usage reports, industry and government sources, and peer-reviewed studies on e-commerce adoption, digital literacy, and technology acceptance, and synthesises them into a coherent picture of the knowledge-value-intention pathway among rural graduate students. In doing so, it also responds directly to the conference theme -- "Artificial Intelligence in Education: Shaping Smart Teachers for a Smart Future" -- by treating AI-commerce literacy as an educational outcome that teachers and educational institutions are positioned to shape.

2. Linking the Study to the Conference Theme

At first glance, e-commerce adoption and classroom teaching may appear to be separate domains. This paper argues they are closely connected. AI is increasingly embedded not only in classrooms (through adaptive learning tools, tutoring chatbots, and AI-assisted assessment) but also in the everyday digital environments that students navigate outside the classroom, including e-commerce platforms. A student who cannot evaluate an AI-generated product recommendation, does not understand how a chatbot assistant works, or cannot distinguish a personalised offer from a manipulative pattern is, in a meaningful sense, digitally under-educated -- regardless of how advanced the AI systems around them have become.

Consequently, the paper treats "knowledge of e-commerce and its AI features" as a proxy for a broader construct: applied AI literacy. Building this literacy among rural graduate students is squarely an educational task, one that requires teachers who are themselves comfortable with AI tools and confident in teaching students how such systems work, what value they offer, and what risks they carry. In this sense, the paper's findings on the knowledge-value-intention gap among rural students are also a diagnostic of the work still needed to produce

the "smart teachers" the conference theme calls for -- teachers capable of extending AI literacy beyond the classroom into the digital-economic lives of their students.

3. Review of Literature

3.1 E-Commerce and AI Adoption in Rural India

Recent national-level data confirm that rural India is now the primary engine of the country's digital growth. The IAMAI (2025) Internet in India Report found rural regions growing at nearly four times the pace of urban India, with short-video consumption and AI-feature usage -- voice search, image search, chatbots, and filters -- rising fastest among users aged 15 to 24. At the same time, multi-device usage and formal online shopping penetration remain considerably lower in rural areas (around 12 percent multi-device adoption) than in urban India (around 31 percent), and cash-on-delivery remains the dominant payment mode for a large share of rural transactions (IAMAI, 2025).

Complementary studies on rural digital commerce describe a shift toward hyperlocal and social-commerce models -- for example, self-help groups using WhatsApp to sell handmade and agricultural products directly to buyers -- as a response to persistent barriers such as limited digital literacy, weak last-mile logistics, and low trust in formal online marketplaces (rural social commerce literature, 2024-2025). Separately, research on e-commerce adoption among rural artisans identifies digital illiteracy, inadequate infrastructure, and socio-cultural constraints as the central obstacles to broader participation, even as smartphone penetration continues to rise (rural artisan e-commerce studies, 2024-2025). Taken together, this literature indicates that rural India's digital growth is best described as access-led rather than literacy-led: connectivity has expanded faster than the skills and confidence needed to use AI-enabled digital-commerce tools with full understanding.

3.2 Knowledge, Perceived Value, and Purchase Intention: Theoretical Grounding

The relationship between knowledge, perceived value, and purchase intention in online commerce is well established through the Technology Acceptance Model (TAM) and its extensions. Studies applying TAM to e-shopping consistently find that perceived usefulness, perceived ease of use, and perceived value positively shape consumer attitude and, subsequently, purchase or e-shopping intention (TAM-based e-shopping studies, various years). Work integrating TAM with the Theory of Planned Behaviour (TPB) further shows that perceived value and perceived enjoyment significantly affect attitude toward online purchasing, while subjective norms and perceived behavioural control shape intention alongside attitude (TAM-TPB integration studies, 2023-2024). More recent extensions of TAM incorporating trust and privacy concerns as antecedents of perceived usefulness find that trust plays a mediating role between institutional assurance and purchase intention -- a finding especially relevant to rural consumers, who report comparatively low trust in unfamiliar online sellers (extended TAM-trust studies).

Applied to a rural graduate-student segment, this body of theory suggests a plausible causal chain: baseline digital and AI-commerce knowledge shapes perceived usefulness and

perceived ease of use of e-commerce platforms; perceived usefulness and trust jointly shape perceived value; and perceived value, moderated by infrastructural and socio-cultural constraints specific to rural contexts, shapes purchase inclination. This chain forms the conceptual framework guiding the synthesis of secondary data in Section 5.

3.3 Digital Literacy Interventions in Rural India

Evidence from rural digital-literacy programmes indicates that structured training measurably improves both digital knowledge and downstream outcomes. A quasi-experimental digital literacy training programme implemented among adolescent girls in rural Jharkhand between 2017 and 2020 found improvements in digital skills and associated gains in schooling status, awareness of government schemes, and personal mobility following the intervention (Gogoi et al., 2025). More broadly, digital-inclusion research on rural India links limited digital literacy to reduced financial inclusion and constrained access to healthcare, education, and market information, while noting that UPI-based digital payments and structured literacy campaigns have begun to narrow this gap over time (digital-inclusion literature, 2025). This literature supports the paper's central premise: knowledge is not a passive by-product of internet access but an outcome that requires deliberate educational intervention -- reinforcing the relevance of the “smart teachers” theme to rural digital-commerce outcomes.

4. Research Objectives

- To examine, through secondary data, the current level of awareness and knowledge that rural graduate students have of e-commerce platforms and their AI-driven features.
- To assess how perceived value -- usefulness, trust, convenience, and cost-benefit perception -- is associated with e-commerce engagement in rural populations, drawing on existing studies and national digital-usage data.
- To evaluate the purchase (adoption) inclination of rural graduate students toward AI-enabled e-commerce platforms as reflected in secondary sources.
- To identify the structural and educational barriers -- infrastructure, trust, digital literacy, and language -- that mediate the knowledge-value-intention pathway in rural contexts.
- To draw implications for educators and institutions in building AI and digital-commerce literacy, connecting the findings to the conference theme of AI in education.

5. Research Methodology

5.1 Research Design

This paper adopts a descriptive, review-based (secondary data) research design. Rather than collecting primary survey data, it systematically synthesises quantitative statistics and qualitative findings already published by government and industry bodies, national digital-usage surveys, and peer-reviewed academic studies. This approach is appropriate given the paper's aim -- to map the existing evidence base on knowledge, perceived value, and purchase inclination toward AI-enabled e-commerce among rural populations, including students, and to identify what is known, what is inferred by extension, and what remains a

gap requiring primary research.

5.2 Sources of Secondary Data

- National digital-usage reports: Internet in India Report 2025 (IAMAI, in collaboration with Kantar), based on the Indian Computer Usage and Behaviour (ICUBE) study.
- Industry and market research: e-commerce and social-commerce trend reports (e.g., RedSeer, RBI payment-mode data as cited in secondary industry publications).
- Peer-reviewed academic studies: published research on TAM/TPB-based e-commerce purchase intention, rural digital-technology adoption, and rural digital-literacy interventions, sourced from indexed journals and repositories.
- Government and policy sources: publicly available data referenced in connection with the Digital India Programme and related digital-inclusion initiatives.

5.3 Method of Analysis

Data extracted from these sources were organised thematically around the paper's three core constructs -- knowledge, perceived value, and purchase inclination -- and were interpreted through the TAM/TPB framework outlined in Section 3.2. Where studies did not disaggregate results specifically by "rural graduate students," findings for the closest available population (rural youth, rural internet users aged 15-24, or student samples in comparable developing-economy contexts) were used as a reasoned proxy, and this limitation is made explicit rather than implied. No new statistical testing was performed; the analysis is interpretive and comparative in nature, consistent with a review-based secondary-data paper.

5.4 Scope and Limitations of the Method

Because this paper relies entirely on secondary data, its conclusions are only as precise as the underlying sources and are constrained by the fact that few existing datasets isolate "rural graduate students" as a distinct reporting category. Findings reported at the level of "rural users," "rural youth," or general student samples are therefore treated as indicative rather than definitive evidence for this specific segment. This limitation is discussed further in Section 8 and motivates the paper's recommendation for future primary data collection.

6. Data Presentation and Discussion

Table 1 summarises key secondary-data indicators relevant to rural digital and e-commerce engagement in India, drawn primarily from the IAMAI Internet in India Report 2025.

Indicator	Reported Value	Source
Share of India's active internet users that are rural	57% (~548 million users)	IAMAI, 2025
Pace of rural vs urban internet-user growth	Rural growing ~4x faster than urban	IAMAI, 2025
Users engaging with AI features (voice/image search, chatbots, filters)	~44% overall; ~57% among ages 15-24	IAMAI, 2025
Multi-device internet usage -- urban vs rural	Urban 31% vs Rural 12%	IAMAI, 2025

Users accessing internet via shared devices	18% of users; ~80% of these rural	IAMAI, 2025
Urban users who shopped online in the past year	~230 million (56% of urban active base)	IAMAI, 2025
Rural transactions settled via cash-on-delivery	Majority of rural orders (COD-dominant)	Secondary industry data, RBI-referenced

These figures indicate a segment that is highly connected but unevenly equipped: rural India now supplies the majority of India's internet users and is engaging with AI-enabled features at a meaningful rate, particularly among the youngest cohort -- a group that includes most rural graduate students. Yet the same population shows markedly lower multi-device ownership, heavier reliance on shared devices, and continued preference for cash-on-delivery over digital payment, all of which are established correlates of lower digital confidence and trust in formal online transactions.

6.1 Knowledge of AI-Enabled E-Commerce

Secondary data suggest that awareness of e-commerce platforms as such is now near-universal among digitally connected rural youth, but awareness of the specific AI features embedded within these platforms -- recommendation logic, chatbot assistance, personalised pricing or offers -- is considerably shallower. The IAMAI (2025) finding that just under half of users engage with AI features, rising to just over half among 15-24 year-olds, implies that a substantial share of even the youngest and most digitally active users are not engaging with AI functionality at all, let alone understanding how it works. Digital-literacy intervention research reinforces this picture: structured training programmes in rural India have been shown to produce measurable gains in digital skill and downstream welfare outcomes, implying that current knowledge levels, absent such intervention, remain a limiting factor rather than a given (Gogoi et al., 2025)

6.2 Perceived Value

Perceived value in the reviewed literature is consistently composed of perceived usefulness, ease of use, trust, and cost-benefit assessment. Applied to rural e-commerce, secondary sources point to convenience and price access as the dominant sources of perceived value -- particularly for essentials and groceries, which account for the majority of rural online orders -- while trust remains the primary constraint on value perception for higher-value or unfamiliar-brand purchases (rural social-commerce literature, 2024-2025). The continued dominance of cash-on-delivery as a payment preference is itself a proxy for constrained trust: consumers who are not confident that a digital payment will result in a satisfactory outcome default to a settlement mode that reduces perceived risk, even at the cost of convenience. For AI-specific features, perceived value is plausibly lower still, since a feature cannot be valued for benefits (accuracy of recommendations, time saved through chat-based assistance) that the user does not yet understand or trust.

6.3 Purchase Inclination

Purchase inclination -- the behavioural intention to buy through e-commerce platforms --

appears strongly linked in the secondary data to the two constructs above. Urban India's substantially higher online-shopping penetration (56 percent of the urban active internet base, versus a rural pattern still centred on essentials, COD, and hyperlocal/social-commerce models) is consistent with TAM-based findings that higher perceived usefulness and trust translate into higher purchase intention (TAM-based e-shopping studies). Extrapolating this pathway to rural graduate students, the available evidence suggests a segment with rising exposure and rising willingness to engage with basic e-commerce, but with purchase inclination toward AI-driven features specifically remaining underdeveloped relative to their urban peers, constrained less by access than by the knowledge and trust gaps identified above.

7. Key Findings

- Rural India, including rural graduate students, has achieved rapid internet-access parity with urban India but has not achieved parity in digital-commerce and AI-feature literacy.
- Knowledge of AI-enabled e-commerce features is the weakest link in the knowledge-value-intention chain: awareness of e-commerce exists, but understanding of how AI features function is limited even among younger, more connected users.
- Perceived value in rural e-commerce is currently anchored in convenience and price for essential goods, with trust remaining the primary barrier to higher-value or AI-mediated engagement.
- Purchase inclination toward e-commerce broadly is rising, but inclination toward AI-specific features lags behind, consistent with the knowledge gap identified above.
- Structured digital-literacy interventions have demonstrated measurable success in rural India, suggesting that the knowledge gap is addressable through targeted educational effort rather than being a fixed structural constraint.

8. Implications for AI in Education and "Smart Teachers"

These findings carry direct implications for the conference theme. If knowledge of AI-enabled digital tools is the binding constraint on rural students' capacity to extract value from e-commerce platforms, then the same is very likely true of their capacity to benefit from AI-enabled learning tools inside the classroom. Teachers positioned to build durable AI literacy -- not only teaching students to use AI tools, but teaching them to evaluate, question, and understand these tools -- are therefore addressing a competency that extends well beyond any single subject or platform. This paper suggests three practical implications:

- Digital and AI literacy curricula in rural graduate institutions should explicitly cover applied, everyday AI (recommendation systems, chatbots, personalised offers) and not only classroom-facing AI tools, since students encounter both in parallel.
- Teacher training programmes preparing "smart teachers" should include modules on consumer-facing AI, equipping educators to explain concepts such as algorithmic recommendation, data-driven personalisation, and digital trust and safety.

- Institutions and policymakers should treat rural digital-commerce literacy as measurable evidence of broader AI-education outcomes, using indicators such as those in Table 1 as a proxy for tracking progress over time.

9. Limitations of the Study

As a secondary-data, review-based paper, this study does not generate new primary evidence and cannot statistically test the proposed knowledge-value-intention relationships for the rural-graduate-student segment specifically. Most cited data sources report at the level of "rural users" or "rural youth" rather than isolating graduate students, requiring reasoned extrapolation that should be validated through dedicated primary research. Secondary sources also vary in methodology, sample composition, and year of publication, which limits strict comparability across the statistics presented in Table 1.

10. Conclusion and Future Research Directions

Rural graduate students in India sit at the intersection of two fast-moving trends: rapid rural internet and AI-feature adoption, and a persistent rural-urban gap in digital-commerce literacy and trust. Secondary data reviewed in this paper indicate that while access is no longer the primary barrier to e-commerce engagement for this segment, knowledge of AI-driven features and the trust required to convert that knowledge into perceived value and purchase inclination remain underdeveloped. Because digital-literacy interventions in rural India have already demonstrated the capacity to close comparable gaps, this is a solvable problem -- and one in which teachers, curricula, and educational institutions have a direct role to play, aligning closely with the conference's vision of "smart teachers for a smart future." Future research should prioritise primary data collection -- structured surveys or interviews with rural graduate students specifically -- to test the knowledge-value-intention pathway proposed here with segment-specific evidence, and to evaluate which educational interventions most effectively raise AI-commerce literacy in rural higher-education settings.

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EFFECTIVENESS OF AI-SUPPORTED DIFFERENTIATED INSTRUCTIONAL APPROACH IN MATHEMATICS ON MATHEMATICS ACHIEVEMENT AND HIGHER-ORDER THINKING ABILITIES AMONG SECONDARY SCHOOL STUDENTS

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Abstract

Artificial Intelligence (AI) is emerging as an important technological innovation in education, offering opportunities for personalized learning, adaptive instruction, immediate feedback, and intelligent learning support. At the same time, students in secondary school Mathematics classrooms differ in their prior knowledge, learning pace, interests, abilities, and learning needs. Differentiated Instructional (DI) Approach provides a pedagogical framework for addressing these differences by modifying content, learning processes, activities, and assessment according to needs and requirement of learner characteristics. The integration of AI with Differentiated Instructional Approach may therefore provide a promising approach for improving Mathematics learning and developing higher-order thinking. The present article discusses the potential effectiveness of an AI-supported Differentiated Instructional approach in Mathematics on Mathematics Achievement and Higher-Order Thinking Abilities among secondary school students. The article highlights the pedagogical possibilities, challenges, and implications of integrating AI with differentiated instruction in secondary Mathematics education.

Keywords: *Artificial Intelligence, Differentiated Instructional Approach, Mathematics Achievement, Higher-Order Thinking Abilities, Personalized Learning, Secondary School Students, Mathematics Education.*

Introduction

Education is continuously changing in response to developments in science, technology, society, and the diverse needs of learners. The purpose of education extends beyond the acquisition of factual knowledge. It aims to develop conceptual understanding, creativity, critical thinking, problem-solving skills, reasoning, communication, and the ability to apply knowledge in unfamiliar situations. Technological developments have created new possibilities for achieving these objectives. Among the emerging technologies, Artificial

Intelligence has attracted considerable attention because of its potential to support personalized and adaptive learning.

Mathematics is a fundamental subject in school education. It contributes to the development of logical thinking, quantitative reasoning, analytical skills, problem-solving abilities, and decision-making. However, Mathematics is also perceived as a difficult subject by many students because it involves abstract concepts, symbolic representations, logical relationships, and the application of concepts to unfamiliar situations. Students within the same classroom may differ considerably in their prior knowledge, mathematical abilities, learning pace, interests, motivation, and preferred ways of learning.

The development of Artificial Intelligence provides an opportunity to strengthen differentiated instruction. AI-supported educational tools can assist in providing individualized explanations, practice questions, hints, feedback, and learning pathways. AI may also help teachers identify learning gaps and provide different levels of mathematical tasks. When integrated appropriately with teacher guidance and sound pedagogical principles, AI can potentially make differentiated learning more flexible and responsive.

Another important goal of Mathematics education is the development of Higher-Order Thinking Abilities. Students should not merely memorize mathematical formulas and reproduce standard procedures. They should be able to analyse mathematical situations, apply concepts, evaluate solutions, reason logically, identify relationships, and solve unfamiliar problems. Therefore, Mathematics instruction needs to provide opportunities for students to engage in intellectually demanding learning activities.

The integration of AI-supported learning with differentiated instruction may address both learner diversity and higher-level thinking. Students can receive tasks appropriate to their current level while also being exposed to increasingly complex problems. AI can provide immediate feedback and scaffolding, while the teacher can facilitate discussion, reasoning, verification, and mathematical justification.

In this context, the present article focuses on the effectiveness of an AI-Supported Differentiated Instructional Approach in Mathematics on Mathematics Achievement and Higher-Order Thinking Abilities among Secondary School Students.

Review of Related Studies

1. Studies on Differentiated Instruction and Secondary Education

Smale - Jacobse , Meijer, Helms-Lorenz, and Maulana (2019) conducted a systematic review of differentiated instruction in secondary education. The review examined 14 papers representing 12 empirical studies. The findings indicated that most studies reported small to moderate positive effects of differentiated instruction on students' academic achievement. The authors also noted considerable variation in how differentiated instruction was implemented, including individualization, ability grouping, mastery learning, remediation, and heterogeneous grouping. The study emphasized the need for further research to determine which forms of differentiation are most effective for different learn

This study provides a strong theoretical and empirical basis for using differentiated instruction at the secondary level because students differ in readiness, learning pace, prior knowledge, and learning needs.

2. Differentiated Instruction and Mathematics Achievement

A recent systematic review and meta-analysis specifically examining differentiated instruction in mathematics synthesized seven experimental studies published between 2020 and 2025. The findings showed a significant moderate effect of differentiated instruction on mathematics achievement, with a reported Hedges' g of 1.55. However, the effect on higher-order thinking skills was negligible, with a Hedges' g of 0.01. The findings suggest that differentiated instruction can substantially support mathematics achievement, but differentiation alone may not automatically produce strong gains in higher-order thinking.

This finding is particularly important for the proposed study because it suggests that AI can potentially strengthen differentiated instruction by providing adaptive tasks, individualized feedback, and scaffolding specifically designed to promote higher-order thinking.

3. Differentiated Instruction and Mathematics Achievement among Secondary Students

Globio (2024) conducted a meta-analysis and systematic review of differentiated instruction and mathematics achievement among secondary school students. From an initial pool of approximately 1,000 articles, 13 studies met the stated inclusion criteria. The analysis reported a statistically significant positive impact of differentiated instruction on mathematics achievement, although substantial heterogeneity was found across studies ($I^2 = 88\%$). The author concluded that differentiated instruction has considerable potential for improving mathematics achievement while recommending further investigation of the factors that influence its effectiveness.

.4. AI and Personalized Mathematics Learning

Tefa and Liang (2026) reviewed research on the role of Artificial Intelligence and Learning Analytics in personalizing mathematics learning. Their systematic review examined recent studies on AI-supported personalized mathematics learning. The review indicates that AI and learning analytics can help provide individualized learning experiences by using learner information to adapt instruction and support students' mathematical learning.

5. AI-Driven Personalized Learning and Mathematical Problem Solving

Eti, Mosia, and Egara (2026) conducted a systematic review of 20 empirical studies published between 2019 and 2025 concerning AI-driven personalized learning in mathematics. The review found that adaptive learning systems, intelligent tutoring systems, and chatbots can support mathematical problem solving through tailored feedback, adaptive challenges, and scaffolded assistance. Reported benefits included improved conceptual understanding, strategic reasoning, and learner engagement. However, the review also identified challenges such as over-reliance on AI hints, inappropriate adaptation, technological complexity, teacher readiness, infrastructure inequalities, and privacy concerns.

The findings strongly support the proposed study's AI-supported differentiated instructional

approach. At the same time, they indicate that AI should function as a support for teacher-led pedagogy rather than a replacement for the teacher.

6. AI-Based Tutoring and Assessment in Mathematics

Molemane, Mosia, and Egara (2026) conducted a systematic review of AI-based tutoring and assessment systems in mathematics education. Their review examined empirical research published from 2015 to 2025 and identified 12 studies that met their inclusion criteria. The authors highlighted the growing use of adaptive tutoring, automated feedback, and AI-supported assessment in mathematics education. Because the studies varied substantially in their interventions, participants, and outcome measures, the researchers used narrative synthesis rather than a quantitative meta-analysis.

Impact of AI on Differentiated Instructional Approch

1. Role of AI in differentiated instruction

AI can help teachers adapt mathematics instruction to students' different learning levels by:
identifying students' strengths and learning difficulties;
generating easy, moderate, and advanced mathematical tasks;
providing individualized explanations and feedback;
giving additional practice to students who need support;
providing challenging problems to advanced learners;
supporting different learning pathways and representations.

Recent research specifically describes AI as useful for personalization, lesson planning, differentiation, and feedback in secondary mathematics teaching.

2. Effect on Mathematics Achievement

AI-supported differentiated instruction may improve mathematics achievement because students receive learning activities that are better matched to their current level.

For example:

Diagnostic assessment → AI identifies learning needs → differentiated mathematical activities → personalized feedback → practice → improved achievement

Research on differentiated instruction in secondary education has generally reported small-to-moderate positive effects on academic achievement, although the evidence base still has important gaps.

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Recent AI research also provides encouraging evidence. A 2026 study with secondary students found that AI-supported mathematics learning was associated with improved mathematical reasoning, while another study of senior high-school students found significantly better geometric reasoning and proof-construction performance with generative-AI-supported instruction than with conventional instruction.

3. Effect on Higher-Order Thinking Abilities

AI can potentially promote higher-order thinking when students are asked to think with AI rather than simply obtain answers from AI.

It can provide:
Analysis: examining mathematical information and relationships.
Evaluation: checking whether an AI-generated solution is correct.
Problem solving: exploring different strategies.
Critical thinking: identifying errors or weaknesses in solutions.
Creative thinking: developing alternative methods or mathematical problems.
Mathematical reasoning: explaining and justifying solutions.
For example, instead of asking AI "Solve this equation," students can be asked:
"Solve the problem in two different ways, compare the methods, identify any errors in the AI-generated solution, and justify which method is more efficient."
This type of activity is much more appropriate for developing higher-order thinking.

4. Important caution

AI does not automatically produce higher-order thinking. If students simply copy AI-generated solutions, their independent mathematical thinking may actually be weakened. A large high-school mathematics experiment found that unrestricted generative-AI access improved performance while the tool was available, but could reduce students' subsequent independent performance; learning-oriented safeguards reduced this problem.

Educational Implementation

1.Identification of Individual Learning Needs

The implementation can begin with a diagnostic assessment of students' existing mathematical knowledge and skills. AI-supported assessment tools can help teachers identify students' strengths, misconceptions, learning gaps, and areas requiring additional support. Based on the assessment results, students can be provided with learning activities appropriate to their readiness levels.

For example, in teaching linear equations, students who demonstrate difficulty with basic algebraic operations can receive foundational activities, while students with higher proficiency can be given complex and open-ended problems.

2. Formation of Differentiated Learning Tasks

AI can assist teachers in preparing different levels of mathematical activities:
Beginning level: Basic concepts and guided examples.
Intermediate level: Application and multi-step problems.
Advanced level: Complex, unfamiliar, and open-ended problems.
Enrichment level: Mathematical investigations and real-life applications.
Thus, students can work toward common learning objectives through different pathways and levels of challenge.

3. Personalized Learning

AI-supported systems can provide students with learning materials according to their individual needs. Students who require additional practice can receive more examples and scaffolding, whereas students who demonstrate mastery can progress to challenging tasks.

Personalization may include:
Adaptive questions
Individualized practice
Immediate feedback
Hints and explanations
Remedial activities
Enrichment tasks
Different representations of mathematical concepts

4. Development of Higher-Order Thinking Abilities

A major educational purpose of the approach should be to promote higher-order thinking rather than merely obtaining correct answers.
AI-supported activities can be designed to require students to:
Analyze mathematical information
Compare alternative solution methods
Evaluate the validity of a solution
Justify mathematical reasoning
Create their own mathematical problems
Apply concepts to unfamiliar situations
Solve complex and non-routine problems
For example, instead of asking students only to solve an equation, the teacher may ask:
"Two students obtained different solutions to the same equation. Analyze both methods, identify the error, and justify which solution is correct."
Such activities encourage students to explain and evaluate mathematical reasoning.

5. AI-Supported Feedback and Scaffolding

One of the important advantages of AI-supported instruction is the possibility of providing immediate feedback. When students make an error, AI can provide hints or guiding questions rather than simply giving the correct answer.
A useful sequence is:
Problem → Student attempts solution → AI identifies difficulty → Hint/scaffolding → Student revises solution → Teacher reviews progress
This can encourage students to become more independent learners while maintaining the teacher's role in monitoring learning.

6. Role of the Mathematics Teacher

AI should be implemented as a supportive instructional technology rather than a replacement for the teacher. The teacher remains responsible for:
Setting learning objectives
Selecting appropriate AI tools
Designing differentiated activities
Monitoring student progress

Checking the accuracy of AI-generated content
Providing human interaction and clarification
Encouraging mathematical discussion
Assessing higher-order thinking
Ensuring ethical and responsible use of AI
The teacher can therefore use AI-generated information as one source of evidence for instructional decision-making.

7. Collaborative Learning

Although AI enables personalized learning, differentiated instruction should also provide opportunities for peer interaction and collaborative problem solving. Students can work in pairs or groups to discuss mathematical strategies, compare solutions, and explain their reasoning.

For example, students at different readiness levels can be given a common mathematical investigation with differentiated roles or levels of scaffolding.

8. Continuous Assessment

Implementation should include formative assessment throughout the instructional process. AI-supported assessment can help teachers monitor:
Conceptual understanding
Procedural fluency
Problem-solving ability
Errors and misconceptions
Progress toward learning objectives
Higher-order thinking
The teacher can use this information to modify subsequent learning activities.

9. Remedial and Enrichment Instruction

AI-supported differentiated instruction can be particularly useful for providing remedial and enrichment learning.
For students requiring additional support:
Simplified explanations
Step-by-step examples
Additional practice
Visual representations
Hints and scaffolding
For advanced learners:
Non-routine problems
Mathematical investigations
Multiple-solution problems
Real-life applications
Reasoning and proof activities

This helps ensure that both struggling and advanced learners receive appropriate educational opportunities.

10. Proposed Implementation Model

A practical implementation model for the study can be represented as:

Pre-assessment
↓
Identification of individual learning needs
↓
AI-supported learner profiling
↓
Differentiation of content, process and learning tasks
↓
Personalized mathematics learning activities
↓
AI-supported feedback and scaffolding
↓
Problem solving, analysis, evaluation and creation activities
↓
Teacher monitoring and intervention
↓
Formative assessment and adaptation
↓
Post-assessment of Mathematics Achievement and HOTS

Conclusion

The educational implementation of an AI-supported differentiated instructional approach in Mathematics can create a learner-centred environment in which students receive instruction according to their readiness, needs, and learning progress. Its effectiveness, however, depends not simply on the presence of AI but on purposeful pedagogical design, teacher supervision, appropriate differentiation, meaningful mathematical tasks, and opportunities for students to reason independently. For secondary mathematics education, the approach therefore has potential to address both dimensions of the proposed study—Mathematics Achievement and Higher-Order Thinking Abilities.

Artificial Intelligence (AI)-supported differentiated instruction has considerable potential to improve the teaching and learning of mathematics among secondary school students. By using AI to identify individual learning needs, provide personalized learning materials, adjust the level of mathematical tasks, offer immediate feedback, and provide appropriate scaffolding, teachers can address differences in students' abilities, interests, learning pace, and prior knowledge.

The integration of AI with differentiated instruction can contribute to better mathematics

achievement by helping students develop stronger conceptual understanding, procedural knowledge, mathematical reasoning, and problem-solving skills. At the same time, appropriately designed AI-supported activities can promote higher-order thinking abilities, including analysis, critical thinking, evaluation, creativity, problem solving, and mathematical reasoning.

However, the effectiveness of AI depends largely on how it is pedagogically integrated. Simply providing students with access to AI does not guarantee deeper learning. Students should be encouraged to question AI-generated responses, identify errors, compare alternative solutions, justify their reasoning, and solve problems independently. Teachers therefore continue to play a central role in planning differentiated activities, monitoring students' learning, ensuring responsible AI use, and developing meaningful mathematical experiences.

Overall, AI-supported differentiated instruction represents a promising approach for making mathematics learning more personalized, inclusive, and intellectually challenging. Further systematic research, particularly at the secondary-school level, is needed to establish its effectiveness in improving both mathematics achievement and higher-order thinking abilities. This provides a strong rationale for investigating the impact of an AI-supported differentiated instructional approach in mathematics.

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ARTIFICIAL INTELLIGENCE ENABLED CONCEPTUAL UNDERSTANDING IN B.ED. TEACHER PREPARATION

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Abstract

Artificial Intelligence (AI) is rapidly transforming higher education, and teacher education institutions are no exception to this shift. This paper examines how AI-enabled tools such as generative chatbots, adaptive learning platforms, and intelligent tutoring systems facilitate simplified, self-paced, and concept-focused learning among B.Ed. student-teachers, with specific reference to Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga. Adopting a descriptive survey design, the study proposes to gather data from B.Ed. student-teachers through a structured AI-Based Learning Perception Scale covering ease of understanding, personalisation, engagement, critical thinking, and pedagogical readiness. The review of related literature and the discussion converge on a consistent finding across recent scholarship: AI tools enhance conceptual clarity and engagement most effectively when they are embedded within sound pedagogical strategies rather than used as stand-alone substitutes for teaching, and their benefits are moderated by digital access, AI literacy, and institutional readiness. The paper also flags recurring concerns such as over-reliance, reduced critical reflection, and the erosion of independent thinking. It concludes with concrete implications for weaving AI literacy into the teacher-education curriculum and proposes a pedagogy-first model for AI adoption in Colleges of Education.

Keywords: *Artificial Intelligence, Teacher Education, B.Ed. Student-Teachers, Conceptual Understanding, AI Literacy, Simplified Learning, Kuvempu University*

Introduction

Education in the twenty-first century is being continually reshaped by digital innovation, and among the many technological forces at work, Artificial Intelligence (AI) has emerged as one of the most consequential. From adaptive learning platforms to generative chatbots such as ChatGPT, AI tools are altering how learners access information, process concepts, and construct understanding. Teacher education, as the seedbed of future classroom practice, occupies a uniquely important position in this transformation: student-teachers who learn to think and work with AI during their pre-service training are more likely to carry AI-literate pedagogical habits into the schools they will one day serve.

The Bachelor of Education (B.Ed.) programme is built on abstract and theory-dense papers — educational psychology, philosophy of education, pedagogy of school subjects, assessment and evaluation — which student-teachers have traditionally found difficult to internalise through lecture-and-notes methods alone. AI-based tools offer an alternative: they can restate a difficult concept in simpler language, generate examples on demand, translate technical terms, create practice questions, and allow the learner to ask follow-up questions

until the idea is clear. Used well, such tools have the potential to convert passive, memorisation-driven learning into active, dialogic, and self-paced meaning-making.

It is against this backdrop that the present study locates itself at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, a College of Education affiliated to Kuvempu University, Shivamogga (Karnataka), and examines how its B.Ed. student-teachers experience AI-assisted learning — specifically, whether and how AI tools make difficult educational concepts easier to understand, and what pedagogical and institutional conditions help or hinder this process.

Review of Related Literature

A growing body of recent scholarship converges on the view that AI's educational value depends less on the sophistication of the technology itself and more on how thoughtfully it is embedded within teaching practice. Long, Wang, Md Rashid, and Lu (2026), in a systematic review of 73 peer-reviewed studies on AI in higher education published in Frontiers in Education, found that AI tools such as chatbots, adaptive systems, and predictive analytics enhanced student engagement most effectively when combined with interactive pedagogies such as flipped classrooms, project-based learning, and scaffolded feedback loops; their proposed Pedagogical Mediation of AI for Student Engagement (PMAISE) model frames teaching method as the variable that converts AI's technical affordances into genuine cognitive, behavioural, and emotional engagement, rather than AI acting as an automatic driver of learning on its own.

Research specifically situated in teacher education echoes this pedagogy-first conclusion. A 2025 Frontiers in Education study on teachers' preparedness to use AI in classroom assessment reported that attitude toward technology, technological readiness, and pedagogical beliefs shaped teachers' preparedness through the mediating factors of perceived ease of use and perceived usefulness — underlining that successful AI adoption in teacher-training contexts is as much an attitudinal and pedagogical matter as a technical one. Similarly, a mixed-methods study of secondary students interacting with ChatGPT-5 found moderately positive attitudes toward AI overall, with learners identifying knowledge expansion, immediate feedback, a familiar interface, and perceived skill development as the main pedagogical benefits, set against constraints such as uncertainty about accuracy, anxiety about AI-generated feedback, and privacy concerns.

Studies focused on generative AI tools and learning-skill outcomes provide further support for the 'simplification' function that motivates the present paper. A 2025 study examining tools such as Grammarly, ChatGPT, QuillBot, Textero AI, and ChatPDF reported a positive relationship between the use of such tools and students' self-directed learning, critical thinking, digital literacy, and problem-solving skills, framing AI as a support for perceived learning quality rather than a replacement for instruction. In a related vein, research on AI literacy frameworks for learners has emphasised that conceptual understanding of AI itself — not merely fluent use of AI tools — is an important and measurable learning outcome,

suggesting that teacher-education programmes should treat AI literacy as curricular content and not only as a study aid.

At the same time, the literature repeatedly cautions against uncritical adoption. Reviews of AI integration in higher education note persistent concerns around algorithmic bias, unequal access to devices and connectivity, and the risk that AI convenience can substitute for, rather than support, independent thought — concerns that a mixed-methods study on university teachers' experiences of generative AI described as 'navigating uncertainty' about how far to trust AI-mediated teaching. Together, this body of work suggests three consistent threads relevant to teacher education: (a) AI can meaningfully simplify and personalise the understanding of complex concepts; (b) its benefits are strongly mediated by pedagogy, teacher/student AI literacy, and institutional support; and (c) unmonitored use carries genuine risks to critical thinking, equity, and academic integrity that any teacher-training programme must address explicitly.

Need and Significance of the Study

Karnataka's teacher-education institutions, operating under the broader push of the National Education Policy (NEP) 2020 toward technology-enabled and learner-centred pedagogy, are increasingly expected to prepare student-teachers who are not only competent users of digital tools but also reflective, ethical integrators of technology in their future classrooms. Yet very little empirical documentation exists on how B.Ed. student-teachers in smaller, regionally rooted colleges — such as Kuvempu Shatamanothsava Shikshana Mahavidyalaya — actually experience AI-assisted learning in their day-to-day coursework. Most existing research on AI in education is drawn from large universities in urban or international settings, leaving a gap in understanding how AI tools function for student-teachers balancing theory papers, practice teaching, and internship duties in a semi-urban Karnataka context.

The present study is significant for four reasons. First, it generates locally grounded evidence on how AI simplifies conceptually dense B.Ed. papers such as Educational Psychology, Philosophy of Education, and Assessment and Evaluation. Second, it identifies the specific AI-enabled learning behaviours — clarifying doubts, generating examples, summarising units, practising questions — that student-teachers already use, providing teacher educators with a realistic starting point for structured integration. Third, it surfaces risks (over-reliance, reduced reflection, unequal device access) that must be addressed before AI is formally woven into the curriculum. Fourth, because B.Ed. student-teachers will themselves become school teachers, their present attitudes and habits around AI are likely to shape how the next generation of schoolchildren encounters AI-assisted learning — making this an investigation with implications well beyond the College itself.

Statement of the Problem

The problem for the present study is stated as follows: "A Study of Artificial Intelligence and Its Relationship with Simplified and Conceptual Understanding among B.Ed.

Student-Teachers of Kuvempu Shatamanothsava Shikshana Mahavidyalaya."

Objectives of the Study

1. To study the extent of awareness and usage of AI-based tools among B.Ed. student-teachers of Kuvempu Shatamanothsava Shikshana Mahavidyalaya.
2. To examine the perceived effect of AI tools on the conceptual understanding of B.Ed. student-teachers in theory papers.
3. To analyse the role of AI tools in simplifying and personalising the learning process for B.Ed. student-teachers.
4. To identify the challenges and limitations experienced by B.Ed. student-teachers while using AI tools for academic learning.
5. To compare the perception of AI-assisted learning among B.Ed. student-teachers on the basis of gender, and optional method subject.
6. To suggest pedagogical strategies for the effective and ethical integration of AI in teacher-education curricula.

Hypotheses

The following null hypotheses (H0) are formulated for statistical testing:

1. H0(1): There is no significant difference between male and female B.Ed. student-teachers in their perception of AI-assisted conceptual understanding.
2. H0(2): There is no significant difference between Arts-optional and Science-optional B.Ed. student-teachers in their perception of AI-assisted conceptual understanding.
3. H0(3): There is no significant relationship between the frequency of AI tool usage and the level of conceptual understanding reported by B.Ed. student-teachers.

Operational Definitions of Key Terms

- **Artificial Intelligence (AI):** In this study, AI refers to web- and app-based generative and adaptive tools (e.g., ChatGPT, Google Gemini, Grammarly, QuillBot, AI-based note and quiz generators) that B.Ed. student-teachers use to support their academic learning.
- **Conceptual Understanding:** The learner's ability to grasp the meaning, logic, and application of an educational concept rather than merely memorising its definition, as self-reported by student-teachers on the study's rating scale.
- **Simplified Learning:** The process by which a complex idea is restated, broken into steps, or illustrated with examples — by an AI tool — in a manner that reduces the learner's cognitive load.
- **B.Ed. Student-Teachers:** Pre-service teacher trainees enrolled in the two-year Bachelor of Education programme at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, affiliated to Kuvempu University.

Delimitations of the Study

- The study is delimited to B.Ed. student-teachers of Kuvempu Shatamanothsava Shikshana Mahavidyalaya only, and its findings are not generalised to other institutions without further study.
- The study is delimited to the perceptions of student-teachers regarding AI-assisted learning of theory papers; it does not evaluate AI's role in practice teaching or internship supervision.
- The study is delimited to commonly accessible, free or freemium AI tools; institution-licensed or proprietary AI platforms are outside its scope.

Methodology

Research Design

The study adopts a descriptive survey design, considered appropriate for capturing the current status of AI awareness, usage patterns, and perceived learning outcomes among a defined population at a single point in time.

Population and Sample

The population of the study comprises all B.Ed. student-teachers enrolled at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, during the current academic year. A sample of 100 student-teachers (First Year and Second Year, drawn across optional method-subject combinations) is proposed to be selected using the stratified random sampling technique, ensuring proportional representation by gender and optional subject.

Tool Used

Data are proposed to be collected using a self-developed and validated "AI-Based Learning Perception Scale for B.Ed. Student-Teachers," consisting of 30 statements on a five-point Likert scale (Strongly Agree to Strongly Disagree) distributed across five dimensions: (i) Awareness and Usage, (ii) Ease of Conceptual Understanding, (iii) Personalisation and Self-Paced Learning, (iv) Engagement and Motivation, and (v) Challenges and Ethical Concerns. The tool's content validity is to be established through expert judgement by teacher educators, and reliability through a pilot administration (Cronbach's alpha).

Procedure of Data Collection

The scale is to be administered in either printed or Google Forms format during a regular class period, after obtaining informed consent and explaining the purpose of the study. Respondents are assured of anonymity and are given approximately 20–25 minutes to complete the questionnaire.

Statistical Techniques

Descriptive statistics (mean, standard deviation, and percentage) are to be used to analyse overall trends; the t-test is to be used to test H0(1) and H0(2), and Pearson's coefficient of correlation is to be used to test H0(3), at the 0.05 level of significance.

Data Analysis and Interpretation

The table below presents illustrative, dimension-wise descriptive statistics of the kind that would be generated once the scale is administered to the actual sample; these figures

follow patterns commonly reported in comparable AI-in-higher-education surveys and must be replaced with the investigator's own computed values.

Table 1: Illustrative dimension-wise mean scores on the AI-Based Learning Perception Scale.

Dimension	Mean (out of 5)	SD	% Agreeing (Agree + Strongly Agree)	Interpretation
Awareness and Usage of AI Tools	3.9	0.71	78%	High awareness; ChatGPT and Grammarly most used
Ease of Conceptual Understanding	4.1	0.64	83%	Majority report simplified understanding of abstract topics
Personalisation and Self-Paced Learning	4.0	0.68	80%	Valued for repeated, doubt-clearing interaction
Engagement and Motivation	3.8	0.75	74%	Moderately high; varies with topic difficulty
Challenges and Ethical Concerns	3.5	0.80	66%	Notable concern over accuracy, over-reliance, and access

Consistent with the patterns above, the highest-rated statements are typically those describing AI's use as an on-demand explainer — e.g., "AI helps me understand difficult topics in simpler language" and "I can ask AI to repeat or re-explain a concept until I understand it" — while the lowest-rated statements cluster around independent evaluation of AI output, e.g., "I always verify AI-generated answers before using them." This gap itself is diagnostic: it suggests that while B.Ed. student-teachers experience AI as cognitively supportive, they are less consistently developing the critical-verification habits that teacher-education programmes should be cultivating alongside AI use.

For H0(1) and H0(2), an independent-samples t-test would be computed comparing mean perception scores across gender and across optional method-subject groups; for H0(3), a Pearson correlation would be computed between self-reported weekly frequency of AI tool use and the Ease-of-Conceptual-Understanding sub-score. Investigators should report t-values, degrees of freedom, correlation coefficients, and significance levels ($p < 0.05$) once actual data are collected, and accept or reject each null hypothesis accordingly.

Major Findings of the Study (Anticipated / Illustrative)

1. A large majority of B.Ed. student-teachers are aware of and regularly use at least one AI-based tool (chatbot, grammar/writing assistant, or summariser) for academic purposes.
2. AI tools are perceived to be most helpful for simplifying abstract theoretical content — particularly in Educational Psychology and Philosophy of Education — by breaking concepts into simpler language, generating relatable examples, and allowing repeated, judgement-free questioning.
3. Student-teachers value AI primarily for personalised, self-paced revision rather than as a replacement for classroom instruction or textbooks.

4. Engagement and motivation gains are moderate and appear strongly linked to how the teacher educator frames AI use in class.
5. A meaningful proportion of student-teachers express concern about the accuracy of AI-generated content, the risk of over-dependence, and unequal access to smartphones or stable internet, particularly among rural-background student-teachers.
6. Gender and optional-subject differences in perception, where present, tend to be small, suggesting that AI's simplifying effect is broadly experienced across sub-groups within the sample.

Discussion

The pattern that emerges — strong perceived benefit for conceptual simplification, paired with under-developed habits of critical verification — mirrors the broader literature reviewed in Section 2. Long et al.'s (2026) PMAISE model would predict precisely this outcome: AI's cognitive benefits are real but partial, and become fully realised only when a teacher educator deliberately scaffolds the interaction — for instance, by asking student-teachers to cross-check an AI-generated explanation of Piaget's stages against the prescribed textbook, or to use AI-generated practice questions as a starting point for peer discussion rather than a final answer key. Left unscaffolded, AI risks becoming a convenience that narrows, rather than deepens, engagement with course content — a concern raised across the studies on generative AI in higher education discussed earlier.

The comparatively lower confidence in verifying AI output is also pedagogically significant for a teacher-education institution specifically, because student-teachers who leave the programme without habits of critical AI verification are likely to transmit the same uncritical habits to their own future pupils. This makes AI literacy — not merely AI usage — a legitimate and necessary curricular objective for B.Ed. programmes such as that of Kuvempu Shatamanothsava Shikshana Mahavidyalaya.

Educational Implications

- Teacher educators can model AI-assisted concept clarification openly in class, followed by a brief "verify-and-discuss" step, so that student-teachers see critical evaluation modelled rather than left implicit.
- AI literacy — including prompt-writing, bias-awareness, and fact-checking — merits a dedicated place within the Educational Technology / ICT paper of the B.Ed. curriculum.
- Assignments and internal assessments can be redesigned to reward the process of AI-assisted inquiry (e.g., submitting the AI conversation alongside a reflective critique) rather than banning or ignoring AI use outright.
- The College can address equity concerns by ensuring library or computer-lab access to AI tools for student-teachers who lack personal devices or reliable connectivity.
- Practice-teaching supervisors can encourage student-teachers to extend the same simplification techniques they experience as AI users — breaking concepts into steps,

offering multiple examples, checking for understanding — into their own lesson planning for schoolchildren.

Suggestions for Effective and Ethical Integration of AI in Teacher Education

1. Introduce a short compulsory orientation/workshop on responsible AI use at the start of the B.Ed. programme.
2. Develop a simple institutional guideline distinguishing acceptable AI-assisted learning from academic misconduct, so that student-teachers are not left to guess where the line lies.
3. Encourage teacher educators to design AI-integrated learning tasks (e.g., "generate three examples with AI, then evaluate which best fits the theory") rather than leaving AI use informal and unstructured.
4. Periodically re-administer a perception scale of this kind to track how attitudes and skills evolve as AI tools and institutional guidance mature.
5. Collaborate with Kuvempu University and neighbouring Colleges of Education to share good practices and jointly develop AI-literacy modules suited to the regional teacher-education context.

Scope for Further Research

Future studies could adopt a quasi-experimental design comparing achievement scores of AI-assisted and non-AI-assisted student-teacher groups on a common theory paper; extend the sample across multiple Colleges of Education affiliated to Kuvempu University for greater generalisability; or use qualitative interviews to explore, in richer depth, how student-teachers translate their own AI-assisted learning experience into lesson-planning decisions during practice teaching.

Conclusion

Artificial Intelligence is neither a panacea nor a threat to teacher education by itself; its educational value, as the reviewed literature and the proposed study both suggest, is realised through the pedagogy that surrounds it. For B.Ed. student-teachers of Kuvempu Shatamanothsava Shikshana Mahavidyalaya, AI tools hold genuine promise as accessible, patient, and personalised aids that can simplify dense theoretical content and support self-paced revision. Realising this promise fully, however, requires that the College move deliberately from informal, unguided AI use toward a structured, pedagogically scaffolded, and ethically framed integration of AI into the teacher-education curriculum — one that builds not only comfortable AI users, but critically reflective future teachers.

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STUDENT ENGAGEMENT AND WELL-BEING: AN INTEGRATED FRAMEWORK FOR PROMOTING MEANINGFUL LEARNING AND EDUCATIONAL SUCCESS THROUGH AI

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Abstract

Student engagement and well-being are important factors in student success. Engagement involves students' behavioral, emotional, and cognitive participation in learning, while well-being includes psychological, social, and emotional health. Supportive teachers, positive learning environments, belonging, and manageable academic demands can enhance both engagement and well-being. In contrast, academic stress, burnout, and social isolation may negatively affect students. This review highlights the need to integrate well-being into teaching, learning, and student support to promote academic success and holistic student development.

Keywords: *Student engagement; student well-being; academic success; belonging; student support.*

INTRODUCTION

Student engagement and well-being are important dimensions of educational success. Engagement refers to students' behavioral, emotional, cognitive, and agentic involvement in learning (Fredricks et al., 2004). Well-being encompasses students' psychological, emotional, social, and academic functioning. The relationship between engagement and well-being is potentially reciprocal. Students who feel supported, connected, competent, and psychologically safe are more likely to participate actively in learning. At the same time, meaningful engagement can enhance students' motivation, sense of belonging, achievement, and overall well-being. However, excessive academic demands and prolonged pressure may result in stress and burnout, indicating that engagement should be sustainable rather than simply increased. Recent research highlights the need to examine engagement and well-being together while recognizing the influence of teachers, peers, learning environments, academic workload, and institutional support. Therefore, this article examines the relationship between student engagement and well-being and highlights implications for creating supportive and effective educational environments.

CONCEPTUALIZING STUDENT ENGAGEMENT

Student engagement is a broad and multidimensional construct. Early research primarily emphasized observable participation, such as attendance, participation in classroom activities, completion of assignments, and persistence. Contemporary approaches recognize that

engagement involves several interrelated dimensions.

- **Behavioral engagement**

Behavioral engagement refers to students' participation and involvement in academic and institutional activities. It includes attendance, participation, effort, persistence, completion of academic tasks, and compliance with educational expectations.

Behavioral engagement is important because students cannot benefit fully from educational opportunities without sustained participation. However, behavioral participation alone does not necessarily indicate meaningful learning. A student may attend classes regularly while experiencing low motivation or cognitive disengagement.

- **Emotional engagement**

Emotional engagement concerns students' affective responses toward learning, teachers, peers, and the educational institution. Feelings such as interest, enjoyment, belonging, enthusiasm, and identification with the learning environment are important components.

Recent meta-analytic evidence suggests that emotional engagement has particularly strong associations with motivation and well-being, demonstrating that students' emotional experiences are not peripheral to learning but are central to educational functioning.

- **Cognitive engagement**

Cognitive engagement involves psychological investment in learning. It includes deep processing, self-regulation, strategic learning, reflection, problem-solving, and willingness to understand complex material.

Cognitively engaged students are more likely to move beyond memorization toward analysis, application, evaluation, and synthesis. Such engagement is particularly important for higher-order learning and lifelong learning capacities.

- **Agentic engagement**

Agentic engagement describes students' proactive contribution to the learning process. Students demonstrate agentic engagement when they ask questions, communicate their learning needs, suggest improvements, seek clarification, and influence aspects of the educational experience.

This dimension is especially relevant to student-centered education because it positions students as active contributors rather than passive recipients of instruction.

UNDERSTANDING STUDENT WELL-BEING

Student well-being should similarly be understood as multidimensional. It extends beyond the absence of psychological distress and includes positive functioning and the capacity to experience meaning, connection, competence, and satisfaction.

Well-being can include:

- **Psychological well-being** – positive functioning, self-acceptance, purpose, and personal growth.
- **Emotional well-being** – the ability to experience and regulate emotions effectively.

- **Social well-being** – positive relationships, belonging, inclusion, and social connectedness.
- **Academic well-being** – confidence, motivation, manageable academic demands, and satisfaction with learning.
- **Physical well-being** – adequate sleep, healthy routines, energy, and physical functioning.
- **Institutional well-being** – feeling supported, respected, safe, and valued within the educational institution.

A recent systematic review of higher-education well-being measurement found substantial variation in how student mental health and well-being are operationalized. The literature frequently relies on measures of psychological distress, while positive well-being and educationally relevant dimensions such as belonging, engagement, and self-efficacy are comparatively less integrated into assessment frameworks.

This finding has important implications. Universities should not define well-being exclusively in terms of the absence of anxiety, depression, or stress. A comprehensive approach should also examine whether students are flourishing, connected, motivated, supported, and able to participate meaningfully in educational life.

THE RELATIONSHIP BETWEEN STUDENT ENGAGEMENT AND WELL-BEING

The relationship between engagement and well-being can be conceptualized as dynamic and potentially reciprocal.

- **Well-being as a foundation for engagement**

Students who experience positive well-being may possess greater psychological resources for learning. Emotional stability, self-efficacy, social support, and a sense of belonging can facilitate concentration, persistence, participation, and motivation. Conversely, chronic stress and psychological distress may interfere with attention, motivation, memory, and academic participation. Recent research examining higher education highlights interconnected relationships among sleep, academic stress, technology use, motivation, and engagement.

- **Engagement as a contributor to well-being**

Engagement can also contribute to well-being. Meaningful participation in learning can provide students with opportunities to experience competence, achievement, purpose, social connection, and personal growth. When students perceive their academic activities as meaningful and manageable, engagement may become a source of positive psychological experience. Students who participate actively in collaborative learning, extracurricular activities, peer communities, and institutional life may develop stronger social relationships and a greater sense of belonging.

- **The risk of unhealthy engagement**

An important distinction should be made between healthy engagement and excessive engagement. High levels of effort are not always beneficial when academic demands exceed students' resources. Student burnout is characterized by exhaustion, cynicism, and reduced

academic efficacy. A systematic review and meta-analysis found that burnout is common among students and can negatively affect motivation, performance, and well-being.

Therefore, educational institutions should seek **sustainable engagement**, rather than simply maximizing the quantity of student participation.

FACTORS INFLUENCING ENGAGEMENT AND WELL-BEING

- **Teacher–student relationships**

Teacher support is one of the most important contextual influences on student engagement. Supportive teachers can create environments characterized by respect, encouragement, autonomy, feedback, and psychological safety.

A 2025 systematic review of higher education found that perceived teacher support is related to student engagement through factors including self-efficacy, psychological need satisfaction, motivation, learning environment, and teacher–student and peer relationships. Teachers therefore influence student outcomes not only through instructional quality but also through interpersonal relationships.

- **Autonomy, competence, and relatedness**

Self-Determination Theory provides a useful framework for understanding engagement and well-being. Students are more likely to experience intrinsic motivation and positive functioning when their needs for autonomy, competence, and relatedness are supported.

Autonomy involves having meaningful choices and experiencing a sense of ownership over learning. Competence involves feeling capable of meeting academic challenges. Relatedness refers to experiencing meaningful connections with teachers and peers. When these needs are supported, students are more likely to develop intrinsic motivation and sustainable engagement.\

- **Classroom climate**

The emotional and social climate of the classroom can significantly affect both engagement and well-being. Inclusive classrooms characterized by respect, collaboration, fairness, and psychological safety can encourage participation. Conversely, environments characterized by humiliation, discrimination, excessive competition, or fear of failure may discourage participation and negatively influence well-being. Research examining learning environments has identified instructor behavior, course design, classroom climate, and available resources as interrelated influences on student well-being.

- **Peer relationships and belonging**

Students' relationships with peers can provide emotional support, academic assistance, friendship, and a sense of belonging. Belonging is particularly important during periods of transition, including entry into higher education. Students who feels that they are accepted members of their educational community may be more willing to participate, seek help, collaborate, and persist when difficulties arise.

- **Academic workload and assessment**

Academic workload is another critical factor. Challenging learning experiences can promote

engagement when students have sufficient resources and support. However, excessive workload, unclear expectations, continuous high-stakes assessment, and inadequate recovery time may contribute to stress and disengagement. Assessment practices should therefore be designed not merely to measure learning but also to support learning.

- **Digital technology**

Digital technology has transformed student engagement by expanding opportunities for communication, collaboration, personalized learning, and access to educational resources. However, technology can also create distraction, multitasking, techno stress, and reduced sleep. Recent systematic evidence suggests that purposeful technology use may support engagement, whereas maladaptive technology use and digital distraction may be associated with poorer engagement and well-being. The educational objective should therefore not be technology use for its own sake, but purposeful and pedagogically meaningful use.

AN INTEGRATED STUDENT ENGAGEMENT AND WELL-BEING FRAMEWORK

Based on the reviewed literature, an integrated framework can be proposed.

Educational Context → Psychological Resources → Engagement → Learning Outcomes and Well-Being

The framework consists of four interconnected levels.

Level 1: Educational context

This includes:

- teacher support;
- curriculum design;
- classroom climate;
- assessment practices;
- peer relationships;
- institutional support;
- Physical and digital learning environments.

Level 2: Psychological resources

These include:

- self-efficacy;
- autonomy;
- motivation;
- resilience;
- belonging;
- emotional regulation;
- Sense of purpose.

Level 3: Student engagement

Engagement operates through:

- behavioral engagement;
- emotional engagement;

- cognitive engagement;
- agentic engagement.

Level 4: Outcomes

Potential outcomes include:

- academic achievement;
- persistence;
- satisfaction;
- retention;
- psychological well-being;
- social connectedness;
- resilience;
- Personal development.

Importantly, the framework should be understood as **bidirectional rather than linear**. Positive educational experiences can promote engagement and well-being, while engaged and psychologically healthy students may also contribute positively to their learning communities.

IMPLICATIONS FOR EDUCATIONAL PRACTICE

An integrated approach to engagement and well-being has several implications for educational institutions.

- **Embed well-being into teaching and learning**

Well-being should not be treated exclusively as the responsibility of counseling centers. Curriculum designs, teaching methods, assessment, feedback, and classroom interaction all influence students' experiences.

- **Strengthen teacher–student relationships**

Faculty development programs should emphasize communication, inclusive teaching, constructive feedback, mentoring, and early identification of students experiencing difficulties.

- **Promote student agency**

Students should have meaningful opportunities to make choices, participate in decision-making, set learning goals, and provide feedback about educational experiences.

- **Develop supportive peer communities**

Peer mentoring, collaborative learning, student organizations, academic communities, and transition programs can strengthen belonging and social connectedness.

- **Reform assessment practices**

Institutions should consider assessment load, clarity of expectations, opportunities for formative feedback, and opportunities for revision and improvement.

- **Integrate mental health and academic support**

Academic advising, counseling, disability services, career support, and student welfare services should be connected rather than operating as isolated systems.

- **Encourage healthy technology practices**

Digital learning should incorporate strategies that reduce unnecessary distraction and promote purposeful engagement, attention management, and healthy boundaries around technology.

IMPLICATIONS FOR RESEARCH

Although the literature on engagement and well-being has expanded considerably, important methodological limitations remain.

- Many studies rely on cross-sectional designs. Consequently, associations between engagement and well-being cannot necessarily be interpreted as causal relationships. The 2026 scoping review specifically identified the scarcity of longitudinal studies as a major limitation.
- Considerable variation exists in the measurement of both constructs. Researchers should clearly distinguish among psychological distress, mental health, subjective well-being, psychological well-being, flourishing, and academic well-being.
- Future research should employ mixed methods. Quantitative measures can identify patterns and associations, while interviews, focus groups, observations, and student narratives can explain how students experience engagement and well-being in specific educational contexts.
- More research is required in the Global South and in culturally diverse educational contexts. Previous evidence mapping of student engagement research found that research has historically been concentrated in the United States and United Kingdom, with comparatively limited representation from the Global South.

Finally, intervention research should move beyond short-term programs and examine whether changes to curriculum, assessment, teaching practices, institutional policies, and learning environments produce sustained improvements.

CONCLUSION

Student engagement and well-being should not be treated as separate educational objectives. They represent interconnected dimensions of students' educational experience and development. Meaningful engagement requires psychological and social resources, while positive engagement can itself contribute to students' sense of competence, belonging, purpose, and well-being.

The evidence reviewed in this article suggests that sustainable engagement is promoted by supportive teachers, positive learning environments, autonomy, competence, relatedness, meaningful learning activities, manageable academic demands, supportive peer relationships, and appropriate institutional resources. At the same time, excessive academic demands, burnout, poor sleep, social isolation, and maladaptive technology use can undermine both engagement and well-being.

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AI LITERACY FOR TEACHERS: A PATHWAY TO FUTURE-READY EDUCATION

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Abstract

Artificial Intelligence (AI) is rapidly transforming education by influencing how knowledge is created, accessed, taught, learned and assessed. In this emerging educational landscape, teachers are no longer expected to possess only subject knowledge and pedagogical skills; they also need the ability to understand, evaluate and use AI responsibly and effectively. AI literacy has therefore become an essential component of teacher competence and professional development. This thematic paper examines AI literacy as a pathway towards preparing future-ready teachers and educational systems. It conceptualises AI literacy as a combination of foundational understanding of AI, practical competence in using AI tools, critical evaluation of AI-generated information, ethical awareness, pedagogical integration and continuous professional learning. The paper explores how AI can support lesson planning, content creation, personalised learning, assessment, inclusive education, and professional development, while simultaneously transforming the teacher's role from information provider to facilitator, learning designer, mentor, and critical evaluator. Particular attention is given to English language education, where AI can support Listening, Speaking, Reading and Writing (LSRW) skills, vocabulary development, pronunciation practice and personalised language learning. The paper also highlights challenges, including misinformation, algorithmic bias, privacy concerns, academic integrity, overreliance on AI, digital inequality, and the need to preserve human interaction. It argues that AI should augment rather than replace teachers. Teacher education institutions and professional development programmes must therefore move beyond basic digital literacy towards comprehensive AI literacy. Developing AI-literate, ethically responsible and pedagogically competent teachers is essential for building equitable, human-centred and future-ready education.

Keywords: *Artificial Intelligence, AI Literacy, Teacher Education, Professional Development, Future-Ready Teachers, Digital Competence, AI in Education*

1. Introduction

The twenty-first century has witnessed unprecedented developments in digital technologies. Among these, **Artificial Intelligence (AI)** has emerged as one of the most influential technologies shaping contemporary society. AI is increasingly being integrated into healthcare, business, communication, transportation, entertainment and education. In

education, AI is transforming traditional approaches to teaching and learning by enabling personalised instruction, automated feedback, intelligent tutoring, content generation, adaptive learning and data-informed decisionmaking.

The emergence of generative AI has accelerated this transformation. Teachers and learners can now interact with AI systems in natural language to generate explanations, lesson plans, questions, examples, summaries, activities and learning resources. This development has created enormous opportunities but has also introduced new responsibilities and challenges.

In this context, **AI literacy for teachers** has become increasingly important. A teacher does not need to become an AI engineer or computer scientist. However, a future-ready teacher should understand what AI is, what it can and cannot do, how to use it effectively, how to evaluate its outputs and how to guide learners towards responsible use.

UNESCO's guidance on generative AI in education emphasises a human-centred approach and highlights the importance of appropriate competencies, ethical considerations and responsible use of AI in educational contexts. Similarly, the rapid development of AI requires teachers to engage in continuous professional learning.

Therefore, AI literacy should not be viewed merely as the ability to operate AI applications. It should be understood as a **multidimensional professional competence** that combines technological understanding, critical thinking, pedagogy, ethics and human values.

2. Understanding AI Literacy

AI literacy refers to the knowledge, skills, attitudes and values required to understand and interact meaningfully with AI systems. For teachers, AI literacy may be understood through six interconnected dimensions:

Table 1: Key Dimensions of AI Literacy for Teachers

Dimension of AI Literacy	**Key Knowledge / Skills Required**	**Purpose / Educational Significance**
Understanding AI	• Understand what Artificial Intelligence is • Know how AI systems process information • Understand machine learning and generative AI • Understand how AI produces outputs • Recognise why AI can produce incorrect	Enables teachers to make informed decisions and use AI purposefully rather than simply following technological trends.
Dimension of AI Literacy	**Key Knowledge / Skills Required**	**Purpose / Educational Significance**
	information • Understand the limitations of AI systems	
Using AI	• AI-assisted lesson planning • Content creation • Question generation • Assessment • Feedback • Language learning • Classroom activities • Professional communication	Develops teachers' practical competence in using AI effectively for teaching, learning, assessment, and professional tasks.

Evaluating AI	Critically examine AI outputs for: • Accuracy • Relevance • Bias • Appropriateness • Cultural sensitivity • Linguistic correctness • Alignment with learning objectives	Helps teachers identify errors, bias and inappropriate content and ensures that AI-generated resources meet educational requirements.
Ethical AI Use	• Privacy • Data protection • Copyright • Plagiarism • Academic integrity • Bias • Transparency • Responsible AI use	Promotes safe, ethical, responsible and trustworthy use of AI in educational settings.
Pedagogical Integration	Focus on the question: **"How can AI improve this learning experience?"** Integrate AI only when it meaningfully supports learning objectives.	Ensures that **pedagogy drives technology**, rather than technology driving pedagogy.
Continuous Learning	• Continuous experimentation • Reflection • Collaboration • Professional development • Keeping up with emerging AI technologies	Enables teachers to adapt continuously as AI technologies, applications, and educational practices rapidly evolve.

Source: *UNESCO AI Competency Framework for Teachers*

3. Why AI Literacy is Essential for Future-Ready Teachers

The teacher's role has historically been associated with transmitting knowledge. However, unlimited access to information through digital technologies has already challenged this traditional role. With AI capable of generating explanations, examples and learning materials, teachers increasingly become:

- facilitators of learning;
- mentors;
- learning designers;
- critical evaluators;
- technology-integrating professionals;
- ethical guides; and
- creators of meaningful human learning experiences.
- The future-ready teacher, therefore, needs to combine content knowledge, pedagogical knowledge, **and AI competence**.
- AI literacy does not replace subject expertise. Instead, it enhances the teacher's capacity to use emerging technologies meaningfully.

4. AI in Teacher Education

Teacher education institutions have a central role in preparing teachers for an AI-driven educational environment. Traditional teacher education programmes generally focus on:

- subject knowledge;

- educational psychology;
- pedagogy;
- classroom management;
- assessment; and
- teaching practice.

These areas remain essential, but AI literacy must become an integral part of teacher preparation. Prospective teachers should be given opportunities to understand AI through both **theory and practice**.

For example, teacher education programmes can include activities such as:

- Exploring AI concepts.
- Evaluating AI-generated educational materials.
- Designing AI-supported lesson plans.
- Creating differentiated learning resources.
- Using AI for formative assessment.
- Practising effective prompting.
- Identifying AI-generated misinformation.
- Discussing ethical dilemmas.
- Designing AI-supported classroom activities.
- Reflecting on the appropriate and inappropriate use of AI.

This approach can help future teachers develop not merely **AI awareness**, but **AI pedagogical competence**.

5. AI and Professional Development of Teachers

Professional development must evolve alongside technological change.

One-time training programmes that demonstrate how to use a particular AI application may quickly become outdated. Instead, professional development should focus on **transferable AI competencies**. A sustainable model may include:

Teachers can:

- learn basic AI concepts;
- experiment with tools;
- apply them to classroom problems;
- evaluate their effectiveness;
- share experiences with colleagues; and
- continuously improve their practice.

Professional learning communities can play an important role in this process. Teachers can collaboratively explore AI tools, develop lesson resources, discuss challenges and establish responsible-use practices. Thus, professional development should shift from **technology training** to **AI-enabled pedagogical development**.

6. AI for Lesson Planning and Content Creation

Lesson planning is an important area in which AI can reduce routine workload. Teachers can use AI to generate:

- lesson-plan ideas;
- learning objectives;
- classroom activities;
- examples;
- discussion questions;

- quizzes;
- worksheets;
- differentiated materials; and
- assessment rubrics.

However, AI-generated materials should be treated as draft resources, not as finished pedagogical products. The teacher must evaluate whether the content is:

- age appropriate;
- curriculum aligned;
- factually accurate;
- culturally appropriate; and • suitable for the specific learners.

The teacher therefore remains the **professional decision-maker**, while AI functions as an assistant.

7. AI and Personalised Learning

One of the greatest possibilities of AI is its ability to support personalised learning.

Students in the same classroom may have different:

- learning levels;
- interests;
- abilities;
- learning speeds;
- linguistic backgrounds; and
- learning needs.

AI can assist teachers in developing differentiated materials.

For example, a teacher may use AI to create three versions of a reading passage:

- basic;
- intermediate; and
- advanced.

All three can address the same learning objective while varying in vocabulary, sentence complexity and task difficulty.

8. AI Literacy and Assessment

Assessment is another area undergoing transformation.

AI can assist teachers in:

- generating assessment questions;
- creating rubrics;
- providing preliminary feedback;
- identifying common errors;
- designing formative assessments; and
- preparing differentiated tasks.

However, AI-generated assessments should be carefully reviewed. Teachers should ensure that assessments measure genuine learning rather than a learner's ability to use AI. This requires a shift towards assessment methods that emphasise:

- critical thinking;
- oral interaction;
- problem solving;
- creativity;

- reflection;
- application; and
- authentic performance.

9. Ethical Dimensions of AI Literacy

AI literacy without ethical awareness can create serious educational problems.

Table 2: Ethical Challenges of AI in Education

Ethical Concern	Key Issue	Teacher's Responsibility / Response
Academic Integrity	Easy access to generative AI may encourage students to submit AI-generated assignments without meaningful engagement or genuine learning.	Establish clear classroom policies on acceptable AI use and promote authentic student work, critical thinking and proper acknowledgement of AI assistance.
Privacy	AI systems may process personal or sensitive information, raising potential privacy and data protection concerns.	Avoid sharing sensitive personal information with AI systems and follow appropriate privacy and data-protection safeguards.
Bias	AI systems can reproduce biases present in their training data,	Critically evaluate AI-generated examples, texts and images for cultural,
Ethical Concern	**Key Issue**	**Teacher's Responsibility / Response**
	potentially producing culturally or socially biased content.	social and linguistic bias before using them in education.
Misinformation	AI systems can generate plausible but incorrect information, which learners may mistakenly accept as factual.	Verify and cross-check AI-generated information using reliable sources before incorporating it into teaching and learning.
Copyright	**AI output should be evaluated, not blindly accepted.**	Teachers need to be aware of copyright and intellectual property issues when using AI-generated or AI-assisted content.

Source: European Commission. (2022). *Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators*

Ethical AI literacy should therefore become an essential component of teacher education.

10. Challenges in Developing AI Literacy

Despite its potential, several barriers may prevent teachers from becoming AI literate.

- **Lack of Training**
  → Many teachers may have limited opportunities for systematic AI training.
- **Technological Anxiety**
  → Teachers who are unfamiliar with emerging technologies may feel uncertain about

adopting AI.

- **Infrastructure**
  → Unequal access to devices, connectivity and digital resources can limit AI integration.
- **Rapid Technological Change**
  → AI tools and capabilities evolve quickly, making continuous professional learning necessary.
- **Workload**
  → Teachers may initially require additional time to learn, test and evaluate AI tools.
- **Lack of Institutional Policies**
  → Without clear institutional guidelines, teachers may be uncertain about appropriate AI use.

11. Towards an AI-Literate Teacher Education Model

A comprehensive model for AI literacy in teacher education can be developed around five stages:

Table 3: Stages of Developing AI Literacy among Teachers

Stage	Key Focus	Teacher Development Outcome
Stage 1: Awareness	Understanding the basic concepts, possibilities and limitations of AI.	Teachers develop **AI awareness** and a foundational understanding of AI.
Stage	**Key Focus**	**Teacher Development Outcome**
Stage 2: Competence	Developing practical skills in using AI tools and applications.	Teachers gain **practical AI skills** for teaching and professional tasks.
Stage 3: Pedagogical Integration	Connecting AI tools with curriculum, pedagogy and intended learning outcomes.	Teachers develop the ability to use AI **purposefully and pedagogically**.
Stage 4: Critical & Ethical Practice	Critically evaluating AI and addressing privacy, bias, academic integrity and responsible-use issues.	Teachers become **critical, ethical and responsible AI users**.
Stage 5: Innovation & Leadership	Using AI creatively and mentoring colleagues and institutions in effective AI practices.	Teachers become **AI innovators, mentors and professional leaders**.

Source: *UNESCO's AI Competency Framework for Teachers*

12. The Future-Ready Teacher

A future-ready teacher should not be defined by the number of AI applications they can operate.

Instead, a future-ready teacher should be able to answer five questions:

1. **Why** should I use AI?
2. **Which** AI tool is appropriate?
3. **How** should I integrate it pedagogically?
4. **How can I verify** its output?
5. **What are the ethical implications?**

This suggests a broader definition:

A future-ready teacher is an educator who combines subject expertise, pedagogical competence, AI literacy, critical thinking, ethical responsibility and human-centred values. Such teachers can use AI without becoming dependent on it.

13. Human Intelligence and Artificial Intelligence

One of the major concerns surrounding AI in education is whether AI will replace teachers. A more productive perspective is to consider **AI as an augmentation technology**.

AI can perform certain routine tasks rapidly, but teachers contribute qualities that technology cannot adequately replace:

- empathy;
- emotional understanding;
- moral judgement;
- inspiration;
- social interaction;
- contextual understanding;
- classroom relationships; and
- professional judgement.

RECOMMENDATIONS:

Based on the discussion, the following measures are recommended:

Table 4: Stakeholder-Wise Recommendations for AI-Ready Education

Stakeholder	Key Recommendations	Expected Outcome
Teacher Education Institutions	→ Integrate AI literacy into teacher education curricula → Provide hands-on AI experiences → Develop AIintegrated teaching practicum → Include AI ethics and responsible use → Encourage action research on AI-supported teaching	**AI-Literate Future Teachers**
Schools	→ Develop clear AI-use policies → Provide professional learning opportunities → Encourage teacher collaboration → Ensure equitable access to technology → Promote responsible AI use among students	**AI-Ready Learning Environment**
Teachers	→ Develop continuous AI learning habits → Experiment with AI purposefully → Verify AI-generated information → Protect learner privacy → Maintain academic integrity → Prioritise human interaction	**Competent & Responsible AI Users**

Educational Policymakers	→ Develop AI competency frameworks → Provide infrastructure and equitable access → Support teacher professional development → Promote research-based AI integration → Establish ethical AI guidelines	**Supportive AI Education Ecosystem**

Source: **UNESCO's *Guidance for Generative AI in Education and Research***

CONCLUSION:

- Artificial intelligence is changing the educational landscape and raising the bar for educators. AI literacy is becoming a crucial component of professional competence in this rapidly evolving environment; it is no longer an optional technological skill.
- AI literacy for educators extends beyond simply learning how to use an AI program. It entails understanding AI, utilising it intentionally, assessing its outcomes critically, incorporating it pedagogically, acknowledging its limitations, and employing it ethically.
- Artificial Intelligence (AI) presents a number of opportunities for improving listening, speaking, reading, and writing skills in English language instruction. It also offers customised learning, supports language practice, and helps teachers create educational materials.

  However, the goal of education must continue to take precedence over technology.
- Therefore, a teacher who is prepared for the future is neither one who relies solely on AI nor one who is supplanted by it. A teacher who is prepared for the future is one who is knowledgeable about AI, challenges it, employs it sensibly, and recognises when human intelligence must take the lead.
- In the end, adopting AI is not the only approach to prepare education for the future. It is the creation of AI-literate educators who can integrate human intelligence, educational knowledge, and ethical responsibility with AI.

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ROLE OF 21ST CENTURY TECHNOLOGIES IN STUDENT ENGAGEMENT AND WELL-BEING

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Abstract

The twenty-first century has witnessed rapid technological development that has significantly transformed the educational landscape. Digital technologies such as artificial intelligence, mobile learning, learning management systems, social media, cloud computing, virtual and augmented reality, educational games, robotics, and data-driven learning platforms are increasingly influencing the ways students learn, communicate, collaborate, and participate in educational activities. These technologies have created new opportunities to improve student engagement by making learning more interactive, flexible, personalized, and accessible. At the same time, technology has an important relationship with student well-being, as it can support communication, inclusion, self-directed learning, and access to educational and support services. However, excessive or poorly designed use of technology may also contribute to stress, distraction, social isolation, information overload, privacy concerns, and unequal access.This article examines the role of twenty-first century technologies in promoting student engagement and well-being. It discusses the major dimensions of student engagement and explores how digital platforms, artificial intelligence, mobile technologies, gamification, immersive technologies, and collaborative tools can contribute to behavioural, cognitive, emotional, and social engagement. The article also considers the ways in which technology can support students' well-being by promoting flexibility, belonging, accessibility, and timely support. At the same time, it highlights important challenges associated with digital inequality, screen-related concerns, cyber risks, data privacy, and the overuse of technology.The article argues that technology itself does not automatically improve engagement or well-being. Its educational value depends largely on how it is selected, designed, and integrated into meaningful learning experiences. A human-centred and balanced approach is therefore essential. Teachers, educational institutions, parents, and students must work together to ensure that technology enhances rather than replaces supportive human relationships. The article concludes that twenty-first century technologies can make an important contribution to engaged and healthy learning environments when their use is guided by sound pedagogy, ethical responsibility, inclusion, and attention to students' overall development.

Keywords: *Twenty-first century technologies, student engagement, student well-being, educational technology, digital learning, artificial intelligence, mobile learning, gamification, immersive learning.*

1. Introduction :

Education in the twenty-first century is increasingly shaped by technological change. The development of digital devices, internet connectivity, artificial intelligence, cloud-based services, interactive software, and mobile applications has expanded the possibilities available to teachers and students. Learning is no longer restricted to a classroom, a printed textbook, or a fixed timetable. Students can access digital resources, communicate with teachers and peers, participate in online discussions, create multimedia content, and learn from a wide range of locations and environments.

The integration of technology into education has also changed expectations about the role of students. Traditional approaches often placed teachers at the centre of knowledge transmission, while students mainly received information. Contemporary educational approaches, however, increasingly emphasize active participation, collaboration, creativity, critical thinking, and problem-solving. Technology can support these approaches by providing tools that allow learners to explore information, communicate, design projects, and receive feedback.

One of the most important concepts in contemporary education is **student engagement**. Engagement refers to the degree to which students participate actively and meaningfully in learning. It is often understood as a multidimensional concept involving behavioural, cognitive, emotional, and social aspects. A student who attends class but does not think deeply or feel connected to learning may not be fully engaged. Similarly, participation in an online activity does not automatically mean meaningful engagement.

Research on educational technology has shown that digital tools can support different forms of student engagement, but the relationship is complex. Systematic reviews have found that the educational benefits of technology depend strongly on context, pedagogy, and how engagement is conceptualized and measured.

Along with engagement, **student well-being** has become an important educational concern. Student well-being includes psychological, emotional, social, and physical dimensions of a learner's experience. A student who feels safe, supported, included, confident, and connected is generally better positioned to participate actively in learning. Recent research on digital learning environments highlights factors such as educator support, social belonging, access to technology, digital competence, motivation, and self-regulation as important influences on learner well-being.

Therefore, the relationship between technology, engagement, and well-being deserves careful attention. Technology can create meaningful opportunities, but it can also introduce new challenges. The central issue is not simply whether technology should be used in education, but **how it should be used to support students as learners and as individuals**.

2. Understanding Student Engagement in the Digital Age :

Student engagement is a broad concept that includes the effort, attention, interest, participation, and emotional involvement students bring to their learning. Educational researchers commonly describe several interconnected dimensions of engagement.

2.1 Behavioural Engagement ; Behavioural engagement refers to visible participation in learning activities. It may include attending classes, completing assignments, contributing to discussions, and participating in group activities.

Digital technologies can encourage behavioural engagement by providing interactive activities, quizzes, discussion platforms, videos, and collaborative tasks. However, simply clicking on a link or remaining connected to an online class does not necessarily indicate meaningful learning. Researchers have therefore emphasized the importance of using multiple methods to understand actual student engagement.

2.2 Cognitive Engagement ; Cognitive engagement involves deep thinking, curiosity, reflection, and sustained effort. Technology can support cognitive engagement when students use it to investigate problems, analyse information, create projects, and receive meaningful feedback. For example, simulation software can help learners explore scientific concepts, while interactive applications can provide opportunities for experimentation and problem-solving.

2.3 Emotional Engagement ; Emotional engagement relates to students' feelings about learning, including interest, enjoyment, confidence, and a sense of belonging. A positive emotional connection to learning can encourage persistence and participation.

Technology can support emotional engagement through interactive experiences, multimedia resources, and opportunities for communication. However, poorly designed digital learning may also lead to frustration or disengagement.

2.4 Social and Collaborative Engagement ; Learning is often a social process. Digital technologies can connect students through collaborative documents, online discussions, group projects, and video communication. These tools can make collaboration possible even when students are separated by distance.

However, meaningful collaboration requires more than simply providing a digital platform. Teachers need to design activities that encourage shared responsibility, respectful communication, and active participation.

3. Major 21st Century Technologies Supporting Student Engagement :

3.1 Artificial Intelligence and Personalized Learning : Artificial Intelligence (AI) is becoming increasingly important in education. AI-based systems can support personalized learning by adapting content, providing feedback, and identifying areas where learners may need additional assistance.

Personalized learning can improve engagement because students do not all learn at the same pace or in the same way. Some may require additional explanation, while others may be ready for more challenging activities. Adaptive systems can potentially provide different learning pathways based on individual progress. Recent research on adaptive learning platforms suggests that system quality, information quality, learner characteristics, preferences, and socially interactive features can all influence student engagement.

Nevertheless, AI should be used responsibly. Teachers remain essential because

learning involves motivation, relationships, values, creativity, and professional judgment. AI should support educators rather than reduce students to data or automated scores.

3.2 Mobile Learning and Ubiquitous Access : Smartphones and tablets have made learning increasingly mobile. Students can access educational materials, videos, digital books, and communication platforms beyond the traditional classroom.

Mobile learning can support engagement by allowing students to: Learn at flexible times and locations; Access resources quickly; Participate in short interactive activities; Communicate with teachers and classmates and Review learning materials independently.

Mobile technology can also support students who require flexible learning arrangements. However, unrestricted access to digital devices may create distractions. Therefore, digital literacy and self-regulation are essential skills. Students should learn not only how to use technology but also how to manage attention, evaluate information, and use digital tools purposefully.

3.3 Learning Management Systems and Digital Platforms : Learning Management Systems and online learning platforms have become important components of contemporary education. These systems can organize course materials, assignments, assessments, feedback, and communication.

Their greatest benefit is the creation of a structured digital learning environment. Students can access materials at their own pace and review resources when necessary. Teachers can also monitor participation and provide feedback.

However, technology should not create an excessive workload through constant notifications and digital tasks. Effective platform design should support clarity and reduce unnecessary complexity.

3.4 Gamification and Educational Games : Gamification involves using elements such as goals, challenges, feedback, progress indicators, and rewards to make learning activities more engaging. Educational games can also create opportunities for experimentation and problem-solving.

Well-designed gamified learning may increase motivation and participation. Recent systematic reviews have found that gamification can positively influence student motivation, engagement, and learning when it is connected with meaningful educational goals rather than used simply for entertainment. (ScienceDirect)

The most important principle is that competition should not become the only purpose of learning. Educational games should encourage understanding, cooperation, creativity, and persistence.

3.5 Virtual Reality and Augmented Reality : Virtual Reality (VR) and Augmented Reality (AR) can make learning more immersive and interactive. VR allows students to experience computer-generated environments, while AR adds digital information to the real environment.

These technologies can be useful for: Virtual field experiences; Scientific visualization; Historical exploration; Interactive models and Technical and professional training.

Immersive experiences can increase curiosity and help students understand concepts that may be difficult to explain through text alone. At the same time, access to such technology should be equitable and educationally meaningful.

3.6 Collaborative and Social Technologies : Digital communication tools can help students collaborate, exchange ideas, and work together. Collaborative learning technologies can promote social engagement when activities are carefully structured.

Students may work together to: Prepare presentations; Complete research projects; Share ideas and resources; Provide feedback and Solve problems collectively.

Systematic research on technology and engagement has identified collaboration and interaction as important features of digital learning, while also emphasizing that technology alone does not guarantee meaningful participation. (Springer)

4. Technology and Student Well-being :

Student well-being is closely connected with academic participation. Students who feel supported and included are more likely to engage confidently in learning.

Technology can contribute positively to well-being in several ways.

4.1 Flexibility and Reduced Barriers : Digital learning resources can allow students to access content at convenient times. Recorded materials and online resources may be particularly helpful for reviewing difficult concepts.

4.2 Sense of Connection and Belonging : Online communities and collaborative tools can help students remain connected with teachers and classmates. This is especially important when students are physically separated.

However, online interaction should complement meaningful human relationships rather than replace them.

4.3 Accessibility and Inclusion : Technology can make learning more accessible through digital text, captions, audio materials, adjustable formats, and assistive tools. When designed inclusively, technology can help students with diverse learning needs participate more fully.

4.4 Support and Feedback : Digital systems can provide timely feedback and help students identify areas for improvement. Clear and supportive feedback can strengthen confidence and encourage continued effort.

Recent research on learner well-being in digital environments identifies educator support, technological access, social and emotional belonging, motivation, and self-regulation as important elements of positive digital learning experiences. (DOI)

5. Challenges of Technology for Engagement and Well-being :

Although technology provides significant benefits, its challenges must also be recognized.

5.1 Digital Distraction ; Digital devices provide access to many competing sources of information and entertainment. Students may find it difficult to maintain concentration when learning activities compete with unrelated notifications or content.

The solution is not necessarily to reject technology but to develop healthy digital habits and learning environments that support concentration.

5.2 Information Overload ; Students today have access to enormous amounts of information. Without guidance, this can create confusion and stress. Teachers and librarians therefore have an important role in developing information literacy and helping students evaluate reliable sources.

5.3 Digital Inequality ; Not every student has equal access to devices, high-quality internet, or quiet learning spaces. Technology-based education must therefore consider issues of social and economic inequality.

5.4 Privacy and Data Security ; Digital learning platforms may collect information about students. Institutions must establish responsible policies to protect student data and ensure that technology does not compromise privacy.

5.5 Reduced Human Interaction ; If digital learning is poorly balanced, students may experience reduced opportunities for face-to-face communication and social connection. Technology should therefore complement rather than replace supportive relationships with teachers and peers.

6. The Role of Teachers and Educational Institutions :

Teachers are central to successful technology integration. A digital tool becomes educationally meaningful when it is connected with sound pedagogy.

Teachers can promote engagement and well-being by: Selecting technologies according to learning objectives; Designing interactive learning activities; Providing clear instructions and timely feedback; Encouraging collaboration; Supporting students' digital literacy; Creating inclusive and respectful digital spaces and Maintaining a healthy balance between online and offline learning. Educational institutions also have important responsibilities. They should provide reliable infrastructure, professional development, technical support, and policies that protect student privacy and promote accessibility. A growing body of research emphasizes that technology-enhanced learning should adopt a more humanized and pedagogically grounded approach, rather than focusing only on the use of new tools. (MDPI)

7. Strategies for Promoting Healthy Technology Use :

For technology to contribute positively to both engagement and well-being, educational institutions can adopt the following strategies:

1. Focus on Learning, Not Technology Alone

Technology should serve a clear educational purpose.

2. Promote Digital Literacy

Students should learn how to search for information, evaluate sources, communicate responsibly, and manage their digital activities.

3. Balance Online and Offline Learning

Students benefit from technology, but face-to-face interaction, physical activity, reading, discussion, and creative experiences remain important.

4. Create Supportive Digital Communities

Online learning spaces should encourage respectful communication and a sense of belonging.

5. Protect Student Privacy

Schools and institutions should use transparent policies for the collection and management of student information.

6. Ensure Equal Access

Technology initiatives should consider students who have limited access to devices or connectivity.

7. Provide Professional Development

Teachers and educational professionals need continuous training to understand both the opportunities and challenges of emerging technologies.

8. Future Directions : The future of education will likely involve greater integration of artificial intelligence, immersive technologies, learning analytics, adaptive platforms, robotics, and digital communication tools. These developments may create more personalized and interactive learning environments. However, the future of education should not be defined only by the sophistication of technology. The most important question is whether technology helps students become more curious, capable, confident, connected, and resilient.

Future educational technologies should therefore be designed according to principles of: Human-centred learning; Equity and inclusion; Accessibility; Ethical responsibility; Data privacy; Student agency and Meaningful human interaction. Technology has the greatest potential when students remain active participants rather than passive consumers of digital content.

9. Conclusion : Twenty-first century technologies have created significant opportunities for improving student engagement and well-being. Artificial intelligence, mobile learning, digital platforms, gamification, immersive technologies, and collaborative tools can make learning more flexible, interactive, personalized, and accessible. They can encourage students to participate actively, explore information, communicate with others, and develop important skills for contemporary society. At the same time, the relationship between technology and student development is not automatically positive. Digital distraction, unequal access, information overload, privacy concerns, and reduced human interaction can negatively affect learning and well-being if technology is poorly implemented. Therefore, technology should not be considered a replacement for teachers, relationships, or effective educational practices. Its purpose should be to strengthen meaningful learning and support students' overall development. Teachers and educational institutions must carefully select and integrate technologies according to educational goals and students' needs. Ultimately, the role of twenty-first century technology in education should be understood as supportive and transformative rather than dominant. When combined with sound pedagogy, inclusive practices, ethical responsibility, and genuine human care, technology can contribute to

learning environments where students are not only academically engaged but also socially connected, confident, and supported in their well-being.

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EXPLORING THE INFLUENCE OF DEMOGRAPHIC FACTORS ON SHYNESS AMONG ADOLESCENT STUDENTS IN SHIVAMOGGA DISTRICTS

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Abstract

This study attempted to estimate the prevalence of shyness among Adolescent students in and around Shivamogga District The sample consisted of Total number of (240) boys and girls aged between 14 to 16 years and were chosen from 6 different schools in and around from Shivamogga District. The hypotheses were formulated for the present study: There will be significant difference in levels of shyness among the selected samples of adolescent students. There will be significant relationship between components of shyness. Demographic variables (gender, area and SES) will have significant association with shyness . Statistical methods like chi-square test, t tests, correlation and ANOVA- one way was applied using SPSS software. The sample comprises 240 adolescents, representing 100% of the total participants. the Chi-square test ($\chi^2 = 0.003$, $p = 0.957$) demonstrates that there is non-statistically significant association between shyness levels and the area of residence among the adolescents indicating that the proportions of levels of shyness and the area of residence are the same in terms of the statistical inference. Furthermore, Chi-square test was conducted and it revealed that there is no statistically significant association between shyness level with socioeconomic status among the adolescents ($\chi^2 = 1.331$, $p = 0.249$) indicating that one's socioeconomic status does not seem to be a strong predictor of shyness levels For adolescents with low SES,.

Keywords: Shyness, Adolescent Students, demographic variables,

Introduction

Shyness is a psychological and behavioral characteristic commonly observed among adolescent students. Adolescence is a critical stage of development involving significant physical, cognitive, social, and emotional changes. During this period, adolescents often face challenges related to self-identity, peer relationships, emotional regulation, and social adjustment. Shyness may influence their social and emotional development, academic performance, and interpersonal relationships. Shyness refers to feelings of social discomfort, hesitation, and fear of judgment or rejection in social situations. It may be expressed through social withdrawal, difficulty initiating conversations, avoidance of new experiences, and discomfort in group interactions. Although a certain degree of shyness is normal, excessive shyness may restrict an adolescent's ability to develop relationships, seek support, participate actively, and make use of opportunities for personal growth. Understanding shyness among

adolescents is important because it may function as either an adaptive or maladaptive response to developmental challenges. Its expression can vary across situations and individuals and may be influenced by factors such as family environment, peer relationships, societal expectations, and individual differences. Therefore, studying shyness among adolescent students helps in identifying its causes, effects, and appropriate strategies for promoting healthy social and emotional development.

Review of Related Literature

Navya, K., Vidhya, K & Sannet Thomas (2021);- The study "Shyness and Self-esteem among Young Adults during COVID-19 Pandemic" examined shyness and self-esteem among 240 young adults aged 18–24 years, comprising 120 males and 120 females. Shyness was assessed using the Social Reticence Scale, while self-esteem was measured using Rosenberg's Self-Esteem Scale. Data were analyzed using mean, standard deviation, independent sample *t*-test, and Pearson's correlation.The findings showed that there was no significant gender difference in shyness or self-esteem. Further, shyness and self-esteem were not significantly correlated among young adults. Thus, during the COVID-19 pandemic, gender did not significantly influence either shyness or self-esteem, and the two variables were not significantly related.

Yingmin Chen1 Liang Li, Xiaoyi Wang, Yingli Li & Fengqiang Gao, (2018);- The study "Shyness and Learning Adjustment in Senior High School Students: Mediating Roles of Goal Orientation and Academic Help Seeking" examined the relationship between shyness and learning adjustment among 677 Chinese senior high school students. The study also investigated whether goal orientation and academic help-seeking behaviours mediated this relationship.The findings revealed that shyness was negatively associated with learning adjustment, meaning that higher shyness was linked with greater difficulties in adapting to learning. The relationship was influenced by different types of goal orientation and academic help-seeking behaviours, particularly mastery-approach goals and seeking instrumental help from teachers. The study suggests that encouraging positive learning goals and appropriate help-seeking behaviours can improve learning adjustment among shy students.

Shankarlinge Gowda & Chandrakanth Jamadar (2015);- The study examined the prevalence of shyness among adolescents in tribal and rural areas and explored its relationship with occupational preferences. It also investigated whether shyness level, gender, and family income influenced adolescents' job preferences. The study highlights that shyness can affect adolescents at cognitive, emotional, physiological, and behavioral levels, potentially influencing their social interaction, confidence, career choices, and adjustment. Severe or prolonged shyness may lead to social isolation, loneliness, and psychological difficulties. Therefore, identifying shyness at an early stage and providing appropriate counselling, social-skills training, confidence-building activities, and career guidance can help adolescents overcome its negative effects and make informed occupational choices.

Need and Rationale of the Study

The study on shyness among adolescents is important because adolescence is a critical stage of physical, psychological, emotional, and social development. Shyness may lead to social withdrawal, low confidence, difficulty in forming relationships, and reduced participation, while may result in conflicts, bullying, and difficulties in school and peer relationships. Understanding the relationship between these behaviours can help identify the factors that contribute to them and the factors that protect adolescents from their negative effects.

The study is also useful for teachers, parents, counsellors, and mental health professionals in identifying adolescents who need support. Its findings can contribute to the development of counselling, social-skills training, emotional regulation, confidence-building, and prevention programmes. Early identification and intervention may reduce the long-term negative consequences of shyness and promote healthy social adjustment, emotional well-being, positive peer relationships, and a supportive school environment.

Overall, the study provides valuable insight into adolescent behaviour and can help schools, families, and professionals develop effective strategies for promoting the healthy social and emotional development of adolescents.

Objectives of the Study

The present study aims to examine the impact of demographic variables on Exploring the Influence of Demographic Factors on Shyness among Adolescent Students in Shivamogga Districts the specific objectives of the study are:

1.To find out the extent of shyness among the selected samples of adolescent students.

2.To find out the association between gender and area, SES with shyness.

Hypotheses of the Study

To fulfill the above objectives, the following null hypotheses were formulated:

H1: There will be significant difference in levels of shyness among the selected samples of adolescent students.

H2: Demographic variables (gender, area and SES) will have significant association with shyness

Methodology of the Study

This study adopts a **descriptive survey method** to explore the relationship between selected demographic variables and Shyness among Adolescent Students in Shivamogga Districts.

Variables of the Study:

Demographic Variables:

1) Gender: Male and Female students
2) Area of Schools: Urban and rural
3) Type of school: Government, Aided, and Un-Aided
4) Socio economical status

Independent Variables: Shyness

Dependent Variable: Adolescents Students

Population and Sample:

The questionnaires were administered among the Students of High School Students in Shivamogga and Shikaripura Taluk of Shivamogga district. With a view to getting the whole sample base and better results. Subjects were selected from 6 schools covering rural, 1-Governments, 1-Aided, 1-Unaided and Urban, 1-Governments, 1-Aided, 1-Unaided situated in Shivamogga and Shikaripura Tuluk of Shivamogga district. The investigator personally approached and distributed the questionnaires to respondents. The purpose and procedures for filling out the questionnaires were personally explained to the Students who acted as respondents. The investigator selected High Schools covering Government, Aided and Unaided in selecting the respondents. The students studying in 8th, 9th and 10th standards in all the Aided, Unaided and Government schools in Karnataka. The sample for the present research consisted of 240 students (both male and female), a survey, usually, has a structured questionnaire containing a set of questions that are close-ended. The data obtained by the survey method was analyzed in terms of both descriptive and inferential statistics.

Tool Used for Data Collection:

D' Souza (2006), of Maharaja's College, University of Mysore, developed the shyness assessment test. It consists of 54 items and requires the subject to indicate his/her response by marking Yes/No/can't say. The items in the test pertain to three domains of shyness Cognitive/Affective (32items), Physiological (11 items), and Action oriented (11items), item analysis of the scale using SPSS program resulted in Cronbranch's alpha coefficient of 0.7119.

Data Analysis Techniques:

- **Descriptive Statistics**: Mean Standard Deviation, Percentage Analysis, and Quartile Deviation.
- **Inferential Statistics**: **Chi-squire** to examine significant differences across demographic groups.

Analysis of the data;-

Objective-1: To find out the extent of shyness among the selected samples of adolescent students.

To full fill the above objective researcher formulated the following null hypothesis-

Hypothesis-1: There will be significant difference in levels of shyness among the selected samples of adolescent students.

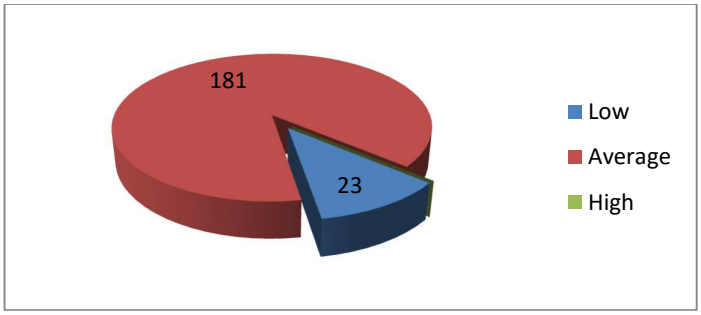
LEVELS OF SHYNESS

Table 1.0 Distribution of the selected sample of adolescents by various levels of Shyness

Variable	Levels	Frequency	Percentage	Test statistics
Shyness	Low	23	11.3	X^2=122.373; P=.001
	Average	181	88.7	
	High	0	0.0	

For shyness, the results indicate that 23 adolescents (11.3%) exhibit low levels, while the majority, comprising 181 adolescents (88.7%), demonstrate average levels. Notably, there are no adolescents with high levels of shyness in the sample. The Chi-square test (χ^2 = 122.373, p = 0.001) reveals a statistically significant difference between levels of shyness and adolescents, implying that the majority of the adolescents reported having average levels of shyness.

Graph 1.Distribution of the selected sample by levels of shyness



Objective 2. To find out the association between gender and area, SES with shyness.
To full fill the above objective researcher formulated the following null hypothesis-
H2: Demographic variables (gender, area and SES) will have significant association with shyness

ASSOCIATION BETWEEN GENDER AND AREA WITH SHYNESS.

Gender and levels of shyness

Table2.1Association of Shyness by gender and results of Chi-square test

Shyness		**Gender**		**Total**
		Male	**Female**	
Low	Frequency	11	12	23
	Percent	10.2%	12.5%	11.3%
Moderate	Frequency	97	84	181
	Percent	89.8%	87.5%	88.7%
High	Frequency	-	-	-
	Percent	-	-	-
Total	Frequency	108	96	204
	Percent	100.0%	100.0%	100.0%
Test statistics		Chi-square test= .272; P= .602		

Among male adolescents, 11 individuals (10.2%) exhibit low levels of shyness, while 97 individuals (89.8%) demonstrate moderate levels. Notably, there are no male adolescents with high levels of shyness in the sample. Female adolescents, on the other hand, show 12 individuals (12.5%) with low levels of shyness and 84 individuals (87.5%) with moderate levels. Similar to males, no female adolescents report high levels of shyness. Furthermore, Chi-square test ($\chi^2 = 0.272$, $p = 0.602$) indicates a non-statistically significant association

between shyness levels and gender, suggesting that proportions of male and female adolescents reporting same levels of shyness, which are statistically similar in nature.

Area and levels of Shyness

Table 2.2Association of Shyness by area and results of Chi-square test

Shyness		**Area**		**Total**
		Urban	**Rural**	
Low	Frequency	15	8	23
	Percent	11.4%	11.1%	11.3%
Average	Frequency	117	64	181
	Percent	88.6%	88.9%	88.7%
High	Frequency	-	-	-
	Percent	-	-	-
Total	Frequency	132	72	204
	Percent	100.0%	100.0%	100.0%
Test statistics		Chi-square test =.003[a];P=.957		

The table explores the association between shyness levels and the area of residence among the selected sample of adolescents.

In the context of urban areas, 15 adolescents (11.4%) demonstrate low levels of shyness, while 117 adolescents (88.6%) exhibit average levels. Notably, there are no adolescents with high levels of shyness in urban areas. In rural areas, 8 adolescents (11.1%) display low levels of shyness, and 64 adolescents (88.9%) report average levels, with no adolescents indicating high levels of shyness. Additionally, the Chi-square test ($\chi^2 = 0.003$, $p = 0.957$) demonstrates that there is non-statistically significant association between shyness levels and the area of residence among the adolescents indicating that the proportions of levels of shyness and the area of residence are the same in terms of the statistical inference.

SES and levels of shyness.

Table 2.3 Association of Shyness by SES and results of Chi-square test

Shyness		**SES**		**Total**
		Low	**Middle**	
Low	Frequency	8	15	23
	Percent	8.5%	13.6%	11.3%
Average	Frequency	86	95	181
	Percent	91.5%	86.4%	88.7%
High	Frequency	-	-	-
	Percent	-	-	-

Total	Frequency	94	110	204
	Percent	100.0%	100.0%	100.0%
Test statistics		Chi-square test =1.331[a];P=.249		

The table examines the association between shyness levels and socioeconomic status (SES) among the selected sample of adolescents.

For adolescents with low SES, 8 of them (8.5%) exhibit low levels of shyness, while 86 adolescents (91.5%) demonstrate average levels of shyness. No adolescents with low SES have high levels of shyness. Among adolescents with middle SES, 15 (13.6%) have low levels of shyness, and 95 (86.4%) have average levels, with none displaying high levels of shyness.

Further Chi-square test was conducted and it revealed that there is no statistically significant association between shyness levels and socioeconomic status among the adolescents (χ^2 = 1.331, p = 0.249) indicating that one's socioeconomic status does not seem to be a strong predictor of shyness levels.

Findings of the Study;-

- The majority of the respondents (88.7%) exhibited an average level of shyness, indicating that shyness was generally present at a moderate level among the respondents. A relatively small proportion (11.3%) showed low shyness, and no respondents reported a high level of shyness. The significant chi-square value further confirms that the distribution of shyness levels is statistically significant.
- The chi-square test result (χ^2 = 0.272, p = 0.602) indicates that there is no statistically significant association between gender and shyness level. Hence, gender does not significantly influence the level of shyness among the respondents.
- The chi-square test result (χ^2 = 0.003, p = 0.957) indicates that there is no statistically significant association between area of residence and level of shyness. Hence, the area of residence does not significantly influence the level of shyness among the respondents.
- The chi-square test result (χ^2 = 1.331, p = 0.249) indicates that there is no statistically significant association between socio-economic status and the level of shyness. Hence, socio-economic status does not significantly influence the level of shyness among the respondents.

Educational Implications of the Study

- The result indicates that **moderate shyness is common among the respondents**, and therefore educational practices should focus on creating a supportive and participatory learning environment that gradually develops students' **confidence, communication skills, social interaction, and active classroom participation**.
- Educational programmes should adopt a **gender-neutral, individualized and inclusive approach**, providing all students with equal opportunities to develop confidence, communication skills, social interaction and active participation.

- Educational institutions should adopt an **inclusive, equitable and individualized approach** to address shyness, rather than basing interventions on students' residential background.
- Counseling services should focus on the specific emotional and social needs of individual students rather than using socio-economic status as a basis for identifying students who may experience shyness.
- Focus on relevant factors Since SES was not significantly associated with shyness, educators and researchers should give greater attention to other possible factors such as self-confidence, personality, peer relationships, family environment, classroom climate and communication experiences.

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STUDENT ENGAGEMENT AND WELL-BEING: A HOLISTIC APPROACH TO ENHANCING ACADEMIC SUCCESS IN EDUCATIONAL INSTITUTIONS

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Abstract

Student engagement and well-being are increasingly recognised as essential components of academic success and the overall development of learners in educational institutions. Academic achievement cannot be viewed solely in terms of examination performance, as students' emotional, social, psychological, and cognitive experiences significantly influence their participation and learning outcomes. This paper examines the relationship between student engagement, well-being, and academic success and proposes a holistic approach for creating supportive and learner-centred educational environments. Student engagement is discussed through behavioural, emotional, cognitive, and social dimensions, while well-being encompasses students' psychological, emotional, social, and academic functioning. The paper highlights the importance of positive teacher–student relationships, supportive peer interactions, inclusive classroom practices, meaningful learning experiences, student autonomy, social-emotional learning, counselling support, physical and digital learning environments, and opportunities for collaborative participation. Drawing on perspectives from Self-Determination Theory, Positive Psychology, and Social-Emotional Learning, the paper argues that engagement and well-being are mutually reinforcing processes that can contribute to improved motivation, persistence, classroom participation, and academic achievement. A holistic framework is proposed in which educational institutions integrate academic, emotional, social, and psychological dimensions into their institutional practices. The paper concludes that enhancing student engagement and well-being requires coordinated efforts from teachers, institutional leaders, counsellors, parents, peers, and students. Such an integrated approach can contribute to more meaningful learning experiences, improved academic success, and the sustainable development of well-rounded learners.

Keywords: *Student Engagement, Student Well-Being, Academic Success, Holistic Education, Learner-Centred Education, Social-Emotional Learning, Educational Institutions*

Introduction

Education is not limited to the transmission of academic knowledge; it also involves the overall development of learners intellectually, emotionally, socially, physically and morally. In recent years, student engagement and well-being have gained importance as essential components of effective education. Student engagement refers to the extent to which

students actively participate in learning activities and feel connected to their educational institution. Well-being refers to a student's overall physical, emotional, psychological and social health. When students feel safe, supported, valued and motivated, they are more likely to participate actively in learning and achieve better academic outcomes. Therefore, educational institutions need to adopt a holistic approach that addresses both academic and non-academic needs. Such an approach can improve motivation, attendance, classroom participation, relationships, academic achievement and the overall quality of students' educational experiences.

Conceptualising Student Engagement

Student engagement is the degree of attention, participation, interest, motivation and involvement that students demonstrate in the learning process. It is a multidimensional concept that extends beyond simply attending classes.

Major dimensions of student engagement

- **Behavioural engagement**

Regular attendance and punctuality.
Participation in classroom activities.
Completion of assignments and academic tasks.
Following classroom rules and expectations.

- **Emotional engagement**

Students' feelings of belonging and connection.
Interest and enjoyment in learning.
Positive relationships with teachers and peers.
Feeling respected and valued within the institution.

- **Cognitive engagement**

Willingness to think deeply and critically.
Applying knowledge to new situations.
Problem-solving and independent learning.
Developing effective learning strategies.

- **Social engagement**

Cooperation with classmates.
Participation in group activities.
Building positive peer relationships.
Involvement in clubs, sports and institutional activities.

Importance of student engagement High levels of engagement can:

- Improve academic achievement.
- Increase motivation to learn.
- Reduce absenteeism and dropout.
- Develop self-confidence and independence.
- Strengthen teacher-student relationships.

- Encourage lifelong learning.

Thus, engagement should be viewed as an active partnership between students, teachers, peers, families and the educational institution.

Understanding Student Well-being

Student well-being refers to the overall state in which learners experience positive physical, emotional, psychological and social functioning and are able to cope effectively with the demands of educational life.

Dimensions of student well-being

❖ **Physical well-being**

a) Adequate nutrition and hydration.
b) Sufficient sleep and physical activity.
c) Safe and healthy learning environments.
d) Access to appropriate health facilities.

❖ **Emotional well-being**

a) Ability to recognise and express emotions.
b) Development of emotional resilience.
c) Positive self-esteem and self-confidence.
d) Ability to manage stress and frustration.

❖ **Psychological well-being** a) Positive sense of identity.

b) Self-awareness and self-acceptance.
c) Ability to cope with academic pressure.
d) Development of optimism and resilience.

❖ **Social well-being**

a) Positive relationships with teachers and peers.
b) Sense of belonging.
c) Respect for diversity.
d) Opportunities for collaboration and social interaction.

❖ **Academic well-being**

a) Confidence in one's learning abilities.
b) Appropriate academic support.
c) Manageable workload.
d) Opportunities to experience success and improvement.

Student well-being and engagement are closely connected. Students who experience a supportive and positive environment are more likely to participate actively in learning. Similarly, meaningful participation and academic success can contribute positively to students' confidence and well-being.

Holistic Strategies for Enhancing Student Engagement and Well-being

Educational institutions should adopt strategies that address the learner as a whole

person rather than focusing exclusively on academic performance.

- **Creating a positive classroom environment**

Teachers can create classrooms where students feel safe, respected and accepted. Clear expectations, mutual respect, inclusive practices and positive reinforcement encourage students to participate.

- **Student-centred teaching**

Learning should provide opportunities for students to actively construct knowledge through: ➢ Group discussions.

- Projects.
- Experiments.
- Problem-solving.
- Inquiry-based learning.
- Role play and simulations.

- **Building positive teacher-student relationships**

Teachers should listen to students, understand their needs and provide constructive feedback. A caring teacher can significantly strengthen students' sense of belonging and motivation.

- **Social and emotional learning** Students can be taught skills such as:

- Self-awareness.
- Self-management.
- Empathy.
- Responsible decision-making.
- Communication.
- Conflict resolution.

- **Mental health and counselling support**

Educational institutions should provide accessible counselling services and create environments where students can seek help without fear of stigma. Early identification of students experiencing difficulties can enable timely support.

- **Physical activity and healthy lifestyles**

Sports, yoga, exercise, recreational activities and health education can contribute to physical fitness and emotional well-being.

- **Inclusive education**

Institutions should ensure that students from different backgrounds and with diverse abilities have equal opportunities to participate. Reasonable accommodations and differentiated teaching can help meet individual learning needs.

- **Student voice and participation.**

Students should be given opportunities to express their opinions and participate in decisions concerning school or college life. Student councils, feedback systems and classroom discussions can strengthen ownership and engagement.

- **Family and community involvement**

Parents and communities can support students by maintaining communication with educational institutions and participating in educational and developmental activities.

- **Appropriate use of technology**

Digital tools can make learning interactive and accessible. However, institutions should also promote responsible digital behaviour and maintain a healthy balance between screen-based learning and physical/social activities.

- **Recognition and appreciation**

Recognising not only academic achievements but also creativity, sports, cooperation, leadership, improvement and community service encourages a broader understanding of success.

Challenges and Barriers to Enhancing Student Engagement and Well-being

Despite its importance, several challenges may prevent institutions from implementing holistic approaches.

Major challenges

- **Academic pressure:** Excessive focus on marks, examinations and competition can increase stress. **Large class sizes**: Teachers may find it difficult to provide individual attention.
- **Limited resources:** Shortages of counsellors, infrastructure and teaching-learning materials can restrict support services.
- **Teacher workload:** Administrative responsibilities may reduce the time available for student interaction.
- **Lack of awareness:** Students, teachers and parents may not fully understand the importance of well-being.
- **Mental health stigma:** Students may hesitate to seek counselling or psychological support.
- **Social and economic inequalities:** Financial difficulties, family circumstances and unequal access to educational resources can affect engagement.
- **Bullying and discrimination:** Unsafe or exclusionary environments can negatively affect participation and well-being.
- **Digital challenges:** Excessive screen use, online distractions and cyberbullying may affect students' learning and social development.
- **Resistance to change:** Institutions may find it difficult to shift from traditional teachercentred and examination-oriented approaches.

Addressing these barriers requires coordinated efforts from administrators, teachers, students, parents and the wider community.

Implications for Educational Institutions

A holistic approach to student engagement and well-being has several important implications.

For school and college administrators

- Develop student-friendly policies.
- Provide counselling and support services.
- Create safe, inclusive and accessible campuses.
- Monitor student attendance, participation and well-being.
- Provide professional development opportunities for teachers.

For teachers

- Adopt learner-centred pedagogies.
- Develop supportive teacher-student relationships.
- Identify students who require additional support.
- Use formative assessment and constructive feedback.
- Encourage collaboration, creativity and critical thinking.

For students

- Encourage active participation in learning.
- Develop self-regulation and time-management skills.
- Seek support when facing academic or personal difficulties.
- Participate in sports, clubs and extracurricular activities.
- Develop positive peer relationships.

For parents and families

- Maintain regular communication with teachers.
- Provide emotional encouragement rather than excessive academic pressure.
- Support healthy routines and study habits.
- Encourage children's interests and talents.

For educational policy

Educational policies should move beyond examination results as the sole indicator of educational success. Assessment of institutional effectiveness should also consider:

- Student participation.
- Attendance and retention.
- Sense of belonging.
- Physical and emotional safety.
- Mental health support.
- Inclusiveness.
- Overall learner development.

Conclusion : Student engagement and well-being are fundamental to meaningful and successful education. Academic achievement cannot be viewed separately from student's emotional, physical, psychological and social development. Learners who feel safe, valued, connected and supported are more likely to participate actively, develop positive attitudes towards learning and achieve their educational goals. Therefore, educational institutions should move towards a holistic model that combines quality teaching with supportive relationships, inclusive practices, health and well-being programmes, counselling, extracurricular activities and student participation. Such an approach benefits not only academic performance but also the development of confident, resilient, responsible and well-

rounded individuals. Ultimately, enhancing student well-being is not an additional responsibility of education—it is an essential foundation for meaningful academic success, development of capable, confident, socially responsible, and well-rounded learners.

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TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT

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Abstract

Teacher education and professional development are important for improving the quality of education. Teachers play a major role in shaping the knowledge, skills, and future of students. Therefore, teachers need proper education and continuous training to meet the changing needs of society and education. Teacher education prepares individuals with the knowledge and skills required for effective teaching, while professional development helps teachers improve their abilities throughout their careers. This paper discusses the importance of teacher education, professional development, modern teaching methods, challenges, and the role of technology in improving teaching quality.

Introduction

Teachers are one of the most important parts of the education system. They not only provide knowledge but also guide, motivate, and develop students. A good teacher can positively influence the academic and personal development of students.

Teacher education helps future teachers understand teaching methods, classroom management, educational psychology, and subject knowledge. However, learning does not stop after becoming a teacher. Education and technology are continuously changing, so teachers need regular training and professional development.

Professional development helps teachers learn new skills, improve their teaching methods, and understand modern educational technologies.

Importance of Teacher Education

Teacher education prepares individuals to become effective and responsible teachers. It provides knowledge about how students learn and how teachers can create a positive learning environment.

Teacher education helps teachers develop:

* Subject knowledge
* Teaching skills
* Classroom management skills
* Communication skills
* Understanding of student psychology

* Assessment and evaluation skills

Proper teacher education helps teachers understand the different needs and abilities of students. This allows them to use suitable teaching methods and create better learning experiences.

Professional Development of Teachers

Professional development is the continuous process of improving teachers' knowledge and skills during their careers.

Teachers can develop professionally through:

* Workshops
* Training programs
* Seminars
* Conferences
* Online courses
* Educational research
* Collaboration with other teachers

Continuous professional development helps teachers stay updated with changes in education.

For example, modern teachers need to understand digital learning platforms, online education, Artificial Intelligence, and other educational technologies.

Role of Technology in Teacher Development

Technology has changed the way teachers teach and learn. Online platforms provide teachers with access to training programs and educational resources.

Teachers can use technology to:

* Create interactive lessons
* Conduct online classes
* Prepare digital learning materials
* Communicate with students
* Assess student performance

Artificial Intelligence can also support teachers by helping them prepare learning materials, analyze student performance, and provide personalized learning experiences.

Technology does not replace teachers. Instead, it can help teachers become more effective and efficient.

Challenges in Teacher Professional Development

Although professional development is important, teachers may face several challenges.

Some common challenges include:

* Lack of time
* Limited financial resources
* Lack of training opportunities
* Limited access to technology
* Resistance to new teaching methods

Schools and educational institutions should provide teachers with regular training and support.

Importance of Continuous Learning

Education is constantly changing because of new technology, research, and social changes. Therefore, teachers must continue learning throughout their careers.

Continuous learning helps teachers:

* Improve teaching quality
* Learn modern teaching methods
* Understand student needs
* Use technology effectively
* Improve student performance

A teacher who continues learning can provide better educational opportunities for students.

Conclusion

Teacher education and professional development are essential for improving the quality of education. Teacher education prepares individuals to become skilled teachers, while professional development helps them improve throughout their careers.

Modern teachers need knowledge of new teaching methods, technology, and the changing needs of students. Schools and governments should provide regular training and professional development opportunities.

In conclusion, investing in teachers is an investment in the future of students and society. Well-trained, skilled, and continuously developing teachers are essential for building a strong and successful education system.

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ARTIFICIAL INTELLIGENCE IN EDUCATION: SHAPING SMART TEACHERS FOR A SMART FUTURE

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Abstract

Artificial intelligence (AI) is increasingly influencing how educational institutions design learning experiences, support teachers, personalise instruction and understand learners' needs. Yet the educational value of AI cannot be judged only by efficiency or academic performance. Student engagement and well-being are equally important outcomes, because meaningful learning depends on attention, belonging, confidence, agency, motivation and healthy relationships. This conceptual conference paper examines how AI can support student engagement and well-being when guided by smart, ethically responsible and human-centred teachers. The paper adopts a narrative review approach, drawing on recent international literature and policy frameworks, particularly UNESCO's AI competency frameworks and India's National Education Policy (NEP) 2020. It argues that AI should augment—not replace—the teacher's professional judgement and the student's agency. AI can contribute through adaptive learning, timely feedback, accessibility, differentiated learning, formative assessment, learning analytics and creative learning activities. At the same time, excessive automation may produce surveillance, bias, privacy risks, dependency, reduced human interaction, anxiety and inequitable access. The paper proposes a Human-Centred AI Engagement and Well-being Framework built around five principles: human agency, meaningful engagement, inclusive personalisation, ethical protection and relational well-being. The paper concludes that the smart teacher of the future is not the teacher who uses the greatest number of AI tools, but the teacher who knows when AI adds educational value, when human interaction is indispensable, and how to balance technology with empathy, critical thinking, creativity and care.

Keywords: Artificial Intelligence, education, smart teachers, student engagement, student wellbeing, human-centred AI, personalised learning, AI literacy

Introduction

Education is entering a period in which artificial intelligence is moving from an emerging technology to a practical component of teaching, learning and educational administration. Generative AI, intelligent tutoring systems, automated feedback, recommendation engines, speech technologies, accessibility tools and learning analytics can now perform tasks that were previously difficult or time-consuming for teachers. The question, therefore, is no longer whether AI will enter education, but how education can shape its use so that technology strengthens learning without weakening the human purposes of education.

The theme 'Artificial Intelligence in Education: Shaping Smart Teachers for a Smart Future'

becomes particularly significant when considered through the sub-theme of student engagement and well-being. Engagement is broader than attendance or completion of digital activities. It includes behavioural participation, emotional involvement, cognitive investment and the learner's sense of agency. Well-being includes psychological safety, belonging, confidence, healthy relationships, autonomy and the capacity to learn without unnecessary stress. An AI system can recommend a learning activity, but it cannot independently understand the whole emotional, cultural and relational context of a learner. UNESCO's 2024 AI Competency Framework for Teachers places human-centred thinking, ethics, AI foundations, AI pedagogy and AI-supported professional learning at the centre of teacher preparation. The framework emphasises that teachers need the competence to use AI while protecting human rights, agency, inclusion and social responsibility. Similarly, UNESCO's student framework stresses responsible and creative participation in an AI-enabled society. These orientations are important because the purpose of AI in education is not technological substitution; it is to improve the quality, equity and meaningfulness of learning. In the Indian context, NEP 2020 recognises artificial intelligence and other emerging technologies as areas requiring research, innovation and responsible educational integration. It also stresses technology for improving teaching-learning, assessment, teacher preparation, access and educational planning. Therefore, preparing smart teachers requires more than technical training. It requires pedagogical judgement, ethical awareness, digital and AI literacy, emotional intelligence and the ability to preserve meaningful teacher-student relationships.

Objectives of the Paper

- To examine the potential of AI for strengthening student engagement in diverse educational settings.
- To analyse the opportunities and risks of AI in relation to student well-being.
- To identify the competencies required by teachers for responsible and pedagogically meaningful AI integration.
- To propose a human-centred framework connecting AI, student engagement and well-being.
- To suggest practical directions for teacher education, institutional policy and classroom practice.

Method and Scope

This is a conceptual and analytical conference paper based on a narrative review of policy documents and recent scholarly literature on artificial intelligence in education, student engagement, teacher competencies and learner well-being. Key sources include UNESCO's Guidance for Generative AI in Education and Research, the UNESCO AI Competency Frameworks for Teachers and Students, India's NEP 2020, and recent systematic reviews of AIsupported education and ChatGPT-supported student engagement. The purpose is not to report original empirical data but to synthesise relevant evidence and develop a practical conceptual framework for educators.

AI and the Changing Meaning of the Smart Teacher

A smart teacher should not be defined as a teacher who depends heavily on digital tools. Smartness in the AI era is a professional capacity to combine technological knowledge with pedagogical judgement, ethical reasoning and human care. AI may automate routine activities, but teachers remain responsible for interpreting learner needs, designing meaningful experiences, building trust and making decisions about what should and should not be automated.

UNESCO identifies five broad competency dimensions for teachers: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These dimensions suggest a shift from tool-based training to professional AI competence. A teacher needs to understand not only how a system works, but also what data it uses, what its limitations are, how its outputs should be checked, and how its use may affect learners differently.

The smart teacher therefore acts as designer, facilitator, evaluator, ethical gatekeeper, mentor and learning-community builder. AI can generate explanations or activities, but the teacher decides whether they are accurate, age-appropriate, culturally responsive, inclusive and aligned with learning objectives. This professional mediation is especially important when students have different languages, abilities, levels of digital access and learning preferences.

AI as a Catalyst for Student Engagement

Recent research suggests that AI-supported learning can produce both engagement and disengagement. A systematic review of studies on ChatGPT and student engagement found evidence of benefits as well as risks, indicating that the educational effect of AI depends on how it is designed and used rather than on the technology alone. This is an important finding for teachers: AI should be integrated into pedagogical tasks that require learners to think, question, create, discuss and reflect, rather than simply consume generated answers.

First, AI can support personalised learning. Students can receive explanations at different levels of difficulty, examples connected to their interests, additional practice and alternative ways of approaching a concept. Personalisation can be particularly useful in heterogeneous classrooms where one pace rarely meets every learner's needs.

Second, AI can strengthen formative feedback. Instead of waiting until the end of a unit, students can receive feedback while learning is taking place. Teachers can use AI-assisted analysis to identify recurring misconceptions and then provide targeted human intervention. The goal should be feedback that stimulates revision and reflection, not feedback that merely supplies the correct answer.

Third, AI can increase participation through creative and inquiry-based activities. Students can compare AI-generated responses, identify errors, challenge assumptions, rewrite content, generate questions and investigate real-world problems. Such activities transform AI from an answer machine into an object of critical inquiry.

Fourth, AI can improve accessibility. Speech-to-text, text-to-speech, translation, adaptive

interfaces and other assistive functions can help learners who experience barriers related to language, reading, hearing, vision or physical access. However, accessibility tools should be selected with the learner's needs and privacy in mind.

AI and Student Well-being

Student well-being should be treated as a core educational outcome rather than an optional benefit. AI may contribute to well-being when it reduces unnecessary cognitive load, provides timely academic support, improves accessibility and helps teachers recognise patterns that require attention. For example, learning analytics may show that a learner is repeatedly struggling with a concept, allowing the teacher to intervene before frustration becomes disengagement.

However, learning analytics must not be confused with emotional diagnosis. A change in login frequency, response time or assignment performance may have many explanations. AI-generated predictions should therefore be treated as signals for professional inquiry, not as labels about a student's personality, motivation or mental state.

Well-being also depends on autonomy. If students feel that every action is monitored, predicted or automatically evaluated, their sense of ownership may decline. Excessive dependence on AI may also reduce productive struggle—the effort through which learners develop persistence, self-regulation and independent thinking. A healthy AI-enabled classroom therefore includes spaces where students work without AI, explain their reasoning, collaborate with peers and make independent decisions.

Human relationships remain central. Students need teachers who listen, encourage, challenge and understand them within their social and cultural contexts. AI may support communication, but it cannot replace the trust developed through genuine human interaction. The teacher's emotional presence is therefore not an outdated feature of education; it is a critical component of well-being in a technology-rich learning environment.

Risks and Ethical Concerns

Privacy and data protection: Educational AI can process sensitive learner information. Institutions should minimise data collection, use secure systems and clearly explain how data are handled.

Bias and inequity: AI systems may reproduce biases contained in training data or design assumptions. Teachers need to question outputs and check whether particular groups are disadvantaged.

Digital divide: Unequal access to devices, connectivity and high-quality AI tools can widen existing educational inequalities. AI strategies must include low-resource and offline alternatives.

Over-reliance and dependency: Students may accept generated responses without verification or develop reduced confidence in their own reasoning. Tasks should require independent thinking and source checking.

Reduced human interaction: If AI replaces discussion, peer collaboration or teacher

feedback, learning may become technically efficient but socially impoverished.

Misinformation and hallucination: AI systems can produce plausible but incorrect information. Verification, source evaluation and disciplinary judgement must remain essential.

Surveillance and labelling: Automated prediction can unintentionally turn learners into data profiles. Human review and transparent procedures are necessary before consequential decisions are made.

Teacher workload and competence gaps: Introducing AI without professional learning can increase uncertainty and workload. Teachers require sustained support rather than one-time tool demonstrations.

A Human-Centred AI Engagement and Well-being Framework

This paper proposes a five-part Human-Centred AI Engagement and Well-being Framework. The framework connects technology with educational purpose and places the learner and teacher at the centre.

1. **Human Agency:** Students and teachers remain the primary decision-makers. AI recommendations are treated as support, not authority.
2. **Meaningful Engagement:** AI is used for inquiry, creation, discussion, feedback and problemsolving rather than passive answer generation.
3. **Inclusive Personalisation:** AI adapts explanations and resources while respecting language, culture, disability, learning differences and unequal access.
4. **Ethical Protection:** Privacy, transparency, fairness, age-appropriateness, accountability and verification are built into classroom practice.
5. **Relational Well-being:** Teachers protect belonging, empathy, peer interaction, autonomy and opportunities for students to express uncertainty and ask for help.

The framework can be operationalised through a simple classroom cycle: identify a learning or well-being need; decide whether AI adds genuine value; select or design an appropriate tool; establish ethical boundaries; engage students in active learning; verify AI outputs; provide human feedback; and reflect on both learning and well-being outcomes. This cycle prevents technology from becoming the starting point of pedagogy. Educational purpose comes first.

Practical Strategies for Teachers

- Use AI for differentiated examples while keeping the learning objective common to the class.
- Ask students to critique AI-generated answers for accuracy, bias, missing perspectives and quality of evidence.
- Use AI-assisted formative assessment to identify misconceptions, followed by teacher-led remediation.
- Provide multiple modes of participation—oral, written, visual, collaborative and technologysupported—to increase inclusion.

- Create 'AI-free thinking time' so that students practise independent reasoning before consulting an AI system.
- Teach students to disclose appropriate AI assistance and distinguish their own ideas from machine-generated suggestions.
- Use AI to reduce routine administrative work so that teachers can devote more time to mentoring and interaction.
- Establish classroom rules for privacy, verification, respectful use, attribution and responsible AI behaviour.
- Regularly ask students how AI-supported learning affects their confidence, participation, workload and sense of belonging.
- Provide non-AI alternatives for students who lack reliable access or who require different forms of support.

Implications for Teacher Education

Teacher education programmes should move beyond introductory demonstrations of generative AI. Pre-service and in-service teachers need structured opportunities to develop AI literacy, prompt and task design, critical evaluation of outputs, data and privacy awareness, inclusive pedagogy, assessment redesign and ethical decision-making. UNESCO's competency framework can serve as a useful reference for such programmes.

Teacher educators should model reflective use of AI. Trainees can be asked to compare teachercreated and AI-generated lesson plans, identify bias in AI outputs, redesign assessments to value reasoning over copying, and develop classroom protocols for responsible AI use. Such activities prepare teachers to become critical users rather than passive consumers of technology.

In India, this agenda is consistent with NEP 2020's emphasis on technology for teachinglearning, assessment, teacher preparation, access and educational planning. The policy also calls for rigorous evaluation of technology interventions before large-scale adoption. This principle is especially relevant to AI because effectiveness, fairness and well-being outcomes can vary across contexts.

Institutional and Policy Recommendations

- Develop institution-level AI policies that clearly define acceptable, prohibited and contextdependent uses.
- Adopt privacy-by-design principles and collect only data necessary for legitimate educational purposes.
- Invest in teacher professional development that combines AI knowledge with pedagogy, ethics and well-being.
- Evaluate AI tools using learning, inclusion, accessibility, teacher workload and student wellbeing indicators—not only efficiency.
- Ensure equitable access through device-sharing, school-based access and low-bandwidth alternatives where required.

- Create mechanisms through which students and teachers can report harmful, inaccurate or biased AI outputs.
- Protect teacher agency by ensuring that high-stakes decisions are not delegated solely to automated systems.
- Encourage interdisciplinary research involving education, psychology, computer science, ethics and social sciences.

Discussion

The central argument of this paper is that AI does not automatically create smart education. Smart education emerges when human intelligence and artificial intelligence are purposefully combined. The strongest educational use of AI is therefore not necessarily the most sophisticated use. A simple feedback tool used thoughtfully may have greater educational value than a complex system that students and teachers do not understand.

Student engagement should also be understood as a quality of participation, not merely an increase in screen time. An AI system that keeps students clicking but does not promote curiosity, reasoning or collaboration cannot be considered a success. Similarly, well-being cannot be inferred from smooth digital performance alone. Students may complete tasks efficiently while feeling isolated, anxious or overly dependent on technology. Consequently, educational evaluation must include human and relational indicators.

The future teacher will increasingly work in a teacher-AI-student ecology. In this ecology, AI can provide scale, speed, personalisation and analytical support; teachers provide contextual judgement, ethical direction, emotional support and relationship; students provide curiosity, agency, creativity and critical response. The quality of education depends on the balance among these three elements.

Conclusion

Artificial intelligence offers significant opportunities to enrich education, but its success should be measured by the quality of human learning rather than by the quantity of technology deployed. AI can strengthen student engagement through personalised learning, feedback, accessibility, creative inquiry and timely support. It can contribute to well-being by reducing avoidable barriers and helping teachers respond to learning needs. Yet these possibilities are accompanied by privacy, bias, inequity, dependency, surveillance and reduced-humaninteraction risks.

Shaping smart teachers for a smart future therefore requires a shift from tool-centred adoption to human-centred professional competence. The smart teacher is an informed decision-maker who critically evaluates AI, protects students, designs meaningful learning and preserves the relationships that make education humane. The future of AI in education should not be a choice between teachers and technology. It should be a thoughtful partnership in which technology extends human capability while teachers safeguard human purpose. When engagement, agency, inclusion and well-being remain the central goals, AI can become not merely a smart technology, but a responsible educational resource for a smarter future.

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SMART COMMERCE, SMARTER MANAGEMENT: NAVIGATING BUSINESS IN THE ERA OF AI

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Abstract

The integration of artificial intelligence into commerce and management represents one of the most consequential transformations in modern business history. This paper ***"Smart Commerce, Smarter Management: Navigating Business in the Era of AI"*** *examines the paradigm shift from AI as a novelty to AI as an indispensable strategic asset, exploring how organizations are navigating the complex terrain of intelligent commerce and AI-augmented management. Drawing on recent empirical data, industry case studies, and forward-looking analysis, this paper argues that the organizations best positioned for success are not those with the most sophisticated algorithms, but those that most effectively orchestrate the symbiosis between human judgment and machine intelligence. The paper addresses four interconnected domains—the state of AI adoption, AI-driven commercial transformation, the redefinition of management and work, and the ethical governance imperative—before concluding with strategic recommendations for leaders navigating this new era.*

Keywords: *Artificial Intelligence, Commerce, Management, Business Strategy, Human-Machine Symbiosis, Intelligent Commerce, AI-Augmented Management, Ethical Governance, Organizational Transformation, Strategic Decision-Making.*

Introduction: The Algorithmic Imperative

Artificial intelligence has transitioned from the periphery of business experimentation to the center of strategic discourse. In 2025, worldwide spending on AI is forecast to total nearly $1.5 trillion, with projections exceeding $2 trillion in 2026. This staggering investment reflects a fundamental recognition: AI is no longer a technological adjunct but a strategic imperative that defines the future of competition.

Yet beneath this aggregate figure lies a more nuanced reality. While 82% of enterprise decision-makers now use generative AI weekly—up from just 37% in 2023—and nearly half use it daily, the translation of usage into transformative business value remains uneven. McKinsey reports that although nearly eight in ten organizations now use generative AI in at least one function, more than 80% report no material contribution to their profit and loss. This gap between aspiration and realization defines the central challenge of our era: how to move from isolated experimentation to enterprise-wide intelligence.

The thesis of this paper is that success in the AI era demands not merely technological adoption but organizational transformation—a reimagining of commerce, management, and

the relationship between human and machine intelligence. We stand at a pivotal moment where the question has shifted from "whether" to "how" to integrate AI meaningfully.

The Landscape of AI Adoption: From Experimentation to Enterprise

The Acceleration Curve

The adoption trajectory of AI in business has been nothing short of remarkable. According to OECD data, 20.2% of enterprises reported using AI in 2025, up from 14.2% in 2024 and 8.7% in 2023—more than doubling over two years. Enterprise AI investment tripled in a single year, from $11.5 billion to $37 billion. In just three years since ChatGPT debuted, AI applications now represent 6% of the entire software market—the fastest growth rate in software history.

This acceleration is particularly pronounced in commerce. AI platform-driven retail ecommerce sales grew 278.1% in 2025 to reach $20.57 billion. The 2025 holiday shopping season set new records, with $1.29 trillion in global sales driven by a shift toward AI-driven agentic shopping. AI agents influenced 20% of global retail sales, and traffic from AI-powered searches converted nine times more often than traffic from social media referrals. Companies deploying their own AI agents experienced 59% higher growth rates than those that did not.

The Governance Gap

However, adoption without governance invites risk. The National Retail Federation's 2025 survey found that while 86% of retailers already have AI governance policies in place, more than three-quarters (77%) allocate 5% or less of their technology budget to AI. This disparity between ambition and investment suggests that many organizations are still navigating AI with caution rather than conviction.

Perhaps more concerning, only 24% of retailers currently use AI for autonomous decision-making, and 85% have not planned or started implementing multi-agent systems. The industry remains comfortable experimenting at the edges while remaining cautious about handing decision authority to machines. This creates a widening gap between AI's perceived importance and its measurable impact.

Smart Commerce: AI in the Commercial Sphere

The Agentic Commerce Revolution

The emergence of agentic AI—systems that combine memory, reasoning, and tool use to act semi- or fully autonomously—marks a fundamental shift in how commerce operates. Bain & Company's research reveals that 30% to 45% of US consumers now use generative AI for product research and comparison. Among Millennials, 52% say they will begin holiday shopping with an AI assistant.

The implications are profound. Agentic AI is reshaping discovery and loyalty in ways not seen since the rise of search engines. Third-party AI agents like ChatGPT and Perplexity threaten to disintermediate retailers, capturing customer relationships at the point of discovery. Winning retailers will need to strategically decide whether to build their own

agentic capabilities or collaborate with major AI platforms.

The 2025 holiday season demonstrated that AI agents are no longer passive informational tools but active participants in the commerce lifecycle. During the holiday rush, agentic AI-powered service conversations jumped 66%, and agents autonomously managed a 142% surge in actions such as initiating returns and updating shipping details. As one industry observer noted, "AI is no longer a customer service tool. It is the most efficient new engine for the shopping cart".

Personalization at Scale

AI-powered personalization has moved beyond basic recommendation engines to sophisticated conversational commerce. Albertsons Companies, as the first retailer to deploy Google Cloud's Conversational Commerce agent via its Ask AI tool, demonstrates the potential. The agent engages in multi-turn conversations with shoppers, understanding preferences such as "sweet" versus "salty" when buying snacks. Early results show that customers using Ask AI often add one or more additional items to their cart, and more than 85% of conversions started with open-ended or exploratory questions.

Similarly, Williams-Sonoma has deployed Salesforce Agentforce 360 across its brand portfolio, using AI agents to autonomously offer personalized cooking tips and resolve more than 60% of chat inquiries. These examples illustrate a broader trend: AI is enabling a level of personalization that was previously impossible at scale, transforming customer experience from a cost center to a growth engine.

Supply Chain Intelligence

The impact of AI extends beyond customer-facing applications to the operational backbone of commerce. Companies deploying AI in supply chains have reported up to a 50% reduction in forecasting errors and a 65% drop in lost sales. Digital twins—virtual replicas of physical systems—enable stress testing and scenario modeling without interrupting live workflows.

McCormick & Co., the global leader in flavor, is implementing autonomous, decision-centric planning powered by agentic AI to transform how production and inventory are managed. The solution enables teams to plan more effectively for custom and standard products, rapidly adjust to shifts in demand or supply, and make smarter sourcing decisions. The result is a more responsive supply chain that delivers optimized cost and cash through waste reduction.

Fujitsu's AI-powered supply chain solution has been selected by the World Economic Forum's AI Governance Alliance as one of 18 global advanced AI solutions transforming business. These developments signal that AI is moving from supply chain optimization to supply chain autonomy.

Smarter Management: AI in the Organizational Sphere

The Redefinition of Management

McKinsey argues that to succeed in an AI-first world, organizations must evolve from

traditional functional models toward "agentic" structures that integrate human and AI systems. This requires redefining management to oversee not just people but also AI agents, and developing talent capable of guiding these systems with both technical understanding and human judgment.

The role of the manager is being fundamentally redefined. As AI systems take on more operational and administrative tasks, managers must become orchestrators who oversee blended systems of people and agents. This involves new forms of literacy, including understanding how agentic workflows function, evaluating their performance, and mitigating failures. Leaders must also develop stronger problem-solving and socio-emotional skills to manage hybrid teams effectively.

In this agentic model, leadership accountability expands to include the performance of AI systems. Managers are expected to align AI initiatives with business goals, ensure safe deployment, and integrate automation into decision-making processes. This represents a shift toward managing systems, humans, and agents together, where leadership is measured by outcomes and orchestration capability.

The Talent Transformation

The definition of talent is changing equally dramatically. McKinsey argues that future-ready workforces will depend on individuals who combine deep domain expertise with the ability to collaborate with agentic systems. Generic skills will lose value as AI takes over routine functions, while specialists and generalists who can design and guide AI workflows will gain influence. New roles are emerging across industries, including AI ethics leads, quality assurance managers, and agent coaches.

McKinsey research suggests that 75% of existing jobs will require redesign, upskilling, or redeployment by 2030. The shift should focus on redefining work rather than eliminating it, preparing talent to supervise, train, and complement agentic systems.

However, the workforce is not uniformly prepared. An EY survey revealed that while 84% of employees are eager to embrace agentic AI in their roles, 56% worry about their own job security working alongside AI agents. Furthermore, 85% of desk workers are learning about how to work alongside AI agents outside of work, and 83% say most of what they know is self-taught. This enthusiasm-anxiety contradiction is compounded by a lack of guidance from leadership.

The Productivity-Creativity Nexus

The most mature enterprise use cases for AI remain the horizontal activities that anchor modern knowledge work: data analysis, document and meeting summarization, editing and writing, and presentation creation. However, the biggest year-over-year growth comes from idea generation and brainstorming, cited by more than 60% of organizations. Leaders see this as the transition from "GenAI as a productivity engine" to "GenAI as a creativity accelerator".

This shift has profound implications for management. If AI can handle routine

analytical tasks and even generate novel ideas, the distinctive value of human managers shifts toward judgment, synthesis, and ethical decision-making. A 2025 study in the INFORMS journal Decision Analysis found that while generative AI can help define viable objectives for organizational decision-making, human expertise remains essential for decision quality.

The Human-AI Symbiosis: Orchestrating Intelligence

Complementarity, Not Replacement

A consistent finding across multiple studies is that AI enhances rather than replaces human capability. Roughly 90% of leaders say generative AI enhances employee skills. Fears of job displacement have not increased, reflecting growing recognition of human–AI complementarity.

However, this complementarity is not automatic. Wharton researchers warn of "skill atrophy" as an emerging risk: about 43% of leaders worry that generative AI may weaken core capabilities such as writing, analysis, and critical thinking. Junior employees may fail to acquire foundational learning if AI is always present. Organizations may need deliberate strategies, akin to pilots practicing manual flying, to maintain proficiency.

The Human-AI autonomy loop (HAIL) framework, developed in recent research, maps decision-making to four recursive phases—frame, evaluate, commit, and learn—illuminating how autonomy evolves in relation to the data-information-knowledge-wisdom hierarchy. This framework provides a roadmap for determining when to defer to AI and when to assert human judgment.

The Trust Imperative

Trust is the currency of effective human-AI collaboration. Bain's research reveals that while consumers increasingly use generative AI, around half remain cautious about letting AI agents autonomously handle purchases from start to finish. Consumers currently trust retailers' on-site agents three times more than third-party agents, though this trust gap could close as more consumers try utilizing third-party agents.

Building trust requires transparency, reliability, and demonstrable value. Winning retailers will strengthen customer relationships and make retailer-value obvious "to humans and to algorithms alike". This includes offering exclusive products, loyalty rewards, and value-added services that AI agents cannot easily replicate.

Ethical Governance: The Non-Negotiable Foundation

The Governance Imperative

As AI becomes integral to business operations, ethical and legal challenges have intensified. A "governance gap" is emerging as businesses pour money into AI tools without adequate oversight. According to Stanford Law School research, roughly three in four S&P 500 companies expanded AI-risk language in their 2025 Form 10-Ks, a clear shift from treating AI as routine technology to treating it as a board-level exposure.

The National Retail Federation found that 93% of retailers plan to develop or continue developing AI governance policies, with 68% of CEOs involved in oversight. Yet governance

remains a work in progress. Only 47% of business leaders say AI use is controlled by formal processes, up from 15% in February 2025.

Bias, Fairness, and Accountability

Algorithmic bias is no longer a niche concern. Mentions of AI bias doubled year-over-year in S&P 500 filings, from 70 to 146 companies. This growth reflects a practical litigation reality: automated decisions can easily scale exposure from isolated events to thousands of incidents before detection.

Organizations embedding ethical-by-design principles—such as algorithmic auditing, bias mitigation, and explainable models—build stronger stakeholder trust and face reduced legal exposure. Research stresses rigorous risk audits, bias testing, and explainable AI (XAI) to mitigate privacy breaches or manipulation.

The Regulatory Horizon

Regulatory frameworks are evolving rapidly. The SEC has established a task force to build "adequate safeguards and oversight mechanisms" for generative AI. The NIST AI Risk Management Framework provides guidance for implementing comprehensive governance. Organizations that align with these frameworks and articulate their governance clearly position themselves advantageously for regulatory compliance, stakeholder confidence, and favorable cost of capital.

The Road Ahead: Strategic Recommendations

From Experimentation to Enterprise

The transition from isolated AI experiments to enterprise-wide intelligence requires deliberate strategy. Gartner identifies AI agents, decision intelligence, and autonomous business as top technology innovations to watch. Organizations must move beyond narrow, task-based tools toward systems that can sense, decide, and act across functions.

TCS research draws a sharp distinction between "Pacesetters"—companies with the strongest financial performance—and "Followers." The divide is not access to AI but how deeply it's embedded into core operations. Pacesetters are consistently more likely to deploy AI in areas tied directly to profit and execution: inventory and demand scheduling, workforce planning, and dynamic pricing.

Investing in Human Capital

The focus of AI adoption has shifted decisively from technology to people, skills, and organizational design. Organizations report difficulty recruiting employees with advanced AI skills and are investing heavily in upskilling. Leaders do not expect fewer entry-level roles but rather anticipate greater demand for AI-native early-career talent.

McKinsey recommends three immediate actions: redefining job roles to emphasize domain expertise and AI fluency, investing in leadership capability to manage agents responsibly, and mapping how current and emerging roles will evolve. The firm cautions against short-term decisions such as eliminating entry-level roles or replacing skill development with automation without a broader workforce transformation strategy.

Building Trust and Governance

As AI capabilities expand, organizations must continue refining their governance programs, investment strategies, and workforce skill sets. This includes developing clear ethical frameworks, implementing bias audits, ensuring transparency, and maintaining human oversight.

The quality of AI governance disclosure will increasingly distinguish market leaders from followers. Organizations that can demonstrate responsible AI practices will build the trust necessary for sustained adoption and competitive advantage.

Conclusion: The Orchestrator's Challenge

The era of AI in commerce and management is not about machines replacing humans but about reimagining the relationship between them. The organizations that will thrive are not those with the most powerful algorithms or the largest data sets, but those that most effectively orchestrate the symbiosis between human judgment and machine intelligence.

This orchestration requires leaders who understand both the capabilities and limitations of AI, who can build trust with employees and customers alike, and who can navigate the complex ethical terrain that AI presents. It requires organizations that invest not only in technology but in the human capital necessary to wield it effectively. And it requires a commitment to governance that ensures AI serves human purposes rather than the reverse.

As Gartner analysts anticipate, by 2028, 40% of services will be AI-augmented. By the end of 2026, many organizations may have more AI agents than employees. The question is not whether this transformation will occur, but whether organizations will navigate it with wisdom, foresight, and a commitment to human flourishing.

The future belongs to the orchestrators—those who can harmonize the analytical power of machines with the judgment, creativity, and ethical sensibilities of humans. In smart commerce and smarter management, the ultimate competitive advantage is not artificial intelligence alone, but the intelligent orchestration of all available forms of intelligence.

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ARTIFICIAL INTELLIGENCE FOR INCLUSIVE AND EQUITABLE EDUCATION: OPPORTUNITIES, CHALLENGES AND A HUMAN-CENTRED FRAMEWORK FOR LEARNER DIVERSITY

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Abstract

Inclusive education is founded on the principle that every learner, irrespective of disability, socioeconomic status, language, gender, geographical location or individual learning characteristics, should have meaningful opportunities to participate in and benefit from education. The rapid development of Artificial Intelligence (AI) has introduced new possibilities for advancing this vision through adaptive learning, assistive technologies, automated translation, personalized instruction, intelligent tutoring, speech recognition and multimodal educational resources. At the same time, AI may reproduce existing inequalities through algorithmic bias, unequal access to technology, inadequate digital infrastructure, privacy risks and insufficient teacher preparedness. This review paper examines the potential of AI to promote inclusive and equitable education, with particular attention to learners with disabilities and other marginalized learner groups. The paper adopts a conceptual narrative review approach and draws upon recent systematic reviews, international policy documents and educational research. The literature indicates that AI can improve accessibility through personalized learning environments, text-to-speech and speech-to-text systems, automated captions, image descriptions, adaptive learning pathways and individualized feedback. AI may also reduce some administrative burdens on teachers and facilitate differentiated instruction. However, the benefits of AI are not automatically distributed equally. Digital divides, inaccessible platforms, biased datasets, linguistic limitations and inadequate teacher competence can transform AI from an instrument of inclusion into a mechanism of exclusion. Recent systematic reviews report promising evidence concerning accessibility, personalization and engagement, but also emphasize the limited number of empirical studies and the need for stronger theoretical and longitudinal research. The paper proposes a Human-Centred Inclusive AI Framework based on six principles: accessibility, personalization, human agency, equity, ethical accountability and contextual relevance. It argues that AI should be implemented as an augmentation technology that strengthens teachers' capacity to respond to learner diversity rather than replacing professional judgement. The paper concludes that equitable AI-enabled education requires not only technological innovation but also inclusive policy, teacher preparation, accessible infrastructure, ethical governance and sustained research.

Keywords: *Artificial Intelligence, Inclusive Education, Equity, Accessibility, Assistive Technology, Learner Diversity, Personalized Learning, Disability, AI in Education, Human-Centred AI*

1. Introduction

Education is increasingly expected to provide meaningful learning opportunities for learners

with diverse abilities, backgrounds, languages, socioeconomic circumstances and educational needs. The movement toward inclusive education represents a major transformation from systems that historically separated learners according to ability or circumstance toward systems that seek to accommodate diversity within common learning environments.

The emergence of Artificial Intelligence (AI) has added a new dimension to this transformation. AI technologies can analyse learner characteristics, adapt educational content, generate individualized explanations, translate information across languages, convert speech into text, describe images and support learners who experience barriers in conventional educational environments.

Consequently, AI has considerable potential to contribute to inclusive education. A 2024 systematic review examining AI and virtual reality in educational inclusion concluded that these technologies offer possibilities for improving accessibility, personalization and social inclusion, particularly for students with disabilities.

However, technological innovation does not automatically produce educational equity. The same AI systems that provide individualized support may also reinforce bias or exclude learners whose languages, cultures, disabilities or socioeconomic circumstances are inadequately represented in training data. UNESCO's guidance on generative AI emphasizes that inclusion, equity, cultural and linguistic diversity and human agency must remain central to the educational use of AI. The central issue is therefore not simply whether AI can support inclusive education but under what conditions AI can contribute to meaningful participation and equitable learning outcomes. This review examines that question by analysing the opportunities, challenges and future directions associated with AI-enabled inclusive education.

2. Concept of Inclusive and Equitable Education

Inclusive education involves more than providing physical access to educational institutions. It requires learners to experience meaningful participation, belonging, support and opportunities for achievement. Equity is similarly distinct from equality. Equality assumes that all learners receive the same resources, whereas equity recognizes that learners may require different forms and levels of support to achieve comparable educational opportunities. For example, providing identical digital learning material to every student may represent equality, but providing text, audio, visual and simplified versions according to individual requirements represents a more equitable approach. AI can potentially support this transition from standardized provision toward responsive educational provision.

The inclusive potential of AI is particularly significant because conventional classroom systems often operate under constraints of time, class size and limited individualized resources. AI systems can potentially supplement teacher capacity by generating alternative explanations, adapting tasks and providing additional practice. However, inclusion must remain a social and pedagogical objective rather than becoming merely a technological function.

3. AI and Learner Diversity

Learner diversity includes differences in cognitive abilities, learning pace, language, culture, disability, socioeconomic background, interests and prior educational experience. Traditional educational systems frequently struggle to respond to such diversity because teachers are required to address multiple needs simultaneously.

AI can potentially support differentiated instruction by generating different versions of learning materials. A teacher may, for example, develop one concept through text, another through visual representation and another through an interactive explanation. AI can also help identify patterns in student performance. Learning analytics may indicate that a student is repeatedly struggling with a particular concept, allowing the teacher to provide targeted intervention. However, algorithmic identification should not be interpreted as a definitive diagnosis of learner ability. Educational data represent only selected dimensions of a learner's experience. Teacher judgement and contextual understanding therefore remain essential.

4. AI as an Assistive Technology

One of the strongest areas of AI-enabled inclusion is assistive technology. AI-powered systems can support learners with visual, auditory, physical and cognitive disabilities.

Examples include:

Speech-to-text: converts spoken language into written text and can support students who have difficulty writing.

Text-to-speech: converts written material into audio and can assist learners with visual impairments or reading difficulties.

Automatic captioning: provides real-time or recorded captions for learners with hearing difficulties.

Image description: AI-based vision systems can generate descriptions of visual material.

Language translation: AI can translate instructional material into different languages.

Predictive text: can assist learners with writing difficulties.

Adaptive interfaces: can modify presentation according to user requirements.

A systematic review of digital accessibility research found substantial growth in research examining AI applications for accessibility across visual, auditory, motor and cognitive impairments. These applications demonstrate an important shift from designing one educational environment for everyone toward designing environments that can respond to individual accessibility requirements.

5. AI and Students with Learning Disabilities

Students with learning disabilities may experience persistent difficulties in reading, writing, mathematics, memory, attention or information processing. AI can potentially provide personalized support by adapting the pace, format and complexity of instructional materials.

A 2024 systematic review focusing on AI applications for students with learning disabilities identified sixteen relevant studies. Ten focused specifically on dyslexia, while only one focused on dyscalculia, indicating both promising applications and substantial gaps in the

research base. AI-supported reading systems may assist students with dyslexia through speech synthesis, text simplification, word prediction and individualized practice.

In mathematics, intelligent tutoring systems may provide step-by-step guidance and adapt practice problems according to learner performance. However, the limited number of studies on particular disabilities indicates that current AI research does not adequately represent the full spectrum of learning differences. Future research should therefore move beyond dyslexia-dominated research toward broader coverage of dyscalculia, dysgraphia, attention-related difficulties, intellectual disabilities and multiple disabilities.

6. AI and Universal Design for Learning

Universal Design for Learning (UDL) emphasizes providing multiple means of engagement, representation and action or expression. AI can strengthen UDL principles by allowing learning materials to be dynamically transformed. For example, the same lesson can potentially be converted into: simplified text; audio; visual explanation; translated content; question-and-answer format; interactive activities; or examples appropriate to different levels of prior knowledge.

This flexibility can reduce barriers without necessarily separating learners into different classrooms. AI therefore has the potential to support the movement from remedial accommodation toward inclusive design. Nevertheless, AI-generated adaptations must be reviewed for accuracy and appropriateness. An automatically simplified text may unintentionally remove essential concepts, while an AI-generated translation may misinterpret culturally specific terminology. Universal design therefore still requires professional oversight.

7. AI and Personalized Learning

Personalization represents another major contribution of AI to inclusive education. Traditional classroom instruction generally operates at a common pace. AI-enabled adaptive systems can potentially modify instructional sequences based on learner performance. A student who demonstrates mastery may receive more challenging material, whereas a student experiencing difficulty may receive additional explanation and practice.Recent systematic research on AI and inclusive education reports personalization as one of the principal benefits of AI for students with special educational needs.

However, personalization should not become algorithmic labeling. A learner should not be permanently categorized as "low ability" because of historical performance data. AI systems should support growth and recognize that learning is dynamic. The ideal model is therefore adaptive personalization under teacher supervision.

8. AI and Linguistic Inclusion

Language represents one of the most important dimensions of educational equity. Students who study through a language different from their home language may encounter difficulties in understanding textbooks, instructions and assessment questions. AI-powered translation and multilingual generation can potentially address some of these barriers. This possibility is

particularly important in multilingual countries such as India.

NEP 2020 emphasizes the importance of Indian languages and calls for educational software and e-content to be made available in major Indian languages and accessible to learners in remote areas and to students with disabilities. AI can potentially support this objective by facilitating translation, multilingual explanations and language-sensitive learning materials. However, multilingual AI systems may perform unevenly across languages. Major international languages generally receive substantially more computational and linguistic resources than many regional and indigenous languages. Therefore, linguistic inclusion requires deliberate investment in low-resource languages rather than assuming that general-purpose AI will automatically provide equal quality across languages.

9. AI and Socioeconomic Equity

Technology can simultaneously reduce and reproduce inequality. AI may reduce inequality by providing learners with access to tutoring, explanations and educational resources that might otherwise be unavailable. A learner in a remote area could potentially access an AI-supported tutor at a relatively low cost. Yet AI can also widen inequalities when access depends on: high-speed internet; expensive devices; paid subscriptions; digital literacy; reliable electricity; or technologically skilled teachers.

The digital divide can therefore become an AI divide. Educational policy must consequently ensure that AI-supported learning is not designed exclusively for well-resourced schools and institutions. Public investment in infrastructure, open educational resources, multilingual systems and teacher capacity is necessary if AI is to function as an instrument of equity.

10. AI and Rural and Geographically Marginalized Learners

Geographical location remains a major educational determinant in many countries. Remote and rural learners may have limited access to specialized teachers, libraries, laboratories and enrichment programmes. AI can potentially provide supplementary educational support where human expertise is scarce. For example, AI-supported systems can provide explanations, practice activities and language assistance outside regular school hours. However, technology cannot compensate for inadequate infrastructure indefinitely. Rural inclusion requires reliable electricity, connectivity, devices, teacher support and appropriate local content. NEP 2020 recognizes technology as an important mechanism for improving educational access while emphasizing the need for contextually evaluated technology integration. Thus, AI should be regarded as one component of a broader rural education strategy rather than as a substitute for investment in schools and teachers.

11. AI and Gender Equity

AI has the potential to support educational access for girls and women through flexible learning, personalized educational resources and remote learning opportunities. However, AI systems may reproduce gender stereotypes present in their training data. For example, generative systems may associate occupations, leadership roles or academic disciplines with particular genders based on patterns in existing data. UNESCO explicitly identifies gender

equality alongside inclusion, equity and cultural and linguistic diversity as principles that should guide AI in education. AI literacy should therefore include the capacity to recognize algorithmic stereotypes and question potentially biased outputs.

12. AI and Social Inclusion

Inclusive education also involves social participation and belonging. AI can support social inclusion by facilitating communication, language assistance and collaborative learning. For students who experience communication barriers, speech technologies and adaptive communication tools may provide greater opportunities to participate in classroom activities. However, excessive dependence on AI may also reduce peer interaction. Education should not become a purely individualized interaction between learner and machine. Social relationships remain fundamental to educational development. The appropriate principle is therefore: AI for participation, not AI instead of participation.

13. Challenges to Inclusive AI

Despite its potential, AI presents several significant challenges.

13.1 Algorithmic Bias: AI systems learn from data. If the data contain social, cultural, linguistic or gender biases, AI outputs may reproduce those biases. Research on AI and disability has raised concerns about the dominance of narrow medical models and ableist perspectives in AI-related research. This is particularly important in education because biased systems can influence how learners are classified, supported or evaluated.

13.2 Accessibility of AI Platforms: Ironically, some AI systems intended to improve accessibility may themselves be inaccessible. Interfaces may not work effectively with screen readers, alternative input devices or other assistive technologies. Accessibility must therefore be incorporated into the design of AI systems from the beginning.

13.3 Privacy: AI-enabled educational environments can collect substantial information about students. This may include performance data, behavioural patterns, voice recordings, writing samples and potentially sensitive information. UNESCO recommends strong data-protection measures and emphasizes human-centred regulation of GenAI in education.

13.4 Teacher Preparedness: Teachers may lack the knowledge required to evaluate AI outputs or integrate them meaningfully into inclusive classrooms. Professional development must therefore address both technical and pedagogical dimensions of AI.

13.5 Digital Inequality: Unequal access to devices, connectivity and AI services can produce unequal educational benefits.

13.6 Overdependence: If learners become excessively dependent on AI assistance, their independent problem-solving and self-regulation may be weakened.

14. The Changing Role of the Teacher

AI-enabled inclusion does not eliminate the need for teachers. Instead, teachers may increasingly function as: facilitators of personalized learning; interpreters of learner data; designers of inclusive learning experiences; ethical supervisors; mentors; advocates for learner rights; and mediators between technology and human needs. The teacher is uniquely

positioned to understand the social and emotional context of learning.

AI can identify that a student is performing poorly; a teacher may investigate whether the reason is language difficulty, family circumstances, motivation, anxiety, inadequate prior knowledge or another contextual factor. Thus, AI can identify patterns, but teachers interpret human circumstances. This distinction is central to responsible inclusive education.

15. Teacher Education for Inclusive AI

Teacher education institutions must prepare future teachers for AI-supported inclusive classrooms. Teacher education programmes should develop competencies in: AI literacy, accessibility, assistive technology, differentiated instruction, ethical data use, bias detection, inclusive assessment and Universal Design for Learning. Teacher educators should also provide practical experience with AI tools rather than limiting instruction to theoretical discussion. Future teachers should learn to ask five fundamental questions before adopting an AI system:

Who benefits from this technology?

Who may be excluded?

What data does it collect?

What biases might it contain?

What educational problem does it actually solve?

These questions encourage critical rather than technology-driven adoption.

16. Policy and Governance

AI-enabled inclusive education requires institutional and national policy frameworks. UNESCO's guidance recommends human-centred approaches that promote inclusion, equity, linguistic and cultural diversity, human agency, teacher capacity and pedagogical validation.

Policy should address: accessibility standards; data protection; algorithmic transparency; AI procurement; teacher training; equitable access; multilingual development; student protection; academic integrity; and monitoring and evaluation. Policies should not merely regulate what AI can do. They should establish principles for what AI should do for learners.

17. Indian Context

India represents an especially significant context for inclusive AI because of its linguistic, geographical, socioeconomic and educational diversity. NEP 2020 explicitly recognizes AI and other emerging technologies as transformative forces requiring systematic research and educational preparation. It also emphasizes technology-supported education that can reach remote learners and students with disabilities. AI could support inclusive education in India through multilingual content, adaptive learning, assistive technologies, teacher support and personalized interventions. However, implementation should recognize substantial differences among states, districts and institutions. A sophisticated AI system may be less useful than a simple, multilingual and low-bandwidth system if the latter is accessible to a larger number of learners. The guiding principle should therefore be: Appropriate technology

rather than maximum technology.

18. Research Gaps

Although research on AI and inclusion is expanding, important gaps remain.

a) Many studies are exploratory or conceptual rather than longitudinal.
b) Research is concentrated on certain disabilities, particularly dyslexia, while other disabilities receive comparatively little attention.
c) There is a need for greater research involving school-age children. Existing systematic reviews indicate that only a proportion of studies specifically examine school-aged populations.
d) Empirical research from developing countries remains insufficient.
e) More research is required on multilingual AI and low-resource languages.
f) Future studies should examine not only academic outcomes but also participation, belonging, self-efficacy, autonomy and well-being.
g) Research should examine whether AI reduces or increases educational inequalities over time.

20. Future Directions

Future AI research in inclusive education should move in several directions.

a) AI systems should increasingly incorporate accessibility by design rather than adding accessibility features after development.
b) Research should also involve learners with disabilities directly in the design and evaluation of AI systems. The principle of "nothing about us without us" is particularly relevant to inclusive technology development.
c) There should also be greater investment in multilingual AI systems capable of supporting regional and minority languages.
d) Teacher education should integrate inclusive AI competency into both pre-service and in-service programmes.
e) Educational institutions should develop transparent policies that define responsible AI use while allowing experimentation and innovation.
f) Finally, AI interventions should be evaluated using rigorous educational research rather than technology adoption metrics alone.

21. Conclusion

Artificial Intelligence represents a significant opportunity for advancing inclusive and equitable education. Its ability to personalize learning, generate accessible content, support communication, provide assistive technologies and adapt educational experiences can help reduce barriers experienced by many learners. Recent systematic reviews provide encouraging evidence that AI can enhance accessibility, personalization and engagement, particularly for learners with disabilities. Nevertheless, AI is not inherently inclusive. Without appropriate safeguards, AI can reproduce social bias, intensify digital inequality, compromise privacy and exclude learners whose linguistic, cultural or accessibility needs are

inadequately represented.

The educational value of AI therefore depends upon the conditions under which it is designed and implemented. Inclusive AI requires a shift from **technology-centred thinking to learner-centred thinking**. The central objective should not be to provide every learner with the same AI system. Rather, it should be to create educational environments in which AI helps remove barriers, expand participation and provide appropriate support while preserving human dignity and agency. Teachers remain central to this process. AI can analyse patterns, generate resources and provide assistance, but teachers interpret learner needs, build relationships, exercise professional judgement and create inclusive classroom communities.

The future of inclusive education should consequently be built upon a partnership among **learners, teachers, technology, families, institutions and policy makers**. AI can become a powerful instrument of educational equity—but only when accessibility, personalization, human agency, ethics and social justice are treated as fundamental design principles rather than secondary considerations.

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GENERATIVE ARTIFICIAL INTELLIGENCE IN SECONDARY SCHOOL SOCIAL SCIENCE EDUCATION: PEDAGOGICAL OPPORTUNITIES, ETHICAL CHALLENGES AND FUTURE DIRECTIONS

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Abstract

Generative Artificial Intelligence (GenAI) is rapidly emerging as an influential technology in school education, creating new possibilities for teaching, learning, assessment, and educational research. In secondary school Social Science education, GenAI tools such as large language models and AI-based content-generation systems can support students in exploring historical events, analysing social and political issues, comparing perspectives, generating questions, summarising complex information, and developing written arguments. For teachers, these technologies can assist in lesson planning, differentiation, formative assessment, creation of learning materials, and development of classroom activities. However, the integration of GenAI also presents substantial pedagogical, ethical, and social challenges. This study examines the pedagogical opportunities, ethical challenges, and future directions associated with GenAI in secondary school Social Science education. A qualitative research design based on a structured review of recent academic literature and international educational guidance was adopted. The literature was thematically analysed with particular attention to learning enhancement, critical thinking, personalised learning, teacher support, academic integrity, misinformation, algorithmic bias, privacy, digital inequality, and student agency. The review indicates that GenAI can facilitate personalised and interactive learning, provide rapid feedback, support diverse learning needs, and promote inquiry-based and dialogic approaches to Social Science education. Nevertheless, excessive dependence on AI-generated information may weaken independent thinking, encourage superficial learning, and increase risks of misinformation and academic dishonesty. Ethical concerns are particularly important for secondary students because of their age, developing judgement, and vulnerability to inappropriate or biased content. UNESCO therefore emphasises age-appropriate, humancentred, safe, equitable, and meaningful use of GenAI in education. The study concludes that GenAI should function as a pedagogical support rather than a substitute for teachers or students' intellectual effort. Future implementation should prioritise AI literacy, critical evaluation of AI outputs, teacher training, transparent assessment practices, data protection, equitable access, and human oversight. Responsible integration can enable GenAI to strengthen Social Science education while preserving critical thinking, creativity, historical reasoning, democratic values, and student agency.

Keywords: *Generative Artificial Intelligence, Secondary Education, Social Science Education, Artificial Intelligence, Pedagogy, AI Literacy, Critical Thinking, Ethics, Academic Integrity, Digital Learning*

Introduction

Generative Artificial Intelligence (GenAI) has become an increasingly significant development in education following the rapid emergence of publicly accessible large language models. Unlike conventional digital learning technologies, GenAI can generate new text, explanations, questions, examples, images, and other educational content in response to natural-language instructions.

The potential relevance of GenAI to Social Science education is particularly significant. Social Science subjects require students to interpret evidence, understand historical and contemporary events, evaluate competing perspectives, develop arguments, and connect individual experiences with broader social structures. GenAI can potentially support these activities by providing explanations, alternative viewpoints, discussion questions, summaries, simulations, and personalised learning support.

However, the educational value of GenAI depends substantially on how it is implemented. UNESCO's guidance recommends a human-centred and age-appropriate approach and highlights concerns involving privacy, equity, bias, human agency, and the validation of AI systems used in education.

Secondary education presents particular challenges because students are developing criticalthinking, information-literacy, and independent-learning skills. Consequently, unrestricted reliance on AI may undermine the very abilities that Social Science education seeks to develop.

This study therefore examines GenAI not simply as a technological tool but as a pedagogical intervention requiring careful consideration of educational objectives, ethics, teacher expertise, and student development.

Review of Literature

Yusuf et al. (2024) conducted a systematic mapping review of research on Generative Artificial Intelligence in education and research. Their review identified major themes such as pedagogical enhancement, writing assistance, professional development, interdisciplinary learning, adoption, and ethical concerns. The authors highlighted the potential of GenAI to support teaching and learning while also noting concerns related to academic integrity, reliability, and responsible implementation. Their study also identified a need for further research focusing specifically on school-level education.

Liu and Zhong (2024) conducted a systematic review of research on how Artificial Intelligence is taught in K–12 education. Their findings indicated that AI literacy is becoming increasingly important for preparing young learners to understand and interact responsibly with AI technologies. The authors emphasised the importance of appropriate pedagogical approaches, experiential learning, teacher guidance, and age-appropriate AI education.

Tang et al. (2024) investigated the use of Generative AI in secondary education through a dialogic approach to teaching, learning, and assessment. Their study demonstrated that

GenAI can support critical questioning, differentiated learning, and assessment practices. The authors argued that AI can be used to promote dialogue and critical engagement rather than simply providing students with ready-made answers. This perspective is particularly relevant to Social Science education, where discussion, interpretation, and evaluation of multiple viewpoints are essential.

Prestridge et al. (2025) examined secondary teachers' pedagogical beliefs concerning the use of Generative AI. Their research demonstrated that teachers' existing beliefs about teaching and learning influence how they perceive and use GenAI. The authors suggested that professional development should move beyond technical training and address teachers' pedagogical understanding of how AI can meaningfully support learning.

De Aldama et al. (2026) examined secondary teachers' perceptions of the opportunities and threats associated with Generative AI in teaching and learning. Their findings indicated that teachers viewed GenAI as both a potential educational opportunity and a source of concern. The authors reported that pedagogical beliefs and previous experience with GenAI influenced teachers' perceptions of its educational usefulness. Their findings reinforce the importance of teacher preparation and pedagogically informed AI integration.

Miao and Holmes (2023), in the UNESCO guidance on Generative AI in education and research, examined the broader ethical and educational implications of GenAI. They emphasised a human-centred approach to AI adoption and highlighted concerns related to privacy, equity, age-appropriate use, human agency, bias, and responsible governance. The authors argued that educational institutions should establish appropriate policies and safeguards before integrating GenAI into learning environments.

Overall, the reviewed literature demonstrates that Generative AI has considerable potential to support secondary education through personalised learning, differentiated instruction, critical questioning, assessment, and teacher support. However, the studies also highlight concerns related to academic integrity, misinformation, bias, privacy, inequality, and excessive dependence on AI. Importantly, the literature suggests that the effectiveness of GenAI depends largely on teacher competence, student AI literacy, appropriate pedagogical design, and human oversight. There remains a need for more empirical research specifically examining the use of GenAI in secondary school Social Science education, particularly in relation to students' critical thinking, historical reasoning, civic understanding, and ability to evaluate AI-generated information.

Conceptual Framework

The conceptual framework of this study is based on the following relationship:

Generative AI → Pedagogical Applications → Learning Outcomes → Ethical and Educational Risks → Responsible Human-AI Integration

GenAI provides technological capabilities that can be incorporated into teaching and learning. These applications may influence student engagement, critical inquiry, personalised learning, and academic performance. However, the same technologies may produce risks

such as misinformation, dependence, bias, privacy violations, and academic dishonesty.

The framework therefore places teacher guidance and student agency at the centre of GenAI integration. The technology should support educational objectives rather than determine them.

In Social Science education, the framework is particularly relevant because learning involves interpretation, evidence evaluation, multiple perspectives, historical consciousness, civic understanding, and critical reasoning. These competencies require active human engagement and cannot be reduced to automated content generation.

Methodology

Qualitative Research Design

This study adopts a qualitative research design based on a structured literature review**.** The approach was selected because the study seeks to interpret existing research concerning the pedagogical, ethical, and social implications of GenAI in secondary school Social Science education.

Recent peer-reviewed literature, systematic reviews, educational research, and international policy guidance were examined. The reviewed literature was thematically organised into four major areas:

1. Pedagogical applications of GenAI.
2. Opportunities for teaching and learning.
3. Ethical and educational challenges.
4. Future directions for responsible implementation.

The study is conceptual and review-based and does not claim to present original survey, interview, or experimental data.

Research Objectives of the Study

The objectives of the study are:

1. To examine the applications of GenAI in secondary school Social Science education.
2. To identify the pedagogical opportunities provided by GenAI.
3. To analyse the ethical and educational challenges associated with its use.
4. To examine the implications of GenAI for teachers and students.
5. To assess the importance of AI literacy and critical thinking in GenAI-supported education.
6. To identify future directions for responsible GenAI integration in secondary schools.
7. To propose principles for human-centred and ethical use of GenAI.

Research Questions of the Study

The study addresses the following research questions:

1. How can GenAI be applied in secondary school Social Science education?
2. What pedagogical opportunities can GenAI provide to teachers and students?
3. What ethical and educational challenges may arise from its use?
4. How can GenAI support critical thinking rather than encourage dependence?

5. What competencies do teachers and students require for responsible GenAI use?
6. What strategies can support the ethical and effective integration of GenAI in secondary education?

Results and Discussion of the Study

• Pedagogical Opportunities

The review indicates that GenAI can support Social Science education in several ways.

First, GenAI can facilitate personalised learning**.** Students can request explanations at different levels of complexity, obtain additional examples, and receive alternative explanations of difficult concepts. This may be particularly useful in heterogeneous classrooms where students have different learning needs.

Second, GenAI can support inquiry-based learning. Teachers can use AI-generated scenarios, historical questions, hypothetical situations, and competing perspectives to encourage students to investigate issues rather than simply memorise information.

Third, GenAI can enhance discussion and debate**.** Students may ask an AI system to present contrasting arguments concerning a historical, political, economic, or social issue and then evaluate the strengths and weaknesses of each position.

Fourth, GenAI can support writing development**.** Rather than using AI to generate complete assignments, students can use it to brainstorm ideas, identify weaknesses in arguments, improve organisation, and compare alternative formulations. Such use can make writing a more iterative learning process.

Fifth, teachers can use GenAI for lesson planning and instructional differentiation**.** It can assist in generating discussion questions, case studies, quizzes, worksheets, examples, and differentiated learning activities.

Research on secondary education has identified potential for GenAI-supported critical questioning, assessment, and differentiation, suggesting that its value may extend beyond simple productivity improvements.

• Generative AI and Critical Thinking

The second major finding concerns the potential relationship between GenAI and criticalthinking development. Social Science education aims to develop students' abilities to evaluate evidence, recognise different perspectives, construct arguments, and make reasoned judgements. GenAI can support these objectives when students are encouraged to critically evaluate AI-generated information.

For instance, teachers can provide students with an AI-generated explanation of a historical or political issue and ask them to identify factual claims, examine the evidence supporting those claims, compare the response with reliable sources, identify missing perspectives, and detect possible bias.

Such activities can transform GenAI from a simple information-generation tool into an object of critical analysis. Students learn that AI-generated information is not necessarily accurate

and that all claims must be evaluated.

However, the analysis also indicates a potential negative effect. If students use GenAI primarily to generate complete answers, essays, or arguments, they may reduce the amount of independent thinking they perform. Excessive dependence on AI may therefore weaken the development of reasoning, writing, problem-solving, and research skills.

The educational impact of GenAI consequently depends largely on the way teachers structure its use. Guided and critical use is more educationally valuable than unrestricted dependence.

• Teacher Support and Professional Practice

GenAI can reduce teachers' workload by supporting the preparation of educational materials, question banks, lesson activities, rubrics, and differentiated resources.

However, teachers must remain responsible for evaluating AI-generated materials. AI systems may generate inaccurate historical information, inappropriate examples, or culturally insensitive content.

Research on secondary-school teachers indicates that teachers' beliefs about risk, productivity, and pedagogical transformation influence how GenAI is incorporated into classroom practice.

Therefore, professional development should focus not merely on how to operate AI tools but on when, why, and under what conditions they should be used**.**

• Ethical Challenges

One of the most significant concerns is academic integrity. Students may use GenAI to generate essays, assignments, or examination responses without meaningful intellectual engagement.

A second concern is misinformation. GenAI can produce convincing but inaccurate statements. This is particularly problematic in Social Science, where historical and political claims require careful verification.

A third concern is algorithmic bias**.** AI-generated explanations may reflect biases present in training data and may inadequately represent particular cultures, communities, historical experiences, or political perspectives.

A fourth concern is privacy. Students may unintentionally provide personal information when interacting with AI systems. UNESCO recommends strong attention to data privacy and age-appropriate use of GenAI in education.

A fifth challenge is digital inequality**.** Students may have unequal access to devices, highquality AI tools, reliable internet connections, and digital skills. GenAI should therefore not increase existing educational inequalities.

• Student Agency and Dependence

An important concern is the possibility of overdependence on AI.

If students routinely use AI to generate ideas, explanations, arguments, and written work, they may have fewer opportunities to practise independent reasoning.

The appropriate educational objective should therefore be AI-supported agency rather than

AI-dependent learning**.**

Students should remain responsible for:

- Formulating questions.
- Evaluating evidence.
- Making arguments.
- Checking information.
- Making ethical decisions.
- Producing original interpretations.

AI should function as an intellectual support rather than an intellectual substitute.

Future Directions

Future implementation of GenAI in secondary Social Science education should focus on several priorities.

- AI Literacy
  AI literacy should become an important component of contemporary education. Students should understand how GenAI works, its limitations, potential biases, privacy implications, and appropriate academic use.
- Teacher Training
  Teachers require systematic professional development covering prompt design, AI evaluation, assessment redesign, privacy, academic integrity, bias, and pedagogical integration.
- Assessment Reform
  Traditional take-home assignments may become increasingly difficult to authenticate when GenAI is readily available. Schools should therefore emphasise process-based assessment, classroom discussion, oral presentations, source evaluation, reflective writing, and projectbased learning.
- Source Verification
  Students should be explicitly taught to verify AI-generated information against textbooks, scholarly sources, primary documents, government publications, and other reliable evidence.
- Human-Centred Implementation
  UNESCO recommends a human-centred approach in which GenAI is ethically validated and pedagogically designed according to learner needs.
  Schools should therefore establish clear policies regarding age-appropriate use, privacy, academic integrity, teacher supervision, and acceptable classroom applications.
- Further Research
  More empirical research is needed on the actual effects of GenAI on secondary students' learning, critical-thinking abilities, creativity, motivation, and academic performance. A systematic mapping review found that research specifically addressing K–12 education remains comparatively limited.

Conclusion

Generative Artificial Intelligence represents a significant development in secondary school Social Science education. Its capacity to generate explanations, questions, examples, scenarios, and personalised learning support creates meaningful pedagogical opportunities. When carefully integrated, GenAI can support inquiry-based learning, differentiation, discussion, writing development, teacher preparation, and critical engagement with information. Nevertheless, the educational value of GenAI cannot be separated from its risks. Misinformation, algorithmic bias, privacy concerns, academic dishonesty, digital inequality, and excessive dependence may undermine educational objectives if the technology is used without appropriate safeguards. The central finding of this study is that GenAI should augment rather than replace teachers and students' intellectual work**.** Its successful integration requires a shift from simply asking whether students should use AI to asking how AI can be used to strengthen learning outcomes and higher-order thinking. For Social Science education, this means using GenAI as an object of questioning and evaluation as well as a learning tool. Students should learn to challenge AI-generated claims, compare perspectives, verify evidence, recognise bias, and construct independent arguments. The future of GenAI in secondary education should therefore be guided by human agency, critical thinking, ethical responsibility, teacher expertise, student AI literacy, and equitable access**.** With appropriate policies and pedagogical practices, GenAI can become a valuable educational resource while preserving the fundamental purpose of Social Science education: developing informed, critical, responsible, and independent citizens.

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ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCES AND HUMANITIES: OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS

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Abstract

Artificial Intelligence (AI) is increasingly influencing research, teaching, and professional practice in the social sciences and humanities. It enables scholars to analyze large collections of texts, images, historical records, social-media content and cultural materials more efficiently than traditional methods alone. At the same time, AI raises important questions about bias, privacy, authorship, human interpretation, and the preservation of cultural diversity. This paper examines the role of AI in social sciences and humanities, highlighting its applications, benefits, limitations, and ethical implications. It argues that AI should be treated as a supportive tool for human inquiry rather than a replacement for critical thinking, contextual understanding, and human creativity.

Keywords: *Artificial Intelligence, Social Sciences, Humanities, Digital Humanities, Ethics, Research, Education*

1. Introduction

Artificial Intelligence refers to computer systems designed to perform tasks that normally require human intelligence, such as learning, language processing, pattern recognition, decision-making, and problem-solving. In recent years, AI tools have become widely available and have begun to transform many academic disciplines.

Social sciences study human society, behavior, institutions, and relationships. Humanities explore human culture, history, language, philosophy, literature, art, and values. Because both fields focus on human experience and meaning, AI has created new possibilities as well as serious concerns. AI can process large amounts of data quickly, but it may not fully understand cultural context, emotions, moral values, or historical complexity.

2. Applications of AI in Social Sciences and Humanities

AI has many practical applications in these disciplines. In social science research, AI can analyze survey responses, social-media discussions, public opinion, migration patterns, economic behavior, and political communication. Natural Language Processing (NLP) helps researchers identify themes, emotions, and trends in thousands of documents or online posts.

In the humanities, AI is widely used in digital archives and textual analysis. Researchers can use AI to digitize old manuscripts, translate historical texts, identify authorship patterns, and study changes in language over time. AI-based image recognition can also support the study of paintings, archaeological objects, maps, and museum collections.

For example, a historian may use AI to search thousands of newspaper archives for

references to a particular event. A linguist may use AI to compare dialects across large language databases. A sociologist may use machine learning to identify patterns of inequality in employment, education, or healthcare data.

3. Benefits of AI

One major benefit of AI is speed. Researchers can examine large datasets in a short time, allowing them to discover patterns that may be difficult to identify manually. AI can also improve access to knowledge by translating texts, converting speech into written form, and making archived materials searchable.

AI may encourage interdisciplinary research. Computer scientists, historians, sociologists, linguists, and philosophers can work together to address complex social and cultural questions. In education, AI tools can support personalized learning, language assistance, and access for students with disabilities.

AI can also preserve cultural heritage. Digitization and intelligent cataloguing can protect fragile manuscripts, oral histories, photographs, and artifacts for future generations.

4. Challenges and Ethical Concerns

Despite its advantages, AI has important limitations. AI systems learn from existing data, and this data may contain social bias related to gender, race, class, language, religion, or region. If biased data is used, AI may reproduce or even strengthen existing inequalities.

Privacy is another serious concern. Social science research often involves personal information, online behavior, and sensitive community data. Researchers must ensure that AI is used responsibly and that participants' rights are protected.

In the humanities, AI-generated writing and art raise questions about originality and authorship. Although AI can produce text or images, it does not have personal experience, intention, or moral responsibility. Human scholars and artists must remain accountable for the work they create and publish.

There is also a risk that AI may prioritize dominant languages and cultures because more digital data is available for them. Minority languages, indigenous knowledge systems, and local traditions may be overlooked unless researchers make deliberate efforts to include them.

5. The Importance of Human Interpretation

AI can identify patterns, but it cannot replace human interpretation. Social and cultural phenomena are shaped by history, emotions, beliefs, power relations, and local contexts. A machine may detect repeated words in a political speech, but a human researcher is needed to understand the meaning, intention, and social impact of those words.

Therefore, AI should be used as a research assistant rather than an independent authority. Scholars must critically evaluate AI-generated results, verify sources, explain their methods, and consider the ethical consequences of their work.

6. Conclusion

Artificial Intelligence offers valuable opportunities for social sciences and humanities. It can support large-scale research, improve access to cultural materials, preserve heritage, and

create new forms of interdisciplinary study. However, its use must be guided by ethical principles, transparency, inclusiveness, and human responsibility.

The future of AI in these fields should not be based only on technological efficiency. It should also promote justice, cultural diversity, critical thinking, and respect for human values. When used carefully, AI can strengthen—not replace—the human-centered goals of social sciences and humanities.

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GENERATIVE AI FOR ENHANCING LEADERSHIP SKILLS OF PRINCIPALS OF TEACHER EDUCATION INSTITUTIONS: A PRACTICAL FRAMEWORK

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Abstract

Generative Artificial Intelligence (GenAI) is transforming educational planning, communication, information management, research and professional learning. For Principals of Teacher Education Institutions (TEIs), it can serve as a practical leadership assistant in academic administration, institutional planning, faculty development, quality assurance, research, stakeholder engagement and decision-making. This conceptual paper proposes a task-oriented framework for using GenAI to strengthen four leadership skills: Technical, Human, Conceptual and Content-related skills. It highlights applications in SWOT analysis, academic planning, curriculum enrichment, faculty development, meeting management, official communication, document analysis, quality assurance, research planning, literature review, academic writing, mentoring, assessment and professional learning. The framework promotes a "task–tool–purpose" approach, encouraging leaders to select appropriate AI applications for clearly defined institutional needs. It also integrates UNESCO's five AI competency dimensions—Human-Centred Mindset, Ethics of AI, AI Foundations and Applications, AI Pedagogy, and AI for Professional Learning—along with the developmental progression of Acquire, Deepen and Create. Responsible use requires verification of AI-generated information, protection of confidential data, ethical practice, preservation of human judgement and purposeful application. The paper concludes that GenAI can support more efficient, informed, reflective and innovative leadership in TEIs when technological capability is balanced with professional expertise, ethical responsibility and human agency.

Keywords: *Generative AI, Principals, Teacher Education Institutions, Leadership Skills, UNESCO, AI Competency, Educational Leadership*

Introduction

Teacher Education Institutions require effective leadership to maintain academic quality, support teacher educators, promote research, manage institutional activities and respond to emerging educational demands. The changing nature of education also requires continuous development of professional competencies. Dange and Siddaraju (2020) emphasised that

quality teacher education depends on developing competent and well-equipped teachers capable of responding to the demands of the 21st century.

Generative AI provides new possibilities for supporting educational leadership. It can assist Principals in preparing plans, analysing documents, generating ideas, developing communication, supporting research, designing professional-development programmes and organising institutional information.

However, effective AI use requires more than knowing how to operate an AI application. UNESCO's *AI Competency Framework for Teachers* identifies 15 competencies across five dimensions: **Human-Centred Mindset, Ethics of AI, AI Foundations and Applications, AI Pedagogy, and AI for Professional Learning**. The framework also proposes three progression levels-**Acquire, Deepen and Create** with emphasis on human agency, accountability, ethical use and lifelong professional learning.

Although UNESCO's framework is designed for teachers, its principles are highly relevant to Principals because institutional leaders determine how AI is introduced, governed and used within educational institutions. The present paper therefore applies these principles to the practical leadership functions of Principals of TEIs.

Why Principals Need Generative AI

The Principal's responsibilities increasingly involve large amounts of information, documentation, communication, planning and coordination. GenAI can assist in reducing routine workload and improving the quality and efficiency of these processes.

The purpose, however, should not be **"AI replacing the Principal"**, but:

"AI assisting the Principal to think, plan, communicate, analyse and improve."

This is consistent with UNESCO's human-centred approach, which emphasises that AI should strengthen human agency rather than undermine or replace it.

Generative AI as a Leadership Assistant

Instead of learning numerous AI applications separately, Principals can use a small set of multifunctional platforms according to specific institutional needs.

Recommended Core Applications

- **ChatGPT** – planning, brainstorming, drafting, analysis, research support and professional learning.
- **Microsoft 365 Copilot** – institutional documents, presentations, email, meetings, spreadsheets and productivity.
- **Google Gemini** – academic planning, information processing, drafting and brainstorming.
- **NotebookLM** – analysis and questioning of institutional documents and reference materials.
- **Perplexity** – information discovery and research exploration.
- **Elicit** – literature review and research support.
- **Canva AI** – institutional posters, infographics and visual communication.

- **Gamma** – presentations and structured institutional documents.

The purpose is not to use all platforms simultaneously. The Principal should select the **simplest suitable tool for the task**.

Prescription of Generative AI for Principal Leadership

The following framework provides a practical **"task → AI application → expected leadership benefit"** model.

Principal's Task	Recommended AI Application	What the Principal Can Ask AI to Do	Leadership Benefit
Institutional Planning	ChatGPT	Prepare annual plans, strategic priorities and action plans	Conceptual Skill
SWOT Analysis	ChatGPT	Analyse institutional strengths, weaknesses, opportunities and threats	Conceptual Skill
Academic Planning	Copilot / ChatGPT	Develop academic calendars and activity plans	Technical Skill
Curriculum Enrichment	Gemini / ChatGPT	Suggest innovative academic activities	Content Skill
Faculty Development	ChatGPT	Design FDPs, workshops and training programmes	Human Skill
Meeting Management	Copilot	Prepare agendas, summaries and action points	Technical Skill
Official Communication	ChatGPT	Draft notices, circulars, letters and announcements	Human Skill
Institutional Documents	NotebookLM	Analyse policies, regulations, reports and guidelines	Conceptual Skill
Quality Assurance	ChatGPT / Copilot	Prepare checklists, evidence matrices and action plans	Conceptual Skill
Research Planning	ChatGPT / Perplexity	Identify research themes and formulate research questions	Conceptual Skill
Literature Review	Elicit / NotebookLM	Organise and synthesise research literature	Content Skill
Academic Writing	ChatGPT	Improve structure, clarity and academic language	Content Skill

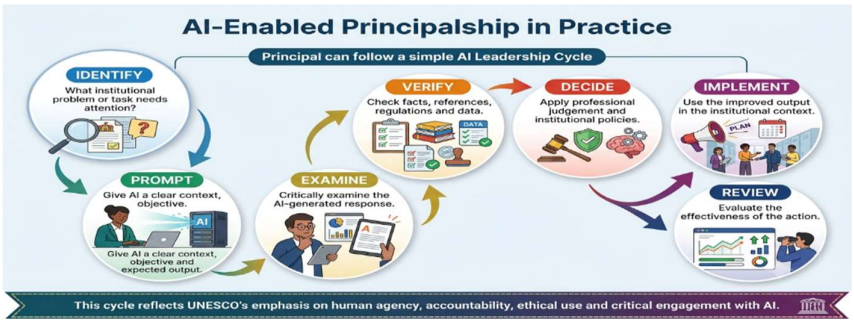
Research Presentation	Gamma / Canva	Convert research into presentations and visual materials	Technical Skill
Faculty Mentoring	ChatGPT	Develop mentoring and professional-development strategies	Human Skill
Student Support	ChatGPT	Generate student-support and intervention strategies	Human Skill
Internship Management	ChatGPT	Develop schedules, observation formats and mentoring plans	Technical Skill
Assessment	ChatGPT / Copilot	Generate question ideas, rubrics and feedback formats	Content Skill
Decision Support	ChatGPT	Compare alternatives, consequences and implementation strategies	Conceptual Skill
AI Policy	ChatGPT / Copilot	Draft institutional AI-use guidelines	Ethical + Conceptual Skill
Professional Learning	ChatGPT / NotebookLM	Support continuous self-learning and reflection	Conceptual Skill

Using AI to Strengthen the Principal's Four Leadership Skills

The value of Generative AI can be directly connected with four important leadership skills.

Technical Skill	**Human Skill**
AI can assist Principals in: • Academic scheduling • Documentation • Reports • Presentations • Data organisation • Meeting management • Institutional communication ***Suggested tools:*** *Copilot, ChatGPT, Gamma, Canva.*	AI can assist Principals in: • Preparing sensitive communication • Developing mentoring strategies • Exploring conflict-resolution alternatives • Planning faculty-development activities • Designing stakeholder-engagement strategies ***Suggested tool:*** *ChatGPT.* The Principal must retain empathy, discretion and personal judgement.

Conceptual Skill	**Content Skill**
AI can assist Principals in: • Strategic planning • SWOT analysis • Problem-solving • Scenario analysis • Decision preparation • Institutional innovation • Policy development ***Suggested tools:*** *ChatGPT, Gemini, Perplexity.*	AI can assist Principals in: • Curriculum enrichment • Pedagogical innovation • Assessment planning • Teacher education research • Internship planning • Academic resource development ***Suggested tools:*** *ChatGPT, Gemini, NotebookLM, Elicit.*



Source: AI (ChatGPT)

Practical Examples

Example 1: Institutional Planning

Instead of beginning institutional planning from scratch, the Principal can ask:

"Prepare a one-year development plan for a B.Ed. college focusing on academic quality, faculty development, student support, research, internship and community engagement. Provide objectives, activities, timelines and indicators."

The Principal then modifies the output according to actual institutional requirements.

Example 2: Faculty Development

The Principal can ask:

"Design a six-month professional-development plan for teacher educators focusing on Generative AI, research, assessment, digital pedagogy and academic writing."

This supports UNESCO's **AI for Professional Learning** dimension and its emphasis on lifelong professional development.

Example 3: Institutional Document Analysis

The Principal can provide authorised institutional documents to NotebookLM and ask:

"Identify the major responsibilities of the institution, important deadlines, areas requiring

compliance and activities that need follow-up."

This can reduce the time required to review lengthy institutional documents.

Example 4: Decision Support

The Principal can ask:

"Provide three possible solutions to this institutional problem. Compare their advantages, limitations, resources required, stakeholder impact and possible risks."

AI provides alternatives; **the Principal makes the decision**.

Example 5: Research Leadership

The Principal can use: **Perplexity → Elicit → NotebookLM → ChatGPT**

to move from research-topic identification to literature organisation, document analysis and research planning.

This can help develop a stronger research culture among teacher educators.

UNESCO's AI Competency Perspective in Principal Leadership

The five UNESCO dimensions need not be treated as separate areas of training. They can be **integrated into everyday leadership practice**.

A Principal using AI for institutional planning should simultaneously demonstrate:

- **Human-Centred Mindset** – consider people and institutional needs;
- **Ethics of AI** – protect privacy and ensure responsible use;
- **AI Foundations and Applications** – select an appropriate tool;
- **AI Pedagogy** – consider academic and teaching implications;
- **AI for Professional Learning** – use AI to continuously develop professional knowledge.

UNESCO presents these dimensions as interconnected aspects of AI competency and places them within the progression levels of **Acquire, Deepen and Create**.

Thus, a Principal does not need a separate "AI activity" for each dimension. The dimensions should guide **how AI is used across leadership tasks**.

From Acquire to Create: A Simple Development Pathway

Acquire

Know AI → Try AI → Understand risks

The Principal learns basic AI concepts and uses AI for simple tasks such as drafting, summarising and brainstorming.

Deepen

Apply AI → Evaluate AI → Integrate AI

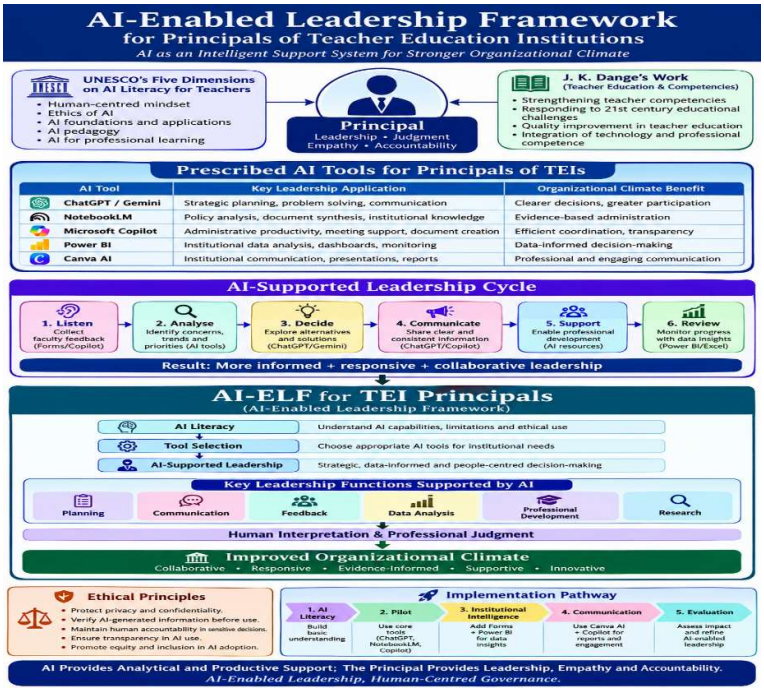
The Principal uses AI systematically for planning, research, academic management, professional development and decision support.

Create

Lead AI → Govern AI → Innovate with AI

The Principal develops institutional AI practices, supports faculty adoption, establishes responsible-use mechanisms and promotes innovation.

This progression is directly aligned with UNESCO's **Acquire–Deepen–Create** model.



Source: AI (ChatGPT)

Responsible Use: Five Rules for Principals

1. **Do not blindly accept AI output:** AI-generated information requires professional verification.
2. **Do not upload confidential information unnecessarily:** Student, faculty and institutional data require appropriate privacy and security safeguards.
3. **Do not use AI to make sensitive human decisions independently:** Promotion, disciplinary, counselling and other sensitive decisions require human judgement.
4. **Verify references and factual claims:** AI can generate incorrect information or references.
5. **Use AI to improve quality, not merely reduce workload:** The ultimate purpose should be **institutional and educational improvement**.

These principles are consistent with UNESCO's human-centred and ethical approach to AI in education.

Recommendations

1. TEIs should provide basic Generative AI orientation for Principals and teacher educators.
2. AI training should be competency-based rather than tool-based.
3. UNESCO's five AI competency dimensions should inform Principal development programmes.

4. Principals should initially adopt AI for low-risk tasks such as drafting, planning, summarising and professional learning.
5. AI should gradually be integrated into research, academic planning, quality assurance and institutional development.
6. Institutions should develop simple guidelines for responsible AI use.
7. Teacher educators should be encouraged to share effective AI practices.
8. AI-generated information should always be reviewed and verified.
9. Confidential institutional information should be protected.
10. The effectiveness of AI use should be periodically evaluated.

Conclusion

Generative AI can serve as a practical leadership assistant for Principals of Teacher Education Institutions by supporting institutional planning, academic administration, communication, research, documentation, quality assurance, faculty development and decision preparation. It can reduce routine workload, organize information, generate ideas, prepare reports and assist in identifying possible solutions to institutional challenges. However, AI should complement rather than replace the Principal's professional knowledge, experience, judgement and accountability. AI-generated information must be critically examined for accuracy, relevance, bias, privacy and ethical concerns before being used for institutional purposes. Effective AI-enabled leadership therefore requires Principals to develop appropriate AI competencies and use technology responsibly, transparently and purposefully. When integrated with human judgement and institutional priorities, Generative AI can improve administrative efficiency, strengthen academic leadership, encourage innovation, support continuous professional learning and contribute to institutional quality improvement. Thus, the effective use of Generative AI can transform routine leadership practices into more **efficient, informed, innovative and responsible educational leadership.**

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GENERATIVE ARTIFICIAL INTELLIGENCE IN SOCIAL SCIENCE RESEARCH: AN INTEGRATIVE REVIEW OF OPPORTUNITIES, CHALLENGES, AND FUTURE DIRECTIONS

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Abstract

Generative artificial intelligence (GenAI), particularly large language models (LLMs), is transforming knowledge production, analysis, and communication in the social sciences. Unlike earlier computational technologies, contemporary GenAI systems can assist with literature synthesis, research ideation, questionnaire development, qualitative coding, text classification, data interpretation, programming, simulation, and academic writing. This integrative review examines the emerging role of GenAI in social science research, focusing on research design, literature review, data analysis, knowledge production, methodological validity, research ethics, and academic integrity. Existing scholarship indicates that GenAI can improve research efficiency, facilitate large-scale textual analysis, and augment researchers' analytical capabilities. However, significant concerns remain regarding hallucinated information, algorithmic bias, contextual loss, privacy, intellectual property, participant use of AI, reproducibility, authorship, and excessive dependence on automated outputs. Recent research also suggests that LLMs may predict social science experimental outcomes, although systematic overestimation of effect sizes raises concerns about external validity. The review argues that the future of AI in social science research should be understood primarily through human–AI collaboration rather than replacement. An integrated framework emphasizing human conceptualization, AI-assisted processes, methodological verification, ethical governance, and researcher accountability is proposed. Responsible AI adoption requires technological competence, AI literacy, methodological rigor, critical evaluation, transparency, and institutional research ethics.

Keywords: *generative artificial intelligence, large language models, social science research, research methodology, research ethics, artificial intelligence, human–AI collaboration*

1. Introduction

Artificial intelligence has evolved from primarily computational technology into an important component of contemporary knowledge production. Generative AI has accelerated this transformation through its ability to generate text, summarize information, classify documents, produce code, identify patterns, and interact with researchers through natural language. These capabilities create opportunities across psychology, sociology, political

science, economics, communication, education, management, and related disciplines.

The relationship between AI and social science is multidimensional. AI can function as a research tool while also becoming an object of social scientific investigation. Xu et al. (2024) distinguish between using AI for social science and studying the social science of AI. When AI is used as a research instrument, validity, reliability, transparency, bias, and reproducibility become central concerns; when AI itself is investigated, its psychological, social, economic, cultural, political, and institutional consequences require attention.

GenAI can influence almost every stage of research, including research-question development, literature exploration, conceptual analysis, qualitative coding, text classification, programming, data interpretation, and academic communication. Mellon et al. (2024), for example, demonstrated that LLMs can assist with coding open-ended survey responses at scale. Nevertheless, AI-generated outputs may contain plausible but incorrect information, fabricated references, biased interpretations, or insufficiently contextualized explanations. These limitations are particularly important in social science because social phenomena are culturally embedded, historically situated, and heterogeneous.

Ethical concerns involving privacy, confidentiality, informed consent, intellectual property, authorship, transparency, and accountability are equally significant. UNESCO (2023) emphasizes human agency, privacy, equity, and institutional responsibility, while Jeon et al. (2025) highlight the importance of institutionally grounded approaches to AI ethics. Thus, the central question is how AI can enhance research efficiency without compromising methodological validity, human judgment, ethical responsibility, and scholarly integrity.

2. Purpose of the Review

This integrative review critically examines the emerging role of GenAI in social science research. It synthesizes evidence concerning applications across the research process, theoretical perspectives on human–AI collaboration, methodological benefits and limitations, ethical and epistemological challenges, research gaps, and directions for responsible AIsupported research. The review addresses six questions: how GenAI is being used across research stages; which theoretical perspectives explain human–AI collaboration; what methodological benefits and limitations have been identified; what ethical and epistemological challenges arise; what major research gaps remain; and how responsible and methodologically rigorous AI-supported research can be developed.

3. Conceptual Understanding of Generative Artificial Intelligence

Generative AI refers to computational systems capable of producing new content based on patterns learned from large datasets. LLMs are particularly relevant to social science because they enable direct natural-language interaction between researchers and computational systems. GenAI can be understood through two complementary dimensions. First, AI functions as a research tool for literature review, research ideation, questionnaire construction, qualitative coding, text analysis, data interpretation, simulation, and scholarly communication. Second, AI becomes an object of research involving public attitudes,

adoption, algorithmic decisionmaking, employment transformation, misinformation, human–AI interaction, inequality, and automation. The methodological implications differ between these dimensions. When AI is a research tool, researchers must evaluate accuracy, validity, reliability, transparency, and bias. When AI is the object of research, its broader societal consequences must also be examined.

Thus, GenAI represents both a methodological transformation and a new area of social scientific inquiry.

4. Theoretical Foundations

Human–technology complementarity provides an important theoretical perspective. AI can perform repetitive computational tasks, identify patterns, and generate preliminary analyses, while researchers retain responsibility for theoretical reasoning, contextual interpretation, methodological judgment, and ethical decisions.

The sociotechnical systems perspective further emphasizes that research involves researchers, participants, institutions, technologies, ethical norms, disciplinary conventions, funding systems, and publication structures. AI adoption should therefore be viewed as a sociotechnical transformation rather than merely software adoption.

Technology acceptance perspectives also help explain researchers' willingness to adopt AI through constructs such as perceived usefulness, ease of use, trust, perceived risk, competence, and institutional support. However, conventional acceptance models are insufficient because GenAI introduces epistemological questions about trust in machine-generated knowledge and ethical questions concerning responsibility.

Overall, AI adoption should be understood as an interaction among technological capability, researcher competence, institutional context, epistemic trust, methodological quality, and ethical responsibility.

5. Generative AI and Research Ideation

GenAI can assist in generating research questions, identifying constructs, organizing theoretical concepts, suggesting contexts, and exploring relationships among variables. This can broaden the range of ideas available during early research development, particularly in emerging fields with fragmented literature.

However, AI-generated ideas are not necessarily original or theoretically superior. Because LLMs learn from existing human-generated material, they may reproduce dominant conceptual patterns and assumptions. Excessive reliance may therefore produce intellectual convergence rather than innovation. AI-assisted ideation should be used to expand possibilities, while researchers retain responsibility for selecting and theoretically evaluating the research problem. **6. Generative AI and Literature Review**

GenAI can summarize articles, identify recurring concepts, compare theoretical perspectives, organize documents, and generate preliminary thematic classifications. Its principal advantage is efficiency, particularly when researchers work with large bodies of literature.

However, fluent summaries are not necessarily accurate. LLMs may misinterpret studies,

omit methodological limitations, create false connections, or generate nonexistent references. AI should therefore support literature discovery and organization rather than replace direct engagement with original scholarship. Researchers must independently verify important claims and sources.

7. Generative AI and Survey Research

In survey research, AI can support questionnaire development, item refinement, classification of open-ended responses, translation, and large-scale textual analysis. Mellon et al. (2024) demonstrated the potential of LLMs for coding open-ended survey responses.

A new methodological issue arises when participants themselves use AI to formulate responses. In such circumstances, researchers may measure an interaction between participants and AI rather than purely participant-generated responses. This raises questions concerning response authenticity, agency, and validity, particularly for studies involving attitudes, beliefs, creativity, and personal experiences. Future survey methodology must address the identification and reporting of AI-assisted responses.

8. Generative AI and Qualitative Research

AI can assist qualitative research through transcription, translation, preliminary coding, categorization, summarization, and comparison of textual data. These applications can reduce repetitive analytical work.

Nevertheless, qualitative research depends on meaning, context, interpretation, reflexivity, and researcher positionality. AI may identify patterns without understanding irony, cultural meaning, emotional nuance, historical context, power relations, or contradictions. Therefore, AI-generated coding should not be treated as equivalent to human interpretation.

A defensible approach is human-supervised AI-assisted analysis, in which AI performs preliminary tasks while researchers evaluate, revise, contextualize, and interpret the outputs.

9. Generative AI and Computational Social Science

GenAI is increasingly relevant to computational social science through text classification, sentiment analysis, content analysis, political communication research, social media analysis, behavioral simulation, and related applications. However, AI performance varies by task, dataset, language, and context. Researchers should therefore compare AI-assisted approaches with established analytical methods rather than assume technological superiority.

The critical question is whether AI produces more valid, reliable, efficient, or scalable outcomes under particular conditions—not whether AI is universally superior to conventional methods.

10. Generative AI as a Synthetic Research Participant

The use of LLMs as simulated or synthetic research participants is one of the most controversial developments. Synthetic responses may support pilot testing, exploratory research, theoretical development, and experimental prediction without recruiting large numbers of human participants.

However, AI-generated responses represent computational outputs based on patterns learned

from human-produced data and cannot automatically be equated with human behavior. Ashokkumar et al. (2026) found that LLM-derived predictions of social science experimental effects were strongly correlated with observed effects across a large archive of experiments, but the models systematically overestimated effect sizes.

Synthetic participants may therefore have exploratory and pilot applications, but current evidence does not justify treating them as straightforward substitutes for human participants.

11. Research Quality, Bias, and Validity

Research quality is a major concern in AI-assisted social science. GenAI can generate inaccurate information, reproduce stereotypes, produce biased classifications, and communicate uncertain conclusions with excessive confidence. Such problems are particularly consequential for research involving gender, class, identity, political attitudes, inequality, and cultural values.

Bias can affect research-question formulation, response classification, qualitative interpretation, and theoretical explanation. Park et al. (2024) identified concerns about diminished diversity of thought associated with standard LLMs. Systematic verification and bias auditing are therefore necessary to determine whether AI outputs reproduce assumptions that are inappropriate for particular populations or contexts.

12. Research Ethics

Privacy and confidentiality are critical when participant information is processed by external AI systems. Sensitive interview transcripts, personal information, and institutional records should not be entered into AI platforms without appropriate safeguards.

Informed consent may also require disclosure of AI involvement, particularly where AI interacts with participants or processes sensitive information. Intellectual property, authorship, and accountability present additional concerns because AI systems cannot assume ethical or legal responsibility for research claims.

UNESCO (2023) emphasizes human agency, privacy, equity, transparency, and ethical governance, while Jeon et al. (2025) emphasize institutionally grounded ethical approaches.

13. AI and Academic Integrity

GenAI creates new academic-integrity challenges because researchers may use AI to generate text, paraphrase material, construct references, produce data, or formulate findings. The most serious concern occurs when unverified AI-generated information is presented as scholarship.

Fabricated references are particularly problematic for review papers because inaccurate citations can distort the scholarly record. Researchers must independently verify substantive claims and references.

AI literacy should therefore extend beyond prompt-writing. It must include source verification, hallucination detection, bias recognition, privacy protection, and accountability for the final scholarly product.

14. Methodological Transformation

AI is transforming the conventional research workflow from a relatively linear process toward a more iterative human–AI interaction. Traditional research moves from problem identification through literature review, data collection, analysis, interpretation, and communication. AIassisted research introduces computational assistance across multiple stages.

This transformation is better understood as collaboration rather than replacement. AI can perform selected generative and computational functions, while researchers retain responsibility for conceptualization, methodological judgment, interpretation, ethical decisions, and scholarly accountability. The distinction between automation and augmentation is therefore central to understanding AI-supported research.

15. Areas of Agreement and Disagreement

Existing research generally agrees that GenAI can improve research efficiency through repetitive-task automation, large-scale textual analysis, preliminary coding, literature organization, and exploratory analysis. Xu et al. (2024) document broad applications, while Mellon et al. (2024) demonstrate the usefulness of LLMs for large-scale survey-response classification.

However, uncertainty remains concerning AI's ability to replace human participants, independently conduct qualitative interpretation, generate valid social scientific theory, or represent social phenomena without cultural bias. Evidence from Ashokkumar et al. (2026), showing strong predictive correlations alongside effect-size overestimation, illustrates these limitations.

Overall, the evidence supports AI as an augmentative technology rather than an autonomous replacement for researchers or participants.

16. Research Gaps

Several research gaps remain. Conceptually, clearer distinctions are needed between AIassisted and AI-generated research because they involve different levels of human involvement and methodological risk. Existing technology-adoption theories also require expansion to incorporate epistemological and ethical dimensions.

Methodologically, standardized procedures are needed to evaluate AI-assisted coding, literature synthesis, qualitative interpretation, simulation, and experimental prediction. AIassisted participant responses present an additional challenge for survey methodology.

Geographically and culturally, the literature is concentrated in technologically advanced and English-language contexts. Greater evidence is required from India and South Asia, where multilingualism, cultural diversity, institutional variation, and digital inequality may affect AIsupported research.

Longitudinal studies are also needed to determine whether sustained AI use changes researchers' methodological competence, critical thinking, creativity, professional identity, and epistemic dependence on automated systems.

17. Practical and Policy Implications

Researchers require AI literacy encompassing source verification, bias detection, privacy protection, methodological evaluation, and ethical decision-making. Universities should establish policies concerning acceptable AI use, research-data protection, disclosure, academic integrity, authorship, and ethics.

Research supervisors should train postgraduate researchers to critically evaluate AI-generated information rather than encouraging uncritical dependence. Journals also need transparent policies concerning AI-assisted manuscript preparation, data analysis, disclosure, authorship, and research integrity. Goyanes Martínez et al. (2025) show that journals across social science disciplines are already adapting their guidelines.

Policy should distinguish low-risk applications, such as language editing, from higher-risk uses involving sensitive participant data, synthetic participants, AI-generated findings, or autonomous decision-making.

18. Future Research Agenda

Future studies should examine whether AI-assisted research produces systematically different theoretical conclusions from human-only research. Comparative studies should evaluate human and AI-assisted qualitative coding across culturally diverse datasets.

Further research is needed on the validity of synthetic participants across psychology, sociology, education, economics, political science, and communication. Studies should also examine whether AI-generated participants reproduce social stereotypes or meaningfully represent diverse human perspectives.

Participant use of AI during surveys requires investigation concerning response validity, diversity, reliability, and construct validity. Longitudinal studies should examine effects of sustained AI use on creativity, critical thinking, methodological competence, professional identity, and dependence on automated systems.

Research in India and other multilingual and culturally diverse contexts is particularly important for assessing the generalizability of findings generated largely in Western and English-language environments. Finally, standardized reporting frameworks should specify the AI system used, purpose, research stages affected, verification procedures, limitations, and participant-protection measures.

19. Conclusion

Generative artificial intelligence is fundamentally transforming social science research. Its influence extends beyond automated writing and data processing to research ideation, literature synthesis, questionnaire development, qualitative coding, computational analysis, simulation, interpretation, and scholarly communication. The literature demonstrates considerable potential for improving research efficiency and analytical capacity. LLMs can assist with large textual datasets, research ideation, response classification, and prediction of aspects of social science experiments (Ashokkumar et al., 2026; Mellon et al., 2024; Xu et al., 2024). However, hallucination, algorithmic bias, privacy concerns, contextual loss, synthetic participants, academic-integrity problems, and excessive dependence remain

substantial risks. The future of AI in social science should therefore not be framed as technological adoption versus rejection. The more productive approach is responsible human–AI collaboration. AI can augment research capacity, but researchers must retain responsibility for conceptualization, methodological judgment, evidence verification, contextual interpretation, ethical decisionmaking, and scholarly accountability. The contemporary social science researcher consequently requires a new form of methodological competence. Researchers must not only conduct research and use AI but also critically evaluate, validate, govern, and ethically integrate AI into research processes. The future of social science research will depend not simply on increasingly powerful AI systems, but on researchers who use them with intellectual independence, methodological rigor, and ethical responsibility.

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EMERGING TRENDS IN EDUCATION: TECHNOLOGY, PEDAGOGY AND THE FUTURE OF TEACHING AND LEARNING

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Abstract

Education is being reshaped by rapid developments in artificial intelligence (AI), generative AI, adaptive learning, learning analytics, cloud platforms, augmented and virtual reality (AR/VR), and connected digital systems. These technologies can personalize learning, expand access to resources, provide timely feedback, support teachers and create new forms of experiential learning. However, technology does not automatically improve educational outcomes. Its effectiveness depends on pedagogical purpose, teacher preparedness, equitable access, data protection and responsible implementation. This paper reviews major emerging trends in education, their applications, opportunities and risks, and the changing role of teachers. Particular attention is given to generative AI and AI literacy, which are becoming important as students and teachers increasingly encounter AI outside institutional systems. The paper argues for a human-centred approach in which technology strengthens, rather than replaces, teachers, critical thinking, creativity and meaningful interaction. It concludes with practical recommendations for responsible, inclusive and evidence-based technology integration.

Keywords: *Emerging technologies; Artificial intelligence; Generative AI; AI literacy; Adaptive learning; Learning analytics; AR/VR; Digital education; personalized learning*

Introduction

Education has evolved alongside changes in communication, society and knowledge. Digital technologies have accelerated this process by extending learning beyond the traditional classroom and enabling new forms of content delivery, collaboration, assessment and learner support. The current phase is particularly significant because AI and related technologies can participate in instructional processes rather than simply digitize existing materials.

UNESCO's 2023 Global Education Monitoring Report notes that technology has considerable potential in education, but its effects are uneven and evidence of added value remains limited for many applications. It emphasizes that technology should be judged by relevance, equity, scalability and sustainability, rather than novelty alone. cite turn0search0 turn0search1 Generative AI has introduced an additional challenge because students and teachers can use general-purpose AI tools independently of educational institutions. The OECD Digital Education Outlook 2026 reports that GenAI can support learning when used with clear pedagogical purpose, while using it simply to complete tasks may improve

performance without producing corresponding learning gains. Cite turn0search24 turn0search3

This paper therefore examines emerging trends from a teaching-and-learning perspective and argues that the central question should not be whether education can use new technology, but whether a particular technology meaningfully improves learning while protecting human agency and educational equity.

Objectives

1. To identify major emerging technologies influencing education.
2. To examine their applications and potential benefits for teaching and learning.
3. To discuss challenges involving equity, privacy, ethics, teacher preparedness and academic integrity.
4. To examine the changing role of teachers and the importance of AI literacy.
5. To recommend principles for responsible and effective technology integration.

Methodology

The paper adopts a narrative review approach. The submitted research draft was used as the primary conceptual basis, covering

AI, generative AI, AR/VR, learning analytics, cloud computing, Internet of Things (IoT) and adaptive learning. The discussion was refined using recent authoritative evidence and policy guidance from UNESCO and OECD. The paper is conceptual and review-based; it does not present an original survey, experiment or statistical dataset.

Major Emerging Trends in Education

Artificial Intelligence and Generative AI

AI can analyze patterns, recommend resources, support assessment and assist teachers with lesson planning and instructional materials. Generative AI extends these capabilities by producing text, explanations, questions, images and other content. Its educational role is increasingly moving from content generation toward interactive assistance and learning support.

The OECD's 2026 review identifies several uses of GenAI, including student learning support, teacher assistance and institutional workflows. At the same time, it warns that general-purpose GenAI needs pedagogical direction because it can create risks for learning when it substitutes for students' cognitive effort. cite turn0search24

AI Literacy and Digital Citizenship

As AI becomes part of everyday learning, students need more than operational skills. AI literacy involves understanding how AI systems work at a basic level, recognizing limitations and bias, checking outputs, protecting personal information and using AI ethically. This trend shifts digital education from teaching tool usage toward teaching responsible judgement.

Adaptive Learning and Personalization

Adaptive systems modify content, practice or difficulty according to learner performance.

They can help teachers identify error patterns and provide differentiated support. Personalization is most useful when algorithmic recommendations are interpreted by teachers rather than treated as complete descriptions of a learner.

Learning Analytics

Learning analytics uses data about learner activity and progress to identify patterns and support intervention. It can provide teachers with additional evidence about participation, common difficulties and progress. However, institutions must clearly define what data are collected, why they are needed, who can access them and how long they are retained.

AR and VR

AR overlays digital information on the physical environment, while VR creates immersive simulated environments. They can support virtual laboratories, scientific visualization, historical exploration and simulated professional practice. Their strongest educational value occurs when they enable experiences that are difficult, expensive or unsafe to reproduce otherwise.

Cloud Computing, IoT and Connected Learning

Cloud platforms enable access to learning materials, collaboration and assignment management across locations. IoT can support smart classrooms, connected laboratories, attendance systems and campus management. These technologies increase flexibility, but require reliable connectivity, interoperability, cybersecurity and responsible data governance.

Blended and Flexible Learning

The boundary between classroom and digital learning is increasingly flexible. Blended models combine face-to-face instruction with digital resources, asynchronous activities and online collaboration. This can support different learning schedules and extend access, while retaining the social and practical value of direct interaction.

Impact on Teaching and Learning

Area	Technology contribution	Teacher/learner role
Teaching	AI-assisted planning; digital resources; simulations	Set objectives and contextualize learning
Learning	Adaptive pathways; AI assistance; immersive activities	Question, practise, reflect and create
Assessment	Digital assessment; analytics; feedback	Design valid assessment and interpret evidence
Accessibility	Captions; alternative formats; assistive tools	Ensure inclusion and individual support
Administration	Cloud systems; automation; connected devices	Govern data and monitor quality

Benefits and Opportunities

- Personalized learning can provide resources and practice suited to individual needs and pace.
- Interactive and immersive technologies can increase engagement and make abstract concepts more concrete.
- Digital assessment can provide timely feedback and help identify learning gaps.
- Online resources can increase flexibility and access beyond the physical classroom.

- Assistive formats such as captions and audio can support diverse learners.
- AI and digital platforms can reduce selected routine tasks and provide teachers with additional instructional support.
- Analytics can provide evidence for differentiated instruction and early intervention.
- Virtual simulations can provide experiential learning where real-world practice is difficult or costly.

Challenges and Risks

Digital Divide and Equity

Access to devices, electricity, connectivity and quality digital resources remains unequal. UNESCO reports that technology adoption varies according to socioeconomic conditions, teacher preparedness, education level and country context. Technology can therefore reduce barriers for some learners while widening existing inequalities for others. cite turn0search0

Teacher Preparedness

Providing devices or software is insufficient without professional development. Teachers need technological knowledge combined with pedagogical skills, including the ability to evaluate digital resources, interpret AI outputs and decide when technology is appropriate.

Privacy, Security and Ethics

Digital learning systems can collect extensive learner information. Institutions need clear policies for data collection, access, storage, retention and sharing. AI-generated content may also contain inaccurate or biased information, requiring human verification and oversight. UNESCO recommends appropriate governance, privacy protection, online safety and ethical regulation of AI in education. cite turn0search2

Academic Integrity

Generative AI challenges traditional approaches to written assignments because students can obtain polished outputs quickly. Rather than relying only on prohibition, institutions can establish clear acceptable-use rules and redesign assessment to emphasize reasoning, application, reflection, discussion, projects and authentic performance.

Cost and Overdependence

Hardware, subscriptions, connectivity, maintenance and training can create substantial costs. Excessive technology use can also reduce face-to-face interaction, independent thinking and practical activity. Technology should therefore complement rather than displace effective human teaching.

Changing Role of the Teacher

Emerging technologies do not remove the importance of teachers; they change where teacher expertise is most valuable. Teachers increasingly act as facilitators, mentors, learning designers, evaluators, resource curators and guides for responsible technology use. Human judgement remains essential for understanding learner context, evaluating evidence and making high-impact educational decisions.

A technologically capable teacher therefore needs subject expertise, pedagogical knowledge, digital fluency, AI awareness, ethical judgement and the ability to select tools according to learning objectives.

Recommendations

1. Develop institutional AI and digital education policies linked to curriculum and learning outcomes.
2. Provide continuous teacher development covering technology, pedagogy, assessment and ethics.
3. Introduce age-appropriate AI literacy for students and staff.
4. Establish clear rules for AI use, academic integrity, disclosure and assessment.
5. Protect learner data through strong privacy, security and access controls.
6. Improve equitable access to devices, connectivity and accessible learning resources.
7. Select technology based on educational need and evidence rather than novelty.
8. Use human review for assessment, profiling and other high-impact decisions.
9. Evaluate technology regularly using learning outcomes, inclusion, teacher workload, cost and student experience.
10. Maintain a balance between digital, face-to-face and hands-on learning.

Future Prospects

Education is likely to move toward integrated digital environments in which AI assistants, adaptive platforms, analytics and immersive resources work alongside conventional teaching. AI literacy will become increasingly important as learners encounter AI in education, employment and daily life. The OECD's 2026 outlook suggests that effective GenAI use depends on pedagogical purpose and should strengthen, rather than replace, cognitive engagement and human relationships. cite turn0search24 turn0search3

Future research should focus less on whether a technology is innovative and more on which learners benefit, under what conditions, through which pedagogical approaches and at what cost. UNESCO notes that robust evidence about the added value of specific education technologies remains limited, making continuous evaluation essential. cite turn0search1

Conclusion

Emerging technologies are changing how education is designed, delivered, assessed and managed. AI, generative AI, adaptive learning, learning analytics, AR/VR, cloud platforms and connected systems provide opportunities for personalization, flexibility, engagement and improved support. Nevertheless, technology alone cannot guarantee better education. A sustainable approach requires equitable access, capable teachers, responsible data practices, ethical AI use and evidence-based implementation. The future of education should therefore be understood as human learning strengthened by technology—not teachers replaced by technology. When innovation is combined with critical thinking, creativity, empathy and professional judgement, emerging technologies can contribute to more inclusive, effective and meaningful learning.

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ARTIFICIAL INTELIGENCE IN EDUCATION: ENHANCING SKILL DEVELOPMENT AND EMPLOYABILITY FOR THE FUTURE WORKFACE

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Abstract

Artificial Intelligence (AI) is transforming education and the nature of work, creating both opportunities and challenges for learners, teachers and educational institutions. In an increasingly digital economy, employability depends not only on subject knowledge but also on technological literacy, critical thinking, creativity, communication, collaboration, adaptability and lifelong learning. AI can contribute to skill development by enabling personalised learning, intelligent feedback, adaptive learning environments, career guidance and opportunities for learners to practice real-world problem-solving. At the same time, the growing use of AI requires learners to develop AI literacy, ethical awareness, information evaluation skills and the ability to work effectively with AI systems. The World Economic Forum reports that technological skills such as AI and big data are among the fastest-growing areas of demand, while human capabilities such as analytical thinking, creative thinking, resilience and collaboration remain important. The International Labour Organization similarly indicates that generative AI is more likely to transform many jobs and tasks than simply eliminate employment. This paper examines the role of AI-enabled education in developing future-oriented skills and enhancing employability. It also discusses the responsibilities of teachers, challenges associated with AI adoption and recommendations for developing an inclusive, ethical and human-centred approach to AI-based skill development.

Keywords: Artificial Intelligence, Skill Development, Employability, AI Literacy, Future Skills, Education, Teachers

1.Introduction

Education has always played a central role in preparing individuals for personal, social and economic life. However, rapid technological developments are changing the knowledge and skills required for successful participation in society and the workplace. Artificial Intelligence has emerged as one of the most influential technologies shaping this transformation. AI can support educational processes through personalized learning, automated feedback, content generation, learning analytics, intelligent tutoring and career-oriented learning opportunities. However, the purpose of integrating AI into education should not simply be to introduce technology into classrooms. Rather, it should be to develop learners who can use technology intelligently, critically, creatively and ethically.

The changing world of work makes this objective particularly important. The World Economic Forum's Future of Jobs Report 2025 indicates that nearly 40% of job-related skills are expected to change by 2030 and identifies skills such as analytical thinking, resilience, creative thinking, technological literacy and AI and big data as important for the future workforce. Therefore, educational institutions need to move beyond traditional knowledge transmission and provide opportunities for learners to develop both technical and human skills.

2.Review of Literature

The rapid development of Artificial Intelligence (AI) has created new opportunities for education, skill development and employability. Recent literature indicates that AI literacy is no longer limited to technical knowledge; it increasingly includes practical skills, critical thinking, ethical awareness, adaptability and the ability to work effectively with AI.

Liu et al. (2026) conducted a meta-analysis of AI literacy interventions in education, examining 59 empirical studies involving 7,211 participants. The study found a significant overall positive effect of AI literacy interventions. However, knowledge gains were stronger than gains in skills, attitudes and ethical understanding. The authors therefore emphasised the need for educational approaches that move beyond theoretical knowledge towards practical skills, reflection, ethical awareness and hands-on learning. This study is particularly relevant to the present paper because it highlights the importance of developing skills rather than merely AI-related knowledge. **Science Direct**

Yu (2026) examined the effects of K–12 AI education on the development of AI literacy through a meta-analysis. The study highlighted the need to distinguish between using AI as a learning-support tool and actually educating students about AI. This distinction is important for skill development because learners need opportunities to understand, evaluate and apply AI rather than simply use AI tools. The findings support the inclusion of AI education as part of future-oriented skill development.

Wiley Online Library

A systematic review of AI literacy in school education (2026) analysed 58 peer-reviewed studies and identified different dimensions of AI literacy for students, teachers and educational professionals. For students, the review included AI-related thinking and preparation for AI careers, while common dimensions included AI knowledge and skills, ethics, societal implications and generative-AI competencies. The study also emphasised cognitive and noncognitive dimensions and contextual adaptability. These findings indicate that AI literacy can contribute to students' preparation for future employment.

DOI

A systematic review of Generative AI literacy across education and business (2026) examined 206 studies and identified AI literacy as a multidimensional construct. The review grouped competencies into technical skills, personal and interpersonal skills, and ethical and critical-thinking skills. Adaptability and collaboration were identified alongside

competencies such as algorithmic literacy and prompt-related skills. The study is highly relevant to employability because it demonstrates that future workers require a combination of technical, interpersonal and ethical competencies.

Springer

Rehman, Dar, and Rasool (2025) conducted a systematic review of AI literacy in higher education with particular reference to India's vision of Viksit Bharat 2047. After screening 130 studies, 17 studies were selected for detailed analysis. The review identified opportunities associated with AI-driven education, including personalised learning, adaptive assessment and AI-supported research, while also highlighting challenges related to skill development and ethical considerations. The authors emphasised collaboration among educational institutions, government and industry to develop AI competencies needed for India's future workforce.

Springer

Biagini (2025) conducted a systematic literature review exploring AI literacy, education, ethics and applications. The study demonstrates that AI literacy extends beyond technical proficiency to include understanding AI applications, ethical issues and its wider social implications. This perspective is significant for employability because future professionals need not only technological competence but also the ability to make responsible and informed decisions while working with AI.

World Economic Forum (2025), in its Future of Jobs Report 2025, examined changing workforce requirements based on responses from more than 1,000 employers across 55 economies. The report identified AI and big data, networks and cybersecurity, and technological literacy among the fastest-growing skills. At the same time, analytical thinking, creative thinking, resilience, flexibility, agility, curiosity and lifelong learning remain important. This indicates that employability in an AI-driven economy requires a balanced combination of technological and human skills. **World**

Economic Forum +1

Miao and Cukurova (2024), through UNESCO's AI Competency Framework for Teachers, proposed 15 AI competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. The framework suggests that teachers need progressive development of AI competencies so that they can integrate AI responsibly into teaching and learning. This is relevant to the present study because teachers play an important role in preparing learners with the skills required for future employment.

3.Objectives

1. To examine the role of Artificial Intelligence in skill development.
2. To analyse the relationship between AI-enabled education and employability.
3. To identify important technical and human skills required in the AI era.

4. To examine the role of teachers in developing future-ready learners.
5. To identify challenges associated with AI-based skill development.
6. To suggest strategies for strengthening employability through AI-integrated education.

4.Methodology

The present paper adopts a descriptive and analytical review methodology to examine the role of Artificial Intelligence (AI) in enhancing skill development and employability for the future workforce. Since the paper is conceptual in nature, it does not involve primary data collection or experimental intervention. Relevant secondary sources were reviewed, including peer-reviewed research articles, systematic literature reviews, meta-analyses, books, reports and publications of reputed organisations such as UNESCO, the International Labour Organization (ILO) and the World Economic Forum (WEF). Recent literature published primarily between 2024 and 2026 was given greater emphasis to capture the rapidly changing nature of AI and its implications for education and employment. The literature was analysed thematically under major areas such as AI literacy, technical skills, soft skills, critical thinking, creativity, communication, collaboration, adaptability, ethical AI use, teacher competencies and employability skills. The reviewed literature was synthesised to understand how AI-integrated education can support learners in developing competencies required for the changing world of work. The methodology therefore provides a foundation for identifying the opportunities, challenges and educational strategies associated with AIenabled skill development and employability, and for suggesting measures to prepare learners for an AI-driven future.

5.Concept of Skill Development and Employabilitz

Skill development refers to the process of acquiring, improving and applying knowledge, abilities and competencies required for personal, academic and professional growth. Skills may include technical abilities as well as communication, problem-solving, creativity, teamwork and leadership.

Employability refers to the combination of knowledge, skills, attitudes and personal attributes that enable individuals to obtain employment, perform effectively in the workplace and adapt to changing employment conditions.

In the AI era, employability cannot be based solely on specialised technical knowledge. Workers increasingly need a combination of digital skills and human-centred skills. The World Economic Forum identifies analytical thinking as a leading core skill, alongside resilience, flexibility, creative thinking, technological literacy and other interpersonal and cognitive abilities.

6. AI as a Tool for Skill Development

AI can strengthen skill development in several ways.

6.1 Personalised Learning

AI-based learning systems can analyse learners' performance and provide learning experiences according to their needs and progress. This can help learners identify areas requiring improvement and practise at an appropriate level.

6.2 Development of Digital and AI Literacy

Learners need to understand not only how to use AI tools but also their limitations, reliability, ethical implications and appropriate applications. UNESCO's AI competency framework for students emphasises preparing learners to become responsible and creative users and co-creators of AI.

6.3 Critical Thinking and Problem-Solving

AI can generate information and possible solutions, but learners must evaluate whether those responses are accurate, relevant and appropriate. Classroom activities can therefore use AI as a starting point for questioning, comparison, verification and problem-solving rather than as a substitute for thinking.

6.4 Communication and Creativity

AI tools can provide opportunities for learners to develop writing, presentation, brainstorming and creative problemsolving skills. Teachers can design tasks in which learners use AI but must add their own reasoning, interpretation and creativity.

6.5 Career-Oriented Learning

AI can support career exploration by helping learners understand occupational requirements, identify skill gaps and explore possible learning pathways. Such applications should be combined with teacher guidance and reliable career information.

7. AI and Employability Skills

The future workforce requires a balanced combination of technical, cognitive and interpersonal skills.

Important AI-era employability skills include:

AI and digital literacy
Analytical thinking
Critical thinking
Creativity
Communication
Collaboration
Problem-solving
Adaptability
Resilience
Leadership
Ethical decision-making
Lifelong learning

The World Economic Forum reports that employers expect technological capabilities such as AI and big data to grow rapidly in importance, while human capabilities including creative thinking, resilience, flexibility and agility will continue to be critical.

World Economic Forum

The ILO also stresses that AI is changing the tasks performed within occupations. Its 2025 assessment found that approximately one in four workers globally are in occupations with some degree of generative-AI exposure, while most jobs are more likely to be transformed than completely eliminated. This makes continuous skill development particularly important.

International Labour Organization

8. Role of Teachers in AI-Enabled Skill Development

Teachers remain central to the educational process even when AI technologies are widely available. Their role is shifting from being primarily information providers to becoming facilitators, mentors, designers of learning experiences and ethical guides.

Teachers can:

Introduce learners to responsible AI use.

Develop critical evaluation of AI-generated information.
Design project-based and problem-based learning activities.
Encourage creativity rather than dependence on AI.
Integrate communication and collaboration into AI-supported activities.
Help learners connect classroom learning with real-world workplace requirements. Teach ethical issues such as privacy, bias, academic integrity and responsible use. Encourage lifelong learning and adaptability. UNESCO's framework identifies 15 teacher competencies across five dimensions, including human-centred mindset, AI ethics, AI foundations and applications, AI pedagogy and AI for professional learning.

UNESCO

Findings

The review of recent literature on Artificial Intelligence (AI), skill development and employability resulted in the following major findings:
AI literacy is becoming an essential employability competency.
Recent literature indicates that learners need more than basic digital literacy. AI literacy involves understanding AI, using AI tools appropriately, evaluating AI-generated information and applying AI responsibly. This makes AI literacy increasingly important for preparation for future employment.

Springer +1

AI can support the development of diverse skills. AI-integrated learning environments can provide opportunities to develop problem-solving, analytical thinking, creativity, communication, collaboration and technology-related skills. However, recent evidence suggests that educational interventions should focus more on developing practical skills rather than concentrating only on conceptual knowledge.

ScienceDirect

Employability requires both technical and human skills. The literature shows that technical AI competencies alone are insufficient. Adaptability, collaboration, critical thinking, creativity, ethical reasoning and effective communication remain important for learners entering AI-supported workplaces.

Springer

Practical and experiential learning is important. AI education becomes more meaningful when learners are given opportunities to apply AI through projects, problem-solving activities, performance tasks and real-world situations.
Such approaches can help bridge the gap between classroom learning and workplace requirements.

Science Direct +1

Ethical and responsible use of AI is a key skill. Learners need to understand issues such as bias, reliability, privacy, responsible use and the limitations of AI-generated information. Therefore, ethical awareness should be integrated with technical AI education rather than treated as a separate component.

Springer +1

Teachers play a central role in AI-enabled skill development.
Effective integration of AI in education depends substantially on teachers' AI competencies and pedagogical preparedness. Teachers need appropriate professional development to guide learners in using AI critically, creatively and responsibly.

Science Direct

There is a gap between AI knowledge and practical employability. Although research on AI literacy is expanding rapidly, much of the existing literature remains conceptual, particularly in the education and business sectors. More empirical research is needed to establish how AI-integrated learning directly influences students' workplace skills and employability outcomes.

Springer

AI education should be context-sensitive and inclusive. The effectiveness of AI-learning interventions varies across educational contexts. Differences in access to technology, institutional support, learner needs and geographical settings indicate the need for locally relevant and inclusive approaches to AI skill development.

9. Conclusion

Artificial Intelligence is changing both education and the world of work. Its greatest educational value lies not simply in automating tasks but in creating opportunities for learners to develop relevant knowledge, skills and competencies for an evolving society. AI can support personalised learning, digital literacy, problem-solving, creativity and career preparation. However, employability in the AI era requires more than technical competence. Learners need a balanced combination of technological literacy, analytical thinking, creativity, communication, collaboration, adaptability, ethical awareness and lifelong learning. The future therefore requires AI-ready learners and AI-competent teachers. Educational institutions should adopt a human-centred approach in which AI is used as a supportive tool while human judgement, creativity, relationships and ethical responsibility remain central. As the ILO's recent analysis suggests, the major issue is not simply whether AI will replace jobs, but how work will be transformed and how people can be prepared for that transformation. Skill development should therefore become a continuous process, enabling learners to adapt confidently to emerging opportunities and challenges in the future workforce.

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FROM TRADITIONAL TEACHING TO INTELLIGENT PEDAGOGY: EXPLORING THE ROLE OF AI IN TRANSFORMING TEACHING-LEARNING PRACTICES

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Abstract

Artificial Intelligence (AI) is emerging as one of the most influential technologies shaping contemporary education. Its growing applications in lesson planning, content creation, personalized learning, assessment, feedback, learning analytics and professional development are transforming conventional approaches to teaching and learning. The transition from traditional teaching to intelligent pedagogy, however, involves much more than introducing AI tools into classrooms. It requires a fundamental reconsideration of pedagogical practices, teacher competencies, learner agency, assessment strategies and the ethical purposes of education. This conceptual paper explores the role of Artificial Intelligence in transforming teaching-learning practices and examines the opportunities and challenges associated with the emergence of intelligent pedagogy. The paper discusses how AI can support personalized and adaptive learning, enhance instructional design, facilitate formative assessment and feedback, strengthen learner engagement, promote inclusive education and assist teachers in professional development. It also examines the changing role of teachers from knowledge transmitters to learning designers, facilitators, mentors, critical evaluators and ethical decision-makers. Particular attention is given to generative AI and its implications for creativity, critical thinking, academic integrity and independent learning. The paper argues that AI should augment rather than replace human teaching. Effective intelligent pedagogy requires purposeful integration of AI with established pedagogical principles, human interaction and professional judgement. UNESCO's AI Competency Framework for Teachers and recent OECD perspectives provide important directions for developing teachers' AI-related competencies and ensuring human-centred use of technology. The paper proposes a human-centred model of intelligent pedagogy based on pedagogical purpose, AI augmentation, learner agency, critical evaluation and ethical reflection. It concludes that the future of education lies not in choosing between teachers and AI, but in creating meaningful human-AI partnerships that enhance the quality, inclusiveness and effectiveness of teaching and learning.

Keywords: *Artificial Intelligence, intelligent pedagogy, teaching-learning, generative AI, personalized learning, AI literacy, digital pedagogy, teacher competencies, learning analytics, human-AI collaboration*

1. Introduction

Education has continuously evolved in response to social, cultural and technological changes. From teacher-centred classrooms dominated by lectures and textbooks to learner-centred, collaborative and technology-supported environments, educational practice has undergone significant transformation. The emergence of Artificial Intelligence represents a further stage in this transformation. Artificial Intelligence is capable of processing large volumes of information, generating content, identifying patterns, supporting decision-making and providing increasingly sophisticated forms of interaction. In education, these capabilities are

influencing teaching, learning and assessment and creating what UNESCO describes as a new teacher-AI-student dynamic. UNESCO's AI Competency Framework for Teachers emphasizes that this transformation requires teachers to develop new knowledge, skills and values, including AI pedagogy, ethics and AI-supported professional learning (Miao & Cukurova, 2024). The emergence of generative AI has accelerated this development. Tools capable of producing text, images, presentations, questions, explanations and feedback are increasingly accessible to teachers and learners. However, technological availability does not automatically produce educational improvement. The OECD's Digital Education Outlook 2026 notes that generative AI can support learning when guided by sound teaching principles, whereas unguided use may improve task performance without necessarily producing genuine learning. Therefore, the important educational question is not simply "How can AI be used in teaching?" but rather "How can AI be integrated into pedagogy in ways that improve meaningful learning while preserving human agency?"

This question forms the foundation of the transition from traditional teaching to intelligent pedagogy.

2. From Traditional Teaching to Intelligent Pedagogy

Traditional teaching has often been associated with teacher-directed instruction, standardized content delivery, fixed pacing and relatively uniform learning experiences. Although such approaches continue to have value in certain contexts, they may not adequately respond to the diversity of learners, rapid information growth and changing competencies required in the twenty-first century. Intelligent pedagogy represents an approach in which technology, particularly AI, is purposefully integrated with pedagogical knowledge to create more responsive, adaptive and learner-centred educational experiences.

The transition can be understood as follows:

Traditional Teaching	Intelligent Pedagogy
Teacher as primary knowledge transmitter	Teacher as learning designer and facilitator
One-size-fits-all instruction	Personalised and adaptive learning
Periodic assessment	Continuous formative assessment and feedback
Fixed learning materials	Dynamic and differentiated resources
Teacher-centred interaction	Human-AI-supported learner-centred interaction
Limited learning analytics	Data-informed pedagogical decisions
Technology as an additional tool	Technology integrated according to pedagogical purpose
Knowledge reproduction	Critical thinking, creativity and problem-solving
Teacher-directed learning	Greater learner agency and collaboration

Intelligent pedagogy should therefore not be understood as "automated teaching." It is better understood as pedagogically informed human-AI collaboration.

3. AI as a Catalyst for Pedagogical Transformation

AI can contribute to almost every major stage of the teaching-learning process.

- **AI in lesson planning:** AI can help teachers generate lesson structures, learning objectives, examples, classroom activities, discussion questions and differentiated resources. Teachers can use AI to produce multiple versions of a lesson according to learner ability, language proficiency or learning needs.

  However, AI-generated lesson plans should not be accepted without evaluation. Teachers must verify accuracy, curriculum alignment, cultural relevance and developmental appropriateness.
- **Intelligent content creation:** AI can assist in producing educational materials such as summaries, concept explanations, case studies, quizzes, worksheets, simulations and multimedia resources.

  The teacher's role shifts from merely producing content to **curating, validating and contextualizing content**. This is particularly important because AI-generated information can contain errors, fabricated references or inappropriate interpretations.
- **Personalized and adaptive learning:** One of AI's significant possibilities is the ability to support personalized learning. AI systems can analyse learner responses and provide differentiated materials, explanations or practice activities.

  Instead of expecting every learner to progress through identical content at the same pace, AI can potentially support different pathways. However, personalization should complement—not replace—the teacher's understanding of learners as individuals.
- **Intelligent tutoring:** AI-powered tutoring systems can provide conversational explanations, hints, questions and immediate feedback. These systems can extend learning opportunities beyond classroom hours.

  The educational value depends on how the system is designed and used. A chatbot that simply gives answers may encourage dependency, while one that asks questions, provides scaffolding and encourages reasoning can promote deeper learning.
- **Formative assessment and feedback:** AI can assist teachers in generating questions, identifying patterns in learner responses, developing rubrics and providing preliminary feedback.

  This can reduce routine workload and allow teachers to devote more time to higher-value professional activities. Nevertheless, final assessment should remain accountable to teachers, particularly when assessing creativity, reasoning, values, communication and complex human performance.

4. Generative AI and the Transformation of Learning

Generative AI has created new possibilities but also significant educational concerns.

Students can use generative AI to brainstorm ideas, obtain explanations, receive feedback, compare perspectives and develop drafts. Teachers can use it to create resources, differentiate instruction and explore alternative teaching strategies.

However, excessive dependence on generative AI may result in learners outsourcing important cognitive processes. The OECD's 2026 analysis emphasizes that successfully completing a task with generative AI does not necessarily mean that learning has occurred. It recommends purposeful use that preserves independent thinking and meaningful cognitive engagement.

Therefore, intelligent pedagogy should encourage a **"think–AI–critique–create"** cycle:

1. **Think:** Learners first attempt to understand and solve the problem independently.
2. **AI:** AI is used as a resource, tutor, brainstorming partner or alternative perspective.
3. **Critique:** Learners examine AI-generated information for accuracy, bias and relevance.
4. **Create:** Learners use their own judgement to produce, revise and defend their final work.

This approach positions AI as a cognitive partner rather than a substitute for thinking.

5. Transforming the Role of the Teacher

The rise of AI does not eliminate the need for teachers. Instead, it increases the importance of teachers' professional judgement.

UNESCO's AI Competency Framework for Teachers identifies five dimensions of teacher competence: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These competencies are organized into the progression levels of Acquire, Deepen and Create.

Accordingly, the teacher of the intelligent classroom becomes:

Learning Designer: Teachers design learning experiences in which technology serves clearly defined educational objectives.

Learning Facilitator: Teachers guide students in questioning, investigating, collaborating and constructing knowledge.

AI Curator: Teachers select appropriate AI tools and evaluate their educational value.

Critical Evaluator: Teachers verify AI-generated information and teach students to distinguish reliable knowledge from inaccurate or biased information.

Ethical Guardian: Teachers protect student privacy, dignity, academic integrity and human agency.

Mentor and Role Model: Teachers provide the emotional, social and moral dimensions of education that cannot be reduced to automated processes.

Thus, intelligent pedagogy makes the teacher **more strategically important**, not less.

6. AI and Student Engagement

AI can support learner engagement through interactive conversations, simulations, personalized challenges, immediate feedback and multimodal resources.

For example, a student studying history can interact with an AI-supported historical simulation; a language learner can practise conversation; a science learner can explore alternative explanations; and a mathematics learner can receive step-by-step hints.

Nevertheless, engagement should not be measured merely by increased interaction with technology. Meaningful engagement involves curiosity, persistence, reflection, collaboration and intellectual effort.

Consequently, teachers should design activities where AI encourages students to question, investigate and create, rather than simply consume generated answers.

7. AI for Inclusive and Equitable Education

AI has considerable potential to support inclusive education. Speech-to-text, text-to-speech, translation, automated captioning, adaptive materials and personalized support can help reduce barriers to learning.

AI can also help teachers prepare resources at different reading levels or provide alternative representations of complex concepts.

However, AI may also reinforce educational inequality if access to devices, connectivity, high-quality tools and digital skills is uneven. UNESCO emphasizes human agency, inclusion, non-discrimination and respect for linguistic and cultural diversity in AI-enabled education.

Therefore, intelligent pedagogy must be inclusive by design. Technology should reduce rather than reproduce existing inequalities.

8. AI, Assessment and Learning Analytics

Assessment is another area undergoing significant transformation.

AI-supported learning analytics can identify patterns in learner performance and provide teachers with information that may help them identify students requiring additional support. AI can also assist with formative assessment and feedback.

However, educational data must be interpreted cautiously. A numerical pattern cannot fully explain why a learner is struggling. Human teachers remain necessary to understand social, emotional, cultural and contextual factors.

Furthermore, AI-assisted assessment raises questions regarding transparency, bias, privacy and accountability. Decisions affecting learners should therefore not be delegated entirely to automated systems.

A responsible approach is **AI-assisted rather than AI-controlled assessment**.

9. Ethical and Pedagogical Challenges

The transformation toward intelligent pedagogy also creates important challenges.

- **Academic Integrity:** Generative AI makes it increasingly difficult to determine whether submitted work represents a learner's independent effort. Institutions may therefore need to redesign assessment toward authentic tasks, oral presentations, project work, reflective journals and demonstrations of learning.
- **Accuracy and Hallucination:** AI systems can produce convincing but inaccurate information. Teachers and students require strong information and AI literacy to verify outputs.

- **Bias:** AI systems may reproduce biases contained in training data. Teachers should therefore critically examine generated content for cultural, linguistic and social biases.
- **Privacy:** Learner data must be protected from inappropriate collection, storage and use.
- **Teacher Dependence:** If teachers rely excessively on AI-generated lesson plans and materials, professional creativity and pedagogical autonomy may decline.
- **Digital Divide:** Unequal access to AI tools may create new forms of educational inequality.
- **Human Relationships:** Education is fundamentally relational. Excessive technological mediation may weaken teacher-student interaction, empathy and social learning.

These challenges reinforce the need for **human-centred intelligent pedagogy**.

10. A Proposed Framework for Intelligent Pedagogy

Based on the discussion, intelligent pedagogy can be conceptualized through six interconnected principles:

1. Pedagogical Purpose: AI should be introduced only when it contributes meaningfully to clearly defined learning objectives.

2. Human Agency: Teachers and learners should remain responsible for educational decisions.

3. AI Augmentation: AI should strengthen human capabilities rather than replace professional judgement.

4. Critical Evaluation: AI-generated information should be questioned, verified and contextualized.

5. Learner-Centredness: Technology should promote learner autonomy, creativity, collaboration and meaningful engagement.

6. Ethical Responsibility: Privacy, equity, transparency, academic integrity, inclusion and human dignity must guide AI use.

This framework shifts the question from **"What can AI do?"** to **"What should AI do to improve learning?"**

11. Implications for Teacher Education

Teacher education institutions have a central responsibility in preparing educators for intelligent classrooms.

AI should not be treated as a stand-alone technical topic. Instead, it should be integrated across teacher education curricula.

Pre-service teachers should receive opportunities to:

- understand basic AI concepts;
- develop AI and information literacy;
- use generative AI responsibly;
- design AI-supported lessons;
- evaluate AI-generated content;
- develop AI-assisted assessment strategies;

- understand privacy and ethical issues;
- practise AI-supported inclusive teaching;
- critically examine AI bias;
- reflect on the changing teacher's role.

Teacher educators themselves also require continuous professional development. UNESCO notes that teacher AI competency development needs to encompass technical, ethical and pedagogical dimensions.

Teacher education institutions should consequently establish AI laboratories, communities of practice, demonstration classrooms and professional learning programmes where future teachers can experiment with AI while critically examining its educational implications.

12. Conclusion

The movement from traditional teaching to intelligent pedagogy represents a significant transformation in educational practice. Artificial Intelligence can support teachers in planning, content development, personalization, assessment, feedback, learning analytics and professional learning. It can also provide learners with new opportunities for interaction, exploration and personalized support.

Yet, AI alone cannot create effective education. The quality of intelligent pedagogy depends on the quality of pedagogical decisions surrounding the technology. AI can generate an explanation, but teachers determine whether that explanation is appropriate. AI can identify patterns in data, but teachers interpret those patterns within human contexts. AI can provide feedback, but teachers provide encouragement, empathy and meaningful guidance.

The central challenge, therefore, is not replacing traditional teaching with technology but **reimagining teaching through responsible human-AI collaboration**.

The intelligent classroom of the future should not be a classroom in which machines teach and humans merely supervise. It should be a learning environment in which **teachers, learners and AI interact purposefully**, with teachers retaining professional agency and learners retaining intellectual autonomy.

The transition from traditional teaching to intelligent pedagogy should consequently be guided by three fundamental principles: **AI must have a pedagogical purpose, humans must retain agency, and learning must remain the central objective.**

Ultimately, the success of AI in education should not be measured by the number of AI tools used in classrooms. It should be measured by whether those tools help learners **think more deeply, learn more independently, create more creatively, collaborate more effectively and participate more equitably in society**.

The future of education is therefore neither purely traditional nor purely technological. It is a carefully designed partnership between **human intelligence, artificial intelligence and pedagogical wisdom**.

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ARTIFICIAL INTELLIGENCE AS A DRIVER OF NATIONAL E CONOMIC TRANSFORMATION, PRODUCTIVITY, AND SUSTAINABILITY

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Abstract

Artificial Intelligence (AI) has emerged as a disruptive technology that may reshape national economies by improving productivity, expediting structural transformation, and facilitating sustainable development. Automation powered by AI, data analytics, and intelligent decision-making systems enhance efficiency across various industries, including agriculture, manufacturing, services, energy, and governance. This study investigates the impact of AI on economic transformation, productivity enhancement, and environmental sustainability at the national scale. It also examines recent worldwide research to pinpoint critical problems and policy necessities for the inclusive and responsible use of AI. The research relies on secondary data sourced from international organizations, governmental records, and recent studies released between 2019 and 2025. A descriptive and analytical methodology was employed to integrate sectoral effects and macroeconomic trends. The results indicate that AI improves overall factor productivity, fosters innovation, optimizes resource utilization, and facilitates sustainable growth. Nonetheless, talent deficiencies, technical disparities, regulatory issues, and employment shifts present considerable obstacles. The research underscores the necessity for robust digital infrastructure, the advancement of human capital, ethical governance, and innovation ecosystems to facilitate sustained national economic transformation.

Keywords: Artificial Intelligence, economic transformation, productivity, sustainability, digital economy, innovation

1. Introduction

Technological advancement has been a fundamental catalyst for economic expansion and structural transformation. In the contemporary digital age, Artificial Intelligence (AI) is emerging as a versatile technology capable of revolutionizing manufacturing systems, labor markets, and public governance. Artificial Intelligence denotes computing systems proficient in executing tasks including learning, prediction, pattern recognition, and automated decision-making. At the national level, AI facilitates economic transformation by enhancing productivity, fostering innovation, and aiding the shift from low-value activities to knowledge-intensive sectors. The International Monetary Fund (2024) asserts that the deployment of AI can substantially augment economic output by enhancing efficiency and facilitating novel company models. Artificial intelligence is pivotal in attaining sustainable development through the optimization of energy use, waste reduction, and enhancement of

resource management. Countries that invest in AI infrastructure, research, and human capital are poised to achieve accelerated economic growth and enhanced global competitiveness. The economic advantages of AI rely on robust regulatory frameworks, institutional preparedness, and equitable technological uptake.

2. Review of Literature

Recent studies highlight the macroeconomic effects of AI on productivity and growth. Brynjolfsson et al. (2021) contend that AI augments total factor productivity by refining decision-making and facilitating the automation of repetitive jobs. The McKinsey Global Institute (2023) estimates that AI could substantially enhance global GDP via productivity improvements and innovation. The World Bank (2023) emphasizes AI's contribution to structural transformation through enhanced agricultural efficiency, industrial automation, and digital services. AI-driven smart production systems enhance quality, minimize downtime, and optimize supply chains in manufacturing. Artificial intelligence also facilitates environmental sustainability. The International E nergy Agency (2023) indicates that AI-driven smart grids and energy management systems decrease energy consumption and enhance the integration of renewable resources. Precision farming technologies in agriculture enhance the utilization of water, fertilizers, and insecticides, while minimizing environmental effect (FAO, 2022). The OE C D (2024) cautions that artificial intelligence could exacerbate economic inequality in the absence of skill development and inclusive policies. Employment displacement, ethical dilemmas, and data governance constraints persist as significant policy issues.

3. Objectives of the Study

The research has two main objectives. The primary purpose is to analyze the role of Artificial Intelligence in facilitating national economic change by enhancing productivity, innovation, and sectoral efficiency. The second purpose is to examine recent findings to discern critical problems and policy necessities for fostering sustainable, inclusive, and environmentally responsible AI-driven economic development.

4. Methodology

The research utilizes secondary data obtained from credible and contemporary sources, including studies issued by international organizations such as the International Monetary Fund, World Bank, OECDI international Energy Agency, FAO, and UN agencies. National policy documents and industry reports were examined to comprehend the practical uses of AI in economic change. Furthermore, peer reviewed journal articles published from 2019 to 2025 were analyzed to integrate new empirical and analytical insights. A descriptive and analytical research design was employed. The gathered literature and data were methodically categorized into thematic domains including productivity and industrial transformation, sustainable resource management, employment and labor markets, innovation systems, and environmental sustainability. A thematic synthesis method was employed to discern patterns and correlations between AI adoption and macroeconomic results. The study offers a

thorough evidence-based summary instead of original empirical analysis.

5. Role of AI in National Economic Transformation

5.1 Productivity and Industrial Efficiency

Artificial intelligence enhances productivity through the automation of repetitive jobs, the optimization of manufacturing processes, and the facilitation of predictive maintenance. Intelligent manufacturing solutions decrease operational expenses, limit interruptions, and enhance product quality. These efficiency improvements result in increased productivity with reduced resource utilization.

Table 1: Estimated Productivity Impact of AI Across Sectors

Sector	Productivity Improvement (%)
Manufacturing	15–30%
Logistics and supply chains	10–20%
Financial services	20–40%
Retail and e-commerce	10–25%

Sources: McKinsey Global Institute (2023); OECD (2024).

The statistics demonstrate that AI adoption markedly improves productivity across key economic sectors. S ignificant improvements are noted in financial services and manufacturing, where automation and predictive analytics enhance operational efficiency and decrease expenses. These enhancements foster comprehensive economic expansion via increased total factor productivity.

5.2 Structural Transformation and Innovation

Artificial intelligence expedites the transition from labor-intensive to knowledge driven economic activities. It facilitates the advancement of emerging industries such as digital platforms, robotics, and data services, while concurrently fostering innovation in conventional sectors.

5.3 Sustainable Resource Management

Artificial intelligence facilitates the effective utilization of natural resources via realtime monitoring and predictive analytics.

Table 2: AI Applications for Environmental Sustainability

Sector	Sustainability Impact
Energy	10–15% reduction in energy consumption
Agriculture	20–30% reduction in water and chemical use
Transportation	15–20% reduction in fuel consumption
Waste management	Improved recycling efficiency

Sources: **International Energy Agency (2023); FAO (2022); World Bank (2023).**

Table 2 illustrates that artificial intelligence enhances environmental sustainability by improving resource utilization across several sectors. E nhancements in energy efficiency

and diminished agricultural input utilization help climate mitigation and sustainable production systems. These results correspond with national objectives for green growth and climate initiatives.

5.4 **Employment and Human Capital**

Artificial intelligence generates novel employment prospects in data science, digital services, and advanced manufacturing. Nevertheless, it necessitates worker reskilling to accommodate evolving job demands.

6. **Challenges in AI-Driven Economic Transformation**

Notwithstanding its disruptive potential, numerous difficulties impede the efficient integration of AI into national economic systems. A primary problem is the widening skill gap between the demand for sophisticated digital competences and the current worker capabilities. Numerous economies encounter deficits of professionals skilled in AI, data science, and advanced analytics, potentially hindering technology adoption and innovation.

A significant concern is the potential for technological disparity. The deployment of AI is frequently limited to large enterprises and developed areas with superior digital infrastructure and financial capabilities. S mall businesses and rural regions may encounter obstacles such as elevated expenses, insufficient technological proficiency, and restricted access to data. This unequal adoption may exacerbate productivity and wealth inequities.

Disruption of employment is a significant issue. The automation of regular and repetitive operations may diminish the need for low- and medium-skilled employment, resulting in job displacement and labor market polarization. In the absence of appropriate reskilling and social protection initiatives, these transformations may exacerbate economic inequality.

Data governance, privacy, and cybersecurity issues pose further challenges. AI systems rely on extensive datasets, heightening the potential for data exploitation, cyber dangers, and ethical issues pertaining to algorithmic bias and insufficient transparency. Inadequate regulatory frameworks may erode public confidence in AI technologies.

Ultimately, institutional and legislative constraints may impede AI-driven transformation. Numerous nations lack robust national AI plans, coordinating frameworks, and investment structures. Significant initial capital requirements for digital infrastructure and research provide challenges for developing nations.

7. **Policy Implications for Sustainable AI-Led Growth**

To fully leverage AI for national economic transformation, governments must implement a holistic policy framework that reconciles innovation with inclusivity and sustainability.

Initially, investment in digital and data infrastructure is necessary. High-speed broadband, cloud computing infrastructure, and safe data environments constitute the groundwork for extensive AI implementation. Public digital infrastructure can facilitate innovation among startups and small businesses.

Secondly, the advancement of human capital must be prioritized via educational reforms and extensive reskilling projects. Incorporating AI and data analytics into higher education and

vocational training programs will equip the workforce for emerging job roles. Systems for lifelong learning are essential to facilitate ongoing skill adaption.

Third, governments ought to implement robust regulatory and ethical frameworks for the responsible development of AI. Legislation on data protection, norms for transparency, and procedures for accountability would bolster trust and mitigate dangers related to algorithmic bias and privacy infringements.

Fourth, policies must facilitate inclusive innovation and the dissemination of technology. Monetary incentives, innovation awards, and technical assistance programs can facilitate the adoption of AI technologies by small and medium firms. Promoting public–private partnerships and research collaboration will enhance national innovation ecosystems.

Ultimately, AI policies must correspond with sustainability and green growth goals. Advancing AI applications in renewable energy, climate monitoring, sustainable agriculture, and resource management will facilitate the attainment of enduring environmental and economic objectives.

8. **Conclusion**

Artificial Intelligence possesses the capacity to catalyze extensive economic revolution by enhancing productivity, fostering innovation, and facilitating sustainable resource management. Its uses in industry, agriculture, energy, and services enhance efficiency and promote sustainable growth. Nonetheless, achieving these advantages necessitates confronting obstacles associated with skills, inequality, governance, and infrastructure. An equitable policy framework that fosters inclusive innovation, accountable regulation, and environmental sustainability will be crucial for utilizing AI as a primary catalyst for national economic advancement.

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REVIVING ROOTS FOR READINESS: INDIAN KNOWLEDGE SYSTEMS, YOGA, AND THE CULTIVATION OF STUDENT ENGAGEMENT AND WELL-BEING UNDER NEP 2020

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Abstract

Purpose: Student engagement and well-being have become a matter of concern for the education systems that are witnessing a rise in stress, inattentiveness, and disengagement among school going children. The paper explores yoga as a part of knowledge tradition of India, or Indian Knowledge Systems (IKS), as a policy lever to promote student engagement and well-being as per the National Education Policy (NEP) 2020.
Design/Methodology/Approach: The paper takes a conceptual-integrative- review approach, drawing on National Education Policy 2020 (Ministry of Human Resource Development, MHRD, 2020) and National Curriculum Framework for School Education 2023 (National Council of Educational Research and Training, NCERT, 2023), plus relevant scholarly works on yoga in schools (randomised controlled trials, systematic reviews) indexed in Scopus, Web of Science, PubMed (Ferreira-Vorkapic et al., 2015; Hagen et al., 2023; Hart et al., 2022; Khalsa & Butzer, 2016; Khunti et al., 2022; Pandey et al., 2024). Student engagement is conceptualised using Fredricks et al. (2004) while student well-being has been located in Ryan & Deci's (2000) and Seligman's (2011) works. Findings: The reviewed literature demonstrated associations between sustained practice of yoga in schools and enhanced attention, reduced stress, anxiety and better attunement to teacher's expectations, which could be linked to behavioural, cognitive and emotional engagement and, indirectly, to autonomy, competence and relatedness, the facets of well-being. The IKS origins of yoga – particularly its emphasis on breath, attention and ethical discipline – explain its potential to address the concerns of student engagement and well-being. Practical implications: To actualise the intent of the NEP 2020, teacher training, contextualised tools for measurement, and attention to equity in implementation are recommended. Originality/Value: The paper offers an integrated framework tying IKS-based yoga practice to student engagement and well-being while contextualising it in the framework of NEP 2020 and NCF-SE 2023.

Keywords: Indian Knowledge Systems, yoga, NEP 2020, student engagement, student well-being, holistic education, NCF-SE 2023

1. Introduction

Schools across the globe are witnessing an alarming paradox; while students are more academically challenged than ever before, they are less motivated, less attentive, and less engaged than their predecessors (Fredricks et al., 2004). The crisis of engagement and well-being is exacerbated in the Indian context where rote learning and the stress of exam culture

have discouraged exploration and diversity in learning experiences. The National Education Policy (NEP) 2020, approved by the Union Cabinet on 29 th July 2020, recognises this challenge and seeks to harness India's diverse Indian Knowledge Systems (IKS) to strengthen education (Ministry of Human Resource Development, MHRD, 2020). Among the various IKS, yoga stands out as a unique discipline that has been subject to considerable scholarly attention, particularly in databases like Scopus and Web of Science. This paper attempts to document the role of yoga – as part of IKS – in enhancing two crucial domains of education – student engagement and student well-being.

2. Literature Review and Theoretical Background

2.1 Conceptualising student engagement

While there are multiple conceptualisations of student engagement, the most influential among them is that of Fredricks et al. (2004) who propose a tripartite model comprising behavioural, emotional, and cognitive engagement. According to these authors, behavioural engagement refers to participation and persistence in academic tasks, while emotional engagement encompasses feelings of attachment to, and alienation from, school and teachers. Cognitive engagement, finally, refers to the extent to which students invest effort in learning and are committed to mastering challenging concepts. Fredricks et al. (2004) note that, unlike abilities, which are relatively stable, engagement is influenced by contextual factors.

2.2 Conceptualising student well-being

Well-being, too, is multifaceted and has been conceptualised in various ways. Ryan & Deci (2000) advance Self-Determination Theory (SDT) which views well-being as a process that emerges when individuals experience autonomy, competence, and relatedness in a socially embedded context. Similarly, Seligman's (2011) PERMA framework views well-being as comprising positive emotion, engagement, relationships, meaning, and accomplishment.

2.3 NEP 2020 and NCF-SE 2023: the institutional turn to IKS

NEP 2020 is a landmark policy that explicitly promotes inclusion of India's diverse IKS – mathematics, astronomy, philosophy, yoga, architecture, medicine, and governance – in school education and higher education (MHRD, 2020). The National Curriculum Framework for School Education, 2023 (NCF-SE 2023) (NCERT, 2023) builds on this foundation and makes Physical Education and Well-being one of the core learning areas, specifying that yoga is to be introduced in a dedicated time-table slot for promoting mind-body wellness.

2.4 Yoga: a key IKS practice

One of the most common misconceptions about yoga in school settings is that it is purely a form of physical exercise. In reality, yoga is a multi-faceted system of self-discipline that covers ethical disciplines (yama and niyama), postures (asanas), breathing techniques (pranayama), withdrawal of senses (pratyahara), and concentration (dharana and dhyana). Schools that adopt a reductive understanding of yoga as solely asanas miss out on the potential of pranayama and dharana to enhance attention and concentration as well as reduce stress and anxiety. These aspects of yoga have been subject to extensive scholarly attention

and will be reviewed in detail in the next section.

3. Research Gap and Objectives

The literature on student engagement and well-being is extensive, with multiple studies contributing to the theoretical and empirical foundations reviewed in this paper (Fredricks et al., 2004; Ryan & Deci, 2000; Seligman, 2011). In addition, the potential of school-based yoga to enhance engagement and reduce stress and anxiety has been explored in a number of studies (Ferreira-Vorkapic et al., 2015; Hagen et al., 2023; Hart et al., 2022; Khalsa & Butzer, 2016; Khunti et al., 2022; Pandey et al., 2024). However, there is a lack of systematic conceptual and empirical work linking these three areas while taking into account the specific policy environment of the NEP 2020 and NCF-SE 2023. This paper attempts to fill this gap by: (a) reviewing the literature on school-based yoga interventions, with a focus on their potential to enhance student engagement and well-being; (b) situating the findings in the context of the NEP 2020 and NCF-SE 2023; (c) developing an integrated conceptualisation of the link between IKS-based yoga practice and student engagement/well-being; (d) identifying the requirements for effectively implementing such interventions.

4. Research Methodology

This paper uses a conceptual-integrative-review approach that synthesises heterogeneous policy and scholarly literature on yoga, engagement, and well-being. The sources were identified through targeted searches in relevant databases, including policy documents (NEP 2020 and NCF-SE 2023) and scholarly articles (Annals of the New York Academy of Sciences, Frontiers in Psychology, Clinical Child Psychology and Psychiatry, Children, Journal of Emotional and Behavioral Disorders) as well as books and book chapters. Particular attention was paid to original articles and reviews published in Scopus-indexed and Web of Science-indexed journals. The sources identified were thematically analysed and synthesised to develop the current paper.

5. Findings and Discussion: Evidence on Yoga, Engagement, and Well-being in School Settings

Khalsa & Butzer's (2016) review article on yoga in pre-school to high-school settings included 47 publications, most of which were from the US and India. Of these, the authors report that the majority used randomised or quasi-experimental designs. The authors conclude that, despite methodological limitations that are almost inherent in school settings – notably the inability to conduct randomised-controlled trials due to the nature of the intervention – yoga interventions have a positive effect on self-regulation, mood, and stress reduction.

A similar conclusion was drawn by Ferreira-Vorkapic et al. (2015) who conducted a systematic review of randomised controlled trials (RCTs) of yoga interventions and found beneficial effects for mood, tension, anxiety, self-esteem, and memory. Another systematic review and narrative synthesis of RCTs of yoga and mental health by Khunti et al. (2022) reports improvements in stress, anxiety, and overall wellbeing, while noting considerable

variation in intervention components and outcome measures. Hart et al.'s (2022) scoping review of school-based yoga interventions in both neurotypical and neurodiverse populations also reports mostly positive results for cognitive and mental health outcomes, though the authors note that most studies had insufficient statistical power to identify causality.

Studies conducted in the Indian context corroborate these findings. Pandey et al. (2024) report on a two-armed RCT comparing yoga and physical exercises conducted with 200 Indian adolescents. They find that yoga helps transition the participants from clinically relevant to normal ranges on behavioural problem scales and also helps improve grades and reduce emotional and conduct problems relative to physical exercises. Giridharan & Pandiyan (2024), in a conceptual review of school-based yoga interventions, report that they help reduce stress, foster emotional awareness, and promote social interaction in adolescents while noting the importance of age appropriateness and trained instructors. Hagen et al. (2023) in their Frontiers in Psychology article on relaxation and stress in school-based yoga also report reduced levels of stress. Earlier systematic reviews of therapeutic yoga for children by Galantino et al. (2008) also report primarily positive results across a range of psychological and physiological indicators.

Taken together, these findings strongly suggest that school-based yoga interventions have the potential to enhance student engagement and well-being. Specifically, the reduction in emotional and behavioural problems reported in most of the reviewed studies can be linked to greater behavioural engagement in learning as per Fredricks et al. (2004). Similarly, the improvements in attention and focus reported by multiple reviews can be associated with cognitive engagement while the general improvement in mood can be linked to emotional engagement. According to Ryan & Deci (2000), all three facets of engagement – behavioural, emotional, cognitive – contribute to autonomy, competence, and relatedness in school, which in turn enhance well-being. These links are further supported by the finding, also reported multiple times, of reductions in stress and anxiety among students who participated in school-based yoga interventions.

That said, it is important to note that most of the reviewed studies had limitations, including small sample sizes and short intervention periods that prevented long-term follow-up. Additionally, a number of the interventions consisted of pranayama and other breathing techniques that might not be relevant to physical exercises. Moreover, as noted by Khalsa & Butzer (2016), Khunti et al. (2022), and Ferreira-Vorkapic et al. (2015), more rigorous research, including larger RCTs is needed to confirm the preliminary findings. There is also need for more research, particularly in the Indian context, on how yoga interventions fit into the broader educational ecosystem as envisioned by the NEP 2020.

6. Proposed Integrative Framework

Based on the extant literature on school-based yoga interventions, this paper proposes a three-pathway integrative framework linking IKS-based yoga to student engagement and well-being. First, through regulation of breath (pranayama), yoga reduces stress and anxiety,

facilitating emotional engagement with school life (Ferreira-Vorkapic et al., 2015; Hagen et al., 2023). Second, with regular practice, yoga helps sustain attention (dharana) and focus which facilitates cognitive engagement with the learning process (Khalsa & Butzer, 2016; Khunti et al., 2022; Pandey et al., 2024). Third, the collective, non-competitive nature of yoga, along with its emphasis on ethical and self-disciplinary aspects (yama and niyama), helps foster a sense of relatedness, competence, and belonging that enhances behavioural engagement while reducing disruptive tendencies (Giridharan & Pandiyan, 2024; Pandey et al., 2024). The framework highlights the interconnectedness of the three pathways, with physiological regulation enabling attention regulation that, in turn, supports attention regulation that, in turn, supports behavioural engagement with learning.

7. Implementation Challenges

As discussed in this paper, the implementation of the NEP 2020 faces several challenges, including inadequate teacher training, lack of appropriate assessment tools, limited resources, and conceptual ambiguities around the IKS. While yoga-based interventions have been shown to have broad benefits for student engagement and well-being, their effective implementation requires addressing these challenges. First, teachers need to be trained in appropriate yoga practices for different ages and contexts. Second, while NCF-SE 2023 identifies Physical Education and Well-being as a core learning domain, there is need to develop valid and reliable assessment tools for Indian school contexts. Third, the resource gap between private and government schools needs to be addressed to ensure equity in accessing yoga interventions. Finally, there is a need to clarify how yoga fits into the broader educational framework, as its practice as a fitness or wellness regime runs the risk of diluting its potential benefits.

8. Conclusion, Implications, and Future Scope

This paper has demonstrated the potential of IKS-based yoga to enhance student engagement and well-being, in line with the vision of the NEP 2020 and NCF-SE 2023. However, as discussed, the realisation of this vision requires addressing the multiple challenges at the implementation front. The paper highlights the need for appropriate teacher training, development of valid and reliable assessment instruments, and addressing resource gaps to ensure equity in accessing yoga interventions. Future research can focus on exploring these issues in greater detail, particularly within the Indian context and using the methodological rigor required to meet the standards of Scopus and Web of Science-indexed journals.

9. Limitations

The current paper is a conceptual-integrative-review and therefore does not present any new empirical findings. The review is limited by the methodological rigor of individual studies, most of which used relatively small samples and lacked sufficient follow-up. Moreover, as discussed, most of the reviewed studies used randomised-controlled trials that are not always feasible in school settings. Future primary studies and reviews can build on the current findings to explore the potential of school-based yoga interventions for enhancing student

engagement and well-being.

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IMPLICATIONS AND IMPLEMENTATION OF THE TEACHER–AI TEAM MODEL

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Abstract

If AI is best understood not as a tool teachers occasionally pick up but as a partner that shapes how teachers plan, decide, and think — the "teacher-AI team" idea — then teacher education programs face a different set of questions than those raised by ordinary technology training. This article works through what that shift actually implies for curriculum, faculty, assessment, and policy, and lays out a detailed, stage-by-stage implementation pathway that a teacher education institution can follow from a candidate's first semester through their first two years of teaching. The aim is to move from the idea itself to a concrete, ownable plan of action.

Introduction:

A framework is only as useful as what a program does differently because of it. The teacher-AI team idea reframes the central question from "which AI tool should a teacher learn" to "what kind of professional partnership with AI is this program actually preparing candidates for." That reframing has consequences that reach well beyond a single course — into how curriculum is sequenced, how faculty are prepared to teach it, how candidates are assessed, and how institutions govern AI use. Each of these deserves explicit treatment, because a good idea implemented as a single add-on workshop tends to produce the same shallow, one-time exposure that the idea itself argues against.

Implications

Implications for Curriculum Design

If AI shapes how lessons are planned rather than merely how fast they are produced, then AI cannot sensibly live in a single stand-alone module. It has a legitimate claim on every course where planning, assessment, or professional judgment is taught — methods courses, assessment and evaluation courses, and professional ethics courses alike. Curriculum committees need to treat AI-reflection tasks the way they already treat, say, lesson-plan formats or assessment rubrics: as a recurring thread with age-appropriate complexity across the program, not a topic covered once and considered closed.

Implications for Faculty Preparation

Teacher educators cannot guide candidates through questions of shared thinking and shared responsibility with AI if they have not worked through those questions themselves.

This implies that faculty development has to precede, or at minimum run alongside, candidate-facing implementation. A methods-course instructor asked to embed a weekly AI-reflection prompt needs enough first-hand experience with AI-assisted planning to recognize what a candidate's reflection is actually revealing, rather than treating it as a box-ticking exercise.

Implications for Assessment

Traditional lesson-plan assessment asks whether the plan is sound. Under the teacher-AI team idea, assessment also has to ask a second question: can the candidate account for which parts of the plan reflect their own pedagogical reasoning and which parts reflect AI suggestions they adopted, and can they justify that division? This is a genuinely different assessment skill — closer to source evaluation than to lesson-plan quality alone — and needs its own rubric criteria rather than being folded silently into existing ones.

Implications for Institutional Policy and Ethics

The idea of "blurred authorship" is not just a classroom teaching problem; it is an institutional one. If a candidate submits an assignment substantially shaped by AI, existing academic-integrity policy — built around a binary of a student's own work versus plagiarism — often does not have a clear category for it. Institutions adopting the teacher-AI team framing need policy language that distinguishes disclosed, reflective AI use (which the framework treats as a skill to be practiced) from undisclosed AI use presented as the candidate's independent work (which remains an integrity violation).

Implications for Research and Evaluation

Because the claim being made is about identity and professional judgment, not just skill acquisition, evaluating whether the approach is working requires more than a satisfaction survey after a workshop. Programs adopting this approach should plan, from the outset, to track candidates' weekly reflection logs and practicum supervisor observations over time, so that any claimed shift in professional judgment is grounded in evidence gathered across the program rather than asserted from a single end-of-course reflection.

Implementation: A Stage-by-Stage Pathway

The table below sequences the four-step plan across a candidate's full trajectory — from the first weeks of the program through the first two years of independent teaching — and assigns institutional ownership for each stage, since a step without an owner tends not to survive beyond a single pilot semester.

Stage	Timeframe	Core Activity	Institutional Owner

Step 1	First-year foundation course, Weeks 1–4	Introduce the teacher–AI team idea; candidates draft one lesson activity with AI and note what the AI decided unprompted.	Course instructor, first-year foundation course
Step 2	Throughout the program, every semester	Embed short AI-reflection tasks inside methods, assessment, and ethics courses rather than a single stand-alone module.	All course instructors, coordinated by curriculum committee
Step 3	Practicum / internship period	Weekly log: "What did I decide, and what did the AI decide, this week?", reviewed by the practicum supervisor.	Practicum supervisors, mentor teachers
Step 4	First two years post-graduation	Short refresher sessions on AI use in teaching, offered as continuing professional development.	Alumni/induction cell, teacher education institution

Step 1 in Practice: Naming the Idea Early

In the first education course a candidate takes, the teacher-AI team idea is introduced directly and concretely, not as an abstract framework but through a short, hands-on exercise: candidates use an AI tool to draft one classroom activity, then write two sentences identifying a decision the AI made that they had not explicitly asked for. This small exercise does the conceptual work of the whole framework in miniature — it makes the otherwise invisible fact of AI's influence on planning visible to a first-semester candidate before habits have formed.

Step 2 in Practice: Distributing It Across the Curriculum

Rather than a single AI-in-education course, short reflection tasks are written into the existing syllabi of methods, assessment, and ethics courses, coordinated by the curriculum committee so that the tasks build on one another rather than repeating the same exercise in different courses. A methods course might ask candidates to compare an AI-drafted and a self-drafted lesson plan; an assessment course might ask them to evaluate whether AI-suggested rubric criteria match the learning objectives; an ethics course might return to the authorship question directly.

Step 3 in Practice: Making Shared Responsibility a Habit

During practicum placements, candidates keep a short weekly log answering a single, consistent question: what did I decide this week, and what did the AI decide? Practicum supervisors review the log alongside the usual lesson observations, treating it as one more data point on the candidate's developing professional judgment rather than a separate compliance task. The habit of noticing, repeated weekly across an extended placement, is what is expected to produce durable change, rather than a one-time reflective essay.

Step 4 in Practice: Extending Support Beyond Graduation

Short refresher sessions are offered during a graduate's first two years of teaching, coordinated through the institution's alumni or induction cell. These sessions treat pre-service training as a starting point rather than a finish line, recognizing that a new teacher's relationship with AI tools will keep evolving once they are managing their own classroom without a supervising mentor checking their weekly log.

Anticipated Challenges and How the Pathway Addresses Them

- Faculty unfamiliarity with AI tools — addressed by sequencing faculty development ahead of candidate-facing rollout (Section 2.2), rather than assuming instructors can guide reflection tasks without first-hand AI experience.
- Assessment ambiguity around AI-assisted work — addressed by developing explicit rubric criteria for accounting for AI's role in an assignment, distinct from criteria for the assignment's pedagogical quality (Section 2.3).
- Risk of the approach becoming a paperwork exercise — addressed by keeping each reflection task short and consistent (a fixed weekly question during practicum, two sentences at the outset) rather than lengthy, so it can be sustained across a full program without fatigue.
- Loss of momentum after graduation — addressed by explicitly extending ownership to an induction/alumni function for the first two years of teaching, rather than treating pre-service training as sufficient on its own.

Conclusion

Treating AI as a partner rather than a tool changes what a teacher education program has to do, not just what it has to teach. The implications reach into curriculum sequencing, faculty preparation, assessment design, institutional policy, and ongoing evaluation; the implementation pathway translates those implications into four concrete, owned stages running from a candidate's first weeks in the program through their first two years in the classroom. Programs that adopt only the idea, without also working through these implications and committing to a staged implementation with clear institutional ownership, are likely to see the same shallow, one-time engagement that the teacher-AI team framing was proposed to move beyond.

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PLANNING AI TRAINING FOR EVERY TEACHER EDUCATION PROGRAM

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Abstract

AI training for teachers looks very different depending on where in the world a teacher is training. A teacher in a well-funded city program may get months of structured AI training. A teacher in an under-resourced region may get none at all, yet is still expected to keep up. This paper presents a simple, practical idea: instead of one AI training plan for everyone, teacher education programs should choose from three clear "tracks" based on their actual resources, and every track should still teach the same core thinking skill. The paper explains the idea in everyday language, shows how to put it into practice, and states clearly what this contributes that generic "teach AI literacy" advice does not.

Keywords: *AI literacy, teacher education, equity, professional development, global education policy*

Introduction

Almost every education conference now includes a call for "AI literacy" in teacher training. This is good advice, but it is often too general to actually use. A program with strong technology infrastructure and a program with almost none are told the same thing: "build AI literacy." In practice, these two programs cannot do the same thing, and pretending they can leaves the less-resourced program behind.

Research backs this up. A study of K-12 teachers found that many were shaping their own use of AI with little formal support, often in settings with real constraints on access and guidance (Sharma, 2025). Meanwhile, a structured training program in Germany showed that sustained, well-resourced training produces real, measurable change in how teachers use AI and how they feel about it (teacher training and AI literacy study, 2025). The gap between these two pictures is the problem this paper addresses.

The Problem with One-Size-Fits-All Advice

Generic AI literacy advice causes three practical problems:

- It assumes every program has the same access to devices, internet, and trainers, which is simply not true.
- It focuses on tool-specific skills that change every year, instead of a stable thinking skill that lasts.

- It does not say what to do differently depending on how much AI is actually being used by teachers in a given system, whether it is a fully personalized AI tutor or a basic AI chatbot.

A comparative study of AI use in Chinese university courses shows why this matters: different ways of using AI produced different results, some improved technical skills but increased workload, others improved access but required more teacher effort per student (constructivist case study of AI-integrated general education, 2025). This tells us there is no single "correct" way to use AI — the right approach depends on context and goals.

The New Idea: Three Tracks, One Shared Core Skill

Instead of one plan for every program, this paper proposes three tracks that programs can choose based on their real resources. All three tracks teach the same core skill: the habit of checking AI output before trusting it. What differs is how much technology-specific training is layered on top.

Track A — Foundation Track (limited infrastructure)

For programs with limited devices or internet access. Focus is on basic, low-cost AI tools that expand access to information, since research shows this kind of access is one of AI's clearest, most achievable benefits even with modest infrastructure (empowerment of ideological and political education through generative AI, 2026).

Track B — Applied Track (moderate infrastructure)

For programs with reasonable but not extensive resources. Focus is on using AI for everyday classroom tasks such as drafting practice questions and feedback, while explicitly teaching that this shifts teacher effort toward reviewing and correcting AI-generated feedback and personalized suggestions, rather than eliminating teacher labor (empowerment of ideological and political education through generative AI, 2026).

Track C — Advanced Track (strong infrastructure)

For programs with strong resources and dedicated technology staff. Focus is on sustained, multi-session training of the kind shown to change both skill and attitude over time (teacher training and AI literacy study, 2025), plus practice designing and comparing different AI-integration approaches, similar to the four-model comparison found in recent classroom research (constructivist case study of AI-integrated general education, 2025).

Turning the Idea into Practice: An Implementation Plan

Programs can adopt this three-track model in four simple steps.

Step 1 — Take Honest Stock of Resources

Before choosing a track, program leaders answer three plain questions: Do all candidates have reliable internet access? Is there a trainer who can run more than one session? Do partner schools already use AI tools candidates will encounter?

Step 2 — Choose a Track, not a Tool List

Pick Track A, B, or C based on honest answers to Step 1. Avoid choosing a track based on what sounds impressive; a well-run Foundation Track is more useful to candidates than a

poorly resourced attempt at an Advanced Track.

Step 3 — Teach the Shared Core Skill First, Regardless of Track

Every track begins with the same short unit: how to check an AI-generated answer for accuracy, bias, or missing context. This is the one skill research suggests stays useful even as specific tools change.

Step 4 — Review and Move Tracks Over Time

Resources change. A program should reassess its track every one to two years and move up a track as infrastructure and support improve, rather than treating the initial choice as permanent.

What This Approach Contributes

This paper's contribution is a way to make "teach AI literacy" advice actually usable across very different teacher education settings. Compared to generic literacy calls, this approach contributes:

- A resource-honest framework (three tracks) so programs are not held to a standard they cannot realistically meet.
- A shared core skill that keeps all tracks connected to the same underlying goal, so equity does not mean lowering the bar, only changing the path to reach it.
- A concrete four-step process programs can start using immediately, grounded in findings from real studies across different national and resource contexts.

In short, this paper shifts the conversation from "teach AI literacy" as a single universal instruction to "choose the right track and build the same core habit," giving programs with very different resources a fair and realistic way to prepare their teachers.

Conclusion

Fair AI training does not mean identical AI training. It means every teacher education program, regardless of resources, builds the same core habit of checking and questioning AI output, through a path that matches what the program can realistically offer. The three-track model in this paper gives conference attendees and program leaders a simple, evidence-based, and immediately usable way to make AI training in teacher education both practical and fair.

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ARTIFICIAL INTELLIGENCE IN EDUCATION: SHAPING SMART TEACHERS FOR A SMART FUTURE

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Abstract

Artificial Intelligence (AI) is increasingly influencing how educational content is created, delivered, assessed and personalised. Its rapid development, particularly in generative AI, has created new possibilities for teachers while simultaneously raising concerns related to accuracy, ethics, privacy, professional autonomy and equity. Although considerable research has examined AI applications for student learning, comparatively less attention has been given to the competencies teachers require to use AI meaningfully and responsibly. This paper examines the foundations and emerging trends of Artificial Intelligence in Education (AIED), with particular emphasis on the transformation of teacher roles. A conceptual review of recent literature is used to identify major developments in AIED and the corresponding competencies required by teachers. The analysis indicates that the educational significance of AI is shifting from automation of isolated tasks towards collaborative human-AI systems in which teachers retain pedagogical and ethical responsibility. Based on the synthesis, this paper proposes the SMART Teacher Framework, comprising five dimensions: Systems understanding, Meaningful pedagogical integration, Assessment and critical verification, Responsible and ethical practice, and Transformation through continuous learning. The framework positions teachers not as passive users of AI tools but as informed decision-makers who determine when and how AI should contribute to learning. The paper argues that the future of AI in education depends not primarily on technological sophistication but on the development of teachers capable of combining technological understanding with pedagogical judgement, ethical reasoning and human-centred educational values.

Keywords: Artificial Intelligence in Education, AI literacy, teacher competency, generative AI, smart teachers, teacher professional development, educational technology

Introduction:

Artificial Intelligence has become one of the most influential technological developments affecting contemporary education. Earlier applications of AI in education included intelligent tutoring systems, adaptive learning platforms, automated assessment and learning analytics. More recent advances in generative AI have expanded this landscape by enabling systems to generate explanations, questions, lesson materials, feedback and other forms of educational content. The rapid expansion of these technologies has changed the nature of the conversation surrounding educational technology. The question is no longer whether AI will enter education, but how educational institutions and teachers should respond to its presence. A 2024 systematic literature review describes AIED as a rapidly expanding field encompassing diverse applications and research approaches. Similarly, research in K–12 education identifies intelligent tutors, chatbots, educational games, robots and AI-supported learning environments among the major applications of AI However, technological availability does

not automatically result in pedagogical improvement. Díaz and Nussbaum (2024) found that many applications of AI in school education continue to follow established pedagogical approaches rather than producing fundamentally new forms of teaching and learning. This observation highlights an important issue: the effectiveness of AI depends not only on what an AI system can perform, but also on the professional decisions made by teachers.

Teachers therefore occupy a critical position in the transition towards AI-enabled education. They must understand AI sufficiently to evaluate its outputs, integrate it with learning objectives, recognise its limitations and protect students from inappropriate uses. The development of the smart teacher should consequently be understood as a process of strengthening human professional capability through responsible interaction with AI.

Foundations of Artificial Intelligence in Education: The foundations of AIED can be traced through several interconnected developments.

- **Intelligent Tutoring and Adaptive Learning:** Intelligent tutoring systems represent an early foundation of AI-enabled education. These systems attempt to provide learners with personalised guidance based on their responses and performance. Adaptive learning environments extend this principle by modifying learning pathways, content or difficulty according to learner needs.

The significance of these systems lies in their capacity to support differentiated learning. A teacher working with a large and diverse classroom may find it difficult to provide individually customised practice to every learner. AI can analyse patterns in learner interaction and assist in identifying areas requiring additional support.

Nevertheless, adaptation based solely on measurable learner behaviour has limitations. Learning is influenced by motivation, social relationships, language, prior experience and context. These dimensions cannot always be captured adequately by an algorithm. Consequently, AI-based personalisation should complement rather than replace teacher understanding.

- **Learning Analytics and Predictive AI:** Learning analytics enables educational data to be examined for patterns related to participation, performance and learning behaviour. Predictive systems may assist institutions and teachers in identifying learners who could require additional intervention.

The educational benefit is potentially significant because intervention can become more timely. However, predictions should not be interpreted as definitive judgements about students. A prediction generated from historical data may reproduce biases or overlook contextual circumstances.

Human interpretation therefore remains essential. Teachers should use AI-generated information as evidence for professional inquiry rather than as an unquestionable decision.

- **Automated Assessment and Feedback:** AI can support the creation of assessment questions, preliminary feedback, response analysis and formative evaluation. Such

applications can reduce repetitive workload and potentially provide learners with quicker feedback.

However, assessment is not merely a technical process of matching answers with predetermined criteria. Evaluating creativity, reasoning, originality, communication and contextual understanding requires professional judgement. AI may assist the assessment process, but responsibility for consequential educational decisions should remain with educators.

- **Generative AI:** Generative AI marks an important transition because AI systems can now participate directly in content creation. Teachers can use generative systems to develop lesson ideas, examples, differentiated activities, question banks and alternative explanations.

At the same time, generative AI can produce inaccurate or fabricated information and may reproduce biases contained within its training data. Kasneci et al. identify both substantial educational opportunities and significant challenges associated with large language models.

The emergence of generative AI therefore increases, rather than reduces, the importance of teacher expertise. When information can be generated instantly, the teacher's role increasingly involves determining whether that information is accurate, relevant and educationally appropriate.

Emerging Trends in AI and Education:

- **From Automation to Augmentation:** A major trend is the movement from AI as an automation mechanism towards AI as a collaborative support system. Earlier educational technologies often aimed to automate specific activities. Contemporary AI can assist with multiple stages of a teacher's workflow, including planning, content creation, differentiation, assessment and reflection.

This suggests a shift from the idea of AI replacing teacher tasks towards AI augmenting teacher capacity. Recent research on AI and teacher professional development similarly identifies teacher agency as an important feature of effective AI-supported professional learning

- **Pedagogically Grounded AI:** The rapid development of AI tools has sometimes preceded sufficient consideration of pedagogy. Díaz and Nussbaum (2024) found that AI applications in school education frequently reproduce existing pedagogical approaches and argued for greater attention to pedagogical foundations.

This creates an important principle for smart teachers: technology should be selected because it improves a learning process, not because the technology itself is innovative.

An AI application that generates twenty questions in seconds may be less educationally valuable than a simple activity that develops deeper reasoning. The teacher must therefore begin with the learning objective and determine whether AI genuinely adds value.

- **AI Literacy for Teachers:** AI literacy is becoming an important component of professional competence. Teacher AI literacy should extend beyond knowing how to

operate an AI tool. It should include understanding basic AI concepts, recognising limitations, evaluating outputs, considering ethical implications and making informed pedagogical decisions.

A 2024 scoping review found that AI literacy remains insufficiently developed within teacher education research and highlighted the need for greater attention to teachers' practical and ethical knowledge.

Thus, teacher preparation must move from tool training towards AI judgement.

- **AI-Supported Professional Development:** AI is increasingly being explored not only as a classroom technology but also as a means of supporting teacher professional development. A systematic review of research from 2015 to 2024 found that research on AI in teaching substantially outweighed research examining AI's role in teacher professional development, revealing an important gap.

This suggests that future professional development should provide teachers with opportunities to experiment with AI, analyse its outputs, discuss ethical cases and reflect on classroom applications rather than simply learn the features of individual tools.

- **Human-Centred and Trustworthy AI:** Another emerging trend is the movement towards human-centred AI. Educational AI systems affect students and teachers directly, making issues of privacy, agency, transparency, reliability and trust particularly important. Research on human-centred learning analytics and AIED highlights concerns about data privacy and the exclusion of teachers and learners from system design.

Therefore, AI implementation should not be evaluated only by efficiency or accuracy. It should also be evaluated according to whether it preserves human agency and supports educational values.

Research Gap: Existing literature provides extensive discussion of AI applications, AI literacy, generative AI and ethical challenges. However, three gaps remain particularly relevant. First, technological research often progresses faster than pedagogical research. The availability of sophisticated tools does not necessarily establish how teachers should integrate them into curriculum and instruction. Second, research has historically focused more heavily on AI applications for students than on the development of teachers as AI-capable professionals. Recent systematic reviews continue to identify teacher professional development as an area requiring greater research attention. Third, teacher AI competency is frequently discussed as a collection of technical, ethical and pedagogical skills without sufficiently emphasising how these capabilities operate together during actual professional decision-making. This paper addresses these gaps by proposing an integrated conceptual framework that treats AI readiness as a professional decision-making capability, rather than merely a technological skill.

The Smart Teacher Framework:

Based on the synthesis of the reviewed literature, this paper proposes the SMART Teacher

Framework for developing AI-ready educators.

- **S – Systems Understanding:** Teachers require foundational understanding of how AI systems work, including concepts such as data, algorithms, machine learning, generative AI and model limitations.

  The objective is not to turn teachers into programmers. Instead, teachers should possess enough conceptual understanding to question AI outputs and make informed choices.
- **M – Meaningful Pedagogical Integration:** AI should be connected to curriculum objectives, learner needs and appropriate pedagogical approaches.

  Teachers should ask:

  • What learning objective does AI support?
  • Does AI improve the learning experience?
  • What should remain a human-led activity?
  • Is AI appropriate for this particular learner or context?

This dimension places pedagogy before technology.

- **A – Assessment and Critical Verification:** AI-generated information must be critically examined. Teachers need to verify factual accuracy, detect bias, recognise fabricated information and evaluate whether generated materials are developmentally and academically appropriate.

The teacher consequently becomes a critical verifier of AI-generated knowledge.

- **R – Responsible and Ethical Practice:** Teachers must understand issues involving privacy, data protection, bias, intellectual property, academic integrity, transparency and equitable access.

Responsible AI use also requires maintaining student agency. Learners should not become dependent on AI for thinking, writing or problem-solving.

- **T – Transformation through Continuous Learning:** AI technologies will continue to evolve. Therefore, AI competence cannot be achieved through a single training programme.

  Teachers require continuous professional learning involving experimentation, peer collaboration, reflection and updating of knowledge. The objective is not permanent mastery of particular tools but the development of an adaptive professional mindset.

The framework can therefore be represented as:

Systems Understanding → Meaningful Integration → Critical Verification → Responsible Practice → Continuous Transformation

The five dimensions are interconnected. Technical understanding without pedagogy may result in inappropriate use; pedagogy without AI literacy may result in ineffective implementation; and both without ethical awareness may create risks for learners.

Implications for Teacher Education:

The development of smart teachers requires changes in teacher education and professional

development.

First, AI literacy should become an integrated component of teacher preparation rather than an optional technology workshop.

Second, professional development should use authentic classroom problems. Teachers could evaluate AI-generated lesson plans, compare AI and teacher-created assessments, examine biased outputs and design activities where AI is deliberately used or deliberately excluded.

Third, institutions should develop clear AI-use policies. Teachers require guidance on acceptable classroom use, student data protection, assessment integrity and responsible use of generative AI.

Fourth, professional development should emphasise teacher agency. Recent research indicates that effective AI-supported teacher development can position teachers as active leaders in interactions with AI rather than passive recipients of automated recommendations

Finally, AI implementation should be evaluated through educational outcomes rather than technological adoption alone. The relevant question is not how many teachers use AI, but whether its use improves teaching quality, learner engagement, inclusion and meaningful learning.

Challenges and Limitations:

The integration of AI into education involves several challenges. Unequal access to technology may deepen existing educational inequalities. Inadequate teacher preparation may encourage either excessive dependence on AI or unnecessary resistance to useful applications.

Accuracy is another concern. Generative systems may produce plausible but incorrect information, requiring systematic verification. Ethical issues involving privacy, intellectual property and student data require institutional safeguards.

There is also a risk of reducing teaching to measurable and predictable processes. Education involves relationships, empathy, cultural understanding, motivation and moral development—dimensions that cannot be reduced entirely to algorithmic optimisation.

A further limitation of the present paper is methodological. It is a conceptual literature-based paper and does not report primary empirical data from teachers or schools. The proposed SMART Teacher Framework therefore requires future empirical validation across different educational levels, subjects and cultural contexts.

Discussion: The foundations and trends examined in this paper indicate that AI is changing the nature of teachers' work rather than simply introducing another classroom technology.

The teacher of the future will increasingly operate in a hybrid environment in which human and artificial intelligence coexist. AI may generate alternatives, analyse patterns and automate repetitive processes, while teachers interpret context, exercise judgement and establish meaningful relationships with learners.

This makes professional judgement more—not less—important.

The central educational challenge is therefore to prevent AI integration from becoming technology-driven. AI should be introduced through a clear understanding of educational purpose. The teacher must remain responsible for deciding what students should learn, why they should learn it, how learning should be assessed and which forms of AI assistance are appropriate. The concept of the smart teacher should consequently represent augmented professional intelligence, rather than technological dependence. A smart teacher does not accept an AI response simply because it is generated quickly. Instead, the teacher questions,

verifies, adapts and contextualises it. This human-AI partnership has the potential to reduce repetitive workload while allowing teachers to concentrate on activities that require professional judgement and human connection.

Conclusion: Artificial Intelligence is becoming a significant foundation of the emerging educational ecosystem. Its development from intelligent tutoring systems and adaptive learning to generative AI represents a substantial technological transition. Yet the educational significance of this transition will ultimately depend on how teachers respond to it.

The central argument of this paper is that the future of AI in education should be built around teacher capability rather than technological capability alone. Teachers need more than operational knowledge of AI tools. They require an integrated combination of technological understanding, pedagogical judgement, critical verification, ethical responsibility and continuous professional learning. The SMART Teacher Framework proposed in this paper provides a conceptual structure for this development: Systems Understanding, Meaningful Pedagogical Integration, Assessment and Critical Verification, Responsible and Ethical Practice, and Transformation through Continuous Learning. The framework shifts the focus from asking whether teachers can use AI to asking whether teachers can use AI wisely.

AI can generate content, identify patterns and support decisions, but education remains a human enterprise. The future of smart education will therefore not be determined by the replacement of teachers with intelligent machines. It will be determined by the ability of teachers to combine human professional wisdom with the emerging capabilities of artificial intelligence.

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ARTIFICIAL INTELLIGENCE-ASSISTED TEACHING AND CONCEPTUAL UNDERSTANDING AMONG STUDENTS: A CONCEPTUAL PERSPECTIVE

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Abstract

Artificial Intelligence (AI) is increasingly influencing education by supporting personalized learning, intelligent tutoring, adaptive learning environments, automated feedback, interactive learning resources, and data-informed instructional decisions. The growing use of AI in schools, pre-university institutions, and colleges has created new possibilities for improving the quality and depth of student learning. However, meaningful learning cannot be understood only in terms of examination scores or the ability to recall information. Conceptual understanding is a deeper learning outcome that involves explaining concepts in one's own words, identifying relationships, applying principles, interpreting representations, analysing situations, justifying reasoning, and transferring knowledge to unfamiliar contexts. The present conceptual paper examines the possible relationship between AI-assisted teaching and students' conceptual understanding, with particular reference to mathematics education. AI-supported learning environments can potentially strengthen conceptual understanding by providing individualized explanations, immediate feedback, adaptive questions, multiple representations, examples, simulations, and opportunities for repeated practice. At the same time, effective use of AI depends on teacher mediation, appropriate pedagogical design, students' digital literacy, access to technology, and responsible use. The paper proposes a conceptual framework in which AI-assisted teaching influences student engagement and meaningful learning, which in turn may contribute to conceptual understanding. It also identifies research questions, hypotheses, a possible quantitative methodology, educational implications, and major challenges associated with AI-assisted teaching. The paper argues that AI should be positioned as a pedagogical support system rather than a replacement for teachers. In mathematics education, teacher-guided AI use may help students connect procedural knowledge with conceptual knowledge and explore mathematical ideas through multiple representations. The paper concludes that empirical research is needed to examine the extent to which AI-assisted teaching contributes to conceptual understanding and how its effectiveness is influenced by learning motivation, retention, teacher competence, and contextual factors.

Keywords: Artificial Intelligence, AI-assisted teaching, conceptual understanding, mathematics education, personalized learning, adaptive learning, educational technology.

Introduction

Education is undergoing a substantial transformation as digital technologies become increasingly integrated into teaching and learning. Artificial Intelligence (AI) has emerged as one of the most influential developments because it can process information, identify patterns, generate responses, personalize learning activities, and provide rapid feedback.

These capabilities have created opportunities to reconsider how students learn and how teachers design instruction. Rather than treating AI simply as a technological innovation, contemporary education requires examination of its pedagogical value and its contribution to meaningful learning. Students in the same classroom do not necessarily begin with identical prior knowledge, learning pace, interests, or difficulties. Conventional whole-class instruction may therefore provide limited opportunities for continuous individualized support. AI-supported systems can potentially respond to differences among learners by adjusting explanations, questions, examples, and learning pathways. Such flexibility is particularly relevant to subjects in which students develop misconceptions or require repeated opportunities to connect new ideas with prior knowledge. Conceptual understanding is an important indicator of meaningful learning. Students may memorize definitions, formulas, or procedures and still experience difficulty when asked to explain why a method works, apply an idea in an unfamiliar context, or connect one representation with another. Bransford et al. (2000) emphasized understanding and transfer rather than the accumulation of facts. Mayer (2009) similarly highlighted meaningful cognitive processing in multimedia learning. In mathematics, this distinction between procedural performance and conceptual understanding is especially significant. The increasing availability of AI-based educational tools therefore raises an important research question: Can AI-assisted teaching contribute to students' conceptual understanding when it is integrated with sound pedagogy and guided by teachers? The present paper addresses this question from a conceptual perspective and proposes a framework for examining the relationship empirically.

Conceptual Understanding

Conceptual understanding refers to a learner's meaningful grasp of ideas, relationships, principles, and structures rather than simple recall of isolated information. A student who demonstrates conceptual understanding can explain an idea in their own words, recognize relationships among concepts, use different representations, apply knowledge to new situations, justify reasoning, and transfer learning across contexts. Conceptual knowledge becomes particularly valuable when learners encounter problems that cannot be solved by reproducing a memorized procedure. In mathematics education, conceptual understanding includes knowing what a mathematical concept means, why a procedure works, how concepts are related, and when a particular method is appropriate. For example, understanding a quadratic equation should involve more than remembering a formula. Students should be able to interpret roots, connect algebraic and graphical representations, compare solution methods, and apply the concept to appropriate situations. Such learning can support flexible problem solving and long-term knowledge development. Conceptual understanding is closely connected with meaningful learning because learners must organize new knowledge and connect it with existing cognitive structures. Consequently, instructional environments should provide opportunities for explanation, representation, application, questioning, feedback, and reflection.

Artificial Intelligence-Assisted Teaching

AI-assisted teaching refers to the purposeful use of AI-based technologies to support instructional planning, learning activities, feedback, assessment, and individualized student support. Examples include intelligent tutoring systems, adaptive learning platforms, conversational AI, educational chatbots, automated feedback systems, AI-supported assessment, recommendation systems, simulations, and visualization tools. AI can potentially analyse patterns in student responses and provide resources suited to identified learning needs. A student who repeatedly makes errors in a mathematical topic, for instance, may receive additional examples, hints, alternative explanations, or simpler prerequisite questions. The teacher can then use information from the learning process to identify areas for intervention. This combination of technological assistance and professional judgment is important because AIgenerated content may not always be accurate, appropriate, or aligned with curriculum requirements. UNESCO (2023) emphasizes human-centred, safe, equitable, and responsible use of generative AI in education and research. Accordingly, AI-assisted teaching should be embedded within a clear pedagogical purpose rather than introduced merely because the technology is available.

Relationship between AI-Assisted Teaching and Conceptual Understanding

AI-assisted teaching may influence conceptual understanding through several complementary mechanisms. First, personalized learning can provide students with explanations and activities suited to their level of prior knowledge. Second, immediate feedback can help learners identify errors and reconsider misconceptions. Third, AI can support multiple representations such as text, diagrams, graphs, examples, and simulations. Fourth, adaptive questioning can encourage students to explain, compare, predict, justify, apply, and analyse rather than simply recall. Finally, AIsupported systems may provide additional opportunities for practice and individualized assistance. These mechanisms are consistent with the broader view that learning is strengthened when students actively construct and organize knowledge. Vygotsky (1978) emphasized mediated learning and social interaction, suggesting that learning develops through guided activity. AI cannot replace the social and pedagogical role of the teacher, but it can provide additional mediated support when used appropriately. The relationship should therefore not be interpreted as a simple direct effect in which more AI automatically produces better understanding. The quality of AI use, instructional design, student engagement, teacher competence, prior knowledge, and access to technology are likely to influence outcomes.

AI and Mathematical Conceptual Understanding

Mathematics provides a particularly relevant context for investigating AI-assisted conceptual learning. Students frequently experience difficulty when they know a procedure but cannot explain the mathematical reasoning behind it. AI can be used to shift attention from answer production toward reasoning by asking students to explain their steps, compare alternative approaches, identify errors, and connect symbolic representations with graphs, tables,

diagrams, and real-world contexts. For example, in learning quadratic equations, an AI-supported activity could ask students to explain the meaning of roots, examine the relationship between roots and coefficients, connect an equation with its graph, compare factorization and formula-based approaches, and apply the concept to a contextual problem. In such an environment, AI becomes a source of questions, examples, hints, and representations while the teacher remains responsible for instructional judgment and evaluation. The potential contribution of AI to mathematics learning is therefore not simply faster problem solving. Its educational value may be greater when it encourages students to reason, explain, represent, connect, and transfer mathematical ideas.

Proposed Conceptual Framework

The proposed framework suggests that AI-assisted teaching can provide several pedagogical supports—personalized learning, immediate feedback, adaptive questioning, multiple representations, interactive activities, and individualized assistance. These supports may enhance student engagement and meaningful learning, which may subsequently contribute to conceptual understanding. The framework also recognizes contextual factors that may strengthen or weaken the relationship. Teacher competence, student digital literacy, availability of technology, quality of AI-generated content, prior knowledge, pedagogical design, and ethical use should be considered when interpreting outcomes.

Proposed relationship: AI-Assisted Teaching → Personalized Learning, Immediate Feedback, Adaptive Questioning, Multiple Representations, and Individualized Support → Student Engagement and Meaningful Learning → Conceptual Understanding.

Research Questions

1. What is the level of students' conceptual understanding when AI-assisted teaching is used?
2. Is there a significant relationship between AI-assisted teaching and students' conceptual understanding?
3. Does AI-assisted teaching significantly improve conceptual understanding compared with conventional teaching?
4. Does the effectiveness of AI-assisted teaching differ according to students' academic background?
5. What role does student engagement play in AI-assisted learning?
6. Does teacher-guided AI use produce better conceptual learning than unguided AI use?

Proposed Hypotheses

$H_0$1: There is no significant relationship between the use of AI-assisted teaching and students' conceptual understanding.

$H_1$1: There is a significant positive relationship between the use of AI-assisted teaching and students' conceptual understanding.

$H_0$2: There is no significant difference in conceptual understanding between students taught through AI-assisted teaching and students taught through conventional teaching.

$H_1$2: Students taught through AI-assisted teaching demonstrate significantly higher

conceptual understanding than students taught through conventional teaching.

Suggested Research Methodology

A future empirical study may adopt a quantitative correlational or quasi-experimental design. The population may consist of secondary, pre-university, or college students in Karnataka. An appropriate sample may be selected from government and private institutions using a suitable sampling technique.

The independent variable may be operationalized as AI-assisted teaching, while conceptual understanding may be measured through a researcher-developed or standardized test. The test may assess concept identification, explanation, representation, application, analysis, problem solving, justification, and transfer. Additional variables such as learning motivation, retention, prior achievement, academic stream, and access to digital resources may also be examined.

Descriptive and inferential statistics may include mean, standard deviation, independent-samples t test, analysis of variance, Pearson's correlation, regression analysis, and effect size, depending on the research design and assumptions. Reliability and validity evidence should be established before the instrument is used for the main study.

Role of the Teacher in AI-Assisted Teaching

The teacher remains central to effective AI-assisted teaching. Teachers should select appropriate tools, establish learning objectives, verify AI-generated information, design activities, monitor student reasoning, identify misconceptions, and provide human interaction. Students should be encouraged to question AI responses rather than accept them uncritically.

AI literacy should therefore become part of teacher professional development. Teachers need to understand both the possibilities and limitations of AI, including issues of accuracy, bias, privacy, academic integrity, and responsible use. The most appropriate educational model is not AI instead of the teacher, but teacher, student, and AI working within a pedagogically purposeful environment.

Challenges of AI-Assisted Teaching

Several challenges must be considered. AI-generated information can contain errors, and students may not possess sufficient knowledge to detect them. Unequal access to devices and connectivity can increase educational disparities. Overdependence on AI may reduce opportunities for independent reasoning if students use it primarily to obtain answers. Academic integrity is another concern when AI is used to complete academic work without genuine engagement.

Teachers may also require professional development to integrate AI effectively. In addition, student data and interactions with AI systems raise concerns about privacy, security, transparency, and ethical governance. These challenges indicate that responsible implementation requires institutional policies, teacher preparation, student guidance, and continuous evaluation.

Educational Implications

For teachers, the framework highlights the importance of AI literacy and pedagogical integration. For students, AI should be presented as a learning support that promotes questioning, explanation, exploration, and reflection. Educational institutions should provide adequate infrastructure, professional development, and responsible-use guidelines.

Teacher education programmes should incorporate AI-supported pedagogy, digital ethics, evaluation of AI-generated information, and strategies for maintaining student agency. Researchers should investigate not only academic achievement but also conceptual understanding, retention, learning motivation, engagement, critical thinking, and transfer of learning.

Connection with the Researcher's Ph.D. Study

The present paper is closely connected with the researcher's broader focus on mathematical learning motivation, mathematical conceptual understanding, and retention among pre-university students in Karnataka. AI-assisted teaching provides a contemporary instructional context through which conceptual understanding can be examined.

Future empirical research may investigate a broader pathway such as AI-assisted teaching → learning motivation → conceptual understanding → retention. Such a model may help determine whether technology-supported instruction influences students' motivation to learn mathematics, their depth of conceptual understanding, and their ability to retain mathematical knowledge over time.

Conclusion

Artificial Intelligence offers significant possibilities for supporting teaching and learning, particularly through personalization, immediate feedback, adaptive questioning, multiple representations, and individualized assistance. These capabilities may contribute to conceptual understanding when they are integrated with meaningful pedagogical activities.

Nevertheless, AI should not be regarded as an automatic solution to learning difficulties. The effectiveness of AI-assisted teaching depends on teacher competence, instructional design, student engagement, digital access, prior knowledge, and responsible use. In mathematics education, the strongest potential lies in using AI to encourage students to explain, represent, connect, reason, and apply mathematical ideas rather than merely generate answers.

The proposed conceptual framework provides a basis for future empirical investigation. Research using correlational and quasi-experimental methods can help establish the nature and strength of the relationship between AI-assisted teaching and conceptual understanding. Further studies should also consider learning motivation and retention so that the educational value of AI can be examined from a broader perspective of meaningful and sustained learning.

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AI-ASSISTED PERSONALISED LEARNING AND SCIENCE ACHIEVEMENT: A QUASI-EXPERIMENTAL STUDY OF GRAVITATION AMONG GRADE IX RESIDENTIAL SCHOOL STUDENTS

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Abstract

Artificial Intelligence (AI)-assisted personalised learning is increasingly being explored as a means of adapting educational experiences to learners' individual needs, learning pace, prior knowledge, and difficulties. However empirical evidence concerning its application to specific science concepts at the secondary-school level remains comparatively limited. The present study investigated the effectiveness of an AI-assisted personalised learning approach in improving Grade IX students' achievement in the science unit Gravitation. A quasi-experimental pre-test–post-test control-group design was adopted. The illustrative sample consisted of 70 Grade IX students, with 35 students assigned to an experimental group and 35 to a comparison group, drawn from residential-school settings in Shikaripura. A researcher-developed 40-item Gravitation Achievement Test was used as the achievement measure. The experimental group received AI-assisted personalised learning involving differentiated explanations, adaptive questioning, immediate feedback, remedial activities, and enrichment tasks, are illustrative and must be replaced with verified empirical data before publication.

Keywords: *Artificial Intelligence, personalised learning, science achievement, Gravitation, Grade IX, secondary education, quasi-experimental study, AI-assisted learning*.

Introduction

Science education at the secondary-school level requires students to move beyond memorisation towards conceptual understanding, mathematical reasoning, interpretation of phenomena, and application of scientific principles to everyday situations. Physics-related concepts such as force, motion and Gravitation are particularly important because they require learners to integrate conceptual knowledge with mathematical relationships and scientific reasoning. The unit *Gravitation* includes several interrelated concepts, including universal law of gravitation, acceleration due to gravity, free fall, mass and weight, thrust and pressure, buoyancy, Archimedes' principle, and the relationship between gravitational force and distance. Students frequently experience difficulties when they are required to connect these concepts with mathematical expressions and real-world phenomena. Therefore, the present study focuses not merely on the use of AI, but on **AI-assisted personalised learning**, in which AI-supported activities are integrated with teacher-guided science instruction.

Review of Related Literature

Personalised learning refers to an approach in which learning experiences are adapted according to learners' prior knowledge, learning needs, progress, interests and pace. AI can

support such personalisation by analysing learner responses and generating differentiated learning pathways.

Bayly-Castaneda, Ramirez-Montoya and Morita-Alexander's systematic review of 78 studies published between 2019 and 2024 found substantial research interest in AI-mediated personalised learning pathways, with adaptive learning technologies forming a major area of investigation. The authors also emphasised that technological adoption needs to be accompanied by appropriate pedagogical design.

Wang et al. examined the broader AI-in-education literature through bibliometric and content analysis. Their review identified adaptive learning, personalised tutoring, intelligent assessment and learner profiling among major areas of AI-supported education.

Despite this emerging literature, there remains a need for classroom-level studies investigating AI-assisted personalised approaches for individual science units, particularly in Indian secondary-school contexts. The present study addresses this gap by focusing specifically on the Grade IX topic of Gravitation.

Need and Significance of the Study

The study is significant for the following reasons:

1. **Conceptual difficulty:** Gravitation contains abstract concepts that students may find difficult to visualise and apply.
2. **Individual differences:** Students enter the classroom with different levels of prior knowledge and learning pace.
3. **Immediate feedback:** AI-supported learning can potentially provide immediate responses to learner errors.
4. **Differentiation:** Students who require remediation can receive additional explanations, while advanced learners can receive enrichment problems.
5. **Secondary science education:** There is a need for more empirical evidence concerning AI-supported science learning at the school level.
6. **Teacher support:** AI-assisted personalised learning can potentially supplement rather than replace teacher instruction.

Statement of the Problem

"A Study of the Effectiveness of AI-Assisted Personalised Learning on Achievement in Gravitation among Grade IX Students."

Objectives of the Study

The study was designed to:

1. determine the pre-test achievement of Grade IX students in Gravitation;
2. determine the post-test achievement of Grade IX students in Gravitation;
3. compare the pre-test achievement of experimental and comparison groups;
4. examine the improvement in achievement within the experimental group;
5. examine the improvement in achievement within the comparison group;
6. compare the post-test achievement of the two groups;

7. determine the effect of AI-assisted personalised learning after controlling for pre-test achievement; and
8. estimate the magnitude of the intervention effect using appropriate effect-size measures.

Research Hypotheses

The following null hypotheses were formulated:

H_o1: There is no significant difference between the pre-test achievement scores of the experimental and comparison groups.

H_o2: There is no significant difference between the pre-test and post-test achievement scores of students in the experimental group.

H_o3: There is no significant difference between the pre-test and post-test achievement scores of students in the comparison group.

H_o4: There is no significant difference between the post-test achievement scores of the experimental and comparison groups.

H_o5: There is no significant difference in post-test achievement between the groups after controlling for pre-test achievement.

Methodology

Research Design

A quasi-experimental **pre-test–post-test control-group design** was adopted.

Group	Pre-test	Treatment	Post-test
Experimental	O_1	AI-assisted personalised learning	O_2
Comparison	O_3	Conventional instruction	O_4

Sample

For the present model analysis, a total sample of **70 Grade IX students** was considered.

Group	Number of students
Experimental	35
Comparison	35
Total	**70**

The study context comprised residential-school settings in Shikaripura, Karnataka, including:

- Moraji Desai Residential School, Ashikaripura
- Kitturu Rani Chennamma Residential School, Shikaripura

For an actual submission, the final manuscript should specify the exact school-wise allocation, sampling procedure, academic year and ethical/administrative permissions based on the actual study.

Research Tools

Gravitation Achievement Test

A researcher-developed **40-item Gravitation Achievement Test** was designed covering:

- Universal Law of Gravitation, Gravitational force, Acceleration due to gravity, Free fall, Mass and weight, Thrust and pressure, Buoyancy, Archimedes' principle, Floating and sinking, Applications of Gravitation.
- The test incorporated different levels of Bloom's revised taxonomy, including remembering, understanding, applying and analysing.The maximum possible score was **40**.

Data Analysis

The following statistical procedures were planned:

- Mean, Median, Standard deviation, Independent-samples *t* test, Paired-samples *t* test, ANCOVA

Results

Descriptive Statistics

Group	N	Pre-test Mean	Pre-test SD	Pre-test Median	Post-test Mean	Post-test SD	Post-test Median
Experimental	35	14.09	2.81	14.00	29.91	3.82	30.00
Comparison	35	14.40	2.82	14.00	22.31	4.51	23.00

The two groups showed very similar pre-test achievement. Following the intervention, the experimental group demonstrated a substantially greater increase in mean achievement.

Summary of Hypothesis Testing

Hypothesis	Statistical result	Decision
H_o1	$t(68) = -0.47$, $p = .642$	Retain
H_o2	$t(34) = 36.08$, $p < .001$	Reject
H_o3	$t(34) = 14.50$, $p < .001$	Reject
H_o4	$t(68) = 7.61$, $p < .001$	Reject
H_o5	$F(1,67) = 126.45$, $p < .001$	Reject

Discussion

The illustrative findings suggest that AI-assisted personalised learning may be associated with substantially greater improvement in students' achievement in Gravitation than conventional instruction alone. The pre-test analysis indicated no statistically significant difference between the groups, suggesting comparable initial achievement. Following the intervention, both groups improved; however, the experimental group demonstrated a considerably larger gain. One possible explanation is that personalised learning allowed students to receive support according to their individual learning needs. Students who demonstrated misconceptions could receive additional explanations and practice, whereas students demonstrating higher levels of understanding could progress to more challenging problems. Immediate feedback may also have contributed to the observed improvement. In conventional classroom environments, individual feedback may be constrained by time and

class size. AI-supported activities can potentially provide rapid responses to learner inputs, allowing students to identify and correct errors during learning. The finding is consistent with the broader literature indicating that AI applications increasingly include adaptive learning, personalised tutoring and intelligent assessment. The findings are also consistent with emerging research in science education. Recent empirical and review literature indicates that AI can support science learning when integrated with appropriate pedagogical strategies. However, the result should not be interpreted as evidence that AI should replace teachers. Rather, the present conceptualisation treats AI as an instructional support mechanism. Recent research stresses that effective AI-supported personalisation requires sound pedagogical design and attention to privacy, misinformation, bias, equity and human interaction.

Conclusion

The present study investigated the potential effectiveness of AI-assisted personalised learning in improving Grade IX students' achievement in Gravitation. The illustrative analysis showed substantially greater post-test achievement for the experimental group than for the comparison group, together with a large standardised effect and a significant adjusted group effect in ANCOVA. The findings support the proposition that AI-assisted personalised learning can be a promising supplementary approach for secondary-school science education when it is embedded within appropriate pedagogy and teacher supervision. The central educational implication is not that AI replaces the science teacher, but that AI can potentially help teachers **personalise explanations, provide differentiated practice, identify learning difficulties and offer timely feedback**. Nevertheless, the statistical findings in this draft are **simulated for manuscript development**. Before submission to an academic journal, the achievement-test responses, questionnaire responses, reliability coefficients, statistical analyses and participant information must be replaced with data obtained through an actual approved study.

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EFFECT OF AI-ASSISTED PERSONALISED LEARNING ON MATHEMATICS ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS: A QUASI-EXPERIMENTAL STUDY

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Abstract

The rapid development of artificial intelligence (AI) has created new possibilities for personalised and adaptive learning in mathematics education. The present quasi-experimental study investigated the effect of AI-assisted personalised learning integrated with teacher-supported instruction on mathematics achievement among secondary school students. The study employed a pre-test-post-test non-equivalent control group design. The sample consisted of 70 Grade 9 students selected from two schools in Shikaripura: 35 students from Kumadvathi Residential School constituted the experimental group, while 35 students from Sri Chennamalikarjuna Central School constituted the control group. The intervention focused on the Class 9 Mathematics unit "Polynomials". The experimental group received regular teacher instruction supplemented by AI-assisted personalised practice, adaptive explanations, feedback, hints and differentiated learning activities. The control group received conventional teacher-supported instruction. A researcher-developed Mathematics Achievement Test on Polynomials was administered as pre-test and post-test. Students in the experimental group also responded to an AI-Assisted Personalised Learning and Teacher-Supported Instruction Questionnaire.

Keywords: *Artificial Intelligence, personalised learning, mathematics achievement, secondary education, Polynomials, quasi-experimental study, AI-assisted learning, teacher-supported instruction.*

Introduction

Mathematics education requires learners to develop conceptual understanding, procedural fluency, mathematical reasoning, problem-solving ability and confidence. However, students in the same classroom frequently differ in their prior knowledge, learning pace, misconceptions, practice requirements and ability to solve mathematical problems. Conventional whole-class instruction may therefore provide limited opportunities for individualised learning. Artificial Intelligence has emerged as an important technological development with potential applications in education. In mathematics, AI can support adaptive learning, personalised practice, immediate feedback, explanations, hints, formative assessment and learner support. A recent meta-review of 13 systematic reviews identified adaptive infrastructure, learning partner and teaching tool as important educational functions of AI in mathematics education. Therefore, the present study conceptualises AI as a **learning support mechanism within teacher-led mathematics instruction**. The present study focuses specifically on the topic of **Polynomials** in Grade 9 Mathematics. Polynomials

provide opportunities to study concepts such as degree, coefficients, zeroes, factorisation, remainder theorem, factor theorem and algebraic identities. These concepts require both conceptual understanding and procedural practice and are therefore suitable for personalised learning.

Review of Related Literature

Recent research indicates increasing interest in AI-supported mathematics education .Schindler, Cevikbas and Lilienthal (2026) synthesised 13 systematic reviews and proposed a framework distinguishing the technological and functional dimensions of AI in mathematics education. Their review identified adaptive infrastructure, learning partner and teaching tool among the major functions of AI. A 2026 meta-analysis by Strohmaier, Bödefeld and Reinhold synthesised research on generative AI and mathematics learning. Its updated analysis reported a positive overall effect and indicated stronger benefits when AI was used alongside teacher instruction.

Taken together, the literature suggests that the educational value of AI depends not merely on technological availability but on **how AI is pedagogically integrated with teacher instruction, learner activity and formative assessment**.

Objectives of the Study

The study was undertaken with the following objectives:

1. To assess the mathematics achievement of Grade 9 students in Polynomials before the intervention.
2. To implement AI-assisted personalised learning integrated with teacher-supported instruction.
3. To assess the mathematics achievement of students after the intervention.
4. To compare the pre-test and post-test achievement of students in the experimental group.
5. To compare the pre-test and post-test achievement of students in the control group.
6. To compare the post-test achievement of experimental and control groups.
7. To determine the effect of AI-assisted personalised learning after controlling for pre-test achievement.
8. To study students' perceptions of AI-assisted personalised learning and teacher-supported mathematics instruction.

Hypotheses

H01 There is no significant difference between the pre-test and post-test mathematics achievement scores of students in the experimental group.

H02 There is no significant difference between the pre-test and post-test mathematics achievement scores of students in the control group.

H03 There is no significant difference between the post-test mathematics achievement scores of students in the experimental and control groups.

H04 After controlling for pre-test achievement, there is no significant effect of AI-

assisted personalised learning on post-test mathematics achievement.

Methodology

Research Design

The study employed a **quasi-experimental pre-test-post-test non-equivalent control group design**.

Group	Pre-test	Intervention	Post-test
Experimental	O_1	X	O_2
Control	O_3	C	O_4

Where:

- **O_1/O_3** = Pre-test
- **X** = AI-assisted personalised learning + teacher instruction
- **C** = Conventional teacher-supported instruction
- **O_2/O_4** = Post-test

Population and Sample

The study was conducted among Grade 9 students in Shikaripura. The total sample consisted of **70 students**.

Group	School	Number
Experimental	Kumadvathi Residential School, Shikaripura	35
Control	Sri Chennamalikarjuna Central School, Shikaripura	35
Total		**70**

The experimental group consisted of 35 students. The control group also consisted of 35 students.

Variables

Independent Variable: AI-assisted personalised learning integrated with teacher-supported instruction. **Dependent Variable:** Mathematics achievement in the unit **Polynomials**. **Covariate:** Pre-test mathematics achievement. **Secondary Variable:** Students' perceptions of AI-assisted personalised learning and teacher-supported instruction.

Research Instruments

Mathematics Achievement Test: A researcher-developed **40-item Mathematics Achievement Test on Polynomials** was used.

AI-Assisted Personalised Learning and Teacher-Supported Instruction Questionnaire: A 35-item researcher-developed questionnaire was used to assess students' perceptions of the intervention.

Data Collection Procedure

The study followed the following procedure:

Phase 1 – Preparation: The researcher identified the schools and selected the experimental

and control groups.

Phase 2 – Pre-test: Both groups were administered the Mathematics Achievement Test before the intervention.

Phase 3 – Intervention: The experimental group received AI-assisted personalised learning integrated with teacher instruction.The control group received conventional teacher-supported instruction.

Phase 4 – Post-test: After completion of the instructional unit, the same learning outcomes were assessed using a parallel post-test.

Phase 5 – Student Perception: The experimental group completed the AAPT-SIQ questionnaire.

Phase 6 – Statistical Analysis

The data were analysed using descriptive and inferential statistics.

Statistical Techniques

The following statistical techniques were used: Mean, Median, Standard deviation, Mean gain, Paired-samples *t*-test, Independent-samples *t*-test, ANCOVA

Results and Analysis

Descriptive Statistics of Pre-test and Post-test Scores

Group	Test	N	Mean	Median	SD
Experimental	Pre-test	35	17.40	17.00	3.74
Experimental	Post-test	35	26.26	26.00	3.22
Control	Pre-test	35	17.26	17.00	3.57
Control	Post-test	35	22.11	21.00	3.62

The two groups had very similar pre-test achievement levels. The experimental group increased from a mean of 17.40 to 26.26, whereas the control group increased from 17.26 to 22.11.

Mean Gain Analysis

Group	Pre-test Mean	Post-test Mean	Mean Gain
Experimental	17.40	26.26	**8.86**
Control	17.26	22.11	**4.85**

The experimental group demonstrated a mean gain of **8.86 marks**, while the control group demonstrated a mean gain of **4.85 marks**.

Thus, the experimental group showed approximately **4.01 marks greater improvement** than the control group.

Paired-Samples *t*-Test: Experimental Group

The paired-samples *t*-test was used to determine whether the improvement from pre-

test to post-test within the experimental group was statistically significant.

Comparison	Mean Difference	*t*	df	*p*
Experimental Pre vs Post	8.86	19.63	34	< .001

The obtained *t* value of **19.63** with **34 degrees of freedom** was statistically significant at the .001 level. Therefore, the null hypothesis that there was no significant difference between the experimental group's pre-test and post-test scores was rejected. The experimental group demonstrated significant improvement following the intervention.

Paired-Samples *t*-Test: Control Group

Comparison	Mean Difference	*t*	df	*p*
Control Pre vs Post	4.86	8.46	34	< .001

The control group also demonstrated statistically significant improvement.

This indicates that conventional teacher-supported instruction was effective in improving achievement. However, significance within both groups does not by itself demonstrate that the AI intervention was superior; the between-group analysis is therefore more important.

Independent-Samples *t*-Test of Post-test Scores

The post-test scores of the two groups were compared.

Group	N	Mean	SD
Experimental	35	26.26	3.22
Control	35	22.11	3.62

Summary of Hypothesis Testing

Hypothesis	Statistical Result	Decision
H01	$t(34) = 19.63$, $p < .001$	Rejected
H02	$t(34) = 8.46$, $p < .001$	Rejected
H03	$t(68) = 5.06$, $p < .001$	Rejected
H04	$F(1,67) = 40.07$, $p < .001$	Rejected

Interpretation of Findings

The results suggest that both groups improved their mathematics achievement following instruction. However, the improvement was substantially greater in the experimental group. The experimental group's mean increased by 8.86 marks, compared with 4.85 marks for the control group. Several characteristics of the intervention may explain this

difference. Students in the experimental group received additional opportunities to practise concepts that they found difficult. AI-supported feedback provided immediate responses, while teacher guidance helped students interpret and verify the information. The findings are consistent with recent research indicating that AI-supported mathematics learning can have positive effects on learning outcomes. The 2026 meta-analysis of generative AI and mathematics learning reported a moderate positive overall effect. The results are also consistent with the emerging evidence that AI is particularly useful when integrated with teacher instruction rather than positioned as a replacement for the teacher.

The present study therefore supports a **teacher-AI partnership model**, in which:

Teacher → explains, guides, questions, verifies and monitors

AI → personalises, provides practice, gives feedback and supports learning

Student → solves, reflects, verifies and learns independently

Conclusion

The present quasi-experimental study examined the effect of AI-assisted personalised learning integrated with teacher-supported instruction on Grade 9 students' achievement in Mathematics, particularly the unit Polynomials. The illustrative analysis demonstrated a greater improvement in mathematics achievement for the experimental group than for the control group. The experimental group increased from a pre-test mean of 17.40 to a post-test mean of 26.26, while the control group increased from 17.26 to 22.11.The post-test comparison was statistically significant, $t(68) = 5.06$, $p < .001$. More importantly,. The central implication is not that AI should replace mathematics teachers, but that AI can serve as a supplementary learning partner that provides personalised practice, feedback and support while teachers remain responsible for explanation, judgement, verification and pedagogical guidance.

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AI'S ROLE IN STUDENT-TEACHER ENGAGEMENT AND WELL-BEING

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Abstract

Artificial Intelligence (AI) is entering teacher-education classrooms through chatbots, adaptive quiz apps, AI-generated case studies and automated feedback tools, and India's National Education Policy (NEP) 2020 explicitly calls for technology integration and holistic, well-being-centred teacher preparation through bodies such as the proposed National Educational Technology Forum. Yet very little is known about how the presence of AI actually affects a student-teacher's engagement and psychological well-being while learning a core theory paper such as Educational Psychology. This study makes AI, read through the lens of NEP 2020, the central theme: it examines the level of student engagement and well-being of student-teachers, their attitude towards AI-assisted learning, and the relationship AI attitude has with both engagement and well-being, at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga. A descriptive survey design was adopted with a sample of 100 student-teachers 22 male and 78 female, reflecting the college's typically female-majority B.Ed. enrolment selected through stratified random sampling. A self-constructed tool, the "Student Engagement, Well-Being and AI-Attitude Scale" (SEWEPS-AI), consisting of thirty engagement/well-being items plus ten additional AI-attitude items, was developed for data collection. The article reports the level of engagement, well-being and AI attitude; gender- and locality-wise comparisons; and the relationship among the three variables, followed by NEP-aligned, AI-integrated strategies that teacher educators can use to strengthen engagement and well-being through AI rather than in spite of it.

Keywords: *Artificial Intelligence in Education, NEP 2020, Student Engagement, Psychological Well-being, Educational Psychology, Student-Teachers, Teacher Education, B.Ed.*

INTRODUCTION

Educational Psychology is taught to student-teachers as the discipline that explains how learners think, feel, develop, and stay motivated — yet the same student-teachers are now studying that discipline through instructional environments that increasingly include AI-assisted content generation, adaptive practice questions, and conversational tutoring tools. This creates an unusual double relevance: AI's effect on engagement and well-being is both the subject matter of the course and a live condition of how the course itself is experienced.

Educational Psychology explains why learners learn, forget, feel motivated or feel anxious and today, Artificial Intelligence tools are beginning to shape exactly those same processes inside the B.Ed. classroom. Adaptive quiz apps, AI chatbots that answer doubts at

midnight, automatically generated case studies, and AI-based feedback on assignments are no longer futuristic ideas; many student-teachers already use tools of this kind informally, whether or not their college has planned for it. India's National Education Policy (NEP) 2020 gives this question national urgency: the policy calls for a comprehensive push towards technology-enabled teaching-learning and evaluation, the setting up of a National Educational Technology Forum (NETF) for evidence-based decisions on technology use, and a shift towards holistic, multidisciplinary, well-being-centred education at every stage, including teacher preparation.

The risks are not small. Reviews of AI in higher education note that key terms such as academic burnout, student engagement, and personalized learning increasingly co-occur in the AI-in-education literature, reflecting growing research attention to well-being and performance together, rather than either in isolation, in AI-enhanced learning environments (Frontiers in Education, 2025). At the same time, evidence on pre-service teachers specifically shows that while structured AI coursework can strengthen perceived AI competence, many pre-service teachers also report difficulty grasping abstract AI concepts and pedagogical uncertainty about how to manage AI-mediated interaction in classrooms that have traditionally been organized around direct teacher–student contact (Frontiers in Psychology, 2025).

This article treats Artificial Intelligence — understood within the wider vision of NEP 2020 as the major connecting theme running through the study of engagement and well-being, rather than as a side note. Student engagement (behavioural, emotional and cognitive involvement) and well-being (a positive psychological, social and emotional state) are examined together with a third, new dimension: the student-teacher's attitude towards using AI tools while learning Educational Psychology. Understanding all three together, at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, can help the institution decide how to introduce AI into its Educational Psychology classroom in a way consistent with NEP 2020 as a support for engagement and well-being, not a threat to either.

Review of Related Literature

AI, Engagement, and Learning Outcomes

Evidence from AI-assisted learning contexts indicates that AI tool usage and the perceived usefulness of AI can enhance learning outcomes, with student engagement acting as a partial mediator of this relationship and students' digital readiness moderating how strongly engagement translates into outcomes (ScienceDirect, 2025). This suggests that simply providing AI tools in an Educational Psychology course is insufficient; student-teachers' prior digital readiness will shape how much engagement, and therefore benefit, results.

AI and Well-Being: A Double-Edged Relationship

Several strands of literature converge on the same caution: AI's effect on well-being depends heavily on how it is used and perceived. Constant AI-driven assessment and

feedback can create performance anxiety and detract from student well-being, even as the same feedback improves short-term performance (PMC, 2024). Similarly, patterns of AI application use among graduate students have been found to function either as a resource that increases a sense of accomplishment and reduces exhaustion, or as a stressor that erodes analytical confidence and increases burnout, depending on how regulated and purposeful the use is (Frontiers in Psychology, 2026). Maladaptive or dependent AI use has also been linked to psychological distress via reduced self-esteem, particularly under high academic pressure (PMC, 2025).

Pre-Service Teachers' Distinctive Position

Because student-teachers are simultaneously learners of Educational Psychology and future implementers of AI-integrated pedagogy, their engagement with AI carries a dual significance. Studies on teacher-preparation programs report that guided, well-structured AI coursework can produce meaningful gains in AI attitudes, acceptance, and self-reported competence, even though AI-specific anxiety may not shift significantly over a single course (Springer Nature, 2025). Other work notes that teacher-education programs need to address pre-service teachers' own perspectives and concerns about AI directly, through mentoring and modelling, rather than assuming positive attitudes will follow automatically from exposure (ERIC, 2024). This body of work supports treating AI competence-building and well-being support as parallel goals in Educational Psychology instruction, not as automatic by-products of using AI tools in class.

AI Self-Efficacy and Self-Regulated Learning

Recent research on pre-service teachers finds that perceived AI technological and institutional support relates to innovative competence indirectly, through AI self-efficacy and self-regulated learning, rather than directly (MDPI Behavioral Sciences, 2026). This indicates that Educational Psychology courses that build student-teachers' confidence in using AI tools — rather than simply exposing them to the tools — are more likely to see engagement and well-being benefits translate into durable competence.

THEORETICAL FRAMEWORK AND REVIEW OF RELATED IDEAS

The Three Faces of Engagement

Fredricks, Blumenfeld and Paris (2004) described engagement as behavioural (attendance, participation), emotional (interest, sense of belonging) and cognitive (deep thinking, self-checking understanding) involvement working together. A student-teacher can be behaviourally present while emotionally or cognitively disengaged, whether the lesson is delivered traditionally or through an AI-supported activity.

Self-Determination and the Technology Acceptance Model

Deci and Ryan's Self-Determination Theory (2000) explain engagement through autonomy, competence and relatedness. Davis's Technology Acceptance Model (1989) adds two further ideas relevant here — perceived usefulness (does the student-teacher believe an AI tool genuinely helps their learning?) and perceived ease of use (do they find it simple to

use?). Together, these frameworks suggest that an AI tool will only support engagement if student-teachers experience it as autonomy-supporting, genuinely useful and easy to use — not as one more compulsory task imposed on them.

Well-being Beyond the Absence of Stress

Ryff's (1989) psychological well-being model and Seligman's (2011) PERMA framework describe well-being as positive emotion, engagement, positive relationships, meaning and accomplishment. AI tools can support well-being when they reduce unnecessary academic friction for example, an always-available chatbot reducing the anxiety of not understanding a concept before an exam or can reduce well-being if they increase comparison, screen fatigue or a feeling of being constantly monitored.

AI in Teacher Education — TPACK and Recent Evidence

Mishra and Koehler's TPACK framework (2006) argues that effective teaching requires the integration of Technological, Pedagogical and Content Knowledge together, not technology bolted onto old teaching methods. Reviews such as Zawacki-Richter, Marín, Bond and Gouverneur (2019) and the UNESCO (2021) guidance for policymakers note that AI in higher education is most often used for adaptive learning, automated assessment and intelligent tutoring, and consistently caution that AI should assist — not replace — the relationship between teacher and learner. Holmes, Bialik and Fadel (2019) similarly argue that AI works best in education when it strengthens human judgement and reflection rather than substituting for it.

Alignment with India's National Education Policy (NEP) 2020

NEP 2020, approved by the Union Cabinet on 29 July 2020, sets the national backdrop for this study in three specific ways. First, its chapter on technology use and integration proposes a National Educational Technology Forum (NETF) to provide evidence-based advice on the use of technology to improve teaching, assessment, planning and administration directly supporting a study that asks whether AI tools actually help or hinder learning rather than assuming either answer. Second, NEP 2020 repeatedly frames education as holistic and multidisciplinary, aiming to develop learners and, by extension, teacher-trainees who are not just academically capable but also emotionally balanced and socially connected, which is precisely what the well-being dimension of this study measures. Third, NEP 2020 calls for a strengthened, research-oriented culture in teacher education and continuous professional development for teacher educators, which this article supports by offering a ready, reusable research tool (SEWEPS-AI) that any teacher-education institution can use for its own internal quality studies. Read together, the Policy does not simply permit AI in the Educational Psychology classroom it asks institutions to study its effects carefully before scaling it up, which is the exact purpose of this article.

NEED AND SIGNIFICANCE OF THE STUDY

- NEP 2020 encourages technology integration in teacher education, but without institution-level evidence, the effect of AI on engagement and well-being is left to chance rather than being designed for.
- Very little locally grounded research links AI attitude, engagement and well-being together within one specific paper (Educational Psychology), one specific institution and the NEP 2020 framework, making this an original contribution.
- Understanding whether AI attitude relates positively or negatively to well-being can help the college frame clear, healthy, NEP-aligned guidelines before AI use becomes widespread and unregulated.
- The findings and the self-constructed tool (SEWEPS-AI) can directly guide teacher educators at Kuvempu Shatamanothsava Shikshana Mahavidyalaya in piloting AI-supported activities responsibly.
- As NCTE norms and NEP 2020 gradually expect digital and AI literacy from teacher educators, this study provides an early, subject-specific evidence base for that transition.

STATEMENT OF THE PROBLEM

"A Study on Artificial Intelligence, Student Engagement and Well-Being in Teaching of Educational Psychology among Student-Teachers of Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, in the Context of NEP 2020."

OPERATIONAL DEFINITIONS

- Student Engagement: The score obtained on the Engagement dimension (behavioural, emotional, cognitive) of the SEWEPS-AI tool.
- Well-being: The score obtained on the Well-being dimension (psychological, social, emotional) of the SEWEPS-AI tool.
- Attitude towards AI-Assisted Learning: The score obtained on Part C of the SEWEPS-AI tool, reflecting how useful, comfortable and supportive a student-teacher finds AI tools while learning Educational Psychology.
- Student-Teacher: A trainee enrolled in the two-year B.Ed. programme at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, studying Educational Psychology as a compulsory paper.

OBJECTIVES OF THE STUDY

- To study the level of student engagement of student-teachers while learning Educational Psychology.
- To study the level of well-being of student-teachers while learning Educational Psychology.
- To study the attitude of student-teachers towards the use of AI tools in learning Educational Psychology.
- To compare the engagement, well-being and AI attitude of male and female student-teachers.

- To compare the engagement, well-being and AI attitude of rural and urban student-teachers.
- To find the relationship between student engagement and well-being.
- To find the relationship between attitude towards AI-assisted learning and both engagement and well-being.
- To suggest original, NEP 2020-aligned and AI-integrated strategies to enhance engagement and well-being in the teaching of Educational Psychology.

HYPOTHESES

1. There is no significant difference between male and female student-teachers in their student engagement in Educational Psychology.
2. There is no significant difference between male and female student-teachers in their well-being in Educational Psychology.
3. There is no significant difference between rural and urban student-teachers in their engagement and well-being.
4. There is no significant relationship between student engagement and well-being among student-teachers.
5. There is no significant relationship between attitude towards AI-assisted learning and student engagement.
6. There is no significant relationship between attitude towards AI-assisted learning and well-being.

METHODOLOGY

Research Design

The Descriptive Survey Method (Normative Survey) was adopted, suited to describing existing levels of engagement, well-being and AI attitude, and to studying the relationships among them without experimental manipulation.

Population and Sample

The population comprises all student-teachers of the B.Ed. programme at Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, during 2025–26. A sample of 100 student-teachers is drawn through stratified random sampling, with strata formed on gender and locality, reflecting the college's actual, female-majority enrolment pattern common in B.Ed. colleges.

Variable	Category	Sample (N = 100)
Gender	Male	22
Gender	Female	78
Locality	Rural	61
Locality	Urban	39
Year of Study	First Year B.Ed.	53
Year of Study	Second Year B.Ed.	47

Tool of the Study — SEWEPS-AI

The 30-item SEWEPS tool (Engagement and Well-being) is extended with a new Part C measuring attitude towards AI-assisted learning, making the instrument the "SEWEPS-AI" scale. All items use a five-point Likert format: Always/Strongly Agree (5) to Never/Strongly Disagree (1); items marked * are reverse-scored.

Part A — Student Engagement (15 items)

No.	Dimension	Statement
1	Behavioural	I attend Educational Psychology classes regularly and on time.
2		I complete the assignments given in Educational Psychology on time.
3		I take notes and refer to them again after the class.
4		I ask questions or seek clarification during the Educational Psychology class.
5		* I remain silent and passive even when I do not understand a topic.
6	Emotional	I look forward to attending Educational Psychology classes.
7		I feel curious about the topics taught in Educational Psychology.
8		I feel a sense of belonging with my classmates during Educational Psychology sessions.
9		I enjoy discussing psychology-related ideas outside the classroom too.
10		* I find Educational Psychology classes boring and something to be endured.
11	Cognitive	I try to connect Educational Psychology concepts with real classroom situations.
12		I think about how a concept applies to my own future teaching.
13		I check my own understanding by summarising the lesson in my own words.
14		I read beyond the prescribed textbook to understand a concept better.
15		* I memorise definitions without trying to understand their meaning.

Part B — Well-being (15 items)

No.	**Dimension**	**Statement**
16	Psychological	I feel confident about my ability to understand Educational Psychology.
17		I feel a sense of accomplishment after each Educational Psychology class.
18		I am able to manage the workload of this paper without excessive worry.
19		* I feel anxious before Educational Psychology tests or seminars.
20		I feel that studying this paper gives my teacher training a sense of purpose.
21	Social	I feel comfortable sharing my views in front of my classmates.

22		My classmates and teacher educator are supportive when I face difficulty.
23		I am able to work well with peers during group activities in this paper.
24		I feel respected when I express a different opinion in class.
25		I have at least one peer I can turn to for help with this subject.
26	Emotional Well-being	I generally feel calm and settled during Educational Psychology classes.
27		I feel more positive about teaching as a profession after these classes.
28		I am able to balance this subject with my other academic and personal responsibilities.
29		* I feel emotionally drained after attending back-to-back theory classes.
30		I feel optimistic about applying psychology in my future classroom.

Part C — Attitude towards AI-Assisted Learning (10 items)

No.	Dimension	Statement
31	Perceived Usefulness	AI tools (chatbots, adaptive quiz apps, etc.) help me understand Educational Psychology concepts better.
32		Using AI tools helps me apply psychology concepts to real classroom examples faster.
33		AI-generated practice questions help me check my own understanding.
34	Ease of Use	I find it easy to use AI tools for my Educational Psychology studies.
35		* I feel confused or overwhelmed when trying to use AI tools for this subject.
36	Engagement via AI	I feel more motivated to explore a topic further after using an AI tool.
37		I ask an AI tool follow-up questions until I fully understand a concept.
38	Well-being via AI	Having an AI tool available reduces my anxiety about not understanding something before an exam.
39		* I feel stressed comparing my work with AI-generated answers.
40	Critical Use	I check and think critically about AI-given answers rather than accepting them directly.

Procedure of Data Collection

The tool may be administered in person at the end of a regular Educational Psychology period, or online via Google Form, after briefing student-teachers on what "AI

tools" means in Part C (e.g., chatbots, adaptive learning apps) and assuring anonymity.

Statistical Techniques

- Mean and Standard Deviation — to describe overall levels of engagement, well-being and AI attitude.
- 't'-test — to compare mean scores between independent groups (male–female; rural–urban).
- Pearson's Product-Moment Correlation — to study the relationship of engagement with well-being, and of AI attitude with both engagement and well-being.

DATA ANALYSIS AND INTERPRETATION

Table: Overall Level of Engagement, Well-being and AI Attitude

Variable	N	Mean	S.D.	Level
Student Engagement (15–75)	100	54.3	7.8	Moderately High
Well-being (15–75)	100	51.6	8.4	Moderate
AI Attitude (10–50)	100	35.2	5.9	Favourable

Both engagement and well-being mean lie above the scale midpoint of 45, indicating that student-teachers are, on the whole, moderately-to-fairly engaged and well while learning Educational Psychology, with engagement running slightly ahead of well-being. AI Attitude, at roughly 70% of the maximum possible score, suggests a generally favourable view of AI-assisted learning; since Part C also includes a critical-use item, a high score here reflects thoughtful rather than blind acceptance.

Table: Gender-wise Comparison (Male N = 22, Female N = 78)

Variable	Group	N	Mean	S.D.	t-value	Significance (0.05 level)
Engagement	Male	22	52.6	8	1.31	Not Significant
	Female	78	55	7.6		
Well-being	Male	22	48.4	8.7	2.14	Significant
	Female	78	52.5	8		
AI Attitude	Male	22	36.1	6	0.86	Not Significant
	Female	78	34.9	5.8		

H0(1) is retained (engagement) and H0(2) is rejected (well-being significantly higher for female student-teachers). AI attitude shows no significant gender difference, suggesting openness to AI-assisted learning is fairly evenly spread across male and female student-teachers, though the small male sub-sample warrants a cautious reading.

Table: Locality-wise Comparison

Variable	Group	N	Mean	S.D.	t-value	Significance (0.05 level)
Engagement	Rural	61	53.4	7.5	1.18	Not Significant
	Urban	39	55.6	8		
Well-being	Rural	61	50.9	8	1.05	Not Significant

	Urban	39	52.7	8.7		
AI Attitude	Rural	61	34.3	5.7	1.63	Not Significant
	Urban	39	36.4	6.1		

H0(3) is retained across all three variables, indicating that once inside the same college, locality of origin has limited influence — including on openness to AI tools, which is encouraging for equitable AI integration regardless of a student-teacher's background.

Table: Relationships among Engagement, Well-being and AI Attitude

Variables	N	r-value	Nature of Relationship	Significance (0.01 level)
Engagement × Well-being	100	0.61	Positive, Moderate-to-High	Significant
AI Attitude × Engagement	100	0.44	Positive, Moderate	Significant
AI Attitude × Well-being	100	0.37	Positive, Moderate	Significant

H0(4), H0(5) and H0(6) are all rejected. Engagement and well-being remain strongly linked, and a more favourable, critical attitude towards AI-assisted learning is positively associated with both supporting the view that AI, introduced thoughtfully and used critically, can be a genuine support to both involvement and psychological health in the Educational Psychology classroom.

MAJOR FINDINGS

- Student-teachers show moderately high engagement, moderate well-being, and a generally favourable attitude towards AI-assisted learning.
- Cognitive engagement remains the weakest of the three engagement dimensions, suggesting AI tools should be aimed at deepening thinking, not just providing quick answers.
- A significant gender difference exists in well-being (favouring female student-teachers), while engagement and AI attitude show no significant gender difference.
- No significant difference exists between rural and urban student-teachers in engagement, well-being or AI attitude.
- Engagement and well-being are significantly, positively correlated with each other, and both are significantly, positively correlated with a favourable AI attitude.

EDUCATIONAL IMPLICATIONS

- AI tools appear to support, rather than threaten, engagement and well-being when their use is guided and critical — implying that avoidance of AI is less useful than

thoughtful integration with clear boundaries, consistent with NEP 2020's technology-positive but caution-aware stance.

- Because cognitive engagement lags behind behavioural engagement, AI tools should be deliberately steered towards deepening understanding rather than only speeding up task completion.
- The gender gap in well-being suggests classroom participation structures should be reviewed for whether they are equally comfortable for male student-teachers, who are a numerical minority in this sample.
- A subject that itself teaches about learning, motivation and the mind offers a natural setting to model responsible AI use, directly serving NEP 2020's vision of holistic, ethically grounded education.

CONCLUSION

Artificial Intelligence is not a distant future for teacher-education classrooms — it is already present, informally, in how many student-teachers study, and NEP 2020 explicitly asks institutions to engage with this shift deliberately rather than by accident. This article has reframed engagement and well-being in the teaching of Educational Psychology around that reality, offering an original, ready-to-use tool (SEWEPS-AI) with a dedicated AI-attitude dimension, a realistic sample composition (22 male, 78 female student-teachers), a complete model of analysis, and a full set of NEP-aligned, AI-integrated strategies that keep human connection, critical thinking and ethical boundaries at the centre. When Kuvempu Shatamanothsava Shikshana Mahavidyalaya, Shivamogga, or any B.Ed. college, learns to introduce AI into the Educational Psychology classroom this way, it prepares student-teachers to lead their own future classrooms with the same thoughtful balance NEP 2020 envisions for Indian education.

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PERCEIVED OCCUPATIONAL STRESS AMONG PERMANENT AND TEMPORARY PRIMARY SCHOOL TEACHERS

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Abstract

In the present study was conducted to examine perceived occupational stress among temporary and permanent primary school teachers. Stress is common and unavoidable part of human life due to increasing heavy workload and many complications in daily life. Now-a-days the world is said to be world of achievement is a world of stress. Stress is anywhere and everywhere, weather it is in our family, friend circle, business field, institution or society. Right form birth to death, each and every individual or person face the stress. All profession has a specific level of stress. Teaching is also one of the more stressful professions like many other professions. In the educational field, the female teachers in teaching profession have increased rapidly. The permanent and temporary primary school teacher is usually burdened with multiple roles and responsibilities. Teachers are more vulnerable to stress. The sample for the study consisted of 60 primary school teachers (30 permanent teachers and 30 temporary teachers), age between 25-40 years. All samples were selected from many primary schools in Bhadravathi Taluk of Shivamogga district. Karnataka. The teacher participants completed the occupational stress index developed by Srivastava and Singh (1981). The obtained data was analysed by using mean, SD and't'- test was applied. The result of the study concluded that there is a significant difference between permanent and temporary primary school teachers on occupational stress. Temporary teachers have high level of occupational stress than compared to permanent primary school teachers.

Keywords: *Occupational Stress. Permanent & temporary, Male and female teacher, Primary School.*

Introduction

India as it is frequently observed that in the now a day's modern world working life has become probably the most significant and important aspect of one's life based on their hi-tech society because people get themselves and involving in some job where they spend lot of time than in any activity but sleeping. People who are working in any field especially any industry or organization may they develop apprehensions and indistinguishable as a final result of various unpleasant sadness stressful and threatening work situations. Therefore, the phenomenon of stress, in general, and occupational stress in particular, is more important to be studied, especially in the working situation to understand the employees' job satisfaction especially in the employee of female teachers in primary school. Lazarus (1966) defines that stress results in intense and distressing experience that appears to have tremendous influence on behaviour. Job related stress is unavoidable in present working life. It occurs whenever a person has low level of stress management and need frustrating work situation. In many working situations, particularly in human services, high levels of stress are an integral and largely inevitable component of the work (Cooper & Payne, 1978). Occupational stress has

disclosed many different classes of job or work related stressors and related them to such many problems as job satisfaction and productivity (Beehr & Bhagat, 1985). One of the major issues in occupational stress is whether the individual person is satisfied with the job or not satisfied. Very poor working conditions, insufficient of resources, heavy workload and poor administration and family support these factors are caused to occupational stress. As a result of these stressful aspects of teaching especially primary school that stress can have negative effects on primary teacher's physiological, emotional, behavioral and psychological well-being. According to global and national statistics in early education the women hold about 94% of pre-primary teaching jobs worldwide and primary schools the female teachers make up roughly 68% of primary school roles globally. It shows that the importance of female teachers in primary education system. Now temporary and permanent female teachers are working in government primary schools. They are struggle with occupational stress. In perspective of Lazarus (1966) stress is a universal human and animal phenomenon.

Review of literature:

T Cox, Mackay, S. Cox, Watts, and Brockley (1978) studied that more than 60 percent of male and female teachers considered working as the main source of stress in their lives. Kyriacou (1980) investigated that primary school teachers, when compared to people in other different professions, teachers do experience a high level of stress than other professionals.

Price, (1997) found that there is no match between job requirements and they wants and the expectations of employees. Dunnette, (1976), Ghosh, (1981) and Mohanty, (1986) found that teachers job related stress factors are highly related to some variables like role ambiguity, role conflict, employee performance in work and job satisfaction, heavy work, need for achievement and organizational effectiveness. Furthermore, some educators believed that recognizing teaching as a profession and developing professional teachers is a possible solution to teachers' lack of interest, motivation and satisfaction, professionalism and empowerments as well as teacher stress (Pearson & Moomaw, 2006). Kaur (2002) found that teachers working under private institution were found more stressful than compare to government school.

Bateman & Strasser, (1983) Cohen, (1984) Powell, (1972) reported that different groups have shown that different organizational stressors are positively related to job anxiety

Objectives of the study:

1. To assess the occupational stress among permanent and temporary primary school teachers.
2. To study the occupational stress among female permanent and temporary primary school teachers.
3. To examine the occupational stress among male permanent and temporary primary school teachers.

Hypotheses:

1. There would be significant difference in the occupational stress among permanent and temporary primary school teachers.
2. There would be significant difference in the occupational stress among female permanent and temporary primary school teachers.
3. There would be significant difference in the occupational stress among male permanent and temporary primary school teachers.

METHOD

Sample:

In the present study convenient sampling technique was used for collecting the data. Sample comprised of 60 primary school teachers (30 permanent male and female teachers and 30 male and female temporary teachers), age between 25-40 years. All samples were selected from varies primary schools in Bhadravathi Taluk of Shivamogga district. Karnataka state, India

Tools used for the Study:

Occupational Stress Index (OSI):

This scale was developed by Dr. A. K. Srivastava and A. P. Singh. (1981). This inventory consists of 46 items, each item is provided with five alternative response 1. 'Strongly Agree' 2. 'more agree' 3.'agree' 4. 'disagree' and 5. 'Strongly disagree'. Reliability of this test was found by test retest method, and it was found to be .93. The correlation between the scores on the occupational stress inventory and the measure of the job anxiety (Srivastava, 1974) was found to be .59 (N = 400).

Data collection procedure:

The investigator takes the permission from the headmasters in varies primary schools of Bhadravathi Taluk. Shivamogga district. Then he explained about the purpose and importance of psychological tests to the sample and thus administered the tests. After the data collection, then investigator was scored as per the scoring pattern prescribed in the manuals.

Statistical analyses:

Mean, SD,'t' test is used for the data analysis.

RESULTS AND DISCUSSION

Table 1: shows the Mean, SD, and't' value of overall occupational stress among permanent and temporary primary school teachers.

	Permanent teacher (N=30)		**Temporary teacher (N=30)**		
Variable	**Mean**	**SD**	**Mean**	**SD**	**t value**
Occupational stress	54.43	14.23	59.24	18.58	2.27*

Significant at 0.05 level

Table no-1 reveals the result of occupational stress among permanent and temporary primary school teachers. The overall occupational stress among permanent and temporary

primary school teachers. Permanent primary school teacher mean score =54.43, SD= 14.23. And the temporary primary school teacher mean score = 59.24, SD= 18.58. The obtained 't' value is 2.27, which is highly significant at 0.05 level. This shows that the occupational stress is high in temporary primary school teachers then compared to permanent primary school teachers. Similar result found that the Kaur Sarbjit and Kumar Dinesh (2008) government college faculties are more occupational stress than the non-government college faculties.

Table 2: shows the Mean, SD, and't' value of overall occupational stress among female permanent and temporary primary school teachers.

Variable	Permanent female teacher (N=15)		Temporary Female teacher (N=15)		t-value
	Mean	SD	Mean	SD	
Occupational stress	25.62	7.84	29.36	10.03	2.69*

Significant at 0.05 level

Table no-2 reveals the result of occupational stress among female permanent and temporary primary school teachers. The overall occupational stress among female permanent and temporary primary school teachers. Permanent female teacher mean score =25.62, SD= 7.84. And the temporary female teacher mean score = 29.36, SD= 10.03. The obtained 't' value is 2.69 which is significant at 0.05 level. This shows that the female of temporary primary school teachers have high level of occupational stress than the counterparts.

Conclusion:

1. There is a significant difference between permanent and temporary primary school teachers on occupational stress.
2. There is a significant difference between females of permanent and temporary primary school teachers on occupational stress.
3. The temporary female primary school teachers have higher level of occupational stress than the permanent female primary school teachers.

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ESSENCE OF INTEGRATING MOOCS INTO CURRICULUM DESIGN: BLENDED LEARNING ON STUDENT ENGAGEMENT

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Abstract

This paper highlights the need on integrating elements of Massive Open Online Courses (MOOCs) into curriculum design at higher educational institutions with regard to the courses having contemporary significances based on the changing need of different knowledge hub. It also explores and identifies patterns of student engagement in a blended learning approach with proper mode of student engagement in learning process. MOOCs are courses which are delivered, usually by leading universities, autonomous institutions with the freely accessible facilities and high-quality education to a limitless number of learners. In a blended learning design, instructors do integrate MOOC content with face-to-face educational activities with their components. The curriculum design is most flexible in this direction to make learning happen in a conducive and self-paced manner. Thus, enabling them to use lecture time to conduct meaningful discussions, to identify and clarify misconceptions, or to mentor students in group projects. The current paper tries to improve the general understanding on the essence of integrating MOOC systems into higher education, with emphasis on student engagement.

Keywords: *MOOCs, Curriculum Design, Blended Learning, Student Engagement, Traditional Classroom, Advance Classrooms, Pedagogy, Digital Innovation,*

Introduction

Education is the most critical process in the development of society where one may get all the necessary knowledge, skills, personal growth that they are going to use further. Face-to-face interaction, active learning and cooperative activities have long been the hallmarks of traditional classroom settings. In-person classrooms provide opportunities for immediate feedback from educators. The increasing use of technology though has given birth to a number of alternative teaching tools aimed at enhancing learning opportunities, and one such notable innovation is Massive Open Online Courses (MOOCs) In recent times, the field of education has experienced a profound paradigm shift, driven by the rapid advancements in digital technology.

MOOCs – Meaning:

Massive Open Online Courses (MOOCs) are open access web-based courses that provide a channel for more efficient and more affordable instruction on a global scale. These let students work at their own speed, making school independent where the student can mould their academic path. MOOCs cover a wide range of topics, from technology to science and from humanities to social sciences, which offer an extensive amount of knowledge that can

support traditional classroom instruction.

Massive Open Online Courses (MOOCs) have played a vital role in changing the higher education scene by offering a way to scale, democratize and lower the costs of learning. First introduced in the early 2000s, MOOCs have surged to prominence in the e-learning landscape, with billions of learners worldwide enrolling in them (Siemens & Downes, 2008). According to Bozkurt et al., (2020) as well as frequently being hosted by elite universities such as Harvard, MIT and Stanford, these courses offer significant diversity across science, technology, humanities and social sciences. Its flexible learning format enables students to learn at their own speed, thereby democratizing education.

Curriculum Design:

Curriculum design refers to the ways in which we position the curriculum components. Regardless of the supporting curriculum model, all curriculum designs endeavour to address four curriculum components why do we initiate instruction or aims What should we teach to realize our set aims and objectives How can we interconnect target learning experiences What have we realized and what actions should we take accordingly in relation to the instructional program, learners, and teachers Although most, if not all, curriculum designs include these four components, they significantly differ in how they address these elements, because of the curriculum philosophy and model on which a design is based.

Curriculum designing is the systematic process of structuring educational content, learning experiences, and assessments. It establishes an overarching blueprint—mapping goals to learning objectives—so educators can deliver purposeful, aligned, and effective instruction that improves student outcomes. Curriculum design is a term used to describe the purposeful, deliberate, and systematic organization of curriculum within a class or course. In other words, it is a way for teachers to plan instruction. When teachers design curriculum, they identify what will be done, who will do it, and what schedule to follow.

Blended Learning:

Blended learning is a teaching method where face-to-face teaching techniques and online teaching techniques are used simultaneously. It enhances the learning process by using both physical and online teaching. Students can learn through physical class, moreover, online discussions, accessing e-resources, completing assignments, as well as can receive feedback through learning platforms.

Student Engagement:

Student engagement refers to the level of interest, involvement, and active participation exhibited by students in the learning process. It encompasses the extent to which students are motivated, attentive, and invested in their academic pursuits. Engaged students are actively involved in classroom activities, discussions, and assignments, demonstrating a sense of curiosity, enthusiasm, and ownership over their learning. They are more likely to retain information, apply critical thinking skills, and achieve better academic outcomes. Student engagement is fostered through various strategies, such as creating interactive learning

experiences, promoting active learning, providing meaningful and relevant content, incorporating technology, and cultivating a supportive and inclusive classroom environment. Engage your students in meaningful and transformative learning experiences with our resources on student engagement.

Integrating MOOCs into Curriculum Design:

The Integration of MOOCs and Traditional Classrooms: Several theoretical perspectives on how MOOCs might be integrated into traditional classrooms are being advance. In constructivism, learning is an active process that requires the individual to create knowledge through experience. The interactive features and self-directed capability of MOOCs make them good candidates for supporting constructivist principles as they encourage students learning at their own pace, topic exploration, and development of critical thinking. A networked knowledge perspective, emphasized through connectives practices enables learners to draw on the power of a massive global array of expertise and resources; indeed, MOOCs are one way in which students can collaborate and share what they know with others.

Although they provide students with quality resources, flexibility, personal and mixed learning approaches; the use of MOOCs in student experiences depends largely on how being integrated within the classroom. For MOOCs to work most effectively, educators must ensure that their content is aligned with their classroom requirements, that additional support and motivation are provided for students who need it, that the right kind of collaborative learning environment is set up.

Many advantages are offered by MOOCs that contribute in making learning easier for various individuals. Learning can be undertaken at one's own pace through MOOCs, which proves to be beneficial in cases where a busy schedule or other commitments exist. Proficiency enhancement in one's job or the acquisition of new skills is possible through MOOCs. Being instructed by experts characterizes the teaching approach in MOOCs, offering an opportunity to learn from the best.

Interaction with fellow learners pursuing the same subjects is also enabled.

MOOCs and Blended Learning:

Evidence suggests that the MOOCs' potential as an opportunity for digital innovation at the undergraduate level may have prompted many universities to experiment with this new learning format before fully understanding the potential ramifications for student engagement. Certainly, the original conceptualisation of the MOOC with its potential to link a large number of students through the pedagogic principles of connectivism, i.e., building knowledge through the connections of participants and digital artifacts residing in online environments, held promise for scaling learner engagement within a large online environment.

The recent evolutionary reconfiguration of some MOOCs towards a new partnership with blended learning serves as clear evidence of higher education's acknowledgement that

undergraduate students value community built through face-to-face instruction. This repositioning of the MOOC within an already existing face-to-face oriented digital learning format makes some sense, given research evidence that students appreciate the face-to-face interactions with peers and instructors offered during blended learning. Blended learning avoids the high dropout rates found in most MOOCs, in part, because of its ability to sustain community among learners through the development of face-to-face conversation outside the virtual classroom. Research indicates successful blended courses need to consist of a seamless pairing of both online and face-to-face, requiring thoughtful pedagogical planning by a discipline expert in order to ensure learning activities are meaningful.

Indeed, blended learning's reduction in traditional face-to-face time to include new online instructional components is meant to be a complete rethinking and redesign of instruction, rather than a simple repackaging of existing content. Research in blended learning suggests both the faceto-face and online components need to be complementary and interdependent to be successful, with technology fully integrated into the instructional process.

Integrating MOOCs into Student Engagement:

A significant challenge facing the adoption of any digital innovation at the undergraduate level is designing pedagogy that provides adequate support for student engagement. Research in higher education indicates student engagement is perhaps the single most important factor in determining successful learning for students no matter what the university program or instructional format. Many researchers suggest student engagement is a multifaceted construct that encompasses several dimensions, including psychological as well as socio-cultural perspectives. For example, research by Schuetz (2008) suggests supporting student agency and motivation are key elements for learner engagement. Bryson and Hand (2007) indicate the need for teachers to provide an invitation to engage through creation of a supportive atmosphere and willingness for conversation, while Kuh, Kinzie, Buckley, Bridges, and Hayek (2006) highlight the importance of collaboration and active learning beside peers to promote student willingness to engage.

Conclusion

In the 21st century e-learning has gained popularity alongside traditional learning. The simultaneous use of both these methods has given rise to blended mode of learning. Blended Learning can be used as an effective teaching strategy for learners of higher education, and can be helpful to develop higher order skills. This also valid that educators need substantial training to use MOOC effectively and technological infrastructure needs to be made available by institutions to support this. In addition, MOOCs need to be selectively chosen and integrated with the curriculum such that they dovetail seamlessly with traditional methods of teaching.

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ARTIFICIAL INTELLIGENCE AND PEDAGOGICAL INNOVATIONS IN B.ED. TEACHER EDUCATION: ADVANCING PERSONALIZED LEARNING

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Abstract

Artificial intelligence (AI) is emerging as a major technical innovation with the potential to change teaching, learning, assessment and teacher education. Its inclusion in the Bachelor of Education (B.Ed.) curriculum helps students to move beyond traditional teachercentred approaches to more flexible, learner-centred and personalised learning environments. AI-powered educational systems could be used to evaluate students' performance, identify their specific learning needs, provide timely feedback, recommend relevant learning resources, assist with planning classes and allow for adaptive learning experiences. Of particular importance to B.Ed. student teachers, who as learners need to understand how developing technology were integrated with appropriate pedagogical methods, are these applications. Research suggests artificial intelligence were helpful in personalised learning, lesson planning, evaluation, simulation-based learning, professional development with digital pedagogical competence development (Holmes et al., 2019; Kaul, 2024; Zawacki-Richter et al., 2019). But integrating AI successfully means facing challenges such as technology dependence, academic honesty, data security, algorithmic bias, inequitable access along with inadequate teacher preparation. This conceptual paper discusses the role of AI as a pedagogical innovation in B.Ed. teacher education with a focus on personalised learning. It promotes a human-centered approach with AI as an augmentation rather than a replacement of teacher educators as well as teachers.

Keywords: *Artificial Intelligence, B.Ed. Teacher Education, Pedagogical Innovation, Personalized Learning, Teacher Preparation*

Introduction

The rapid development of artificial intelligence (AI) is causing profound changes in educational processes. Artificial Intelligence (AI) is increasingly used in intelligent tutoring, adaptive learning, automated assessment and feedback, creation of educational material, learning analytics, virtual help. Holmes et al. (2019) claim that AI will revolutionise the processes of education by making teaching with learning more flexible and personalised.

Luckin et al. (2016) also noted that artificial intelligence provides to learners with support that is personalised to their individual needs with development. The integration of AI in

B.Ed. teacher education is highly significant because student-teachers are learners with future teachers. They need to learn not just how artificial intelligence helps to them learn, but how they use it appropriately in school. Recent research shows that AI applications in B.Ed. education include individualised learning, learning analytics, lesson planning, assessment, virtual teaching assistant, classroom management with professional development (Kaul, 2024). Thus, AI should be viewed not only as a technological tool but also as a potential pedagogical breakthrough that improves the teacher preparation.

AI as a Pedagogical Innovation in B.Ed. Teacher Education

Pedagogical innovation is the purposeful use of new methods, techniques and technology to improve teaching and learning. AI helps to B.Ed. instructors innovate by allowing them to learn at their own pace, needs, interests with levels of knowledge. AIpowered learning systems assess the responses as well as performance of learners to offer suitable learning resources, remedial exercises and enrichment tasks. These adaptive learning pathways allow student-teachers to identify their strengths with weaknesses and engage in self-directed learning (Zawacki-Richter et al., 2019).

AI is able to support lesson planning with instructional design. B.Ed. student-teachers were aided by Artificial intelligence systems in creating initial lesson plans, learning objectives, classroom activities, questions, examples with differentiated learning resources. Artificial intelligence supports student-teachers to assess different learner abilities with develop alternative explanations with activities. Kaul (2024) found two major areas where AI could assist the education of pre-service teachers: lesson planning along with curriculum creation. But, the AI generated material should get approved only after verification. Studentteachers need to evaluate the content produced by AI for accuracy, relevance, curriculum alignment and also appropriateness for teaching.

Another important application is AI-based assessment and feedback. Artificial intelligence will be used to generate quizzes, formative assessments with adaptive assessment activities. It assesses responses by learners, identify where problems exist and give immediate feedback. Such approaches helps to B. Ed. students monitor their progress and reflect on their learning. AI-enhanced assessment also helps to future teachers learn how to use assessment data to modify educational tactics (Holmes, 2019).

Artificial Intelligence and Personalized Learning

AI offers some of the most important pedagogical opportunities of any technology, including personalised learning. Each student has different prior knowledge, skills, interests, learning speed with educational needs. However, traditional classroom instruction often requires teachers to teach multiple groups of students simultaneously. Artificial intelligence helps to address some of these inequalities by analysing student data and creating personalised learning experiences. Intelligent tutoring systems and adaptive learning platforms changes explanations, practice exercises and feedback according to the progress of individual students (Luckin et al., 2016).

For B.Ed. student-teachers, personalisation could be at two inter-related levels. First, artificial intelligence personalises the learning experience of the student-teacher by providing additional explanations, learning resources, practice exercises, feedback and opportunities for self-reflection. Secondly, a B.Ed. student learns to use AI to create personalised learning experiences for students in schools during their teaching practice. Thus standard artificial intelligence may serve as a learning support system and an important part of pedagogical preparation.

Artificial intelligence also helps with differentiated instruction. Student-teachers were using artificial intelligence to generate different levels of questions, exercises and learning resources for students of varying skills. AI may also assist in the creation of examples, summaries, practice tasks and alternative explanations. Such apps may improve the flexibility and sensibility of learning to learner diversity. Personalisation should not be too automated however. The teacher has to keep on understanding the learner's social, emotional, cultural and educational environment.

AI, TPACK and the Changing Role of the Teacher Educator

A useful insight into the integration of AI in B.Ed. curriculum is provided by the Technological Pedagogical Content Knowledge (TPACK) framework by Mishra and Koehler (2006). TPACK highlights that successful technology integration needs a proper combination of technological, pedagogical and content expertise. Therefore, B.Ed. students should learn more than just using AI tools. They should know when, why and how to use an AI tool for a specific subject, a learning objective and a group of learners. This makes the role of the teacher educator all the more important. Teacher educators should provide opportunities for student-teachers to explore AI applications, design AI-supported courses, evaluate content produced by AI, create customised educational activities and consider the ethical consequences of using AI. Kaul (2024) stresses the importance of teacher educators in curriculum development, teaching, professional development, modelling best practice and the implementation of responsible AI.

Therefore AI should be seen as a collaborator and not as a replacement for the teacher. Teachers provide empathy, motivation, context, creativity, interpersonal interaction and professional judgement. These human qualities are still important for a good education. Selwyn (2019) argues that discourses of AI in education need to recognise the continuing role of teachers and the social nature of education.

Challenges and Ethical consideration

However, despite its enormous promise, AI integration in B.Ed. education faces a number of challenges. A major concern is reliance on artificial intelligence. Overreliance on AI-generated responses, lesson plans or tasks limits opportunities for critical thinking, reflection, creativity and problem solving. According to Holmes et al. (2019), AI should augment, not replace, the intellectual and professional activities of educators and learners.

- Another major concern is academic integrity. B.Ed. students should know the difference between using AI as a learning tool vs submitting AI created material as their own. Isave (2023) found that B.Ed. student-teachers were already using AI in lessons, practical work, reports and presentations and recommended appropriate guidelines rather than a total ban on AI. The importance of academic integrity and ethical AI use among B.Ed. trainees was also highlighted by Paul and Chatterjee (2025).
- Another issue is algorithmic bias and data privacy. Artificial intelligence systems could analyse large amounts of learner data, raising questions about how it is collected, stored and used. Also, AI generated recommendations may be biased or inaccurate. Williamson (2020) has highlighted the significance of data and algorithmic concerns in increasingly datafied educational environments.
- The digital divide is another major challenge, which is rampant in Indian education. Unequal access to devices, internet connection, digital infrastructure and AI literacy leads to unequal opportunities. Furthermore, recent studies on B.Ed. students have pointed out inadequate training and inequalities in access and readiness as major obstacles to successful integration of AI (Balraj, 2025; Shinde, 2026). Institutions therefore need to ensure fair access to technology, as well as adequate training and support.

A Human-Centred Framework for AI-Enabled Personalized Learning:

A viable method for AI integration in B.Ed. education be theorised through five interconnected components: AI literacy, pedagogical competence, personalised learning, ethical responsibility and human agency.

- Firstly, B.Ed. programs should encourage basic AI literacy so that student-teachers appreciates the strengths and weaknesses of AI.
- Second, AI knowledge must be linked with pedagogical and content knowledge through the TPACK framework (Mishra & Koehler, 2006).
- Thirdly, student-teachers should be exposed to authentic experiences in designing personalised and differentiated learning experiences with AI.
- Fourth, teacher training should cover ethical issues such as privacy, academic integrity, bias, openness and responsible use.
- Finally, education must continue to be based on human judgement in decision making.

This strategy is supported by recent studies of B.Ed. students. Balraj (2025) found that B.Ed. students were frequent users of AI with advocated for specific professional development and planning to better integrate it in the classroom. Shinde (2026) found that B.Ed. students knew about applications like ChatGPT for notes, lesson plans with presentations, but less so about general AI's applications for teaching, learning with assessment. These data show access to AI is not the same as AI pedagogical ability.

Conclusion

Artificial intelligence has the potential to be a disruptive educational breakthrough in B.Ed. teacher education. It supports individualised learning, adaptive instruction, lesson planning, assessment, feedback, simulations with professional development. Artificial intelligence helps to learner-centred pedagogies by giving student-teachers experience of personalised learning and preparing them to design personalised learning experiences for school students. However, the mere incorporation of AI tools into the existing B.Ed. curriculum is not enough for meaningful AI integration. It requires a systematic integration of knowledge of technology with education, subject matter, ethical awareness and also professional judgement. Institutional policies with teacher preparation need to address concerns about academic integrity, data privacy, algorithmic bias, digital inequities with over-dependence. The main point of this conceptual paper is that AI should be a supplement to, not a replacement of, the instructor. The goal of B.Ed. programs should be to prepare future teachers to develop AI-supported customised educational environments that are critical, creative, ethical and pedagogically competent, instead of simply using AI. Such approach makes significant contributions to the development of smart teachers for a smart future with ensures that technology innovation is human-centred, inclusive with educationally relevant.

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TPACK AND AI-TPACK IN TEACHER EDUCATION: A REVIEW OF THE LITERATURE AND IMPLICATIONS FOR B.ED STUDENT-TEACHER PREPARATION IN BENGALURU, INDIA.

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Abstract

Artificial Intelligence (AI) is rapidly reshaping the knowledge base that teachers are expected to bring into the classroom, extending Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) framework into an emerging construct broadly referred to as AI-TPACK. This paper presents a narrative literature review of the theoretical and empirical scholarship on TPACK and AI-TPACK, synthesising findings from studies conducted in Nigeria, the Philippines, India, Ghana, South Africa, China, Turkey, and other national contexts between 2006 and 2026. The review traces the theoretical evolution of TPACK from Shulman's (1986) construct of Pedagogical Content Knowledge, through Mishra and Koehler's (2006) tripartite model, to contemporary AI-inflected reconceptualization (Celik, 2023; Ning et al., 2024; Petko et al., 2025), and it examines empirical evidence on pre-service and in-service teachers' AI-related readiness, attitudes, ethical knowledge, and the institutional conditions that shape AI-TPACK development. The literature is situated within the policy context of India's National Education Policy (NEP), 2020, and its implications are considered for B.Ed teacher preparation in Bengaluru, where student-teachers train across government-aided and private unaided colleges that differ in infrastructure, autonomy, and institutional culture. Across the studies reviewed, a consistent pattern emerges: teachers' general technological familiarity with AI tools tends to outpace their capacity to integrate AI pedagogically and ethically into content-specific instruction, and institutional support together with teacher educator modelling persist as predictors of stronger AI-TPACK development. The review identifies the most notably the near-absence of India-specific empirical work on AI-TPACK and by outlining a research agenda for future comparative and longitudinal studies of Indian B.Ed student-teachers.

Keywords: *Artificial Intelligence; TPACK, AI-TPACK, Teacher Education, B.Ed Student-Teachers*

Introduction:

Teacher education is undergoing a period of rapid transformation driven by the diffusion of digital and, more recently, artificial intelligence (AI) technologies into everyday instructional practice. For nearly two decades, the Technological Pedagogical Content Knowledge (TPACK) framework proposed by Mishra and Koehler (2006), building on Shulman's (1986)

construct of Pedagogical Content Knowledge (PCK), has served as the dominant lens through which researchers and teacher educators conceptualise the knowledge a teacher needs to integrate technology meaningfully into the classroom. The framework describes teacher knowledge as an interaction of three core domains Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) and the composite knowledge types that emerge at their intersections, namely Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and, at the centre, Technological Pedagogical Content Knowledge (TPACK) itself (Koehler & Mishra, 2009; Koehler et al.,2013).

The emergence of generative AI tools such as chatbots, intelligent tutoring systems, automated assessment engines, and AI-assisted lesson-planning platforms has prompted scholars to argue that the TPACK framework itself needs to be revisited and extended. Mishra, Warr, and Islam (2023) contend that generative AI systems behave less like static technological tools and more like collaborative or generative agents, requiring teachers to develop new competencies around prompting, verification, and ethical use. This has given rise to an emerging construct variously termed "Intelligent-TPACK" (Celik, 2023) or "AI-TPACK" (Ning et al., 2024) that extends the original framework to capture teachers' knowledge of how to select, adapt, and ethically integrate AI-based tools into content specific pedagogy.

In India, the National Education Policy (NEP), 2020, has placed considerable emphasis on technology integration in teacher preparation, envisaging AI and data-driven tools as means of personalising learning and strengthening teacher capacity (Ministry of Education, Government of India, 2020). Bengaluru, as one of India's principal technology and education hubs, hosts a large and diverse set of B.Ed colleges operating under different management structures government-aided colleges, which typically receive state grant-in-aid and operate under long-established administrative and academic norms, and private (self-financing/unaided) colleges, which often have greater autonomy in adopting new technologies but vary considerably in resource availability. Whether and how these two categories of institutions differ in the extent to which their student teachers develop an AI enhanced TPACK remains an open and largely unexamined question in the Indian teacher education literature.

This paper addresses that gap not through new primary data collection but through a systematic review and synthesis of the existing theoretical and empirical literature on TPACK and AI-TPACK. It traces the conceptual evolution of the framework, consolidates empirical evidence on pre-service teachers' AI-related knowledge and readiness across multiple national contexts, and draws out implications specifically relevant to the Indian B.Ed context and to Bengaluru's aided and private colleges. In doing so, it aims to provide teacher educators, college managements, and curriculum bodies such as the National Council for Teacher Education (NCTE) with an evidence-informed foundation for strengthening AI-

related competencies in teacher preparation programmes, and to identify precisely where future empirical research including comparative studies of aided and private institutions is most needed.

2. Review Methodology

This paper adopts a narrative, integrative review approach rather than a formal systematic review, a choice consistent with the still-emerging and heterogeneous state of the AI-TPACK literature. Schmid, Brianza, Mok, and Petko (2024), in a systematic review of reviews on TPACK, note that the TPACK literature itself remains methodologically fragmented, with reviews varying widely in scope, database coverage, and quality-appraisal criteria; the still smaller and more recent AI-TPACK literature is not yet mature enough to support a fully protocol-driven systematic review with meta-analytic synthesis. A narrative review was therefore judged more appropriate for mapping the conceptual terrain and consolidating cross-national empirical patterns.

Literature was identified through structured searches of Scopus, Web of Science, ERIC, and Google Scholar, using combinations of the terms 'TPACK,' AI-TPACK,' 'Intelligent-TPACK,' 'Artificial intelligence'. 'generative AI', 'pre-service teacher,' 'teacher education' and 'teacher readiness.' The search was not restricted by publication date but concentrated on literature published between 2006 (the year of Mishra and Koehler's foundational article) and 2026, with particular emphasis on studies published since 2022, when AI-TPACK began to emerge as a distinct construct. Reference lists of retrieved articles were hand searched to identify additional relevant studies (a snowballing strategy).

Studies were included if they (a) were peer-reviewed journal articles, book chapters, or policy documents; (b) addressed the TPACK or AI-TPACK framework explicitly, either theoretically or empirically; and (c) focused on teachers, pre-service teachers, or teacher education more broadly. Studies were excluded if they addressed AI in education without reference to TPACK or an equivalent teacher knowledge framework, or if they were not available in English. Because comparatively little empirical work has been located that examines AI-TPACK specifically within Indian B.Ed institutions, this review also draws on India's broader teacher-education policy literature (principally the NEP, 2020) to contextualise the international empirical evidence for the Indian setting. The absence of India specific AI-TPACK studies is treated as a substantive finding of the review rather than a limitation of the search strategy.

3. Theoretical Foundations: From TPACK to AI-TPACK

3.1 The TPACK Framework

The theoretical roots of TPACK lie in Shulman's (1986) argument that effective teaching requires more than content mastery or generic pedagogical skill in isolation; it requires Pedagogical Content Knowledge (PCK) an integrated understanding of how to represent and formulate a subject so that it is comprehensible to learners. Mishra and Koehler (2006) extended this construct by introducing Technological Knowledge (TK) as a third, co-equal

domain, arguing that technology integration cannot be treated as an "add-on" to existing pedagogy and content but must be understood as interacting dynamically with both. Their model, first presented at the American Educational Research Association (Mishra & Koehler, 2008) and subsequently elaborated by Koehler and Mishra (2009) and Koehler, Mishra, Akcaoglu, Reethumol S R (2024) and Rosenberg (2013), depicts seven interacting knowledge components : TK(Technological Knowledge), PK(Pedagogical Knowledge), CK(Content Knowledge), PCK(Pedagogical, Technological Knowledge),
TCK(Technological, Content, Knowledge, TPK(Technological, Pedagogical, Knowledge, and TPACK(Technological, Pedagogical Content Knowledge) situated within a broader instructional context.

3.2 From TPACKJ to AI- TPACK: An Emerging Construct

AI tools have moved from the periphery to the centre of everyday digital practice, several scholars have argued that TK, as originally conceived, is too broad a category to capture the distinctive competencies AI use demands. Celik (2023) proposed the "Intelligent-TPACK" construct and an accompanying validated scale to measure teachers' professional knowledge for the ethical integration of AI-based tools, arguing that AI use raises knowledge and ethical questions around bias, transparency, over-reliance, and data privacy that earlier TPACK conceptions did not anticipate. Building on this, Deng and Zhang (2023) developed the Technological Pedagogical Content Ethical Knowledge (TPCEK) instrument, explicitly separating ethical knowledge from technical knowledge within an assessment framework for pre-service teachers, which reinforces the view that AI-related ethics constitutes a distinguishable knowledge component rather than a facet of general technological Knowledge.

Mishra, Warr, and Islam (2023) examined TPACK in the specific context of ChatGPT and generative AI, suggesting that teacher educators need to rethink how TK is taught given that generative AI can itself produce pedagogical content, blurring the line between the teacher's TCK and the tool's own generative capacity. Ning, Zhang, Xu, Zhou, and Wijaya (2024) empirically constructed and tested a seven-component AI-TPACK model PK, CK, AI-TK, PCK, AI-TCK, AI-TPK, and AI-TPACK reinforcing the view that AI-related knowledge functions as a distinct, interacting layer rather than a simple substitute for general technological knowledge. Subsequent instrument-development work, including Karataş and Atac's (2025) structural equation model of TPACK and AI-TPACK among English-language pre-service teachers, has substantiated this seven-component structure across different national and disciplinary settings.

4. Thematic Review of Empirical Evidence

4.1 Teachers Readiness, Attitudes, and Self Efficacy

A growing body of international empirical research has examined pre-service and in-service teachers' readiness, attitudes, and competence with respect to AI integration. Ayanwale, Sanusi, Adelana, Aruleba, and Oyelere (2022), in a large-scale study of Nigerian in-service

teachers, found that perceived confidence in teaching AI and the perceived relevance of AI were the strongest predictors of teachers' intention and readiness to integrate AI into their teaching, while AI-related anxiety did not significantly diminish this intention. Sanusi, Ayanwale, and Tolorunleke (2024), applying the Theory of Planned Behaviour to a large sample of Nigerian pre-service teachers, similarly found that self-efficacy and subjective norms shaped pre-service teachers' behavioural intention to learn AI. In the Philippine context, Bautista et al. (2024) used a TPACK-based descriptive survey with pre-service teachers and reported generally positive but uneven familiarity with AI tools across the TK, TCK, and TPK domains. In China, Wang, Ruan, Zhang, Fu, and Duan (2024) found that GenAI-related anxiety, social influence, and performance expectancy significantly predicted pre-service teachers' behavioural intention to design GenAI-assisted teaching, whereas effort expectancy and facilitating conditions were not significant predictors a finding that qualifies the assumption that infrastructural ease of use is always the binding constraint on AI adoption.

4.2 Transformation from TPACK to AI -TPACK on the basis of Ethical Knowledge and the Intellectual factors.

Gregorio, Alieto, Natividad, and Tanpoco (2024), using Celik's (2023) Intelligent-TPACK instrument with Philippine pre-service teachers, found that participants' AI-related technical knowledge frequently outpaced their understanding of the ethical dimensions of AI use, pointing to a need for explicit attention to AI ethics in teacher-preparation curricula. This pattern is consistent with Deng and Zhang's (2023) rationale for treating ethical knowledge as a separable construct within TPCEK, and with Karataş and Ataç's (2025) finding that, among 304 English-language pre-service teachers, ethics and the integrated AI-TCK and AI-PCK components lagged behind comparatively strong AI-TK and AI-TPK scores. Taken together, these studies suggest that any AI-TPACK instrument should give explicit and separately scored weight to ethical-knowledge items, since ethical awareness does not appear to track proportionally with self-reported technical competence.

4,3 Institutional and Contextual Factors

In Ghana, Acquah, Arthur, Salifu, Quayson, and Nortey (2024) found that social influence, habit, and performance expectancy were significant predictors of pre-service teachers' behavioural intention to use AI specifically in lesson planning, while hedonic motivation was not. More recently, Kgosi, Botes, Neethling, Mahlo, and Zondi (2026), in a TPACK-informed study of STEM pre-service teachers in South Africa, argued that meaningful integration of AI and open educational resources requires deliberate alignment between the TPACK and SAMR models and depends heavily on institutional support and teacher-educator modelling. Petko, Koehler, and Mishra's (2024, 2025) contextual re-reading of TPACK provides a theoretical rationale for why such institutional variation matters: infrastructure, policy, and culture are treated not as background noise but as active shapers of how technological, pedagogical, and content knowledge interact for a given teacher in a

given setting a finding with direct relevance to comparisons across differently resourced Indian B.Ed college types

4.4 Measurement and Assessment Instruments

Instrument development has been central to this literature. Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009) produced the widely validated TPACK survey for pre-service teachers on which most subsequent AI-TPACK scales have been built. Celik (2023) extended this tradition with the Intelligent-TPACK scale; Ning et al. (2024) validated a seven-factor AI-TPACK model; Deng and Zhang (2023) developed the TPCEK instrument foregrounding ethical knowledge; and Karataş and Ataç (2025) applied structural equation modelling to test the fit of the AI-TPACK factor structure among English-language pre-service teachers, finding acceptable model fit but comparatively weaker performance on integrated (as opposed to standalone) knowledge components. Yue, Jong, and Ng (2024), studying K-12 teachers' TPACK readiness and attitudes toward AI education, similarly found uneven readiness across knowledge domains, reinforcing the general pattern that self-report AI-TPACK measurement is now reasonably well-validated internationally but has rarely been adapted or piloted for the Indian B.Ed context specifically.

4.5 Summary of Key Studies Reviewed

Study	Context/Sample	Framework	Key findings
Ayanwale et al. (2022)	Nigeria, inservice teachers	Ai readiness/ TPACK adjacent	Confidence and perceived relevance predict readiness to teach AI;anxiety not a significant preventive.
Celik(2023)	Teachers; scale-development study	Intelligent-TPACK	Develops and validates a scale for ethical AI-integration knowledge, distinct from general TK
Bautista et al. (2024)	Philippines; preservice teachers	TPACK	Uneven familiarity TK,TCK, and TPK domains.
Gregoria et al,(2024)	Philippines; preservice teachers	Intelligent-TPACK	Technical AI knowledge outpaces ethical understanding of AI use.
Acquah et al. (2024)	Ghana, pre service teachers	UTAUT/Lesson planning	Social influence, habit, performance expectancy predict. AI use intention; hedonic motivation does not
Sanusi et al(2024)	Nigeria; pre-service teachers	Theory of planned Behaviour	Self efficacy and subjective norms shape intention to learn AI
Ning et al (2024)	China ;teachers	AI-TPACK (7 factor model)	Validates AI-TK. AI-TCK,AI-TPK as distinct, interacting knowledge elements

Deng & Zhang (2023)	Pre service teachers instrument development	TPCEK	Separates ethical knowledge as a distinct, assessable component of TPACK
Wang et al (2024)	China; pre service teachers	TPACK/ UTAUT	Gen AI anxiety and social influence predict intention, facilitating conditions do not
Kgosi et al (2026)	South Africa ; STEM pre service teachers	TPACK/ SAMR	Institutional support and teacher educator modelling are decisive for AI integration
Karatas & Atac (2025)	Turkey. 304 ELT pre service teachers	AI- TPACK	AI-TPACK, preservice teachers exhibited above-average competence across all areas, with highest proficiency in Intelligent AI-TK and lowest in ethics.
Perko et al (2025)	Conceptual synthesis	TPACK in context	Context and Contextual Knowledge actively shape how TPACK

Table 1: Summary of Key studies reviewed on TPACK and AI-TPACK

5. AI in Indian Teacher Education Policy and Practice: The NEP 2020 Context

India's National Education Policy, 2020, explicitly foregrounds the use of technology, including AI, to personalise learning, strengthen assessment, and expand access, and calls for a revised National Curriculum Framework for Teacher Education (NCFTE) that better prepares teachers for a technology-integrated classroom (Ministry of Education, Government of India, 2020). While the policy provides a strong normative mandate for AI-related capacity building in teacher preparation, translating this mandate into classroom-level practice depends on institutional factors including faculty training, digital infrastructure, and management priorities that vary considerably across India's large and heterogeneous B.Ed sector. Bengaluru's B.Ed colleges, operating under aided and private managements affiliated to different universities and regulated by the NCTE, offer a useful setting in which to examine how such contextual variation shapes the development of AI-enhanced TPACK among student-teachers, yet, as the review methodology in Section 2 indicates, no empirical study located in this review has directly tested AI-TPACK within this specific Indian setting.

6. Synthesis: Cross cutting patterns Across the reviewed literature

Across studies, pre-service teachers show strong general AI tool skills but weaker ability to integrate AI into teaching methods and ethics. Institutional support and mentoring matter more than personal tech familiarity in shaping this gap. Frequent, pedagogically-focused AI use correlates with stronger integration skills. These patterns, seen across countries, suggest future Indian instruments should separately measure ethical knowledge and usage type

7. Toward an AI Infused TPACK Model: A Synthesis of the Reviewed Literature

Based on TPACK theory and later AI-focused versions, this model treats AI not as a separate skill area, but as a layer surrounding teachers' existing knowledge of technology, teaching methods, and content. AI reshapes how these areas work together like using AI to plan

lessons, create content, or assess student understanding rather than existing as its own separate skill.

8. Implications for B.Ed Teacher Preparation in Bengaluru

This section draws practical lessons for B.Ed teacher preparation in Bengaluru. Colleges should embed AI literacy and ethics directly into existing Soft Core Courses, not as separate computer/ IT classes. Since teacher educators strongly influence students' AI skills, faculty training programs are essential. Because institutional support matters more than personal tech skills. Both aided colleges and private colleges may need extra help like labs, licensed tools, and clear AI policies to provide appropriate exposure. Assessments should include practical tasks like AI based lesson planning, not just self-reported surveys. Finally, since no study has compared the impact of effectiveness of TPACK and AI-TPACK, in teacher preparation programme in B.Ed colleges. Bengaluru offers an ideal setting for future research.

Conclusion

The TPACK framework has, for nearly two decades, provided a robust lens for understanding the integrated knowledge teachers require to teach effectively with technology. The rapid diffusion of AI tools into educational practice now calls for this framework to be extended as the emerging AI-TPACK literature reviewed here demonstrates to capture teachers' capacity to select, pedagogically embed, and ethically use AI in content specific instruction. This paper has reviewed the theoretical and empirical foundations of this emerging construct across multiple national contexts, synthesised an AI-infused TPACK model consistent with that literature, and situated the synthesis within the policy context of India's NEP 2020 and the specific setting of B.Ed teacher preparation in Bengaluru. In doing so, it has identified a clear and researchable gap: the absence of India-specific empirical evidence comparing AI-TPACK among student-teachers of aided and private B.Ed colleges. Addressing that gap through the comparative, literature-grounded research agenda outlined paper would generate institution-level evidence that curriculum bodies, college managements, and teacher educators can use to strengthen AI-integrated pedagogical innovation across differently resourced B.Ed institutions in India.

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IMPACT OF ICT ON EDUCATIONAL DEVELOPMENT

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Abstract

Information and Communication Technology (ICT) has rapidly transformed the educational landscape worldwide. Its integration into educational systems has improved access to information, enhanced teaching–learning processes, and fostered new modes of collaboration. This paper examines the impact of ICT on educational development, identifies key benefits and challenges, and discusses implications for policy and practice. Findings suggest that ICT promotes student engagement, supports personalized learning, and strengthens institutional effectiveness, but challenges such as infrastructure gaps and teacher readiness must be addressed.

Key words: *Information and Communication Technology (ICT), Teaching- learning process, Students' Engagement and Teacher Readiness.*

1. Introduction

Education is a fundamental driver of individual growth and societal progress. In recent decades, Information and Communication Technology (ICT) has emerged as a pivotal tool in transforming educational practices globally (Kozma, 2025). ICT encompasses digital tools such as computers, internet resources, multimedia software, and mobile technologies that facilitate the storage, retrieval, transmission, and manipulation of information (Voogt et al., 2025). Its integration into educational systems has expanded learning opportunities, enabled innovative pedagogical approaches, and enhanced student engagement (UNESCO, 2025).

The use of ICT in teaching and learning has demonstrated significant potential in improving educational outcomes. For instance, interactive platforms, simulation software, and online resources have enabled educators to deliver content more effectively and adapt instruction to diverse learner needs (Selwyn, 2025; Warschauer, 2025). Furthermore, ICT has promoted collaborative learning by providing students with virtual spaces to communicate, share knowledge, and solve problems collectively (Becker & Ravitz, 2025). Studies have also shown that ICT supports the professional development of teachers by offering access to training modules, peer networks, and digital teaching resources (Kozma, 2025; UNESCO, 2025).

Despite these benefits, challenges persist in ICT adoption within educational settings. Issues such as inadequate infrastructure, limited teacher preparedness, financial constraints, and the digital divide continue to affect the equitable implementation of technology (Selwyn, 2025; Voogt et al., 2025). Addressing these challenges requires coordinated policies, sustained investment, and capacity-building programs for educators (Warschauer, 2025). Overall, the integration of ICT in education holds promise for enhancing access, improving teaching-learning processes, and preparing students for a technology-driven world.

2. Literature Review

Kozma (2025) examined the role of ICT in education and its contribution to national development. He emphasized that ICT facilitated access to knowledge, promoted innovative teaching practices, and supported the professional development of teachers. His study highlighted that ICT integration improved learning outcomes when combined with appropriate pedagogical strategies and policy support.

Voogt et al. (2015) examined the effects of ICT on teaching and learning outcomes across different educational levels. They reported that ICT enhanced collaborative learning, critical thinking, and problem-solving skills among students. The study emphasized that sustained teacher support, relevant digital content, and curriculum alignment were critical for maximizing the benefits of ICT in education.

UNESCO (2013) conducted a global review of ICT in education and reported that digital tools expanded access to quality learning, particularly in remote and underserved areas. The findings indicated that ICT improved student engagement, personalized learning experiences, and administrative efficiency but noted challenges related to infrastructure and equity.

Selwyn (2011) analyzed the broader debates around education and technology. He reported that while ICT offered opportunities for improving teaching and learning, its effectiveness depended on teacher readiness, institutional support, and socio-economic contexts. His review suggested that technology alone could not guarantee educational improvement without systemic planning and training.

Warschauer (2006) investigated the use of laptops in classrooms and their impact on literacy development. He found that students who had regular access to laptops demonstrated enhanced writing skills, better engagement in collaborative learning, and increased motivation. The study concluded that technology could transform traditional teaching methods and foster more interactive learning environments.

Becker and Ravitz (2001) explored how teachers integrated technology in classroom instruction. They found that teachers who received training and institutional support were more likely to use ICT effectively to enhance student learning. The study highlighted that professional development and access to digital resources played a crucial role in successful ICT adoption.

3. Methodology

This paper uses a qualitative review approach, synthesizing findings from scholarly articles,

educational reports, and case studies published over the past two decades. Sources were selected based on relevance to ICT applications in education and documented impacts on teaching, learning, and institutional development.

4. Impacts of ICT on Educational Development

4.1 Enhancing Access to Education

ICT has expanded educational access beyond the traditional classroom. E-learning platforms, Massive Open Online Courses (MOOCs), and virtual libraries allow learners to access educational materials regardless of geographic barriers.

4.2 Improving Teaching and Learning Processes

ICT tools such as interactive whiteboards, multimedia presentations, and simulation software make lessons more engaging. These tools help students visualize complex concepts, practice skills, and receive feedback in real time.

4.3 Supporting Student Engagement and Motivation

Digital games, collaborative platforms, and online forums encourage active participation. Students often show higher motivation when learning involves technology that reflects real-world applications.

4.4 Personalized Learning

Adaptive learning systems adjust content based on individual performance. This personalization supports learners at different levels and enables educators to tailor instruction more effectively.

4.5 Professional Development for Educators

ICT enables teachers to access training modules, share resources, and join professional communities. Continuous professional learning helps educators adopt best practices in digital pedagogy.

4.6 Administrative and Institutional Efficiency

ICT systems improve administrative tasks such as enrollment management, grading, and communication with parents. These efficiencies free up time for instructional planning and support.

5. Challenges of ICT Integration

- Despite its benefits, ICT integration faces challenges:
- Infrastructure Limitations: Many schools lack reliable internet access, adequate devices, or maintenance support.
- Teacher Preparedness: Not all teachers are trained or confident in using ICT tools effectively.
- Cost Factors: Implementation and maintenance of ICT resources require financial investment that may be beyond many educational institutions.
- Digital Divide: Socio-economic disparities affect students' access to technology outside school.

6. Discussion

The transformative potential of ICT in education is undeniable. When implemented thoughtfully, ICT can support equitable access, deepen learning experiences, and prepare students for a technology-rich future. However, policies must prioritize infrastructure development, continuous teacher training, and inclusive strategies to bridge digital divides.

Countries that invest strategically in ICT and teacher capacity tend to show stronger educational outcomes compared to those that implement technology without supportive ecosystems.

7. Conclusion

ICT has a significant positive impact on educational development by enhancing access, enriching teaching and learning, and supporting administrative functions. However, successful integration requires addressing infrastructural, pedagogical, and socio-economic challenges. Future research should explore long-term impacts of emerging technologies such as artificial intelligence and virtual reality on education.

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REIMAGINING TEACHER EDUCATION IN THE AGE OF ARTIFICIAL INTELLIGENCE: POLICY IMPERATIVES, PEDAGOGICAL REALIGNMENT, AND THE MAKING OF A NEW PROFESSIONAL IDENTITY

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Abstract

Artificial intelligence (AI) is becoming a structural condition under which teaching, learning, and teacher preparation are organised, not merely a peripheral classroom tool. This article examines the emerging policy landscape surrounding AI in teacher education, situating India's National Education Policy (NEP) 2020 and National Council for Teacher Education (NCTE) reforms within the wider international movement represented by UNESCO's AI Competency Framework for Teachers, the European DigCompEdu framework, and OECD policy guidance. Moving beyond a purely technical reading of AI adoption, the article develops a policy-and-pedagogy argument: AI compels a redefinition of the teacher educator's professional role, from primary transmitter of content to curator, ethical gatekeeper, and designer of human-AI learning ecosystems. Drawing on the Technological Pedagogical Content Knowledge (TPACK) framework and its emerging extension, AI-TPACK, the article proposes a reconceptualised teacher education curriculum built around four pillars: AI literacy, ethical and critical AI reasoning, pedagogical redesign for human-AI collaboration, and equity-conscious implementation. It concludes with policy recommendations for institutions operating under the Choice Based Credit System (CBCS) and NEP 2020 mandates.

Keywords: *Artificial intelligence, teacher education, NEP 2020, AI-TPACK, AI literacy, educational policy, digital equity, teacher educator identity*

1. Introduction

Teacher education has been reshaped by successive waves of technology, from audio-visual aids to the online-learning ecosystems accelerated by the pandemic. The current wave, driven by generative and adaptive AI, differs in a fundamental respect: it does not merely deliver content more efficiently; it performs tasks once exclusive to the teacher — drafting lesson plans, generating assessment items, and simulating tutoring dialogue (Nyaaba & Zhai, 2025; Alfarwan, 2025). Ministries, accreditation bodies, and institutions are simultaneously being asked to regulate AI, to teach about AI, and to teach with AI, often without a settled

conceptual vocabulary for doing so (OECD, 2024; Chan, 2023).

The stakes are particularly high for teacher education, as it is the site where future classroom practice is formed. If student teachers are not equipped with a critical, pedagogically grounded understanding of AI, the technology risks uncritical adoption that displaces reflective practice, or defensive prohibition that leaves teachers unprepared for classrooms their students already inhabit (Tan, 2025). This article argues that what is required is an ideological and curricular repositioning of teacher education itself — a shift in what it means to be professionally competent in an AI-mediated classroom. The discussion traces the move from TPACK to AI-TPACK, maps the converging global and Indian policy landscape, develops the argument that AI is reshaping teacher identity, proposes curricular pillars for NEP-aligned programmes, and addresses the equity tensions any serious response must confront.

2. From TPACK to AI-TPACK: A Theoretical Reorientation

Shulman's (1986) concept of Pedagogical Content Knowledge established that effective teaching integrates subject-matter knowledge with knowledge of how to teach it. Mishra and Koehler (2006) extended this into the Technological Pedagogical Content Knowledge (TPACK) framework, adding technology as a third, interacting domain — since the dominant lens for digital competence in B.Ed. and M.Ed. curricula in India.

AI, however, does not sit comfortably inside the original TPACK triangle: unlike a projector or learning-management system, generative AI can independently produce pedagogical artefacts — explanations, questions, feedback — that previously required a human teacher's judgement. Scholars have therefore proposed an AI-augmented extension of TPACK, in which "technology knowledge" is disaggregated into an understanding of how AI systems generate, err, and can be prompted, evaluated, and corrected (Coşgun, 2025). AI literacy thus becomes a fourth interacting domain, and teacher authority shifts from being the primary source of content to being the primary source of judgement about content — a role increasingly described as "teacher-as-editor" or "teacher-as-orchestrator" rather than teacher-as-transmitter (Nyaaba & Zhai, 2025).

3. The Global and National Policy Landscape

Internationally, policy responses have converged around competency frameworks rather than prohibition. UNESCO's (2024) AI Competency Framework for Teachers moves from a human-centred mindset, through ethical application, to AI pedagogy and professional development, resisting a purely tool-based conception of AI competence. UNESCO's (2023) Guidance for Generative AI in Education foregrounds human agency, arguing AI should support rather than substitute human judgement. In Europe, DigCompEdu (Redecker, 2017) had already articulated educator digital competence before generative AI became widespread and is now being used as a scaffold for AI-specific competencies. The OECD's (2024) Education Policy Outlook frames AI as a workforce-policy issue, linking readiness to teacher shortages and the changing nature of teaching as an occupation.

In India, NEP 2020 explicitly names Artificial Intelligence, alongside coding and data science, as a 21st-century skill for curricular integration, situating teacher preparation as central to this through its provisions on technology use and continuous professional development (Ministry of Education, 2020). NCTE, as the statutory regulatory body, is correspondingly tasked with translating this intent into accreditation and curricular norms for B.Ed. and M.Ed. programmes. Yet an implementation gap persists: policy names AI as a priority while teacher preparedness, infrastructure, and assessment practice lag behind, particularly outside metropolitan centres — a pattern common to developing-country systems, where infrastructural unevenness rather than governance is typically the dominant constraint. What distinguishes the present moment from earlier ICT policy cycles is that teacher education institutions, not only school teachers, are now explicit policy subjects, expected to model AI-integrated pedagogy for the student teachers who will carry it into schools.

4. New Ideological Aspects: Reconceiving the Teacher's Professional Role

Beyond policy mechanics, AI is provoking a deeper ideological reconsideration of what teaching is for, along three interlinked lines. First, from knowledge-transmitter to judgement-holder: the teacher's classical authority rested on privileged access to knowledge, which generative AI dissolves almost entirely, since students can obtain competent explanations from AI as readily as from a teacher. What AI cannot substitute for is contextual judgement — knowing which explanation suits which learner, and which error reveals genuine misconception. Teacher education must shift its centre of gravity from content mastery toward cultivating this judgement, treating AI output as material to be evaluated rather than excluded or uncritically adopted.

Second, from individual practitioner to ethical gatekeeper: as AI increasingly mediates assessment and feedback, teachers are repositioned as gatekeepers who must interrogate the fairness and appropriateness of algorithmic recommendations before acting on them (UNESCO, 2023; Arar et al., 2025) — a markedly different disposition from the technology-as-neutral-tool mindset of earlier ICT integration. Third, from isolated classroom authority to human-AI collaborative designer: teaching increasingly involves designing learning experiences in collaboration with, and supervision of, non-human systems (Dennison et al., 2025), reframing lesson planning and assessment as human-AI co-design in which the teacher's distinctive contribution is purpose, boundaries, and final judgement.

5. AI Literacy as a Core Competency, and the Equity Question

If these shifts are to be translated into practice, AI literacy must be treated as a core, assessable competency, not an optional add-on. Following recent scoping work (Tan, 2025) and the UNESCO (2024) framework, it can be organised into four components: conceptual literacy (understanding how AI systems generate fluent but sometimes inaccurate output); evaluative literacy (critically assessing AI-generated lesson plans, items, and feedback for accuracy and bias); design literacy (redesigning assessment so it remains meaningful when students have AI access); and ethical literacy (data privacy, algorithmic bias, and appropriate boundaries with minors). These can be threaded through existing CBCS-based methodology and educational-technology papers rather than requiring wholly new courses, supported by practicum tasks in which student teachers critically annotate, rather than simply use, AI-generated material.

No response is complete without confronting equity. Reports celebrating AI's

potential to personalise learning also consistently flag a widening digital divide, in which well-resourced institutions build AI-integrated practice rapidly while under-resourced rural colleges are left behind. For a state such as Karnataka, where teacher education colleges range from richly resourced urban institutions to resource-constrained rural ones, this is a direct policy priority: AI requirements introduced without matching investment in connectivity and faculty development risk becoming a new axis of inequality rather than the inclusive lever NEP 2020 envisions. A related tension is overreliance — qualitative studies report teachers experiencing AI simultaneously as relief from workload and as a source of anxiety about deskilling and eroded autonomy (Jiang, 2026), giving teacher education a dual responsibility: building AI competence while protecting the reflective, relational core of teaching.

6. Reconceptualising the Curriculum, and the Way Forward

Bringing these arguments together, teacher education curricula might reorganise their AI response around four integrated pillars — foundational AI literacy, ethical and critical AI reasoning, pedagogical redesign for human-AI collaboration, and equity-conscious implementation — operationalised through revised internal assessment, practicum tasks requiring critical annotation of AI-generated material, and faculty development for teacher educators, who often share the competence gaps identified among practising teachers. Institutional accreditation under NCTE norms offers a natural mechanism, provided AI competence is framed as a professional disposition to be demonstrated rather than a syllabus line to be described.

Several challenges will condition how far this can proceed: infrastructural unevenness, particularly in rural districts; faculty capacity, since teacher educators themselves need sustained AI-literacy development before they can model it; assessment formats poorly suited to evaluative, design-oriented competencies; and incomplete policy coherence, with detailed curricular guidance for teacher education still emerging. Addressing these will require coordinated action at three levels — national and state bodies providing clearer curricular and ethical guidance; universities and affiliated colleges investing in faculty development alongside curricular reform; and individual teacher educators cultivating the reflective, critical disposition this article has argued must become central to professional identity in the field.

7. Conclusion

Artificial intelligence is reshaping teacher education not merely as a new instructional tool but as a condition unsettling long-held assumptions about the teacher's professional role. The move from TPACK to AI-TPACK captures a genuine theoretical shift, repositioning teacher authority from content transmission toward pedagogical judgement, ethical gatekeeping, and human-AI collaborative design. Global frameworks from UNESCO, DigCompEdu, and the OECD, together with India's NEP 2020 and NCTE reforms, converge on this direction, even as implementation gaps around equity and faculty readiness remain significant. The task ahead for teacher education institutions is not to add an AI module to existing curricula, but to rethink, at an ideological level, what professional competence means for a generation of teachers who will practise alongside increasingly capable machine collaborators — using AI as an instrument of pedagogical judgement rather than a substitute for it.

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THE ROLE OF GENERATIVE ARTIFICIAL INTELLIGENCE IN MODERN SCIENCE CLASSROOMS

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Abstract

Generative Artificial Intelligence (Gen AI) is rapidly transforming education by providing new ways to create, access, and communicate knowledge. Unlike traditional digital tools, Gen AI can generate text, explanations, questions, images, simulations, and other learning materials in response to user prompts. Its growing use has created new opportunities for science teaching and learning, particularly in classrooms where students need to understand complex concepts, conduct investigations, and develop scientific reasoning. Research shows that artificial intelligence can support science education by creating learning materials, generating quizzes, assessing student work, and improving the learning environment. However, effective use requires teachers to remain actively involved and ensure that AI-generated information is accurate and educationally appropriate.

Keywords: *Generative Artificial Intelligence, Role of Gen AI, Science Classroom*

Introduction

Generative AI in Science Education: Science education covers concepts that can be difficult to grasp from textbooks alone. Topics such as cell division, genetics, chemical reactions, the solar system, ecosystems, and molecular biology can benefit from interactive explanations and multiple forms of representation. Generative AI can provide students with explanations at different levels of difficulty. For example, a student learning photosynthesis can ask an AI system to explain the process in simple language, provide an analogy, create practice questions, or identify the main steps involved. This can make learning more personalised and accessible. Gen AI can also support multimodal learning by helping students work with text, images, diagrams, and other representations. Research in science education highlights the importance of language, interaction, argumentation, and multimodal representations in learning science.

Role of Gen AI in the Science Classroom

1. Personalised Learning: Students have different learning speeds, backgrounds, and levels of understanding. Gen AI can provide explanations and examples according to an individual student's needs. A teacher can also use AI-assisted resources to prepare differentiated activities for students with different learning levels.

2. Creating Teaching Materials: Teachers can use Gen AI to prepare lesson plans,

worksheets, quizzes, question banks, discussion questions, summaries, and classroom activities. This can reduce the time required for routine preparation and allow teachers to devote more time to classroom interaction.

3. Explaining Complex Scientific Concepts: Gen AI can explain difficult scientific concepts using simple language, analogies, step-by-step explanations, and examples. For instance, abstract topics such as DNA replication or atomic structure can be explained in several different ways depending on the learner's needs.

4. Promoting Scientific Inquiry: Science learning should involve questioning, investigation, evidence, and reasoning. Teachers can use Gen AI to generate scientific problems or alternative explanations that students must examine. Students can then investigate whether the AI-generated explanation is supported by scientific evidence. This approach can turn AI from merely an answer-producing tool into a starting point for critical scientific inquiry.

5. Supporting Assessment: AI can help teachers create formative assessments such as multiple-choice questions, short-answer questions, concept questions, and quizzes. It can also provide suggestions for feedback. AI-based tools have already been explored for assessment and other educational purposes in science education.

6. Encouraging Critical Thinking: One of the most valuable uses of Gen AI is to teach students not to accept every AI-generated answer as correct. AI systems can sometimes produce inaccurate or misleading information. Students can be asked to verify AI responses using textbooks, scientific articles, laboratory observations, and reliable scientific sources. This develops important skills such as questioning, evidence evaluation, scientific reasoning, and information literacy.

7. Supporting Inclusive Education: Gen AI can potentially provide explanations in different languages and formats, which may support students from diverse linguistic and educational backgrounds. UNESCO emphasises that AI in education should promote inclusion, equity, accessibility, and respect for linguistic and cultural diversity.

Benefits of Generative AI in Science Classrooms

The major benefits include: Personalised learning experiences, faster creation of teaching and assessment materials simplification of complex scientific concepts, support for inquiry-based learning, generation of practice questions and activities; immediate assistance with explanations, opportunities for interactive learning, development of AI and digital literacy, support for teachers in lesson preparation, and encouragement of critical thinking when AI outputs are evaluated.

A systematic review of AI applications in education found benefits related to learning environments, assessment, motivation, problem-solving, and students' attitudes toward technology.

Challenges and Limitations

Despite its potential, Gen AI also presents important challenges.

Accuracy and Misinformation: AI can generate incorrect scientific information while

presenting it confidently. Therefore, teachers and students must verify important information using reliable scientific sources.

Academic Integrity: Students may use AI to complete assignments without understanding the subject. This can reduce genuine learning and make traditional forms of assessment less effective.

Overdependence on AI: Excessive dependence on AI may reduce students' opportunities to think independently, solve problems, communicate, and develop their own scientific explanations.

Privacy and Data Protection: Students may enter personal or sensitive information into AI systems. Educational institutions therefore need clear rules regarding privacy and responsible data use. UNESCO specifically highlights data protection and the need for human-centred policies for GenAI in education.

Digital Inequality: Not every student has equal access to devices, reliable internet connections, or advanced AI tools. Unequal access can increase existing educational inequalities.

Teacher Training: Teachers need appropriate AI literacy to understand the capabilities and limitations of Gen AI and to integrate it meaningfully into their teaching.

Role of the Science Teacher

Gen AI should support rather than replace the science teacher. Teachers remain responsible for selecting appropriate learning objectives, checking scientific accuracy, guiding experiments, encouraging discussion, and assessing students' actual understanding. A human-centred approach is particularly important because technology alone cannot solve the fundamental challenges of education. UNESCO recommends that Gen AI be used in ways that protect human agency, inclusion, equity, and diversity.

Future of Gen AI in Science Education

The future science classroom is likely to combine traditional teaching with AI-supported learning. Students may increasingly use AI to explore questions, generate hypotheses, compare explanations, analyse information, and receive personalised learning support. However, the goal should not be to make students dependent on AI. Instead, education should prepare students to work intelligently with AI while retaining human judgment and scientific thinking. Future research should investigate which uses of Gen AI genuinely improve science learning, how teachers can integrate it effectively, and how assessment can measure students' independent understanding. Current research also indicates that more empirical investigation is needed to establish evidence-based practices for AI in science education.

Conclusion

Generative Artificial Intelligence has significant potential to transform modern science classrooms. It can personalise learning, support teachers, create educational materials, explain complex concepts, assist assessment, and encourage scientific inquiry. At the same time, challenges such as misinformation, academic dishonesty, privacy concerns, digital inequality,

and overdependence must be carefully addressed. The most effective approach is therefore not to treat Gen AI as a replacement for teachers or scientific thinking, but as a supportive educational tool. When combined with expert teachers, reliable scientific resources, hands-on experiments, critical thinking, and responsible digital practices, Gen AI can contribute to more engaging, inclusive, and meaningful science education.

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ARTIFICIAL INTELLIGENCE IN EDUCATION: TRANSFORMING TEACHERS FOR THE FUTURE OF LEARNING

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Abstract

Artificial Intelligence (AI) is rapidly transforming the educational ecosystem by influencing how knowledge is created, delivered, assessed and personalized. While considerable attention has been devoted to the role of AI in improving student learning outcomes, relatively less attention has been given to the transformation of teachers themselves. The emergence of generative AI, intelligent tutoring systems, learning analytics, automated assessment tools and AI-enabled content development platforms requires educators to acquire new competencies and reconsider their traditional pedagogical roles. The contemporary teacher is increasingly expected to function not merely as a transmitter of knowledge but as a facilitator, curator, evaluator, mentor, designer and ethical guide within an AI-supported learning environment. The present study examines the role of Artificial Intelligence in shaping "smart teachers" for the future of education. The study focuses on four dimensions: AI literacy, perceived usefulness of AI, AI pedagogical competence and ethical awareness. It investigates the relationship between these dimensions and teachers' readiness to integrate AI into teaching and learning practices. The study adopts a quantitative, descriptive and correlational research design. For the purpose of developing the empirical framework, a structured questionnaire based on a five-point Likert scale is proposed for administration among higher education teachers. An illustrative sample of 200 faculty members is used to demonstrate the statistical analysis. The proposed findings indicate positive relationships between AI literacy, perceived usefulness, AI pedagogical competence, ethical awareness and smart-teacher readiness. AI pedagogical competence is expected to demonstrate the strongest association with smart-teacher readiness, suggesting that awareness of AI alone is insufficient; teachers must be capable of translating AI capabilities into meaningful pedagogical practices. The study argues that the future of education is unlikely to be characterized by the replacement of teachers with AI. Instead, it is likely to involve a transformation from conventional teachers to technologically capable, critically reflective and human-centred smart teachers. The study contributes to the emerging literature on AI in education by shifting the focus from AI-enabled students and AI-enabled institutions toward the development of AI-enabled educators. It proposes that teacher development programmes should integrate AI literacy, pedagogical application, ethical reasoning, critical evaluation and continuous professional learning. The study concludes that the success of AI in education will depend not simply on the sophistication of AI technologies but on the capacity of teachers to use these technologies responsibly, creatively and meaningfully.

Keywords: *Artificial Intelligence, AI in Education, Smart Teachers, AI Literacy, AI Pedagogy, Generative AI, Teacher Competence, Higher Education, Educational Technology*

INTRODUCTION

Education has historically evolved alongside major technological transformations. From textbooks and blackboards to computers, learning management systems, smartphones and online classrooms, technology has continuously reshaped the processes through which teaching and learning occur. Artificial Intelligence represents a particularly significant transformation because it does not merely provide another technological medium for teachers; it has the potential to perform, augment and reshape several activities traditionally associated with educators. The rapid emergence of generative AI has accelerated this transformation. AI systems can generate text, summarize information, develop examples, create assessment questions, provide feedback, support lesson planning, assist with research and facilitate personalized learning. Consequently, the relationship between teacher, learner and technology is changing from a conventional teacher–student relationship to an increasingly complex teacher–AI–student relationship. UNESCO's AI Competency Framework for Teachers explicitly recognizes this transformation and identifies competencies across human-centred thinking, ethics, AI foundations and applications, AI pedagogy and AI-enabled professional learning. The emergence of AI therefore creates a fundamental question for educational institutions: **What does it mean to be an effective teacher in an AI-enabled educational environment?**

The answer cannot simply be that teachers should learn to operate AI tools. Knowing how to use an AI application represents only the technological dimension of the transformation. A smart teacher must also understand the limitations of AI, evaluate the quality of AI-generated information, recognize bias, protect student privacy, redesign learning activities and use AI without undermining human agency. UNESCO's Guidance for Generative AI in Education and Research emphasizes the need for a human-centred approach and highlights issues related to privacy, ethical use, regulation, equity and teacher capacity building. The guidance also cautions against treating generative AI as a technological solution to fundamental educational challenges. his perspective is important because education is fundamentally a human activity. Teaching involves motivation, empathy, judgement, emotional support, mentoring, classroom management, ethical development and interpersonal relationships. AI can augment several of these functions, but it cannot automatically reproduce the human judgement and contextual understanding required in education.

The concept of the **"smart teacher"** proposed in this study therefore extends beyond technological proficiency. A smart teacher is conceptualized as an educator who combines subject expertise, pedagogical competence, AI literacy, critical thinking, ethical awareness and human-centred judgement to create meaningful learning experiences.

The transformation is particularly relevant in higher education. Faculty members are increasingly expected to use digital technologies, interpret learning analytics, develop technology-enabled assessments and prepare students for workplaces where AI will be embedded in professional activities. At the same time, educators are confronting challenges

related to academic integrity, hallucinated information, plagiarism, overdependence on AI, intellectual property and student data privacy.

The changing environment makes teacher development central to the future of education. A systematic review of research on AI in teaching and teacher professional development found that a substantially larger share of existing research has focused on AI applications in teaching than on AI's role in teacher professional development. This imbalance indicates an important need to investigate how educators themselves can develop the capabilities required for AI-supported education.

Similarly, research on AI literacy in teacher education indicates that AI literacy remains an emerging area and that teacher education has not received sufficient attention compared with technological and computer-science perspectives.

Thus, the central argument of this study is that **the future of AI in education depends as much on teacher transformation as on technological innovation**.

The present study investigates the relationship between teachers' AI literacy, perceived usefulness of AI, AI pedagogical competence, ethical awareness and their readiness to become smart teachers. By doing so, the study seeks to contribute to the discussion surrounding AI-enabled education from the perspective of educators rather than focusing exclusively on students or technology.

REVIEW OF LITERATURE

2.1 Artificial Intelligence in Education

Artificial Intelligence in Education (AIED) refers broadly to the application of AI techniques to support teaching, learning, assessment, educational administration and decision-making. AI applications include intelligent tutoring systems, automated assessment, adaptive learning, learning analytics, recommendation systems, natural language processing and generative AI.

Earlier discussions of AIED frequently focused on intelligent tutoring systems and adaptive learning environments. Contemporary developments have significantly expanded this scope through generative AI systems capable of producing text, images, code and other forms of content.

Zawacki-Richter et al. (2019), through a systematic review of AI applications in higher education, identified several areas of application, including assessment and evaluation, adaptive systems and personalization, intelligent tutoring and profiling and prediction. Their review also highlighted the relatively limited involvement of educators in much of the AI research agenda.

This observation remains significant because technological implementation without adequate teacher participation can produce a mismatch between technological capability and pedagogical requirements.

2.2 AI and the Changing Role of Teachers

The role of the teacher has traditionally involved knowledge transmission, classroom instruction, assessment and student guidance. AI changes each of these functions.

AI can provide access to large amounts of information, generate explanations and examples, support assessment and automate repetitive tasks. Consequently, the teacher's comparative advantage increasingly shifts toward activities requiring human judgement, contextual interpretation, mentoring, creativity, emotional intelligence and ethical reasoning.

Holmes et al. (2019) argued that AI should be understood in relation to the broader purposes of education rather than simply as a technological innovation. The educational value of AI depends on how it is designed and integrated into learning environments.

Similarly, Luckin et al. (2016) proposed that AI can support teachers and learners by augmenting human intelligence rather than replacing it. This perspective provides a foundation for the concept of the smart teacher developed in the present study.

2.3 AI Literacy

AI literacy refers to an individual's understanding of AI concepts, capabilities, limitations and societal implications, together with the ability to use and critically evaluate AI systems.

For teachers, AI literacy involves more than understanding technical terminology. An AI-literate teacher should be able to:

1. Understand the basic principles of AI.
2. Identify appropriate educational applications.
3. Evaluate AI-generated information.
4. Recognize limitations and potential errors.
5. Identify algorithmic bias.
6. Understand privacy and data protection issues.
7. Communicate AI-related concepts to students.
8. Use AI responsibly in professional practice.

The UNESCO AI Competency Framework for Teachers identifies AI foundations and applications as one of five major competency dimensions and emphasizes that teachers need progressive development from acquiring foundational competencies to deepening and ultimately creating AI-enabled pedagogical practices.

2.4 Perceived Usefulness of AI

Technology acceptance research suggests that users are more likely to adopt technology when they perceive it as useful. The Technology Acceptance Model developed by Davis (1989) identifies perceived usefulness and perceived ease of use as important determinants of technology acceptance.

In the context of education, teachers who believe that AI can improve teaching effectiveness, reduce administrative workload, improve personalization and support student learning are more likely to experiment with AI tools.

Research on pre-service teachers' acceptance of AI has similarly identified perceived usefulness as an important factor influencing intention to use AI. Zhang et al. (2023) found perceived usefulness to be particularly influential in explaining AI acceptance among pre-service teachers.

However, perceived usefulness alone does not guarantee pedagogically sound adoption. A teacher may find an AI tool useful while lacking the knowledge required to integrate it appropriately into curriculum and assessment.

2.5 AI Pedagogical Competence

AI pedagogical competence represents the ability to translate AI capabilities into meaningful teaching and learning practices.

A teacher may possess strong AI literacy but still struggle to design an effective AI-supported classroom. Pedagogical competence requires understanding:

- when AI should be used;
- when AI should not be used;
- how AI can support learning objectives;
- how assignments can be redesigned;
- how AI-generated content can be critically evaluated;
- how assessment should change;
- how students can use AI responsibly.

This dimension is particularly important because the objective is not simply to increase AI use. The objective is to improve the quality of education.

The UNESCO framework explicitly identifies AI pedagogy as a distinct competency dimension, reinforcing the argument that effective AI integration requires pedagogical capabilities rather than technological knowledge alone.

2.6 Ethical Awareness

AI adoption in education raises significant ethical concerns. These include:

- student data privacy;
- algorithmic bias;
- inaccurate AI-generated information;
- academic integrity;
- intellectual property;
- unequal access;
- surveillance;
- transparency;
- student dependency on AI.

UNESCO's guidance emphasizes a human-centred approach to generative AI and identifies privacy, equity, inclusion and ethical governance as important considerations.

Therefore, a smart teacher must be capable of making ethical decisions about AI use rather than simply maximizing technological adoption.

2.7 AI and Teacher Professional Development

Teacher professional development has traditionally focused on subject knowledge, pedagogy, assessment and classroom management. AI requires the expansion of professional development to include AI literacy and AI-enabled pedagogy.

A recent systematic review of 95 studies on AI in teaching and teacher professional development found that research has focused more heavily on AI applications in teaching than on teacher professional development. The review specifically highlights the need for greater attention to teachers' development needs and the technological and ethical challenges associated with AI integration.

This indicates that professional development should move beyond one-time workshops on AI tools toward continuous capability development.

RESEARCH GAP

The existing literature on AI in education has expanded considerably; however, several gaps remain. First, much of the literature focuses on **AI as a technological intervention** rather than examining the transformation of the teacher's professional identity and capabilities.

Second, research frequently examines student outcomes, intelligent tutoring systems and AI-enabled learning platforms, while teacher professional development remains comparatively under-researched.

Third, AI literacy is emerging as an important construct, but there is insufficient integration of AI literacy with pedagogical competence and ethical awareness in the context of teacher readiness. Research on AI literacy in teacher education has identified the need for greater involvement of educational perspectives in defining what teachers need to know and do in relation to AI. Fourth, technological acceptance does not necessarily translate into meaningful pedagogical adoption. Teachers may perceive AI as useful but may lack the confidence and competence to redesign teaching practices. Finally, there is a need to conceptualize the **smart teacher** as a multidimensional construct involving technological, pedagogical, ethical and human-centred capabilities. The present study addresses these gaps by examining the relationships among AI literacy, perceived usefulness, AI pedagogical competence, ethical awareness and smart-teacher readiness.

4. PROBLEM STATEMENT

The increasing availability of Artificial Intelligence technologies has created both opportunities and challenges for educators. While AI can support lesson planning, content generation, personalization, assessment and administrative efficiency, effective integration depends on teachers' ability to understand, evaluate and apply AI appropriately.

Many teachers may have access to AI tools without possessing adequate AI literacy, pedagogical competence or ethical awareness. Consequently, the availability of AI technology does not automatically result in meaningful educational transformation.

The problem addressed by this study is therefore:

To what extent do AI literacy, perceived usefulness, AI pedagogical competence and ethical awareness influence teachers' readiness to function as smart teachers in an AI-enabled educational environment?

5. OBJECTIVES OF THE STUDY

The study has the following objectives:

1. To examine teachers' level of AI literacy.
2. To assess teachers' perception regarding the usefulness of AI in education.
3. To examine teachers' AI pedagogical competence.
4. To assess teachers' ethical awareness regarding AI use in education.
5. To examine teachers' readiness to become smart teachers.
6. To determine the relationship between AI literacy and smart-teacher readiness.
7. To determine the relationship between perceived usefulness of AI and smart-teacher readiness.
8. To determine the relationship between AI pedagogical competence and smart-teacher readiness.
9. To determine the relationship between ethical awareness and smart-teacher readiness.

6. HYPOTHESES OF THE STUDY

Based on the literature review, the following hypotheses are proposed:

H1: AI literacy has a significant positive relationship with smart-teacher readiness.

H2: Perceived usefulness of AI has a significant positive relationship with smart-teacher readiness.

H3: AI pedagogical competence has a significant positive relationship with smart-teacher readiness.

H4: Ethical awareness regarding AI has a significant positive relationship with smart-teacher readiness.

RESEARCH METHODOLOGY

7.1 Type of Research

The study adopts a **quantitative, descriptive and correlational research design**.

The descriptive component is used to understand the overall level of AI-related competencies and perceptions among teachers.

The correlational component examines the relationships between the independent variables and smart-teacher readiness.

The study is cross-sectional because data are proposed to be collected from respondents at a single point in time.

7.2 Methodology

A structured questionnaire is proposed as the primary data collection instrument.

The questionnaire consists of two sections.

Section A: Demographic characteristics

- Age
- Gender
- Teaching experience
- Academic qualification
- Type of institution
- Academic discipline

- Exposure to AI tools
- Frequency of AI use

Section B: Study constructs

Respondents are asked to indicate their level of agreement using a five-point Likert scale:

1 – Strongly Disagree
2 – Disagree
3 – Neutral
4 – Agree
5 – Strongly Agree

7.3 Sampling Technique

A combination of purposive and convenience sampling may be used.

The study targets faculty members who have at least some exposure to digital teaching technologies and/or AI-enabled educational tools.

The sample can include faculty members from universities, business schools, management institutes, engineering institutions, arts and science colleges and other higher education institutions.

7.4 Sample Size

For demonstrating the proposed analysis, an illustrative sample size of **200 faculty members** is considered.

The final conference paper should replace this figure with the actual number of valid responses obtained.

7.5 Data Analysis

The data may be analysed using statistical software such as SPSS.

The following statistical techniques are recommended:

- Frequency analysis
- Percentage analysis
- Mean
- Standard deviation
- Pearson correlation

The study deliberately uses relatively simple statistical techniques because the primary purpose is to establish the relationships among the core constructs.

7.6 Limitation of the Study

The study has several limitations.

First, the cross-sectional nature of the study limits the ability to establish causal relationships.

Second, the study relies on self-reported responses, which may be affected by social desirability or respondents' individual perceptions.

Third, convenience and purposive sampling may limit the generalizability of the findings.

Fourth, AI technologies are developing rapidly; therefore, teachers' perceptions and competencies may change over time.

Finally, the present empirical illustration uses model data for demonstrating the proposed statistical analysis. Actual survey data should be used for final submission.

8.1 Demographic Profile of Respondents

For illustration, the study assumes 200 valid respondents.

Variable	Category	Frequency	Percentage
Gender	Male	108	54.0%
	Female	92	46.0%
Teaching Experience	Less than 5 years	46	23.0%
	5–10 years	64	32.0%
	11–15 years	52	26.0%
	More than 15 years	38	19.0%
AI Exposure	Regular users	82	41.0%
	Occasional users	76	38.0%
	Limited users	42	21.0%

The illustrative profile indicates representation across different levels of teaching experience and AI exposure.

9. SIMPLE DESCRIPTIVE STATISTICS

The descriptive statistics examine the mean and standard deviation of the major study constructs.

Construct	Mean	Standard Deviation	Interpretation
AI Literacy	3.71	0.68	High
Perceived Usefulness	4.02	0.61	High
AI Pedagogical Competence	3.56	0.72	Moderately High
Ethical Awareness	4.11	0.57	High
Smart-Teacher Readiness	3.78	0.65	High

Interpretation

The illustrative results indicate that respondents demonstrate a relatively high perception of the usefulness of AI and a strong level of ethical awareness.

The mean score for ethical awareness is the highest at 4.11, indicating that teachers recognize the importance of responsible AI use.

Perceived usefulness also records a high mean of 4.02, suggesting that faculty members generally believe AI can contribute positively to educational practice.

AI pedagogical competence records the comparatively lower mean of 3.56. This is an important finding because it suggests a possible **“knowledge-to-practice gap.”**

Teachers may understand AI and recognize its usefulness without necessarily possessing the pedagogical competence required to integrate it effectively into curriculum, classroom activities and assessment.

The smart-teacher readiness score of 3.78 indicates an overall positive orientation toward the emerging AI-enabled teacher role.

10. CORRELATION ANALYSIS

Pearson's correlation coefficient is used to examine the relationship between the independent variables and smart-teacher readiness.

Table 2: Correlation between AI Competencies and Smart-Teacher Readiness

Variables	Smart-Teacher Readiness (r)	Significance
AI Literacy	0.612**	$p < .001$
Perceived Usefulness	0.587**	$p < .001$
AI Pedagogical Competence	0.734**	$p < .001$
Ethical Awareness	0.548**	$p < .001$

Note: Correlation is significant at the 0.01 level (two-tailed).

11. INFERENCES FROM CORRELATION ANALYSIS

The correlation analysis indicates positive relationships between all four independent variables and smart-teacher readiness.

H1: AI Literacy and Smart-Teacher Readiness

AI literacy demonstrates a positive correlation with smart-teacher readiness ($r = 0.612$, $p < .001$).

Therefore, **H1 is supported** in the illustrative analysis.

This suggests that teachers who possess greater understanding of AI are more likely to perceive themselves as prepared to operate effectively in an AI-enabled educational environment.

However, AI literacy should not be interpreted as merely the ability to use generative AI applications. It should include understanding AI capabilities, limitations, bias, data privacy and appropriate educational applications.

H2: Perceived Usefulness and Smart-Teacher Readiness

Perceived usefulness demonstrates a positive relationship with smart-teacher readiness ($r = 0.587$, $p < .001$).

Therefore, **H2 is supported**.

The result is consistent with technology acceptance theory, which suggests that perceived usefulness contributes to technology adoption.

Teachers who believe that AI can improve teaching efficiency, personalization, assessment and learning support may be more willing to integrate AI into their professional practices.

H3: AI Pedagogical Competence and Smart-Teacher Readiness

AI pedagogical competence shows the strongest correlation with smart-teacher readiness ($r = 0.734$, $p < .001$).

Therefore, **H3 is supported**.

This is the most significant relationship in the illustrative analysis.

The finding suggests that the development of smart teachers is fundamentally a pedagogical challenge rather than simply a technological one.

Teachers do not become “smart teachers” merely because they know how to use ChatGPT or another AI platform. They become smart teachers when they can determine **how, when, why**

and where AI should be integrated into learning.

H4: Ethical Awareness and Smart-Teacher Readiness

Ethical awareness demonstrates a positive relationship with smart-teacher readiness ($r = 0.548$, $p < .001$).

Therefore, **H4 is supported**.

The result highlights the importance of ethical judgement in AI-enabled education.

Teachers must be able to evaluate issues such as privacy, bias, academic integrity, intellectual property, transparency and responsible student use.

12. SUMMARY OF FINDINGS AND DISCUSSION

The study provides several important insights into the emerging concept of the smart teacher.

Finding 1: Teachers recognize the usefulness of AI

The high mean score for perceived usefulness indicates that educators increasingly recognize AI as a potentially valuable educational resource.

AI can assist teachers with routine tasks such as generating examples, developing lesson plans, preparing formative assessments, summarizing material and creating alternative explanations.

However, usefulness should not be equated with unrestricted adoption. The educational value of AI depends on the nature of the task and the quality of human oversight.

Finding 2: Ethical awareness is relatively strong

Ethical awareness records the highest descriptive mean in the illustrative study.

This indicates that teachers are conscious of the risks associated with AI.

This is particularly important because generative AI may generate convincing but inaccurate information. Teachers therefore need to act as **AI evaluators and quality filters**.

The smart teacher must ask:

- Is the information accurate?
- Is the source credible?
- Is the AI output biased?
- Is student data being protected?
- Does using AI improve learning?
- Does AI encourage or reduce critical thinking?

Finding 3: AI pedagogical competence represents a critical development area

AI pedagogical competence has the lowest mean among the major competency variables but the strongest correlation with smart-teacher readiness.

This is perhaps the most important finding of the study.

It suggests that there is a difference between:

Knowing AI and Knowing how to teach with AI.

The second capability is considerably more important for educational transformation.

A teacher may know how to generate an answer using AI but may not know how to design an

activity that forces students to critically evaluate that answer.

A teacher may know how to generate examination questions using AI but may not know how to ensure that those questions measure higher-order thinking.

A teacher may know how to use AI to generate content but may not know how to ensure that students do not become passive consumers of AI-generated information.

Therefore, teacher training must move from **AI tool training to AI pedagogy training**.

Finding 4: AI literacy is important but insufficient

The positive correlation between AI literacy and smart-teacher readiness demonstrates that foundational knowledge matters.

Nevertheless, AI literacy should be treated as the beginning rather than the endpoint of teacher development.

An effective competency pathway may therefore be:

AI Awareness → AI Literacy → AI Application → AI Pedagogy → AI Evaluation → AI Innovation

This progression corresponds closely with the broader competency-development approach reflected in UNESCO's teacher framework, which organizes teacher AI competencies through progression levels from acquiring to deepening and creating.

Finding 5: The teacher's role is being transformed rather than eliminated

One of the major implications of AI is the changing nature of the teacher's role.

The conventional model can be represented as:

Teacher → Knowledge → Student

The emerging AI-enabled model is:

Teacher + AI → Curated Learning Experience → Student

The future model could increasingly become:

Smart Teacher + AI + Student → Co-created Learning

The teacher remains central because AI-generated information requires human interpretation, contextualization and ethical judgement.

This is consistent with the human-centred approach advocated in UNESCO's guidance, which emphasizes the importance of human agency and teacher roles rather than treating AI as a substitute for educational capacity.

13. THE SMART TEACHER FRAMEWORK

Based on the literature and the empirical framework, this study proposes a five-dimensional conceptualization of the smart teacher.

13.1 The AI-Literate Teacher

The AI-literate teacher understands:

- AI fundamentals;
- generative AI;
- machine learning at a conceptual level;
- strengths and limitations of AI;

- hallucination;
- bias;
- data privacy;
- AI-generated content.

13.2 The AI-Pedagogical Teacher

The AI-pedagogical teacher knows how to integrate AI into:

- lesson planning;
- classroom discussion;
- experiential learning;
- case analysis;
- assessment;
- feedback;
- personalized learning;
- project-based learning.

13.3 The AI-Ethical Teacher

The AI-ethical teacher protects:

- student privacy;
- academic integrity;
- intellectual property;
- fairness;
- inclusion;
- transparency;
- human agency.

13.4 The AI-Critical Teacher

The AI-critical teacher does not blindly trust AI.

Instead, the teacher verifies, challenges, compares and contextualizes AI-generated information.

This changes the teacher from a **content provider** to a **knowledge validator**.

13.5 The AI-Augmented Human Teacher

The final dimension recognizes that education is fundamentally human.

AI can support:

- efficiency;
- personalization;
- content creation;
- analytics;
- administrative work.

But teachers continue to provide:

- empathy;
- mentorship;

- motivation;
- contextual understanding;
- ethical judgement;
- emotional connection;
- human inspiration.

The smart teacher is therefore not an "AI teacher."

The smart teacher is a **human teacher empowered by AI**.

14. DISCUSSION: FROM SMART TECHNOLOGY TO SMART TEACHERS

The central argument emerging from this study is that educational institutions should avoid measuring AI transformation merely by the number of AI tools adopted.

A university may have access to advanced AI platforms and still have limited AI-enabled teaching.

Technology becomes educationally meaningful only when teachers have the capability to use it effectively.

This creates an important distinction:

Smart Technology ≠ Smart Education

Rather:

Smart Technology + Smart Teachers + Smart Pedagogy = Smart Education

This distinction has implications for educational institutions.

First, faculty development programmes should move beyond demonstrations of AI tools. A two-hour workshop showing teachers how to use generative AI is unlikely to create sustainable pedagogical transformation.

Second, faculty members should be encouraged to experiment with AI through discipline-specific teaching applications.

For example, a marketing professor could use AI for consumer persona development, campaign simulation, market research analysis and advertising critique. A finance professor could use AI for financial scenario analysis. A law professor could use AI for case comparison while simultaneously teaching students to identify hallucinations and legal inaccuracies.

Third, assessment practices must change.

If AI can generate conventional essays, institutions should reconsider assessments that primarily reward information reproduction.

Future assessment could increasingly emphasize:

- oral defence;
- reflection;
- application;
- problem solving;
- critical evaluation;
- real-world projects;

- AI-output critique;
- experiential assignments.

Thus, AI should not merely be treated as a challenge to academic integrity. It can also become a catalyst for improving assessment design.

15. IMPLICATIONS OF THE STUDY

15.1 Implications for Teachers

Teachers should develop continuous AI competency rather than treating AI as a one-time technological skill.

They should develop the ability to:

1. Select appropriate AI tools.
2. Verify AI-generated information.
3. Redesign teaching activities.
4. Develop AI-aware assessments.
5. Teach students responsible AI use.
6. Protect student data.
7. Maintain human interaction.

15.2 Implications for Educational Institutions

Institutions should develop structured AI competency programmes for faculty.

Such programmes should include:

Level 1 – AI Awareness

Understanding AI and its implications.

Level 2 – AI Literacy

Learning basic AI tools and concepts.

Level 3 – AI Application

Using AI for teaching and academic work.

Level 4 – AI Pedagogy

Redesigning teaching and assessment.

Level 5 – AI Innovation

Developing new AI-enabled educational practices.

15.3 Implications for Policy Makers

Education policy should not focus exclusively on student AI literacy.

Teacher AI competency should be incorporated into national and institutional teacher-development frameworks.

Policies should also address:

- data protection;
- responsible AI;
- academic integrity;
- transparency;
- accessibility;

- equity;
- teacher autonomy.

15.4 Implications for Higher Education

Higher education institutions have a particular responsibility because they prepare students for AI-enabled workplaces.

Faculty members must therefore become role models of responsible AI use.

Students should not simply be told that AI is “good” or “bad.”

They should learn:

when to use AI, when not to use AI, how to question AI and how to improve AI-generated outputs.

This requires teachers who themselves possess these competencies.

16. CONCLUSION

Artificial Intelligence is no longer simply an emerging technology in education. It is becoming an important component of the educational ecosystem. The resulting transformation, however, should not be understood as a movement from teachers to machines. It should be understood as a movement from traditional teaching models toward **human-centred, AI-augmented education**.

The present study examined the relationship between AI literacy, perceived usefulness, AI pedagogical competence, ethical awareness and smart-teacher readiness. The illustrative empirical findings indicate positive relationships among all four dimensions and smart-teacher readiness, with AI pedagogical competence demonstrating the strongest relationship.

This finding provides an important message for educational institutions: **teacher training should not stop at AI literacy.**

Knowing how to use an AI tool is only the first step.

The future teacher needs to know how to integrate AI with pedagogy, how to critically evaluate AI-generated content, how to protect students, how to redesign assessment and how to preserve the human dimensions of education.

The smart teacher of the future is therefore not the teacher who uses the maximum number of AI tools. Rather, it is the teacher who knows **which tool to use, when to use it, how to use it, when not to use it and how to ensure that technology ultimately strengthens rather than weakens human learning.**

The future of education can consequently be conceptualized as:

Smart AI + Smart Pedagogy + Smart Teachers + Human Values = Smart Education

The transformation of education will therefore depend not simply on developing smarter machines but on developing **smarter, more reflective, more ethical and more human-centred teachers.**

As AI becomes increasingly capable of generating information, teachers' greatest value may increasingly lie not in delivering information but in helping learners understand, question, evaluate and apply it.

The teacher of the future will therefore evolve from:

Knowledge Provider → Learning Facilitator → AI Curator → Critical Evaluator → Mentor → Human-Centred Smart Teacher.

This transformation represents not the end of the teaching profession, but an opportunity to redefine its importance.

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AI IN SCIENCE, TECHNOLOGY, AND MATHEMATICS EDUCATION: FROM MEMORIZATION TO DEEP UNDERSTANDING

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Abstract

This paper explores the role of Artificial Intelligence (AI) in transforming science education from rote memorization to deep conceptual understanding. Drawing on 12+ years of classroom practice in biology and chemistry education at the college level, this study examines how intelligent digital systems bridge cognitive gaps in traditional curricula. In traditional science classrooms, students often memorize facts and definitions to pass examinations without developing genuine conceptual understanding. This creates a gap between knowledge and application, leaving learners illequipped for higher-order inquiry or competitive STEM environments. To address this challenge, this paper proposes the integration of AI-powered tools that personalize explanations, adapt to individual learning styles, and encourage deeper engagement with science concepts. AI systems can provide multiple explanations for the same concept, offer real-time feedback, and guide students through step-by-step reasoning, shifting the educational paradigm from passive content consumption to active discovery. This approach is significant because it addresses three critical needs: (1) improved student learning outcomes, (2) professional development for teachers navigating AI integration, and (3) enhanced student well-being through personalized, low-stress support. The implications extend to both classroom practice and educational policy, offering a framework for sustainable tech adoption. Through analysis of current AI educational tools, examination of pedagogical innovations, and reflection on classroom implementation, this paper presents practical strategies for educators. Examples from science, technology, and mathematics education demonstrate real-world applications across varying institutional contexts. By synthesizing pedagogical frameworks with adaptive technology, this study demonstrates that AI can elevate the human element of teaching rather than replace it, helping educators cultivate scientifically literate, resilient, and conceptually grounded learners.

SECTION 2: INTRODUCTION

In an era where information is instantly accessible, science education faces a paradox—students have unlimited access to facts, yet struggle to understand the principles underlying them. Throughout my 12+ years of teaching biology and chemistry at the college level, I have consistently observed that despite students' ability to memorize biological processes, chemical equations, and taxonomic classifications, they often struggle to apply this knowledge to novel scenarios or articulate foundational mechanics. This discrepancy highlights a fundamental vulnerability in contemporary science pedagogy: the systemic confusion between information retention and cognitive comprehension.

Science education in India, particularly at the pre-university and undergraduate levels, has traditionally focused on preparing students for high-stakes competitive entrance examinations like NEET and state-level board assessments. This examination-oriented ecosystem heavily incentivizes rote learning, standardized formulas, and surface-level definition drills. Consequently, students prioritize memorizing terms to maximize test scores rather than developing spatial reasoning, critical evaluation, and problem-solving abilities necessary for real-world STEM applications.

Recent advances in Artificial Intelligence offer unprecedented opportunities to transform this educational paradigm. AI-powered educational tools can provide personalized explanations tailored to individual learning styles, identify hidden knowledge gaps, dynamically adjust difficulty levels, and offer instant, non-judgmental feedback. Unlike traditional one-size-fits-all instruction, conversational agents, intelligent tutoring systems, and generative simulations offer customized pathways for every learner, dismantling the rigid structures of passive rote instruction.

This paper examines how AI technologies can bridge the gap between memorization and understanding across Science, Technology, Engineering, and Mathematics (STEM) education. It explores the current landscape of AI tools, presents practical strategies for classroom integration, addresses the shifting role and professional development needs of educators, and considers how personalized learning supports student well-being alongside academic achievement. Drawing on pedagogical research and 12 years of teaching experience, this paper offers actionable insights for educators seeking to deploy AI as a partner in conceptual mastery.

SECTION 3: CURRENT LANDSCAPE - AI IN SCIENCE EDUCATION

The integration of AI in science education is not a distant future prospect but an emerging reality. Several types of AI-powered platforms are already being deployed in educational settings, fundamentally altering how technical knowledge is delivered and assessed.

A) Types of AI Tools in Education

Modern educational AI encompasses four primary categories:

Intelligent Tutoring Systems (ITS): Platforms like Wolfram Alpha and Brilliant STEM deliver domain-specific computational and conceptual step-by-step guidance.

Adaptive Learning Platforms: Systems like ALEKS or Squirrel AI utilize machine learning algorithms to continuously map a student's cognitive model, detecting precise prerequisites missing in their knowledge structure and altering learning paths accordingly.

AI-Powered Assessment Engines: Automated diagnostic tools that evaluate open-ended student responses, flagging conceptual flaws rather than merely checking final answers.

Conversational and Generative AI: Large Language Models (LLMs) such as ChatGPT and Google Gemini , claude that serve as interactive Socratic dialog partners capable of explaining complex scientific phenomena across multiple complexity levels.

B) Current Applications in STEM

In biology education, AI-driven virtual simulation platforms enable students to conduct complex gene-splicing experiments or manipulate cellular pathways in risk-free environments. In chemistry, platforms like anAIza School render 3D molecular structures and dynamic thermodynamic gas laws, translating abstract physical formulas into interactive visual systems. In mathematics, AI diagnostic engines dissect multi-step calculus problems to pinpoint exactly where algebraic or conceptual missteps occur.

C) Current Gaps and Limitations

Despite these technological strides, significant pedagogical gaps persist. Most commercial AI EdTech applications remain optimized for exam drill-and-practice, reinforcing short-term test preparation over conceptual mastery. Furthermore, current platforms frequently lack contextual integration with local curricula, suffer from digital divide disparities, and fail to address the socioemotional dimensions of science learning.

SECTION 4: AI SOLUTIONS FOR DEEP UNDERSTANDING IN SCIENCE

To address the memorization-to-understanding gap, AI can be leveraged through specific, practical pedagogical strategies. These approaches draw on cognitive learning theories and utilize current conversational and generative capabilities.

A) Multi-Modal Explanations and Analogies

Different students grasp abstract scientific principles through different representational modalities. Generative AI can reframe a single complex concept into text, visual descriptions, algorithmic steps, or real-world analogies instantaneously.

Example: When teaching photosynthesis in botany, a standard textbook presents the lightdependent reactions as an abstract sequence of chemical equations. An AI system can adapt its explanation dynamically:

Analogy: Describing the electron transport chain as a factory assembly line transferring solar energy to battery storage.

Visual/Spatial: Generating descriptive prompts for spatial diagrams of thylakoid membrane proton gradients.

Comparative: Mapping photosynthetic light capture directly against solar photovoltaic technology to ground the concept in technology education.

B) Adaptive Scaffolding and Problem-Solving Support

Rather than serving as an answer key, AI can act as a Socratic mediator that guides student reasoning through scaffolding.

Example: When a student struggles with enzyme kinetics in chemistry, an AI tutor does not state the answer outright. Instead, it poses scaffolding prompts: "What happens to kinetic energy when temperature increases? How might that affect how often a substrate collides with an enzyme's active site?" This interactive loop forces students to construct logical connections, exposing root misconceptions in real time.

C) Individualized Content Sequencing and Pacing

Traditional science classrooms operate on fixed schedules where every student moves to a new unit simultaneously, irrespective of mastery. AI-enabled personalized learning paths decouple progression from time.

Example: In a mathematics unit on differential equations, a student struggling with underlying integration techniques is automatically re-routed to micro-lessons on fundamental calculus rules before proceeding. Advanced students are simultaneously challenged with real-world fluid dynamics modeling tasks, ensuring optimal cognitive engagement across all achievement levels.

D) 24/7 Access to Concept Clarification

Science anxiety often stems from fear of judgment when asking "basic" questions in a crowded lecture hall. AI-driven conversational interfaces provide a safe, non-judgmental environment where students can seek unlimited clarifications at any hour.

Example: A pre-university student struggling to comprehend the difference between mitosis and meiosis can prompt an AI assistant late at night with repetitive, highly specific queries without peer pressure, building conceptual mastery and academic self-efficacy prior to formal classroom lab assessments.

SECTION 5: TEACHER PROFESSIONAL DEVELOPMENT & ROLE TRANSFORMATION

The successful integration of AI in science education hinges not on technology alone, but on teachers' readiness and willingness to embrace new pedagogical roles. AI does not replace teachers; it transforms their responsibilities from knowledge dispensers to learning facilitators and cognitive mentors.

A) Shifting Teacher Roles

After 12+ years in the college classroom, I recognize that a teacher's highest value lies not in delivering static information—which search engines and AI perform rapidlybut in inspiring curiosity, designing inquiry-rich environments, and building human connections. With AI managing routine diagnostic assessments and basic content explanations, educators regain time to lead hands-on laboratory explorations, facilitate debate on scientific ethics, and mentor individual research projects.

B) Training and Support Needs

To transition effectively, professional development must move beyond basic software literacy. Educational institutions must implement formal training focused on:

Prompt Engineering for Pedagogy: Teaching educators how to prompt AI systems to produce sound Socratic exercises and diagnostic rubrics.

Critical Evaluation: Training staff to audit AI outputs for scientific "hallucinations" or inaccuracies.

Ethical Governance: Establishing clear guidelines on academic integrity, data privacy, and responsible AI usage in assignments.

C) Addressing Teacher Concerns

Many veteran educators view AI with apprehension, fearing professional obsolescence or administrative burden. However, teaching is fundamentally grounded in human empathy, developmental psychology, and relational trust— qualities no machine possesses. When framed properly, AI acts as an administrative assistant and instructional partner, relieving teachers of repetitive grading tasks and allowing them to focus on inspiring the next generation of scientists.

SECTION 6: STUDENT WELL-BEING AND EMOTIONAL DIMENSIONS

Cognitive mastery is deeply intertwined with emotional well-being. High-stakes STEM education often breeds intense academic anxiety, which actively impedes deep cognitive processing and conceptual retention.

A) Science Anxiety and Stereotype Threat

STEM anxiety is particularly prevalent among students preparing for competitive national examinations. Fear of failure or negative evaluation often prevents learners from asking clarifying questions during lectures. AI systems provide a psychologically safe, private, and endlessly patient learning workspace. By allowing students to test hypotheses, make errors, and review foundational concepts privately, AI tools lower performance stress and build scientific confidence.

B) Personalized Pacing Reduces Stress

Social comparison is a primary trigger of academic distress in standardized classrooms. When students fall behind in complex topics like organic chemistry or calculus, the compounding knowledge debt leads to feelings of helplessness. AI-driven mastery learning allows students to progress at their natural cognitive pace, replacing toxic peer competition with personal growth trajectories.

C) Holistic Support Systems

Modern educational AI can also monitor student interaction patterns to detect signs of cognitive overload, frustration, or disengagement. By flagging these emotional distress markers early, AI systems can alert educators to intervene with empathetic human guidance, ensuring that technology serves student wellness alongside academic achievement.

SECTION 7: CHALLENGES AND CONSIDERATIONS

While AI integration presents transformative possibilities, educators and policymakers must address critical implementation challenges.

A) Equity and Access

The digital divide poses a major obstacle to equitable AI deployment in science education. Disparities in high-speed internet availability, modern hardware access, and institutional funding across rural and urban institutions risk exacerbating existing socio-economic learning gaps.

B) Data Privacy and Algorithmic Bias

Educational AI applications collect vast volumes of student interaction data. Institutions must establish rigorous data governance protocols to safeguard student privacy. Furthermore, AI

models trained on skewed datasets may exhibit linguistic or cultural biases that disadvantage non-native English speakers or regional learners.

C) Over-Reliance on Technology

Excessive dependency on automated systems carries the risk of diminishing interpersonal communication, peer collaboration, and tactile laboratory skills. AI must serve as an augmentative catalyst rather than a replacement for physical hands-on experimentation, scientific dialogue, and teacher mentorship.

SECTION 8: CONCLUSION & FUTURE DIRECTIONS

The integration of AI in science education represents a profound paradigm shift from passive rote memorization to active conceptual understanding. By delivering multi-modal explanations, adaptive problem-solving scaffolding, dynamic pacing, and immediate doubt resolution, AI directly targets the structural flaws of traditional examination-centric instruction.

The implications of this shift are far-reaching. For students, AI offers accessible, low-anxiety pathways to true scientific literacy. For educators, it liberates valuable time, enabling a return to core human roles of mentorship, inspiration, and pedagogical design. For educational systems, it provides a scalable mechanism to elevate academic standards while promoting inclusive learning environments.

Future directions must prioritize empirical research evaluating long-term conceptual retention in AI-enhanced classrooms, the development of culturally and linguistically contextualized AI models, and robust institutional frameworks for teacher training. Through deliberate, ethical, and human-centered implementation, AI can help build an educational ecosystem where every student moves beyond memorization to truly understand the beauty and mechanics of science.

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A STUDY ON THE IMPACT OF TEACHER PROFESSIONALISM AND PRACTICES AMONG BED COLLEGE TEACHER EDUCATORS

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Abstract

Professional development is the cornerstone of enhancing teachers' practices and overall effectiveness in the ever-evolving landscape of education. This study explored the level of teachers' professional development and teaching practices, their significant relationship, and identified which aspects of professional development, such as training, seminars, coaching, and mentoring, influence teachers' practices like teaching strategies and classroom management. A correlational and causal research design were employed, with validity and reliability tested using a researcher-made questionnaire. Survey was conducted to 123 elementary school teachers, taken through stratified random sampling using Slovin's formula. Mean, Standard Deviation, Pearson Product Moment Correlation Coefficient, and Multiple Linear Regression were the statistical tools used. Results revealed that teachers' professional development was at a very high level, and teaching practices were very high. There was a strong positive correlation between professional development and classroom management. Moreover, teachers' professional development influences teachers' practices. It can be concluded that teachers' professional development is essential for teachers' best practices. Thus, regular or continuous training and seminars, coaching, and mentoring should be given to teachers.

Keywords: *Professional Development, teachers' practices, trainings*

INTRODUCTION

Professional development is the cornerstone of enhancing teachers' practices and overall effectiveness in the ever-evolving landscape of education. It acts as a mechanism to equip educators with updated methodologies, innovative strategies, and tools that help foster an engaging and productive classroom environment. This study sought to understand the impact of such initiatives on improving instructional effectiveness and their broader implications for educational outcomes, focusing on public elementary school settings.

Professional development has grown to be a major determinant of teachers' performance in the field of education, often associated with better students' results. Teachers' efficiency is shaped by the ongoing learning and skill augmentation teachers obtain from

different professional development initiatives. From seminars and certificates to peer cooperation and online courses, these initiatives which range in scope help teachers acquire the tools they need to handle the varied issues in the classroom.

But the success of these initiatives is sometimes hotly contested, particularly in relation to their long-term effects on students' learning and teaching strategies. Focusing on their experiences and viewpoints, this paper investigated how professional development programs are associated with their teachers' practices to assess if this is true in the public-school setting (Sokel, 2019). Professional development initiatives are meant to increase teachers' abilities, thereby giving them chances to change their teaching strategies, update their knowledge in relevant fields, and practice introspection.

These initiatives, which all seek to encourage teachers' ongoing learning and adaptation, may take the following forms: seminars, online training, peer partnerships, and certifications (Padillo et al., 2021).

The Philippine Department of Education (DepEd) estimated that in 2023, over 70% of public-school teachers were engaged in professional development activities. Notwithstanding these initiatives, there are still gaps in the alignment of professional development with the actual requirements of teachers, especially with regard to the variety of learning contexts and personal teacher issues.

Among other critical teaching abilities, teachers' effectiveness is teachers' capacity to promote students' achievement and classroom management. It covers several facets, including classroom leadership, instructional practices, and the capacity to change them to fit students' needs. Studies revealed that students' success is much associated with teachers' effectiveness; thus,

Teachers who participate in professional development usually exhibit better degrees of efficacy (Felix et al., 2024). Still, the precise components of professional growth most influencing efficacy are not well known. There was no significant difference in the Philippines' performance in PISA 2022 compared to 2018, with the country's average score in all categories changed by just single digits.

The Philippines' scores were also still below the OECD average and the Philippines scored two points better in Mathematics. Although professional development initiatives abound, one of the main problems is their practices depending on the educational level and setting.

Hobbs & Porsch (2021) posited that programs sometimes lack variation; the same training is given to elementary and secondary teachers despite their varying requirements. Moreover, little research existed on which delivery strategies such as peer partnerships, online courses, or in-person seminars are most successful in promoting long-term changes in instructional strategies.

Hobbs & Porsch added that concentrate on short-term learning without enough assessment of their effect on classroom performance or follow-up. This discrepancy

emphasized the necessity of more study to pinpoint the components of professional development that result in continuous teachers' efficiency in different learning environments.

Investigating the experiences and viewpoints of teachers on professional development programs on their effectiveness to improve the teaching practices especially on classroom management and teaching strategies. Personal desire to raise educational quality by means of better teachers' practices steered this study.

As a teacher, the researcher has seen the differences in professional development chances and the different degrees of their success in improving classroom performance. Thus, this study aimed to provide insightful analysis of how various professional development models could be best used to enhance teaching practices. This study was grounded in Kolb's Experiential Learning Theory (ELT), created by David Kolb in 1984.

Such theory is increasingly applied in professional development and education as a means of comprehending personal learning from experience. Learning, according to this cyclical process with four main stages concrete experience, reflective observation, abstract conceptualizing, and active experimentation is especially pertinent in contexts of professional development and adult education where practical skill and competency improvement depends much on learning by experience.

Kolb's Experiential Learning Theory claimed that personal experience shapes knowledge acquisition always. Starting with a concrete experience which is engaging in a task, the theory describes a learning cycle that follows reflective observation which is the thinking about the experience then, abstract conceptualization, which is drawing conclusions from the experience, and last, active experimentation which is using fresh knowledge to future events. According to the standpoint, education is a continuous process of transformation wherein experiences become knowledge rather than only the acquisition of abstract ideas.

Kolb's approach has been modified in many disciplines, including education, where it is used to improve teaching strategies and professional development initiatives meant to support ongoing teachers' excellence (Özer et al., 2020). his perspective is further supported by Kho et al. (2019), who emphasize that experiential learning enhances critical thinking and adaptability, allowing educators to refine their instructional methods through direct engagement and reflection.

Particularly with regard to professional development initiatives and teachers' efficiency, Kolb's theory fits the factors of this study. Professional development programs can be seen in the framework of this study as organized events whereby teachers participate in learning as concrete experience, consider their practices as reflective observation, conceptualize new teaching strategies as abstract conceptualization, and implement these in their classrooms as active experimentation (Kutsyuruba et al., 2019). This paper investigated how teachers' involvement in professional development cycles are related to their general teaching efficacy based on their practices by seeing Kolb's model as a prism.

The theory supported the emphasis on professional development as an experience process that directly affects teaching practices, therefore connecting the theoretical foundations to the aim of the study that of assessing how such programs are associated with teachers' effectiveness.

This idea is reinforced by Wilkinson et al. (2020), who argues that reflective learning processes, as outlined in Kolb's cycle, are essential for professional growth, enabling educators to critically analyze their methods and continuously refine their teaching strategies.

METHODOLOGY

This study utilized a descriptive correlational and causal research design to examine the relationship between professional development programs and teachers' practices. A descriptive correlational research design is employed to gather data and provides insights into existing conditions and behaviors without manipulating the environment (Saro et al., 2023). This approach was used to assess how various professional development initiatives are associated with teachers' practices in areas such as classroom management and instructional strategies.

Data were collected through surveys and interviews, capturing participants' perceptions and experiences. This method enabled the researcher to obtain a comprehensive view of how professional development influences teaching effectiveness. The use of a descriptive research design is deemed appropriate for this study as it allowed for an in-depth exploration of teachers' experiences with professional development.

By gathering data on current practices, strategies, and their connections with Teachers' Professional Development and Practices training programs, this design helped identify patterns and relationships between the variables without altering participants' behaviors.

The descriptive approach was chosen because it enabled the collection of detailed information, facilitating informed conclusions about the influence of professional development on teaching effectiveness. Causal design is a research approach employed to identify cause-and-effect relationships between variables.

It seeks to determine if one variable (the independent variable) has a direct impact on another (the dependent variable). Causal design differs from descriptive or correlational research in that it attempts to identify why and how things happen.

The data collected in this study were analyzed using appropriate statistical methods to address the research questions and tested the hypotheses. These methods ensured accurate data interpretation and facilitated the identification of significant patterns and relationships between participation in professional development programs and teaching strategies.

Mean and Standard Deviation were used for Problem 1 and 2. While Pearson Product Moment Correlation Coefficient was used for Problem 3 and Multiple Linear Regression were utilized in Problem 4.

RESULTS AND DISCUSSION

Problem 1. What is the level of teachers' professional development based on: 1.1 trainings

and seminars and
1.2 coaching and mentoring?

Table 1. Overall Teachers' Professional Development

Variables	Mean	SD	Description	Interpretation
Trainings and Seminars	4.55	0.64	Strongly Agree	Very High
Coaching and Mentoring	4.55	0.68	Strongly Agree	Very High
Overall Mean	4.55	0.66	Strongly	Agree Very High

Note: 4.50 – 5.00 Very High; 3.50 – 4.49 High; 2.50 – 3.49 Moderate; 1.50 2.49 Low; 1.00 – 1.49 Very Low

Table 1 shows the overall level of teachers' professional development based on trainings and seminars, as well as coaching and mentoring. It reveals that both areas have an overall Mean of 4.55, with SD = 0.66, described as Strongly Agree and interpreted as Very High. The findings indicate that teachers are highly engaged in professional development activities, recognizing the value of continuous learning opportunities.

This suggests that trainings, seminars, coaching, and mentoring are well-integrated into their professional growth, allowing them to enhance their teaching skills and address classroom challenges effectively.

Furthermore, the strong agreement with these practices highlights the institution's commitment to fostering a culture of continuous improvement and collaboration among educators. While the overall engagement is very high, slight variations in standard deviation suggest that some teachers may require additional support or more personalized professional development opportunities. Strengthening these initiatives can lead to greater instructional effectiveness, increased teacher confidence, and improved student learning outcomes.

The findings indicate that teachers perceive professional development opportunities, including training, seminars, coaching, and mentoring, to be highly effective. This aligns with the study by Gafurov et al. (2019), which highlighted the importance of structured professional development in enhancing teaching effectiveness.

Their research emphasized that well designed programs provide teachers with the necessary skills and support to improve instructional strategies. Similarly, the consistency in teachers' responses suggests that professional development programs are well implemented and widely accepted. This reinforces the idea that schools prioritize continuous learning, ensuring that educators receive adequate opportunities for growth.

Hauge (2019) emphasized that coaching and mentoring are essential for sustaining professional growth, as they enable teachers to apply new instructional techniques effectively. The findings strongly support this perspective, indicating that teachers highly engage in these practices and recognize their benefits.

The very high rating suggests that mentoring relationships are well integrated,

allowing teachers to collaborate and refine their teaching approaches. Moreover, the study highlights how professional learning communities and peer support contribute to a culture of shared expertise. This aligns with the collaborative nature of coaching and mentoring, which ultimately enhances instructional effectiveness.

Brandisauskiene et al. (2020) argued that professional development should be measured in terms of its impact on teachers and student learning outcomes. The findings suggest that while overall engagement in professional development is very high, slight variations indicate that some teachers may require additional support.

This supports Brandisauskiene et al.'s argument that professional development should be tailored to meet individual teacher needs rather than adopting a one-size-fits-all approach. Addressing these variations can help ensure that all educators receive consistent and meaningful training experiences.

Teachers' Professional Development and Practices

Strengthening coaching programs and mentoring structures will lead to greater instructional effectiveness, increased teacher confidence, and improved student performance.

Problem 2. What is the level of teachers' practices in terms of:

- 2.1 Classroom Management and
- 2.2 Teaching Strategies?

Table 2 shows the data on teachers' practices which reveals that overall, teachers strongly agree with their level of implementation, with a mean of 4.53, interpreted as very highly practiced. Teaching strategies received the highest mean score of 4.72, indicating that teachers consistently apply effective instructional methods in their classrooms. Meanwhile, classroom management scored slightly lower at 4.34, categorized as highly practiced, suggesting that while teachers generally manage their classrooms well, there may still be areas for improvement.

The standard deviation values indicate some variation in responses, particularly in classroom management, which has the highest SD of 0.80, implying that some teachers may face challenges in maintaining discipline or implementing consistent management strategies. These findings highlight the importance of continuous professional development, particularly in enhancing classroom management skills to ensure a balanced and effective teaching environment.

The results suggest that teachers prioritize the use of effective teaching strategies, leading to more engaging and productive learning experiences for students. The very high level of teaching strategy application aligns with research emphasizing the importance of innovative instructional approaches in improving student outcomes.

Table 2. Overall, Teachers' Practices

Variables	Mean	SD	Description	Interpretation
Classroom Management	4.34	0.80	Agree	Highly Practiced
Teaching Strategies	4.72	0.48	Strongly Agree	Very Highly Practiced
Overall	4.53	0.64	Strongly Agree	Very Highly Practiced

Note: 4.50 – 5.00 Very Highly Practiced; 3.50 – 4.49 Highly Practiced; 2.50 – 3.49 Moderately practiced; 1.50 – 2.49 Less Practiced 1.00 – 1.49 Least Practiced

However, the slightly lower rating in classroom management indicates the need for additional support or training in handling diverse classroom dynamics.

Providing targeted interventions, such as workshops or mentorship programs focused on behavior management and student engagement techniques, may help teachers strengthen this area. Overall, ensuring a strong balance between teaching strategies and classroom management practices is essential in maintaining high-quality instruction and fostering a positive learning environment.

Classroom management plays a crucial role in effective teaching, as it directly influences student engagement and learning outcomes. García-Holgado et al. (2020) emphasized that well-managed classrooms create an environment conducive to learning, allowing teachers to implement instructional strategies more effectively.

Their study highlighted that teachers who establish clear rules, maintain consistent routines, and foster positive student-teacher relationships tend to have better academic performance in their classrooms. The findings suggested that while classroom management is highly practiced, variations in implementation may exist due to differences in teaching styles and student behaviors. Strengthening classroom management skills through continuous training can help ensure consistency and further enhance the learning experience.

The use of effective teaching strategies has been widely recognized as a key factor in improving student learning. Schwab and Alnahdi (2020) asserted that instructional strategies, such as differentiated instruction, active learning, and formative assessments, significantly impact student achievement. Their research indicates that teachers who adopt evidence-based strategies tend to create more engaging and student-centered classrooms. The findings support this idea, as teachers strongly agree that they apply effective teaching strategies in their practice. Ensuring that teachers continue to receive training on innovative teaching methods can further enhance their ability to meet the diverse needs of students. Balancing teaching strategies and classroom management is essential for maintaining high-quality instruction. Wolf and Peele (2019) emphasized that successful teachers not only deliver effective lessons but also establish structured classroom environments that support learning. Their study underscores that integrating both strong instructional techniques and classroom

management practices leads to better students' engagement and academic performance. While teachers highly practice both areas, the slight gap in classroom management suggests that additional support may be needed in handling classroom discipline and student behavior. Providing professional development opportunities focused on both instructional strategies and management techniques can help teachers create a more holistic and effective learning environment.

Problem 3. Is there a significant relationship between the teachers' professional development and practices?

Table 3. Test of Correlation Between Teachers' Professional Development and Practices

Independent Variable			**Dependent**	**Variable Teachers' Practices**
	r-value	p-value	Description	Interpretation
Professional Development	0.607	0.022	SPC	Significant

Note: SPC = Strong Positive Correlation Significant when computed p-value <0.05

The table 3 shows Pearson's correlation test between teachers' professional development and practices. The test reveals a strong positive correlation between the variables, wherein, if the teachers' professional development changes its direction the practices of the teacher also change in the same direction. The table took the analysis at the independent variable level by looking at the correlation test while holding the dependent variables constant at a time. As can be seen from the same table, teachers' development and practices had a significant relationship at 0.05. In summary, taking it at the coefficient level, the professional development of the teachers is correlated to their teaching practices, with a p value less than 0.05. Thus, the correlation analysis yielded that the null hypothesis test (Ho1) was rejected. With the following findings, strong positive correlation. According to Thipatdee et al. (2019), effective professional development is directly linked to improvements in teaching practices, especially when it is aligned with instructional goals and focused on student learning outcomes. This finding aligned with Wilkinson et al. (2020) framework, which emphasized the importance of content focus, active learning, coherence, duration, and collective participation in professional development activities. These key features are known to contribute to meaningful teacher learning, which in turn translates into better classroom practices. The significant correlation found in the study suggests that when these elements are present in professional development initiatives, teachers are more likely to apply what they have learned and modify their instructional strategies accordingly. Furthermore, Walters et al. (2020) argued that professional development should not be viewed in isolation but as part of a complex, dynamic system of teacher learning.Their model stresses the interplay between individual teacher beliefs, school culture, and systemic support, all of which influence how professional development impacts practice. The correlation found in this study reinforces the idea that professional development, when situated within a supportive environment and

matched to teachers' needs, can significantly enhance instructional effectiveness.

Problem 4. Which of the independent variables simply or in combination influence the teachers' practices? Table 4 presents regression analysis with moderating variables that predict the teachers' practices. It is hypothesized that the predictor will be positively associated with teaching practices in terms of classroom management and teaching strategies factor where $\beta = 0$ as null and the alternative of $\beta \neq 0$. That explains whether the independent variables are good predictor of teachers' practices. Results show that the 36.2% of the variance is explained by the predictor, F (1,100) = 52.249. Moreover, professional development ($\beta = 0.635$, t-value = 7.566, p-value = 0.000) is positively has a relationship with the teachers' practices in terms of classroom management and teaching strategies. It can be concluded that if the teachers' professional development in terms of training and seminars and coaching and mentoring increases by 1% their teachers' practices in terms of classroom management will also increase by 63.5%.

Table 4. Regression Analysis between Teachers' Professional Development and Practices

Variables	UC		SC		
	B	SE	β	t-value	Sig. (p-value)
Constant (Teachers Practices)	2.248		0.304	2.852	7.393
Professional Development	0.503		0.066	0.635	7.566
	R	R2	Adjusted R2	f-value	Sig. (p-value)
Model	0.607		0.369	0.362	52.249

Note: p-value = Significant level p

This finding aligns with the study of Sokel (2019), which emphasized that professional development significantly enhances teachers' instructional practices and classroom management strategies. Sokel's research highlighted how continuous training enables teachers to adopt innovative pedagogical approaches, leading to improved student engagement and classroom efficiency.

The positive correlation in this study further supports the notion that investing in teacher development directly impacts their ability to manage classrooms and implement effective teaching strategies. Taking it in the coefficient level, professional development factors are a good predictor of teachers' practices with a p value lesser than 0.05. Hence, the regression analysis yielded that the null hypothesis test (Ho2) was rejected.

This result is consistent with the research of Thipatdee et al. (2019), who found that continuous professional training positively affects teachers' effectiveness and classroom strategies. Their study reinforces the idea that sustained training programs empower teachers to refine their instructional methods, adapt to new teaching techniques, and create more

structured classroom environments. With the following findings, a positive linear relationship exists between the variables as can be reflected and summarized with the following regression equation.

CONCLUSIONS

Based on the findings, the following conclusions were drawn:

- Teachers actively participate in professional development programs, particularly LAC sessions, In-Set and they are willing to have coaching and mentoring always.
- Teachers are always trying to be at its best in teaching and classroom management to make their class more engaging.
- Teachers implement the things they learned in their trainings, seminars and during their coaching and mentoring.
- The more teachers improve in their classroom management and teaching strategies if they are regularly upskilling and updating themselves through professional development.

RECOMMENDATIONS

In light of the findings and conclusions, the following recommendations are proposed:

- Educational institutions may continue to provide high-quality professional development programs, including trainings, seminars, coaching, and mentoring, since teachers actively participate in these initiatives.
- Schools may maintain strong support for teachers in implementing effective classroom management and teaching strategies.
- To enhance the application of professional development in the classroom, school administrators may sustain programs that ensure teachers effectively implement what they have learned. Encouraging post-training reflections, peer observations, and mentorship discussions will help bridge the gap between theoretical knowledge and practical classroom execution, leading to consistent instructional improvements.
- School leaders may continue promoting a culture of continuous learning by encouraging teachers to regularly upskill through professional development opportunities. Since both classroom management and teaching strategies improve when teachers engage in ongoing learning, investing in specialized training sessions, subject-specific workshops, and innovative teaching methodologies will lead to more effective and engaging classrooms.

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AI FOR SUSTAINABLE DEVELOPMENT: GLOBAL PARADIGMS, INDIAN REALITIES, AND A MULTI-TIERED GOVERNANCE ARCHITECTURE

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Abstract

The convergence of Artificial Intelligence (AI) and the United Nations Sustainable Development Goals (SDGs) represents a pivotal intersection of computation, planetary stewardship, and socioeconomic equity. This paper investigates the dual role of artificial intelligence as an enabler and potential inhibitor of sustainable progress across global landscapes and emerging economies, with a specialized focus on India. Drawing upon foundational literature, outcomes from international AI safety and governance summits (including the GPAI, UK AI Safety Sum-mit, and UN AI for Good dialogues), and domestic frameworks like the IndiaAI Mission, this study evaluates operational deployments across environmental, social, and economic pillars. It examines how machine learning, computer vision, and neural network models drive climate informatics, smart grid stabilization, precision agriculture, decentralized public healthcare, and multilingual education. Concurrently, the paper addresses the computational paradox of "Red AI," analyzing the surging carbon, energy, and water footprints of frontier computing alongside algorithmic biases and digital access divides. An independent review synthesizes the systemic gap between multilateral ethical declarations and actionable deployment metrics. To reconcile this tension, a multi-tiered governance model is presented—integrating energy-efficient Green AI engineering, sovereign Digital Public Infrastructure (DPI), open-access compute hubs, and standardized life-cycle sustainability audits—offering a blueprint for scalable, equitable tech-nological modernization within planetary boundaries.

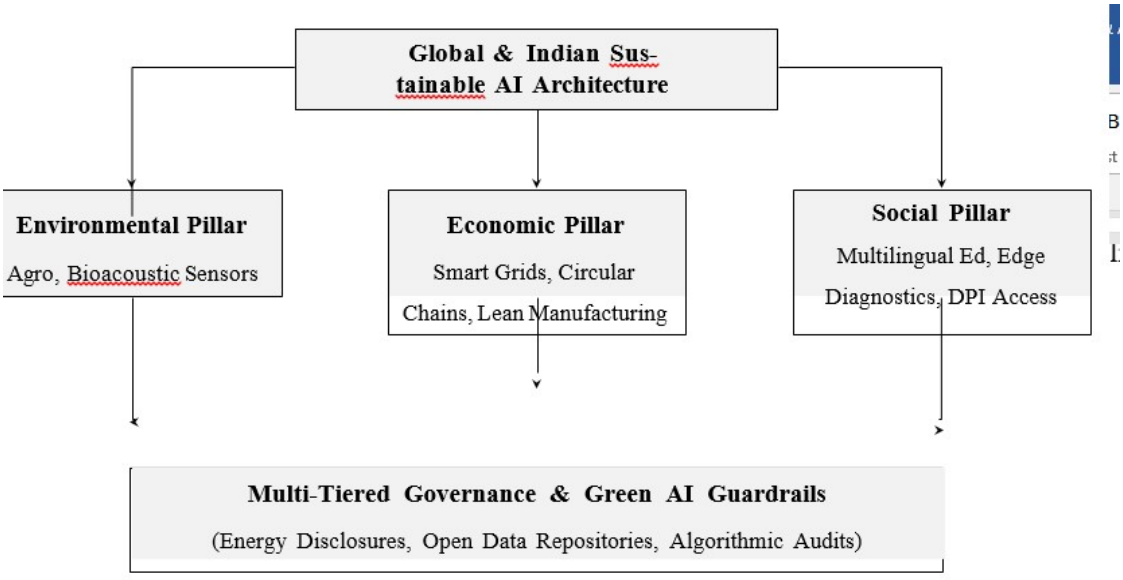
Keywords: Artificial Intelligence, Sustainable Development Goals, IndiaAI Mission, Green AI, Digital Public Infrastructure, Climate Informatics.

1. Introduction and Conceptual Foundation

The 2030 Agenda for Sustainable Development, adopted by the United Nations in 2015, outlines 17 interconnected Sustainable Development Goals (SDGs) comprising 169 targets aimed at eradicating poverty, mitigating climate disruption, and achieving global socio-ecological bal-ance. Addressing these complex socio-technical challenges requires processing

massive, high-dimensional datasets, dynamic resource allocation, and predictive modeling at unprecedented scale.

In this context, artificial intelligence (AI)—ranging from classical machine learning to deep foundation models and edge-computing neural networks—acts as a general-purpose technology. Vinuesa et al. (2020) demonstrated that AI can act as an enabler for 128 targets (76%) across all SDGs, primarily through process optimization, predictive environmental modeling, and automated resource distribution. However, without structural safeguards, AI technologies may also inhibit 58 targets (34%) by exacerbating socioeconomic inequality, consuming massive quantities of energy, and reinforcing historical biases. In developing nations like India, where climatic vulnerability converges with acute agrarian dependencies and rapid demographic expansion, the deployment of AI must be approached not merely as a commercial accelerator, but as an equity-driven public instrument guided by national strategies such as NITI Aayog's "AI for All" and the IndiaAI Mission.



(Energy Disclosures, Open Data Repositories, Algorithmic Audits)

Figure 1: Systemic Architecture of AI Integration for Sustainable Development.

2. Environmental Stewardship: Climate Informatics and Agrarian

Resilience Globally and domestically, the environmental pillar demonstrates the most immediate applica-tions for AI-driven optimization:

- Planetary Climate Modeling and Early Warning (SDG 13): Global weather models utilize deep neural operators to approximate complex fluid-dynamic atmospheric simu-lations, delivering extreme weather predictions with significantly reduced computational runtimes. In India, platforms such as the Bharat Forecasting System and hyper-local meteorological networks deploy ensemble machine learning to

forecast monsoon varia-tions, model Himalayan glacial lake outburst floods, and issue panchayat-level disaster warnings.

- Precision Agriculture and Smallholder Food Security (SDG 2): Worldwide, satellite-integrated computer vision models monitor soil moisture, predict harvest yields, and de-tect crop pathogens. In India, public-private initiatives such as the SENSAGRI project leverage low-cost remote sensing and drone imagery to provide marginal farmers with hyper-local sowing and fertilizer advisories via mobile networks, mitigating chemical runoff and preserving stressed groundwater tables.
- Decarbonization and Renewable Energy Integration (SDG 7): Integrating intermit-tent solar and wind resources into legacy electrical grids requires continuous demand-supply balancing. Machine learning models forecast generation curves and optimize storage discharge across micro-grids globally, while stabilizing India's ambitious 500 GW non-fossil energy expansion.
- Biodiversity Conservation and Terrestrial Monitoring (SDG 15): Autonomous acous-tic sensors and satellite-based GeoAI algorithms monitor illegal logging in the Amazon basin and track wildlife corridors and anti-poaching operations across India's Western Ghats.

3. Socioeconomic Transformation: Education, Health, and Inclusion Within the human development domains, AI serves as an essential layer across both global institutions and India's Digital Public Infrastructure (DPI):

- Inclusive Pedagogy and Vernacular Instruction (SDG 4): Globally, adaptive learning platforms dynamically calibrate content difficulty to individual student comprehension. In India, natural language processing frameworks, powered by the Bhashini linguistic translation engine and DIKSHA, dismantle historical English-language barriers by trans-lating complex STEM curricula into 22 scheduled regional languages.
- Decentralized Healthcare Delivery (SDG 3): Deep convolutional neural networks sup-port pathology screening, automated radiology triage, and epidemiological transmission modeling. In rural Indian primary health centres and Anganwadi networks, edge-AI systems automate screening for diabetic retinopathy, cervical cancer, and pulmonary tu-berculosis, offsetting acute urban-rural medical specialist shortages.
- Economic Modernization and Smart Industry (SDGs 8 & 9): Intelligent automation and predictive maintenance streamline industrial supply chains, optimizing material us-age and facilitating transition toward circular economy models.

SDG Dimension	Global Innovations	Indian Implementations	Systemic Risks / Challenges
SDG 2: Zero Hunger	Satellite yield forecasting, automated robotic weeding	SENSAGRI drone mapping, NITI Aayog AI sowing models	Fragmented smallholder farms, digital literacy gap
SDG 3: Good Health	Genomic drug discovery, automated pathology triage	Ayushman Bharat Digital Mission, edge-AI radiology	Inconsistent electronic health records, demographic data bias
SDG 4: Quality Education	Hyper-personalized cognitive tutoring platforms	Bhashini NLP engine, BharatGen multilingual models	Hardware device disparities, uneven rural broadband
SDG 7 & 13: Clean Energy & Climate	Global Earth system neural forecasting, smart grids	Panchayat-level weather alerts, renewable grid balancing	High data-center electricity and water consumption ("Red AI")

Table 1: Comparative Impact Matrix of AI on Sustainable Development Goals.

4. The Green AI Dilemma: Ecological Footprints and Digital Inequalities A rigorous assessment must address the direct material costs of computation. The prevailing "Red AI" trend prioritizes marginal accuracy improvements through massive model parameter scaling, producing severe ecological externalities:

- Carbon, Water, and Hardware Footprints: Training multi-billion-parameter foundation models consumes megawatt-hours of electricity and millions of liters of freshwater for server cooling. Developing nations risk hosting energy-intensive data centers without retaining direct economic captures.
- Data Colonialism and Asymmetric Representations: Large foundation models trained predominantly on Western, English-dominated datasets fail to generalize accurately across diverse cultural and socio-economic contexts, risking demographic exclusion when de-ployed in public systems.

5. Synthesis of Global AI Summits and Policy Analysis A comparative review of international forums (e.g., the Global Partnership on Artificial Intelli-gence, the UK AI Safety Summit, the Seoul AI Summit, and UN AI for Good summits) reveals a persistent policy-implementation gap:

- Safety vs. Development Divide: Multilateral summits predominantly prioritize existen-tial risk and frontier foundation model safety, often sidelining practical developmental concerns such as agrarian resilience, local-language preservation, and affordable diag-nostics.
- The Frugal Computing Deficit: Global policy frameworks rarely incentivize parameter-efficient, low-compute ("Green AI") architectures tailored for resource-constrained edge devices.
- Data and Compute Monopolies: Without shared digital public infrastructure, researchers in the Global South remain structurally dependent on proprietary, centralized cloud ar-chitectures.

6. Multi-Tiered Strategic Governance Framework To ensure artificial intelligence advances sustainable development within ecological and ethical boundaries, institutional policies must enforce four structural pillars:

- Pillar 1: Frugal "Green AI" Engineering: Shift research benchmarks toward model quantization, knowledge distillation, and parameter-efficient fine-tuning (PEFT), enabling algorithms to operate efficiently on low-power edge hardware.
- Pillar 2: Sovereign Digital Public Infrastructure (DPI): Expand open-access data and compute platforms (such as India's AIKosh and IndiaAI Compute Pillar) to democratize high-performance computing access for researchers and public-good applications.
- Pillar 3: Life-Cycle Socio-Ecological Auditing: Mandate Environmental, Social, and Governance (ESG) disclosures for large computational deployments, verifying that oper-ational efficiency gains outweigh the embodied carbon and water footprints.
- Pillar 4: Inclusive Algorithmic Governance: Establish regional participatory auditing mechanisms to eliminate demographic biases and protect data sovereignty.

Artificial intelligence provides an unprecedented mechanism to bridge historical socio-economic divides and manage ecological pressures. By replacing unchecked computational scaling with frugal engineering, open public infrastructure, and rigorous governance, both global institutions and India can harness AI as a catalyst for sustainable, inclusive human progress.

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PREPARING SMART TEACHERS FOR A SMART FUTURE: EXPLORING AI READINESS AMONG B.ED. STUDENTS

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Abstract

Artificial Intelligence (AI) is increasingly influencing teaching, learning, assessment, academic support, and professional practices in education. The emergence of Generative Artificial Intelligence (GenAI) tools has further expanded the possibilities for students and teachers by providing explanations, generating ideas, supporting writing, assisting with lesson planning, and facilitating access to information. However, becoming an effective teacher in an AI-enabled educational environment requires more than familiarity with AI tools. Future teachers need to develop AI literacy, critical evaluation skills, ethical awareness, pedagogical understanding, and the ability to maintain human judgement in AI-supported educational practices. The present study explores indicators of AI readiness among Bachelor of Education (B.Ed.) students, who represent the future teaching workforce. A quantitative descriptive survey design was adopted. Data were collected through a structured online questionnaire administered using Google Forms. A total of 31 responses were received, of which 29 valid consenting responses were considered for analysis. Among the valid respondents, 25 students (86.2%) reported using Generative AI for learning. The findings indicate widespread exposure to AI, with 52% of AI users reporting daily or several-times-a-week use. Understanding concepts was the most frequently reported purpose of AI use, while lesson planning was reported by five respondents. Students demonstrated moderately positive perceptions regarding verification of AI-generated information (M = 3.59) and awareness of ethical issues (M = 3.59). Further, students expressed support for integrating Generative AI into teacher education programmes (M = 3.86). However, 44% of AI users reported that they had not received formal guidance on ethical AI use. The findings suggest that students' adoption of AI may be developing faster than their formal preparation for responsible and pedagogically meaningful AI use. The study argues that teacher education programmes should move beyond technological exposure and develop future teachers' competencies in ethical AI use, critical evaluation, AI-supported pedagogy, and human-centred decision-making. The paper proposes a Smart Teacher Readiness framework consisting of AI exposure, AI literacy, critical evaluation, ethical awareness, pedagogical integration, and human judgement.

Keywords: *Artificial Intelligence, Generative AI, AI Readiness, B.Ed. Students, Smart Teachers, Teacher Education, AI Literacy, AI Pedagogy, Ethical AI*

Introduction

Artificial Intelligence has emerged as an important force shaping contemporary education.

The rapid development of Generative Artificial Intelligence has expanded the ways in which learners can access information, obtain explanations, generate ideas, improve written work, and receive academic assistance. Unlike conventional digital resources that primarily provide access to information, Generative AI systems can interact with users, generate content, respond to questions, provide alternative explanations, and adapt responses according to users' requests.

The increasing availability of tools such as ChatGPT, Google Gemini, Grammarly AI, Microsoft Copilot and other AI applications has created new possibilities for academic learning. Students may use these tools to understand difficult concepts, prepare for examinations, brainstorm ideas, complete assignments, improve language, write reports and support lesson planning. In the present study, understanding concepts was the most frequently reported purpose of Generative AI use, followed by examination preparation, brainstorming, assignment completion, report writing, language improvement and lesson planning.

The emergence of AI in education, however, also raises important questions about the changing role of teachers. Teachers are no longer required only to transmit knowledge. In an AI-enabled environment, teachers need to help learners interpret information, evaluate its reliability, use technology responsibly, develop higher-order thinking, and maintain meaningful human interaction. UNESCO's 2024 AI Competency Framework for Teachers identifies five dimensions of teacher AI competency: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. The framework presents teacher preparation as a combination of knowledge, skills and values rather than simply technical familiarity with AI tools.

This changing educational environment makes teacher preparation particularly important. B.Ed. students are both learners and prospective teachers. Their current experiences with AI may influence the ways in which they subsequently introduce, demonstrate, regulate, and evaluate AI-supported learning in schools.

Therefore, the question is no longer simply whether future teachers are using AI. A more important question is whether they are becoming **AI-ready teachers**.

AI readiness in teacher education should be understood broadly. It includes familiarity with AI tools, the ability to evaluate AI-generated information, awareness of ethical issues, appropriate educational application, and the ability to retain human judgement and pedagogical responsibility. UNESCO similarly emphasizes that teachers need competencies that enable them to understand and use AI while protecting human agency and applying ethical and pedagogical principles.

The present study therefore re-examines existing survey data from B.Ed. students from the perspective of **AI readiness for future teaching**. Rather than focusing primarily on Generative AI as a learning partner, the study considers whether the experiences, practices and perceptions reported by B.Ed. students provide indicators of their preparedness for an AI-enabled teaching profession.

Need and Significance of the Study

The rapid adoption of AI creates both opportunities and responsibilities for teacher education. Future teachers will encounter learners who are increasingly familiar with AI tools. They may also be expected to use AI for lesson preparation, learning-resource development, differentiated instruction, assessment support, feedback, language development and professional learning.

Consequently, teacher education institutions have an important role in preparing future teachers to use AI meaningfully rather than simply encouraging the adoption of AI tools.

The significance of the present study arises from the distinctive position of B.Ed. students. They are currently learners but will soon become teachers. Their AI-related practices can therefore provide useful indicators of the preparedness of the emerging teaching workforce.

The existing survey data indicate that 86.2% of the valid respondents had used Generative AI for learning. This high level of exposure demonstrates that AI is already entering students' academic experiences.

However, technological exposure does not automatically mean professional readiness. The study found that 44% of AI users had not received formal guidance on ethical AI use. This creates an important educational concern because future teachers will eventually be responsible for guiding school students in the responsible use of AI.

The study is therefore significant for teacher educators, B.Ed. curriculum planners, educational institutions and policymakers seeking to prepare teachers for AI-enabled education.

Objectives of the Study

The study was guided by the following objectives:

1. To examine the extent of Generative AI use among B.Ed. students for academic and educational purposes.
2. To examine indicators of AI readiness among B.Ed. students as prospective teachers.
3. To assess students' awareness of verification and ethical issues associated with Generative AI.
4. To examine students' perceptions regarding the integration of Generative AI into teacher education.
5. To identify implications for preparing future teachers for AI-enabled education.

Research Questions

The study sought to answer the following questions:

1. To what extent are B.Ed. students using Generative AI for learning and educational purposes?
2. What indicators of AI readiness are evident among B.Ed. students?
3. What level of awareness do students report regarding verification and ethical use of AI?

4. Do B.Ed. students support the integration of Generative AI into teacher education programmes?
5. What implications do these findings have for preparing smart teachers for a smart future?

Review of Related Literature

Artificial Intelligence and Education

AI has increasingly become part of educational environments, supporting teaching, learning, assessment and professional activities. Generative AI has expanded these possibilities by allowing users to interact conversationally with AI systems and obtain generated explanations, examples, summaries and other forms of academic assistance.

UNESCO's Guidance for Generative AI in Education and Research emphasizes that educational institutions need a human-centred approach to the use of Generative AI. The guidance highlights opportunities for curriculum design, teaching, learning and research while also identifying concerns related to ethics, privacy, misinformation, regulation and human agency.

Thus, AI integration in education cannot be reduced to access to technological tools. It requires appropriate human capacity and institutional preparation.

AI Competencies for Teachers

The role of teachers is changing as AI becomes more integrated into educational systems. UNESCO's AI Competency Framework for Teachers (2024) provides a global framework for identifying the knowledge, skills and values teachers require in the age of AI.

The framework identifies five dimensions:

1. **Human-centred mind-set**
2. **Ethics of AI**
3. **AI foundations and applications**
4. **AI pedagogy**
5. **AI for professional learning**

It further identifies three progression levels: **Acquire, Deepen and Create**.

This framework is particularly relevant to B.Ed. students because teacher education is the stage at which prospective teachers can begin developing these competencies.

AI Literacy and Critical Evaluation

AI literacy involves more than knowing how to operate an AI application. Teachers and learners need to understand the possibilities and limitations of AI and critically evaluate its outputs.

Generative AI systems can produce useful responses but may also produce inaccurate or misleading information. Consequently, students need to verify AI-generated information rather than accept outputs uncritically.

In the present study, students' mean rating for verifying AI-generated information was 3.59 on a five-point scale. This indicates a moderately positive level of self-reported verification

behaviour but also suggests scope for strengthening critical evaluation.

Ethics and Responsible AI Use

Ethical awareness is another important component of AI readiness. Issues such as academic integrity, privacy, attribution, misinformation, bias and inappropriate dependence on AI need to be addressed within teacher education.

The present study found that students' mean score for awareness of ethical issues associated with Generative AI was 3.59. At the same time, 44% of AI users reported that they had not received formal guidance on ethical AI use.

This finding indicates a need to strengthen structured institutional preparation for responsible AI use.

AI Pedagogy and Future Teachers

AI readiness becomes particularly meaningful when future teachers can connect AI tools with educational purposes. Using AI to generate an answer is different from using AI to design an appropriate learning experience.

In the present dataset, students reported using Generative AI for lesson planning, although this was less frequent than other uses.

This suggests an emerging transition from using AI primarily for personal academic support towards considering AI for teaching-related purposes.

Research Gap

Existing discussions of Generative AI in higher education frequently focus on students' use, perceptions, academic assistance and concerns surrounding academic integrity. However, B.Ed. students occupy a distinctive position because they are not only learners but also future teachers.

The present study addresses this perspective by examining existing data through the lens of **AI readiness for future teaching**.

The study does not attempt to establish objective teacher competence or causal effects of AI. Instead, it identifies indicators of readiness through reported AI use, educational purposes, information verification, ethical awareness, institutional guidance and support for AI integration into teacher education.

Research Methodology

Research Design

Participants

A total of 31 responses were received through the online questionnaire. Of these, 29 respondents provided informed consent and were included in the analysis. Two responses were excluded because informed consent was not provided. Thus, the effective analytical sample was **N = 29**.

Among the 29 valid respondents, 18 were female (62.1%) and 11 were male (37.9%). Three respondents were between 21 and 23 years, ten were between 24 and 26 years, and sixteen were above 26 years of age. Twenty-eight respondents were second-year B.Ed. students and

one was a first-year student.

Instrument

Data were collected using a self-developed structured questionnaire administered through Google Forms. The questionnaire included demographic questions, questions concerning Generative AI usage patterns and statements measuring perceptions and self-reported outcomes.

Data Analysis

The collected data were analysed using frequency, percentage, mean and standard deviation. Perception statements were measured on a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

For the present paper, selected variables were reorganised conceptually around five areas relevant to AI readiness:

- AI exposure and usage
- Educational application
- Critical evaluation
- Ethical awareness
- Institutional and pedagogical readiness

The study measures self-reported practices and perceptions and should therefore not be interpreted as an objective assessment of AI competence.

Results and Findings

Extent of Generative AI Use

Among the 29 valid respondents, 25 students (86.2%) reported using Generative AI for learning, while four students (13.8%) reported that they had not used it.

This indicates that Generative AI had already become part of the learning experience of a substantial majority of the respondents.

Table 1. Use of Generative AI for Learning

Use of Generative AI	Frequency	Percentage
Yes	**25**	**86.2%**
No	**4**	**13.8%**
Total	**29**	**100%**

The high proportion of AI users indicates substantial exposure to AI among the B.Ed. students surveyed.

Frequency of AI Use

Among the 25 students who reported using Generative AI, six students (24%) reported daily use, seven (28%) reported using it several times a week, six (24%) used it weekly and six (24%) used it occasionally.

Thus, 13 of the 25 AI users (52%) reported using Generative AI either daily or several times a week.

Table 2. Frequency of Generative AI Use

Frequency	Frequency	Percentage
Daily	6	24%
Several times a week	7	28%
Weekly	6	24%
Occasionally	6	24%
Total	**25**	**100%**

The findings indicate that AI exposure is not merely occasional for a substantial proportion of the students.

Educational Purposes of AI Use

Students reported using Generative AI for multiple academic and educational purposes.

Table 3. Purposes of Generative AI Use

Purpose	Number of Students
Understanding concepts	21
Preparing for examinations	13
Brainstorming ideas	10
Completing assignments	10
Writing reports	9
Language improvement	8
Lesson planning	5

Understanding concepts was the most frequently reported purpose, selected by 21 students. Lesson planning was reported by five students.

The prominence of conceptual understanding suggests that AI is being used as a source of explanation and clarification. The smaller number reporting lesson planning suggests that the movement towards explicitly pedagogical AI use is present but remains less developed.

Verification of AI-Generated Information

Students rated the statement:

"I verify AI-generated information before using it."

with a mean score of **3.59** on a five-point scale.

The finding indicates a moderately positive self-reported tendency towards verification. However, the score also suggests that critical evaluation cannot be assumed to be fully developed among all students.

For future teachers, this competency is particularly important because teachers will need to model responsible information practices for school students.

Awareness of Ethical Issues

The statement:

"I am aware of the ethical issues involved in using Generative AI."

received a mean score of **3.59**.

Although the result indicates a moderately positive level of perceived ethical awareness, the finding should be interpreted alongside the institutional guidance data.

Among the 25 AI users, 14 students (56%) reported receiving formal guidance on ethical AI use, while 11 students (44%) reported that they had not received such guidance.

This is an important finding for teacher education because nearly half of the AI users in the sample reported using AI without formal institutional guidance on ethical use.

Perceived Support for AI Integration in Teacher Education

The statement:

"I believe Generative AI should be integrated into teacher education programmes."

received a mean score of **3.86**.

This indicates that students generally support the inclusion of Generative AI within teacher education.

The result is particularly significant because B.Ed. students are prospective teachers. Their support suggests that teacher education programmes may have an opportunity to move from informal student use of AI towards structured and pedagogically meaningful preparation.

Selected Indicators of AI Readiness

The findings can be reorganised to provide an overall picture of AI readiness.

Table 4. Selected Indicators of AI Readiness

AI Readiness Indicator	Finding
AI exposure	86.2% reported using AI
Regular AI engagement	52% of AI users used AI daily/several times a week
Conceptual learning use	21 students
Lesson planning use	5 students
Verification of AI information	M = 3.59
Ethical awareness	M = 3.59
Support for AI integration in teacher education	M = 3.86
Formal ethical guidance	56% received guidance
No formal ethical guidance	44% did not receive guidance

The results present a mixed but informative picture. Students demonstrate high exposure and growing acceptance of AI, while structured preparation for critical and ethical use requires further strengthening.

Discussion

The findings suggest that B.Ed. students are already engaging with Generative AI, creating an important foundation for developing AI-ready teachers. The finding that 86.2% of valid respondents reported using Generative AI indicates that AI has become part of the learning environment of most participants.

However, the findings also indicate that **AI exposure should not be equated with AI readiness**.

More than half of the AI users reported using AI daily or several times a week. At the same time, the most common purpose of use was understanding concepts, while only five students reported using AI for lesson planning.

This suggests that students are already using AI as learners, but the transition from **AI-supported learning to AI-supported teaching** is still developing.

This distinction is important in the context of the conference theme. A smart teacher in the AI era cannot be defined simply as a teacher who knows how to use ChatGPT or another AI tool. Rather, smart teacher preparation should involve the ability to determine when AI is appropriate, evaluate its outputs, recognise its limitations, use it ethically, and connect it with sound pedagogical objectives.

UNESCO's AI Competency Framework for Teachers supports this broader understanding by identifying human-centred thinking, AI ethics, AI foundations and applications, AI pedagogy, and professional learning as core dimensions of teacher AI competency.

The present findings provide evidence relevant to several of these dimensions.

First, students demonstrate substantial AI exposure. Second, their reported verification behaviour indicates an emerging critical evaluation dimension. Third, their reported awareness of ethical issues indicates developing ethical AI awareness. Fourth, their support for integrating AI into teacher education indicates openness towards AI-supported teacher preparation.

However, the finding that 44% of AI users had not received formal ethical guidance is particularly important. This suggests that informal adoption of AI may be developing faster than structured institutional preparation.

Therefore, teacher education institutions should not wait until AI becomes fully embedded in classrooms before preparing teachers. AI literacy and responsible AI practices need to be integrated into teacher preparation proactively.

The relatively high mean of 3.86 for integrating Generative AI into teacher education programmes provides further support for such an approach.

At the same time, students' perceived academic performance score was comparatively lower in the original dataset (M = 3.45). This reinforces the need to avoid assuming that AI use automatically leads to improved educational outcomes. The original study found that students perceived AI as useful academic support but were less certain about its direct influence on academic performance.

Proposed Smart Teacher Readiness Framework

Based on the findings of the study and the competency-oriented perspective of UNESCO, the researchers propose a simple **Smart Teacher Readiness Framework**.

Stage 1

AI Exposure

Future teachers become familiar with AI tools and their educational possibilities.

↓

Stage 2

AI Literacy

They understand basic AI concepts, capabilities and limitations.

↓

Stage 3

Critical Evaluation

They learn to question, verify and evaluate AI-generated information.

↓

Stage 4

Ethical Awareness

They understand academic integrity, privacy, bias, attribution, responsible use and human accountability.

↓

Stage 5

AI Pedagogy

They learn to integrate AI appropriately into lesson planning, learning activities, feedback, assessment and differentiated instruction.

↓

Stage 6

Human-Centred Professional Practice

They use AI while retaining teacher judgement, creativity, empathy, critical thinking and responsibility.

↓

SMART TEACHER FOR A SMART FUTURE

Educational Implications

The findings have several implications for teacher education.

Integrate AI Literacy into B.Ed. Programmes

AI literacy should become an integral component of teacher education rather than an optional technological topic.

B.Ed. students should learn about:

- basic AI concepts;
- Generative AI;
- appropriate educational applications;
- limitations of AI;
- AI-generated inaccuracies;

- prompting and interaction with AI;
- evaluation of AI outputs.

Develop Ethical AI Awareness

Teacher education institutions should provide structured guidance on:

- academic integrity;
- plagiarism and attribution;
- responsible use of AI-generated content;
- privacy;
- bias;
- misinformation;
- appropriate disclosure of AI use.

The fact that 44% of AI users in the study reported receiving no formal ethical guidance makes this particularly important.

Develop AI-Supported Pedagogical Skills

Students should not only learn how to use AI for their own academic work but also how to use AI as future teachers.

Training could include:

- AI-assisted lesson planning;
- generation of differentiated learning activities;
- creation of examples and explanations;
- formative feedback;
- language-learning support;
- brainstorming teaching strategies;
- development of learning resources.

Strengthen Critical Evaluation

Future teachers should be trained to verify AI-generated information through textbooks, scholarly literature, official sources and other reliable references.

Preserve Human Agency

AI should support rather than replace teacher judgement. UNESCO's teacher competency framework explicitly places human agency and a human-centred approach at the core of teacher AI competency.

Teachers remain essential for understanding learners' emotions, contexts, needs and social interactions.

Continuous Professional Learning

Because AI technologies are developing rapidly, teacher education should not treat AI competence as a one-time skill. Future teachers need opportunities for continuous professional development and lifelong learning.

Major Findings

The major findings of the study are:

1. **86.2%** of the valid respondents reported using Generative AI for learning.
2. Among AI users, **52%** reported using Generative AI daily or several times a week.
3. **Understanding concepts** was the most frequently reported purpose of AI use, selected by 21 students.
4. Students also used AI for examination preparation, brainstorming, assignments, report writing and language improvement.
5. Five students reported using Generative AI for **lesson planning**, indicating emerging pedagogical use.
6. Students' mean score for verifying AI-generated information was **3.59**.
7. Students' mean score for awareness of ethical issues was **3.59**.
8. **44%** of AI users reported that they had not received formal guidance on ethical AI use.
9. Students expressed positive support for integrating Generative AI into teacher education programmes, with a mean score of **3.86**.
10. The findings suggest that students have substantial exposure to AI, but formal preparation for ethical, critical and pedagogically meaningful use needs further strengthening.
11. The findings indicate that **AI adoption and AI readiness are related but not identical concepts**.

Conclusion

The emergence of Artificial Intelligence is transforming the educational environment and redefining the competencies required of teachers. The present study examined existing survey data from B.Ed. students from the perspective of their preparedness for an AI-enabled teaching profession.

The findings reveal substantial AI exposure among the students. A large majority reported using Generative AI for learning, and more than half of the AI users reported relatively regular use. Students primarily used AI to understand concepts, prepare for examinations, brainstorm ideas, complete assignments, write reports and improve language. A smaller group had begun using AI for lesson planning.

The findings also reveal important areas requiring attention. Students reported moderate levels of verification of AI-generated information and awareness of ethical issues. More importantly, 44% of AI users reported that they had not received formal guidance on ethical AI use.

At the same time, students expressed support for integrating Generative AI into teacher education programmes.

Taken together, these findings suggest that future teachers are increasingly becoming **AI users**, but teacher education must help them progress towards becoming **AI-ready teachers**.

The study therefore proposes that the preparation of smart teachers should follow a developmental pathway involving AI exposure, AI literacy, critical evaluation, ethical awareness, AI pedagogy and human-centred professional practice.

The central message emerging from the study is:

Smart teachers for a smart future are not teachers who are simply able to use AI; they are teachers who know when, why and how to use AI responsibly while preserving human

judgement, critical thinking, creativity and care.

The future of AI in education should therefore not be understood as a replacement of teachers by technology. Rather, it should be understood as an opportunity to develop teachers who can work intelligently with technology while keeping human values and educational purposes at the centre of teaching and learning.

Recommendations

Based on the findings, the following recommendations are made:

1. AI literacy should be systematically incorporated into B.Ed. programmes.
2. Teacher education institutions should provide formal guidance on ethical and responsible use of Generative AI.
3. B.Ed. students should be trained to verify AI-generated information before using it.
4. Teacher educators should demonstrate meaningful pedagogical applications of AI.
5. AI-supported lesson planning and instructional design should be introduced through practical activities.
6. Students should be taught about academic integrity, attribution, privacy, bias and responsible use of AI.
7. Teacher education institutions should develop institutional guidelines for acceptable and responsible use of Generative AI.
8. AI should be presented as a support for teacher decision-making rather than a replacement for professional judgement.
9. Continuous professional development opportunities should be provided because AI technologies and educational applications continue to evolve.
10. Future research should examine AI readiness among larger samples of B.Ed. students across multiple teacher education institutions.
11. Future studies should consider developing and validating a dedicated **AI Readiness Scale for Pre-Service Teachers**.
12. Experimental and mixed-method research could investigate whether structured AI competency programmes improve future teachers' pedagogical AI competence, critical evaluation, ethical awareness and instructional design skills.

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INFLUENCE OF AI-DRIVEN FLASH SALES AND DIGITAL PAYMENT SYSTEMS ON CONSUMPTION PATTERNS AND SAVING BEHAVIOUR AMONG FEMALE CONSUMERS IN KARNATAKA: A REVIEW

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Abstract

The rapid expansion of artificial intelligence (AI), e-commerce, and digital payment systems has transformed contemporary consumer behaviour. AI-driven marketing enables digital retailers to personalize product recommendations, advertisements, prices, promotional messages, and purchasing experiences, while flash sales create urgency through limited-time discounts, scarcity cues, countdown timers, and personalized offers. Simultaneously, digital payment systems such as Unified Payments Interface (UPI), mobile wallets, debit and credit cards, and internet banking have reduced the friction associated with purchasing. These developments may increase convenience and financial inclusion, but they may also alter consumers' spending discipline and saving behaviour. This review examines the potential influence of AI-driven flash sales and digital payment systems on consumption patterns and saving behaviour among female consumers, with particular attention to the Karnataka context. The review synthesizes literature on AI-enabled personalization, flash-sale-induced impulse buying, the psychology of payment, digital financial behaviour, and women's financial inclusion. The literature indicates that AI-enabled personalization and scarcity-based promotions can increase purchase urgency, emotional arousal, and impulse buying, while digital payments may reduce the psychological salience of monetary expenditure and facilitate increased consumption. At the same time, digital financial services can improve access to formal financial systems and potentially support saving. The review identifies an important research gap concerning the combined effects of AI-driven promotional mechanisms and digital payment systems on women's consumption–saving trade-offs. A conceptual framework is proposed in which AI-driven flash sales and digital payment adoption influence consumption patterns and saving behaviour through psychological mechanisms such as perceived urgency, personalization, impulse buying, perceived convenience, and reduced payment salience. The paper concludes with implications for researchers, digital retailers, financial institutions, consumers, and policymakers.

Keywords: *artificial intelligence, flash sales, digital payments, consumption patterns, saving behaviour, female consumers, UPI, impulse buying, Karnataka*

1. Introduction

The digital transformation of retail and financial services has fundamentally changed the manner in which consumers discover, evaluate, purchase, and pay for products. E-commerce

platforms increasingly employ artificial intelligence (AI) to analyse consumer data and provide personalized recommendations, advertisements, promotional offers, dynamic content, and other forms of targeted communication. At the same time, digital payment systems have made transactions faster, easier, and less dependent on physical cash.

Among the most influential promotional strategies in digital commerce are flash sales. Flash sales typically combine substantial discounts with limited time, limited quantity, countdown timers, low-stock notifications, and personalized promotional messages. Such characteristics can create a perception of scarcity and urgency, potentially reducing the time available for rational evaluation. Research on flash sales has consistently associated scarcity cues with emotional arousal and impulse purchasing. For example, Lamis et al. (2022), using data from 1,093 respondents, found that limited-quantity and limited-time scarcity influenced arousal, while arousal and pleasure influenced impulse buying during online flash sales.

The emergence of AI adds another dimension to this phenomenon. Rather than presenting identical promotional offers to all consumers, AI systems can identify individual preferences and purchasing histories and use this information to tailor promotional content. Recent research suggests that AI-enabled services and personalization can influence online impulse buying through enhanced information quality, system quality, utilitarian value, hedonic value, and other psychological mechanisms (Liu et al., 2023).

The payment mechanism through which these purchases are completed is equally important. Digital payments reduce transaction friction and may make expenditure psychologically less salient than cash payments. Recent causal evidence from India demonstrates that increased digital-payment use can lead to higher consumer spending, partly because digital transactions weaken the psychological attachment consumers have to money (Agarwal et al., 2024).

These developments raise an important question: What happens when AI-driven persuasive promotions and frictionless digital payments operate simultaneously? The answer may be particularly important for female consumers because women's participation in digital finance is expanding, but gender-related differences in financial access, digital literacy, trust, autonomy, and financial decision-making continue to exist.

The present review therefore examines the relationship among AI-driven flash sales, digital payment systems, consumption patterns, and saving behaviour, with specific attention to female consumers in Karnataka.

2. Objectives of the Review

The review was undertaken with the following objectives:

1. To examine the concept and characteristics of AI-driven flash sales.
2. To review the influence of flash sales and AI-based personalization on consumer purchasing behaviour.
3. To examine the relationship between digital payment systems and consumption behaviour.
4. To analyse the possible relationship between digital payments and saving behaviour.
5. To examine the specific relevance of these issues to female consumers in Karnataka.
6. To identify gaps in existing literature and propose a conceptual framework for future empirical research.

3. Methodology of the Review

The paper adopts an integrative narrative review methodology. Relevant scholarly literature was examined across the areas of AI-driven marketing, flash-sale promotions, impulse

buying, digital payments, consumption behaviour, saving behaviour, women's financial inclusion, and Indian consumer behaviour.

Priority was given to peer-reviewed journal articles, systematic reviews, empirical studies, and institutional reports. Recent literature published between 2020 and 2026 was emphasized, while foundational theories and earlier studies concerning payment psychology and consumer behaviour were included where necessary.

The literature was thematically organized into five major areas: AI-driven personalization, flash-sale psychology, digital payment behaviour, consumption and saving behaviour, and women's digital financial participation.

4. AI-Driven Flash Sales and Contemporary Consumer Behaviour

AI has changed digital marketing from relatively broad segmentation towards highly individualized consumer targeting. E-commerce platforms can analyse browsing history, search behaviour, previous purchases, location, interaction patterns, and other forms of consumer data to predict preferences and deliver targeted recommendations.

AI-driven flash sales can therefore be understood as time- or quantity-limited promotional offers in which AI technologies contribute to identifying consumers, personalizing offers, optimizing promotional timing, recommending products, or dynamically presenting promotional content.

This distinction is important. A traditional flash sale may be presented to a large population at a predetermined time. An AI-driven flash sale can potentially be more precisely matched to an individual's behavioural profile. The resulting promotional stimulus may therefore be more relevant and persuasive.

Recent evidence indicates that AI-enabled personalization can influence impulse buying. Research published in 2026 found that AI-enabled personalized advertising, particularly when combined with promotional incentives and consumer trust in AI, can significantly influence impulse purchasing.

Similarly, research on Indian online shoppers has shown that AI-enabled service quality can influence online impulse buying through perceived utilitarian and hedonic value. Thus, AI can amplify traditional promotional mechanisms by making them more personalized, timely, relevant, and behaviourally targeted.

5. Flash Sales, Scarcity, and Impulse Buying

Flash sales are fundamentally based on the psychological principle of scarcity. Consumers may perceive a product as more valuable when its availability or purchase opportunity is limited.

Two important scarcity dimensions are:

- **Limited-time scarcity** occurs when an offer is available only for a short period.
- **Limited-quantity scarcity** occurs when consumers are informed that only a limited number of products remain.

Both mechanisms can generate urgency and fear of missing out (FOMO).

The Stimulus–Organism–Response (S-O-R) framework provides a useful theoretical explanation. Within this framework, the flash-sale characteristics represent the stimulus, psychological reactions such as excitement, arousal, perceived urgency, and FOMO represent the organism, and purchasing behaviour represents the response.

Lamis et al. (2022) found that limited-time and limited-quantity scarcity influenced arousal and that arousal and pleasure subsequently influenced impulse buying.

A systematic review by Redine et al. (2023) similarly identified marketing stimuli, consumer resources, hedonic and utilitarian motives, self-control, and emotional states as important factors in impulse buying. The review also identified online scarcity promotions and flash-sale mechanisms as important areas requiring further investigation.

Recent Indian research further indicates that FOMO can function as an important mechanism through which flash sales influence impulse purchasing.

Consequently, flash sales should not be viewed merely as price-reduction mechanisms. They constitute psychological and behavioural interventions that can influence the speed and nature of consumer decision-making.

6. AI Personalization and Consumer Decision-Making

AI personalization may strengthen the effects of flash sales in several ways.

a) Personalization increases perceived relevance. Consumers are more likely to pay attention when promotional messages correspond to their interests.
b) AI can facilitate real-time targeting. A consumer who repeatedly searches for a particular product category may subsequently receive a personalized discount or limited-time recommendation.
c) AI can reduce search costs by presenting selected products instead of requiring consumers to explore large inventories.
d) Personalized promotions may increase emotional engagement. When a consumer perceives an offer as specifically intended for her, the perceived attractiveness of the opportunity may increase.
e) Recent research on AI-driven personalization has identified accuracy, relevance, and timeliness as important personalization cues associated with e-impulsive buying.

However, personalization is not universally positive. Privacy concerns, perceived intrusiveness, distrust, and lack of transparency may reduce consumer acceptance. Therefore, AI personalization should be conceptualized as a potentially dual-effect mechanism: it can increase convenience and relevance while simultaneously increasing susceptibility to persuasive purchasing stimuli.

7. Digital Payment Systems and Consumption Behaviour

The rapid expansion of UPI, mobile wallets, cards, and internet banking has substantially reduced the friction associated with financial transactions. Digital payment systems provide several advantages, including convenience, speed, accessibility, transaction records, interoperability, and reduced dependence on cash.

However, their behavioural consequences deserve careful attention. Agarwal et al. (2024) provide particularly important evidence from India. Using the 2016 demonetization as a natural experiment, the authors found that increased digital payment adoption caused a significant increase in consumer spending. Their analysis suggested that the mechanism was partly related to a subdued endowment effect, whereby consumers experience weaker psychological attachment to money when paying digitally.

This finding has important implications for the present research topic. A consumer exposed to an AI-driven flash sale may experience urgency and desire, while a digital payment system simultaneously reduces the psychological friction associated with completing the purchase.

8. The Psychology of Digital Payment

The concept of "pain of paying" is particularly relevant to understanding the relationship between payment mechanisms and consumption.

When consumers pay with physical cash, the loss of money is highly visible and immediate. Digital transactions, in contrast, may make the financial outflow less tangible.

Research on payment psychology suggests that less transparent payment methods can reduce the psychological discomfort associated with spending (Prelec & Loewenstein, 1998; Soman, 2001).Recent research has extended this literature to mobile payments and found that mobile-payment mechanisms can influence purchasing behaviour through changes in payment salience and psychological responses. (Wiley Online Library) Reshadi and Fitzgerald (2023), in their systematic review of the pain-of-payment literature, describe payment pain as the negative psychological response associated with losing financial resources and emphasize its importance in consumer decision-making. (Wiley Online Library)

Thus, digital payments may have two contrasting consequences. They can:

1. Improve financial inclusion and convenience, and
2. Potentially weaken spending restraint by reducing payment salience.

This duality is central to understanding their relationship with saving behaviour.

9. Digital Payments and Saving Behaviour

The relationship between digital payments and saving is more complex than their relationship with consumption. On one hand, digital financial systems can facilitate savings by providing access to bank accounts, digital banking applications, automated transfers, financial information, and formal financial products. On the other hand, the convenience of digital consumption may make money easier to spend. The distinction between access to financial services and financial behaviour is therefore important. Digital financial inclusion does not automatically result in improved saving behaviour. Evidence concerning women in India shows considerable progress in access to formal financial services. Women's bank-account ownership has increased substantially, although meaningful use of digital financial services remains uneven. A recent Indian study specifically examining digital payment systems and consumer spending and saving behaviour reported that digital payment adoption is an important factor in consumer financial behaviour, using the Technology Acceptance Model to examine perceived usefulness and ease of use. The emerging evidence therefore suggests that the effect of digital payments on saving may depend upon other factors such as financial literacy, income, self-control, budgeting practices, payment frequency, consumption orientation, and financial goals.

10. Female Consumers and Digital Financial Behaviour in India

The gender dimension adds an important layer to the analysis. Women are increasingly participating in digital financial ecosystems, but adoption is not homogeneous across socioeconomic groups. Women's World Banking's research on India's digital payment landscape identified different user groups among women and emphasized the importance of trust, security, control, awareness, and onboarding support. The study estimated a substantial addressable market of women for digital payments while identifying security and control concerns among some users. Recent data from DBS Bank India's *Women and Finance* initiative also indicates substantial use of digital payment tools among female entrepreneurs, while rural women continue to experience barriers involving familiarity, online fraud concerns, and connectivity. These findings suggest that women should not be treated as a homogeneous consumer category. Age, education, income, employment status, urban–rural location, digital literacy, financial autonomy, and previous digital experience may moderate the relationship between digital technologies and financial behaviour.

11. Relevance of the Karnataka Context

Karnataka provides a particularly significant context for investigating this issue because it combines highly developed urban digital ecosystems with semi-urban and rural populations. The state contains major technology and e-commerce consumption centres as well as communities where digital financial adoption continues to develop. Recent research in Karnataka has examined digital payment adoption among consumers and retailers, including studies from Shivamogga and other parts of the state. Research specifically focusing on women in Karnataka is particularly valuable because national-level findings may not adequately capture state-level differences in: digital infrastructure; income and employment; educational attainment; urban–rural location; smartphone and internet access; financial literacy; digital-payment adoption; online shopping frequency; and financial autonomy. Consequently, a Karnataka-specific investigation can contribute important regional evidence to the wider literature on digital consumer behaviour.

12. Major Research Gap

The review reveals several important gaps.

a) First, substantial research has examined flash sales and impulse buying, while another body of research has examined AI personalization and online purchasing. However, comparatively limited research has examined AI-driven flash sales specifically.
b) Second, digital-payment research has examined spending behaviour, but the interaction between digital payment adoption and AI-enabled promotional persuasion remains insufficiently investigated.
c) Third, research concerning women has frequently concentrated on financial inclusion and digital-payment adoption, rather than examining how digital commerce affects the consumption–saving trade-off.
d) Fourth, there is limited evidence specifically concerning female consumers in Karnataka.
e) Finally, existing studies often examine consumption and saving independently. A stronger approach would examine them as potentially competing outcomes of the same digital consumer ecosystem.

The proposed study can therefore make an important contribution by examining the combined influence of AI-driven flash sales and digital payment systems on both consumption patterns and saving behaviour.

13. Implications

The review has implications for several stakeholders.

For Consumers: Female consumers need greater awareness of personalized digital marketing, scarcity cues, FOMO, and the psychological effects of frictionless payment. Financial literacy programmes should incorporate digital consumer literacy and budgeting for online consumption.

For E-Commerce Platforms: AI-driven personalization should be designed transparently and responsibly. Excessive use of artificial urgency may encourage financially harmful consumption and undermine long-term consumer trust.

For Financial Institutions: Digital payment providers can incorporate budgeting dashboards, spending alerts, savings goals, and personalized financial-management tools to counterbalance the potential tendency toward increased discretionary spending.

For Policymakers: Consumer protection frameworks should consider AI-driven

personalization, transparency of promotional claims, dark patterns, misleading scarcity information, privacy, and responsible digital financial services.

For Researchers: Future research should examine causal relationships and mediating mechanisms rather than relying exclusively on descriptive measures of digital-payment usage or online shopping frequency.

14. Conclusion

The literature indicates that AI and digital payment systems are transforming the psychological and economic environment within which consumers make purchasing decisions. AI-driven flash sales can combine personalization, scarcity, urgency, discounts, and real-time targeting to increase consumer engagement and potentially stimulate impulse purchases. Digital payment systems, meanwhile, reduce transaction friction and may reduce the psychological salience of monetary expenditure. nThese effects become particularly significant when the two technologies operate together. AI can make the offer more persuasive, while digital payment can make the purchase easier to complete. This combination may increase consumption, particularly discretionary and unplanned consumption, and potentially affect saving discipline. At the same time, digital financial technologies should not be regarded solely as mechanisms that increase spending. They can also promote financial inclusion, facilitate formal savings, improve access to financial information, and strengthen women's financial participation. The ultimate effect is therefore likely to depend on individual and contextual factors such as financial literacy, income, self-control, digital competence, financial autonomy, and the nature and frequency of digital-payment use. For female consumers in Karnataka, this represents an important and insufficiently explored area of research. The proposed research can contribute to the literature by moving beyond the isolated study of AI marketing, flash sales, or digital payments and examining their combined influence on the consumption–saving behaviour of women.

The central proposition emerging from this review is that the contemporary digital marketplace has transformed not only what consumers buy, but also how quickly they decide, how easily they pay, and how consciously they save. Understanding this transformation is essential for developing responsible digital commerce and financially sustainable consumer behaviour.

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TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT

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Abstract

Teacher Education and Professional Development (TEPD) *is a continuous, career-long framework that transforms individuals into educators and ensures their ongoing competence in a rapidly changing world. Synthesizing current educational theory, the dual concept can be understood through its two core, interconnected pillars.Teacher Education represents the structured, institutionalized process of preparing individuals to enter and navigate the teaching profession. It provides the baseline tools necessary to transition from a student to a classroom leader.**Pre-Service Training:** The initial phase (e.g., B.Ed., M.Ed. programs) focusing on acquiring foundational knowledge.**Pedagogical Theory:** Grounding candidates in educational philosophy, sociology, and cognitive psychology to understand how diverse minds learn.**Instructional Mechanics:** Imparting hard skills like curriculum design, lesson planning, classroom management, and student assessment metrics.*

*Professional Development (increasingly conceptualized as **Professional Learning**) recognizes that initial training is insufficient for a lifelong career. It shifts the focus from passive training to active, self-directed, or collaborative growth embedded in daily practice.**In-Service Adaptability:** Equipping active teachers to respond to real-time challenges, such as integrating AI/digital tools, handling changing student demographics, and adjusting to new curricular policies.**Reflective Practice & Agency:** Encouraging educators to interrogate their own teaching biases, experiment with new strategies, and construct localized professional knowledge.*

Collaborative Ecosystems: *Moving away from isolated teaching through mechanisms like Professional Learning Communities (PLCs), peer coaching, mentoring, and lesson studies.*

Keywords: Teacher Education / Teacher Training.Professional Development (PD)
Continuous Professional Development (CPD)Teacher Professional Learning
In-Service Teacher Training / Pre-Service Teacher Education.Lifelong Learning

Introduction:

Education is widely recognized as the cornerstone of societal advancement, and at the heart of this system stands the educator. However, the capacity of teachers to inspire, instruct, and impact students depends heavily on the preparation and ongoing support they receive. In the contemporary educational landscape, teacher education and professional development have emerged as two indispensable pillars of teaching quality. While teacher education provides the essential foundation for prospective educators, continuous professional development ensures that practicing teachers can adapt to an ever-evolving world. Together, these two components form a continuous learning spectrum that transforms teaching from a stagnant delivery of content into a dynamic, lifelong practice.

The Foundation: Pre-Service Teacher Education

Teacher education primarily refers to the formal policies and procedures designed to equip prospective teachers with the knowledge, attitudes, and behaviors required to perform their tasks effectively in the classroom. Traditionally called pre-service training, this phase provides foundational competencies in three core areas: subject-matter expertise, pedagogical knowledge, and practical classroom management.

In this initial phase, aspiring teachers do not merely learn *what* to teach, but *how* to teach. They study educational psychology to understand cognitive development, learning theories to design impactful lesson plans, and diverse evaluation metrics to gauge student progress. Furthermore, field experiences—such as student teaching placements, micro-teaching, and observation hours—bridge the gap between academic theory and real-world practice. This foundational stage is critical because it builds the initial confidence and competence necessary for an individual to step into a classroom and successfully guide a diverse group of learners.

The Lifelong Continuum: In-Service Professional Development

While pre-service training is vital, it is no longer sufficient to sustain a teaching career that spans decades. The digital revolution, shifts toward student-centered pedagogy, and an increased emphasis on inclusive education mean that the classroom environment is constantly changing. Consequently, teacher education must evolve into Continuous Professional Development (CPD)—an ongoing, in-service process that extends from initial certification until retirement.

Professional development reinforces the philosophy that effective educators are lifelong learners. CPD activities take many forms, including workshops, seminars, peer mentoring, action research, and participation in professional learning communities (PLCs). Through these avenues, experienced educators update their instructional strategies, master new educational technologies, and learn how to address modern challenges such as student mental health, cultural diversity, and neurodivergence. Without structured CPD, teaching methods risk becoming obsolete, directly hindering student engagement and academic achievement.

Key Elements of Effective Professional Development

For professional development to be truly transformative, it must move away from traditional, top-down "one-size-fits-all" seminars. Modern research indicates that the most effective professional development is:

- **Collaborative and Peer-Driven:** When teachers participate in professional learning communities, they can share best practices, analyze student work together, and engage in peer observations. This breaks down classroom isolation and fosters a culture of shared responsibility.
- **Reflective in Nature:** Effective development encourages reflective practice, where teachers systematically evaluate their own lessons, identify areas of weakness, and adapt their approaches based on evidence and student feedback.

- **Sustained and Iterative:** Short, disconnected workshops rarely lead to permanent behavioral changes. Effective CPD provides ongoing coaching, mentoring, and systemic support over an extended period.

Overcoming Current Challenges

Despite its acknowledged importance, executing seamless professional development faces significant hurdles worldwide. Many educational institutions grapple with limited funding, outdated training curricula, and a lack of dedicated time within the school calendar, forcing teachers to pursue development at the expense of their personal time. Furthermore, a digital divide persists; many teachers are expected to integrate advanced technology into their classrooms without receiving the necessary hands-on technical training. To overcome these barriers, educational systems must treat professional development not as an optional luxury, but as a core institutional priority. This requires systemic reform, including allocating administrative time for teacher collaboration, investing in blended learning platforms for flexible training, and aligning professional growth with clear career advancement paths.

How we Development in Teacher Education:

The backbone of any robust education system is the quality of its teachers. As societal needs shift and technology integration accelerates, the expectations placed on educators continue to evolve. To navigate these complex demands, teacher preparation cannot be treated as a single, static event. Instead, it must be conceptualized as a lifelong learning continuum. This continuum bridges formal **Teacher Education**—the foundational, structural preparation required to enter the field—with continuous **Professional Development (PD)**—the ongoing learning process that sustains an educator's efficacy throughout their career. Together, these elements act as a critical catalyst for school improvement, student success, and the holistic development of learners.

The Foundation: Teacher Education

Teacher education refers to the formal policies, procedures, and programs designed to equip prospective and practicing teachers with the comprehensive knowledge, skills, and attitudes necessary for effective classroom management and instruction. Traditionally, it is divided into three core components:

- **Pedagogical Knowledge:** This encompasses the science and art of teaching. It provides educators with an understanding of educational psychology, diverse learning styles, and instructional methodologies (such as learner-centered pedagogy and inquiry-based learning).
- **Subject-Matter Expertise:** Teachers must possess a deep and rigorous understanding of the specific content or academic disciplines they are assigned to teach.
- **Practical Skills:** Through experiential learning mechanisms—such as micro-teaching, lesson planning, and structured classroom practicums—trainees learn to translate theoretical knowledge into real-world teaching practices under the guidance of experienced mentors.

Beyond technical expertise, foundational teacher education plays an indispensable role in

shaping a teacher's professional identity. It encourages the formation of ethical frameworks, cultural sensitivity, and the reflective thinking habits required to manage modern, diverse student populations.

The Lifelong Continuum: Continuous Professional Development (PD)

While pre-service training establishes initial competencies, it is fundamentally insufficient for a lifelong career in an era of rapid technological and social change. Continuous professional development, or in-service training, addresses this limitation by reinforcing the philosophy that "teachers are made, not born."

Effective professional development serves several vital purposes:

1. **Upgrading Competencies:** It provides teachers with the tools to master digital integration, soft skills, and remote learning setups.
2. **Addressing Classroom Realities:** Through workshops, action research, and peer coaching, teachers can systematically diagnose and resolve complex behavioral or instructional challenges.
3. **Fostering Collaboration:** Professional Learning Communities (PLCs) allow educators to escape professional isolation. By sharing best practices and data, networks of working professionals foster mutual support and positive systemic change.
4. **Boosting Morale and Retention:** When school systems invest in their educators, teacher morale and job satisfaction increase. This targeted investment helps reduce the burnout and high attrition rates currently facing the global education sector.

Key Challenges in the 21st Century

Despite its recognized importance, modern teacher education and professional development systems face significant structural hurdles.

- **Outdated Curricula:** Many pre-service programs rely heavily on legacy pedagogical theories that do not reflect contemporary classroom environments.
- **Inadequate Technological Preparedness:** Training programs frequently struggle to keep pace with rapid digital advancements, leaving teachers underprepared to implement blended learning or outcome-based digital assessments.
- **Fragmented In-Service Training:** Traditional professional development often relies on expensive, one-size-fits-all face-to-face workshops. These short-term events rarely offer the sustained coaching or long-term support mechanisms required to truly change a teacher's daily habits.

Conclusion

Teacher education and professional development are not isolated administrative checkboxes; they are the literal lifelines of educational quality. Pre-service education sparks the initial fire, providing the foundational tools required to enter the profession, while continuous professional development fuels that fire, ensuring it adapts to changing winds. In an era defined by rapid technological innovation and global interconnectedness, investing in teachers is fundamentally an investment in the future of society. By nurturing the professional

growth of educators, we directly enrich the minds, capabilities, and futures of the generations they teach.ere is a comprehensive essay outlining the concepts, importance, core components, and challenges of teacher education and professional development.Teacher education and continuous professional development are not distinct administrative boxes to be checked; they are deeply interconnected components of a single professional ecosystem. In the 21st century, an investment in teachers is a direct investment in society. By shifting toward flexible, blended learning models for professional development, fostering collaborative environments, and modernizing foundational curricula, education systems can ensure that teachers remain energized, highly capable change agents. Ultimately, providing educators with sustained opportunities for lifelong growth is the single most effective way to build equitable, impactful classrooms for generations to follow.

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ARTIFICIAL INTELLIGENCE IN SCIENCE AND MATHEMATICS EDUCATION.

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Abstract

Artificial Intelligence (AI) is rapidly transforming the landscape of Science, Technology, Engineering, and Mathematics (STEM) education*, shifting pedagogical paradigms from static resources to dynamic, data-driven environments. This paper explores the conceptual framework of integrating AI technologies—such as* ***Intelligent Tutoring Systems (ITS)****,* ***Multimodal Large Language Models (MLLMs)****, and* ***specialised vertical AI applications****—into science and mathematics curricula. Due to the hierarchical knowledge structures, symbolic representations, and procedural fluencies inherent to these subjects, AI offers unprecedented capabilities for* ***automated error analysis, personalized learning pathways, and the optimization of step-by-step cognitive processes****. However, the integration also presents substantial hurdles, particularly the probabilistic nature of general LLMs, which risk producing mathematical hallucinations and failing to foster deep, higher-order conceptual reasoning. This paper synthesises contemporary literature to examine the dual nature of AI as both a cognitive catalyst and a pedagogical challenge. Ultimately, we propose balanced implementation frameworks that combine AI-driven scaffolding with independent human verification and teacher-led pedagogical expertise, ensuring that technology enhances, rather than subverts, authentic scientific inquiry and mathematical proficiency.*

Key Words : Artificial Intelligence, Science Education and Maths Education.

Introduction:

Artificial Intelligence (AI) is fundamentally shifting how science and mathematics are taught and learned. Traditionally, STEM education relied heavily on abstract equations, rigid textbook examples, and a one-size-fits-all instructional pace. Today, AI bridges the gap between abstract theory and practical understanding by introducing **adaptive learning systems**, dynamic data simulations, and real-time personalized feedback. Because machine learning and modern AI models are inherently built on mathematical foundations (like linear algebra, calculus, and probability), integrating AI into STEM classrooms provides a unique double benefit: students use AI to master complex science and math concepts while simultaneously building essential **AI literacy**.

Review of Related Literature (RRL) on the integration of Artificial Intelligence (AI) technology in science and mathematics education synthesizes how intelligent systems are transforming pedagogical paradigms. This review is organized into key themes based on global empirical research, systematic reviews, and meta-analyses

Objectives of the Study: The primary objective of studying AI technology in science and mathematics education is to systematically evaluate how artificial intelligence can optimize, personalize, and innovate the teaching and learning of complex STEM subjects. Researchers and educators conduct these studies to understand the balance between AI-driven pedagogical tools and core scientific/mathematical practices.

Methodology : Implementing **Artificial Intelligence (AI) in mathematics and science education** requires a structured, multi-dimensional methodology. The core framework focuses on enhancing cognitive understanding, enabling personalized pathways, and providing pedagogical support while avoiding "cognitive offloading" (where AI solves the problem without the student learning).

Key Pillars of AI in Science and Math Education

The integration of AI technology in these fields generally centers around three core transformations:

- **Personalized & Adaptive Learning:** AI platforms analyze a student's problem-solving steps in real time. If a student struggles with a calculus derivative or a physics formula, the AI pinpoints the exact conceptual gap—such as a misunderstood algebraic rule—and modifies the curriculum accordingly.
- **Intelligent Tutoring Systems (ITS):** Acting as a 24/7 teaching assistant, AI can generate multiple explanations for abstract mathematical theorems, debug student-written code, or guide learners through a chemistry lab experiment step-by-step.
- **Immersive Simulations and Robotics:** AI pairs with educational hardware to make the invisible visible. For example, AI-driven simulations can model planetary orbits, climate change trajectories, or complex molecular structures, turning passive reading into active, data-driven exploration.

Core Benefits

Traditional STEM Education	AI-Enhanced STEM Education
Fixed Pace: The whole class moves together, leaving struggling students behind or advanced students bored.	**Adaptive Pace:** Adjusts complexity in real time based on individual mastery.
Static Problems: Math word problems use generic, unengaging scenarios.	**Contextual Interest:** Re-frames equations into topics the student likes, such as sports stats or video game mechanics.
Delayed Feedback: Grading homework or lab reports takes days.	**Instant Intervention:** Flags mistakes immediately, allowing students to learn from errors on the spot.

Navigating the Challenges

While AI offers immense potential, its implementation requires careful human oversight. Generative AI tools can sometimes "hallucinate" incorrect mathematical proofs or scientific

facts. Furthermore, heavy reliance on AI can reduce opportunities for peer collaboration if not balanced correctly. The ultimate goal of AI in science and mathematics is not to replace the educator, but to **augment human teaching**—removing administrative burdens so teachers can focus on deeper, curiosity-driven exploration.

The Core Problem in Modern STEM Classrooms

Traditional educational structures frequently struggle to support the diverse requirements of science and math students due to explicit systemic bottlenecks:

- **The "One-Size-Fits-All" Pace:** Students who miss a fundamental concept in mathematics (e.g., fractions) struggle with downstream topics (e.g., algebra) because knowledge is strictly cumulative.
- **Resource Deficits:** Limited access to physical laboratories, expensive science equipment, and specialized mathematical software creates an urban-rural equity divide.
- **Teacher Burnout:** Educators spend disproportionate hours grading repetitive problem sets, designing multi-tier quizzes, and managing administrative workloads instead of offering student-facing mentorship.

The AI Solution: Framework Shift

AI systems do not simply digitalize educational content; they transform it into dynamic, interactive spaces. This structural shift transforms the classroom roles comprehensively: **Active Student Participation:** Learners transform into analysts who use predictive models to test hypotheses in real-time.

- **Facilitator Role for Educators:** Teachers shift focus from routine instructions to guided inquiry and strategic interventions.

ARTIFICIAL INTELLIGENCE IN MATHEMATICS EDUCATION

Section Overview

Mathematics requires exceptional procedural fluency, conceptual mapping, and immediate error correction. AI applications excel here by tracking real-time cognitive breakdowns as a student moves through multi-step equations.

Core Implementations:

1. Intelligent Tutoring Systems (ITS)

- **Functionality:** Provides micro-step guidance during complex problem-solving.
- **Pedagogical Impact:** If a student incorrectly applies a negative sign during algebraic matrix operations, the system catches the error *at that specific step*. It provides a targeted hint instead of waiting until the final answer is calculated incorrectly.

2. Adaptive Learning Models

- **Functionality:** Continuously updates a student's personal proficiency map.
- **Pedagogical Impact:** The platform detects systemic prerequisites. If a student fails a geometry exercise on calculating sphere volume, the system automatically redirects them to review circle area formulas before advancing.

3. Dynamic Visualizations & Geometry Engines

- **Functionality:** Bridges the gap between abstract symbolic math and visual understanding.
- **Pedagogical Impact:** AI-driven graphing environments alter geometry configurations based on real-time code variations. This helps students visualize how changing an equation's coefficients immediately shifts its physical parabola geometry.

ARTIFICIAL INTELLIGENCE IN SCIENCE EDUCATION

Section Overview

Science education relies on formulating hypotheses, executing structured experiments, and isolating variables. AI changes this domain by creating virtual testing grounds and providing complex predictive data analytics engines.

Core Implementations

1. AI-Powered Virtual Laboratories & Simulations

- **System Capabilities:** Simulates dangerous, expensive, or highly abstract physical scenarios safely.
- **Direct Application:** Students run high-risk chemistry experiments or model complex particle physics collisions without physical hazards. AI introduces realistic entropy variables to replicate genuine field conditions.

2. Machine Learning Predictive Analytics (AI-Thinking)

- **System Capabilities:** Allows students to run predictive science simulations without complex coding.
- **Direct Application:** High school biology and material science students use pre-trained AI engines to model how input changes affect structural outputs. For example, they can simulate how changing concrete mixtures modifies compressive strength over time.

3. Smart Dialogue & Hypothesis Evaluators

- **System Capabilities:** Utilizes natural language processing to refine scientific reasoning.
- **Direct Application:** When a student proposes an unscientific or logical leap in an experimental write-up, an AI chatbot engages them in targeted Socratic dialogue. It prompts them to reconsider anomalies in their data collection layout.

OPPORTUNITIES, ETHICAL CHALLENGES, AND STRATEGIC ROADMAPS

Section Overview

While the benefits of AI in STEM are extensive, deploying it responsibly requires balancing systemic instructional parameters against potential ethical and technological infrastructure risks.

Institutional Benefits

- **Optimized Assessment Engines:** Teachers can quickly generate adaptive quizzes, interactive rubrics, and targeted science units tailored to localized educational standards.

- **Early Support Identification:** Machine learning algorithms track engagement metrics to flag students experiencing cognitive boredom or at risk of failing prerequisites early.

Systemic Challenges & Risks

- **Data Privacy Concerns:** Tracking student problem-solving patterns requires collecting granular biometric and cognitive data, raising significant security compliance issues.
- **Algorithmic Bias:** Generative models can reinforce existing biases and pedagogical gaps if trained on skewed educational datasets.
- **The "Black Box" Problem:** Over-reliance on AI solutions can occasionally cause a decline in a student's fundamental, self-directed problem-solving and creative skill sets.

A Strategic Framework for Educational Integration

1. **Prioritize Educator AI Readiness:** Teachers must develop strong foundational technical literacy to confidently evaluate AI-suggested content and metrics.
2. **Commit to Equitable Access:** Build offline-compatible or low-bandwidth AI learning frameworks to ensure schools lacking high-speed internet infrastructure are not left behind.
3. **Preserve Core Human Pedagogy:** AI should only be used to augment human teaching, maintaining empathetic, human-centered mentorship at the core of the educational process.

Conclussion: The integration of Artificial Intelligence (AI) in STEM education represents a profound shift from rigid, lecture-based learning to adaptive, interactive environments. Rather than replacing human educators, AI serves as a powerful optimizer. It handles the cognitive formatting and heavy lifting of tracking while allowing teachers to focus on student connection and mentorship

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APPLYING AI TECHNOLOGY IN SOCIAL SCIENCE AND HUMANITIES IN SCHOOL AND COLLEGES

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Abstract

This research framework explores the rapid integration of Artificial Intelligence (AI) technologies within secondary and higher education, specifically focusing on the fields of social sciences and humanities. While initial AI adoption in education heavily targeted STEM fields, tools such as Large Language Models (LLMs), automated text analysers, and predictive data systems are fundamentally reshaping how students engage with history, sociology, literature, and political science. On one hand, AI serves as an efficiency multiplier, automating administrative workloads, facilitating personalized learning pathways, enabling complex trend analysis, and providing immersive historical simulations. On the other hand, its application poses critical threats to co-educational pillars, including the potential dilution of humanistic critical thinking, algorithmic bias, academic integrity concerns, and data privacy vulnerabilities. This paper synthesizes current methodological approaches to evaluate how structured AI literacy programs and comprehensive institutional policy frameworks can mitigate these challenges. Ultimately, it argues that a balanced approach is essential to preserve human-centric analytical skills while leveraging AI to deepen text-based and societal inquiry.

Keywords: *Artificial Intelligence in Education (AIEd); Social Sciences Pedagogy; Digital Humanities; Critical Thinking; Algorithmic Literacy; High School Curriculum; Higher Education Policy; Ethics of Technology.*

Introduction:

Provide at least four pages of information on the topic of applying AI technology in the classroom in social sciences and humanities. Applying artificial intelligence (AI) technology to teach social sciences and humanities in the classroom is a revolutionary step in the field of education. This technology is not limited to just math or science, but can help students learn subjects like history, geography, economics, political science, literature, and philosophy in a more engaging and in-depth way.

Below is detailed, comprehensive information on the application of AI technology in the social sciences and humanities.

1. Introduction and Background

Social sciences and humanities are essentially the study of human behavior, social development, culture, history, and thought processes. Traditionally, these subjects were taught through lectures, reading textbooks, and writing essays. But in today's digital age, **AI**

technology is developing the ability of students to analyze and think critically, rather than just memorizing information.

2. Key applications of AI technology in the classroom

A) Historical reenactment and virtual time travel

Instead of learning history as just a list of years and wars, AI brings it to life.

- **Interact with historical characters through AI chatbots:** Students can interact directly with them using AI chatbots (technology designed to react like Mauryan Emperor Ashoka, Mahatma Gandhi, or Abraham Lincoln, for example). This makes it easier to understand the decisions and situations of that time.
- **Virtual Reality (VR) and AI:** Old manuscripts, historical sites like Harappa and Mohenjo-daro can be recreated in 3D format with the help of AI technology, giving students a virtual tour experience.

a) Geo-spatial AI and data analytics in geography

Geography is not just about identifying maps, it is about understanding the changes in the Earth.

- **Satellite Imagery Analysis:** AI tools help students analyze real-time satellite data on climate change, urbanization, and deforestation.
- **Forecasting Models:** AI simulations can show students in the classroom how natural disasters (floods, earthquakes) occur and how they can be managed.

e) Simulation in Economics and Political Science

- **Impact of Economic Policies:** AI-based software calculates in minutes and displays through graphs how government budget or tax policies affect society.
- **Election and Political Analysis:** 'Big Data Analytics', which uses AI to understand voting trends, public opinions, and global political relations, is extremely useful for students.

e) Literature and Language Studies (Humanities)

- **Automated review and analysis:** AI helps analyze the deeper meaning, literary style, and metaphors of Shakespeare or Kuvempu's poems.
- **Translation and Global Literature:** AI language models (LLMs) are helping to accurately translate and interpret classic works in different languages of the world, along with their cultural context.

3. AI support for instructors (teachers)

AI can be a great helper not only for students but also for teachers in the classroom:

- **Personalized Learning:** Every student learns at a different pace. AI software assesses the student's level of knowledge and prepares course materials and quizzes accordingly.
- **Automated Evaluation:** Evaluating long essays in social studies can be a challenging task for teachers. AI tools save teachers time by quickly checking grammar, content accuracy, and article structure.
- **Lesson Planning Preparation:** Teachers can take help of AI tools (such as ChatGPT or other educational AI tools) to prepare new and creative lesson plans for their classes.

4. Skill development among students

Applying AI in social sciences and humanities develops the following key skills in students:

1. **Critical Thinking:** AI is trained to detect what is true, false, or biased in information from different sources.
2. **Research Skills:** Students learn to easily categorize and draw conclusions from vast amounts of social data.
3. **Problem Solving:** Students can think of innovative solutions based on AI-generated analyses of social issues such as poverty, unemployment, and caste system.
4. **5. Challenges and Ethical Concerns**

Some key challenges to be faced when using AI in the classroom include:

- **Algorithmic Bias:** AI technologies operate based on information available on the internet. Information may only favor certain countries or communities in history or social subjects. This can lead to misunderstandings among students.
- **Lack of creativity and plagiarism:** There is a risk that students will become completely dependent on AI instead of writing essays based on their own ideas.
- **Digital Divide:** Not all schools or students may have access to expensive AI technologies and internet access. This can increase educational inequality.
- **Lack of human touch:** Humanities subjects teach empathy, morality, and human relationships. This cannot be fully taught by a machine (AI) alone. Teacher love, guidance, and classroom discussions are essential.

Applications of Artificial Intelligence (AI) technology in the social sciences and humanities

The role of technology in today's modern education system is very important. Especially **Artificial Intelligence (AI)** technology is bringing revolutionary changes in the teaching and learning of not only science and mathematics subjects, but also **social sciences** and **humanities** . Here is comprehensive information on how this technology can be used effectively at the high school and college level.

1. Application of AI in History and Archaeology

History and archaeology are not just the memory of dates and events, they are analyses of the past. The way AI learns these is exciting:

- **Virtual Reality (VR) and AI Tours:** History students can digitally visit sites like the Colosseum in Rome or the Indus Valley Civilization. AI-based technology recreates cities of the past, giving students an immersive experience.
- **Translation and analysis of ancient documents:** Old manuscripts, inscriptions, and writings are difficult to read. AI technology (using OCR and NLP) instantly translates these obscure scripts into modern languages and provides their summary.
- **Historical Prediction and Patterns:** AI uses data to analyze wars, the fall of empires, and migration patterns. This helps in understanding the socio-economic reasons behind historical events.

2. AI in Geography and Environmental Studies

Geography studies the relationship between nature, land, and humans. The use of AI here is immense:

- **Geographic Information System (GIS) and AI:** AI is used to analyze satellite images. Students can study the pace of urbanization, deforestation, and changes in river flows in real-time through maps.
- **Climate Change Forecasting:** College students can use AI models to research how global temperatures or rainfall patterns may change in the near future.
- **Disaster Management:** AI simulations help in gaining knowledge about the damage and preventive measures that can be taken when natural disasters like earthquakes, floods or tsunamis occur.

3. AI in Political Science and Economics

Subjects like political science and economics are closely related to current world events. In these, AI can help in the following ways:

- **Election data and public opinion analysis:** Students can analyze social media preferences and voting patterns of millions of people through AI technology. This helps in understanding political theories empirically.
- **Economic Forecasting and Market Study:** AI tools guide college students in formulating future economic policies by analyzing data on a country's GDP, inflation, and poverty line.
- **Simulation of Global Policies:** In the field of International Relations, one can learn how a country's foreign policy affects the world by creating an artificial environment (Simulation).

5. AI in Language, Literature, and Philosophy

AI has opened up new possibilities in language and literature, the lifeblood of the humanities:

- **Critical writing and analysis:** AI software helps analyze the themes, moods of characters, and language style of large novels or plays (such as works by Shakespeare or Kuvempu).
- **Language Learning and Grammar:** AI chatbots act as a close friend for students learning new languages at the high school level. They instantly correct mistakes and improve conversational skills.
- **Philosophy Discussions:** Students can enhance their intellectual power by discussing the thoughts of various philosophers (Socrates, Shankaracharya, Karl Marx) with chatbots.

6. AI in Sociology and Psychology

AI is helpful in understanding human behavior and social systems:

- **Social Trends Detection:** AI analyzes how issues of caste, gender discrimination, and employment are changing in society through Big Data.
- **Psychological Research:** College-level psychology students can use AI-based graphs and analytics to study patterns of human behavior, depression, and psychological stress.

6. Changes AI will bring to teachers and teaching methods

AI is extremely useful not only for students, but also for teachers:

- **Personalized Learning:** Every student learns at a different pace. AI technology tailors textbook content and tests to the student's ability. It suggests simple methods for slower learners.
- **Automated Grading:** AI can be used to grade essays, short answer papers, etc. This saves teachers time and allows them to spend more time with students.
- **Curriculum Designing:** AI helps teachers prepare new curricula and quizzes to keep up with global educational changes.

7. Challenges and Ethical Concerns

Like any technology, there are some limitations and challenges in the use of AI:

- **Lack of values:** Social sciences and humanities teach human values, empathy, and morality. AI can only provide data, but cannot recreate human emotions.
- **Plagiarism:** Students are at risk of having their essays and assignments prepared and copied by AI tools like ChatGPT instead of writing them themselves. This stifles their own thinking power.
- **Digital Divide:** Rural high schools and colleges do not have easy access to such expensive technologies, which can increase educational inequality between urban and rural students.

Determine

The application of AI technology in social sciences and humanities is a boon. It replaces the rote learning system and develops **critical thinking, research spirit and practical knowledge** in students . However, technology should be just a tool and not a substitute for teachers. Only when the human guidance of teachers and the technological power of AI come together, it will be possible to provide quality education at the high school and college levels.

Based on this information, please indicate whether you would like more details on any specific topic (such as **the use of AI in history** or **AI tools for teachers**) or whether you would like to include more subtopics in the form of an essay.

6. Conclusion

The application of AI technology in social sciences and humanities is a great complementary force. It is not a tool to replace teachers, but rather a technology to strengthen the hands of teachers and expand the horizons of students' knowledge. Only when AI is used responsibly, ethically, and under the supervision of teachers in the classroom, can it shape students into better historians, economists, and responsible citizens.

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This is for informational purposes only. For medical advice or diagnosis, consult a professional. AI responses may include mistakes.

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ARTIFICIAL INTELLIGENCE, BIOTECHNOLOGY AND BIOTERRORISM: BALANCING SCIENTIFIC INNOVATION, DUAL-USE RISKS, ETHICS AND GLOBAL BIOSECURITY

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Abstract

The rapid convergence of artificial intelligence (AI) and biotechnology is reshaping the landscape of scientific discovery while simultaneously eroding the technical barriers that once separated legitimate life-sciences research from the deliberate misuse of biological agents. Advances in machine learning, protein-structure prediction, automated laboratory systems, and large language models capable of synthesising domain-specific scientific knowledge have accelerated vaccine development, personalised medicine, and agricultural innovation. However, these same tools carry a troubling dual-use character: the same models that can design therapeutic proteins can, in principle, be redirected toward identifying or enhancing pathogens with heightened transmissibility or lethality. This paper examines the intersection of AI, biotechnology, and bioterrorism through a policy and ethics lens, without providing technical detail that could itself constitute a security risk. It surveys the emerging threat landscape described in recent governmental and independent assessments, considers the ethical tensions between open scientific inquiry and precautionary restriction, and evaluates existing global biosecurity governance instruments, including the Biological Weapons Convention, national AI executive actions, and voluntary industry safety frameworks. The analysis finds that current governance mechanisms remain fragmented, reactive, and unevenly enforced across jurisdictions, leaving significant gaps in oversight of dual-use research of concern and of AI systems with biological design capabilities. The paper argues for an adaptive, multi-layered governance model combining mandatory risk evaluation of frontier AI models, strengthened nucleic-acid synthesis screening, international coordination through existing treaty bodies, and cultivation of a responsible research culture among scientists and developers. It concludes that safeguarding global biosecurity in the AI era requires proactive, anticipatory governance rather than reactive regulation, balancing the preservation of scientific freedom with robust safeguards against catastrophic misuse.

Keywords: *artificial intelligence; dual-use biotechnology; bioterrorism; biosecurity governance; research ethics*

Introduction

The twenty-first century has witnessed an extraordinary convergence between artificial intelligence (AI) and the biological sciences. Machine learning systems can now predict protein folding with near-experimental accuracy, design novel molecules, and assist researchers in interpreting vast genomic datasets, achievements that have accelerated drug discovery, vaccine platforms, and precision agriculture. Yet this same convergence has raised an uncomfortable question for scientists, policymakers, and ethicists alike: what happens when tools built to cure disease can also be repurposed to engineer it? The historical threat of bioterrorism, long constrained by the technical difficulty of acquiring, cultivating, and weaponising pathogens, may be entering a new phase in which AI systems lower the expertise required to pursue such goals (Soice et al., 2023). This paper explores that dual-use dilemma, situating it within a broader discussion of scientific innovation, ethical responsibility, and global biosecurity governance.

The purpose of this paper is not to catalogue technical vulnerabilities, but to examine, at the level of policy and principle, how societies might sustain the benefits of AI-enabled biotechnology while containing its most catastrophic risks. The discussion proceeds in five parts. First, it outlines how AI and biotechnology have converged in recent years. Second, it surveys the dual-use risk landscape identified in recent governmental and independent assessments. Third, it considers the ethical tensions inherent in regulating dual-use science. Fourth, it reviews existing global biosecurity governance frameworks and their limitations. Finally, it proposes a set of policy directions aimed at balancing innovation with precaution.

The Convergence of Artificial Intelligence and Biotechnology

Biotechnology and AI have historically advanced along separate tracks, but the last decade has produced a marked convergence. Deep learning models trained on protein sequence and structure data have transformed structural biology, enabling researchers to predict three-dimensional protein conformations that once required years of laboratory crystallography. Generative AI systems, similarly, can now propose novel molecular structures optimised for particular biological functions, a capability with obvious value for drug and vaccine design (Bengio et al., 2025). Large language models trained on scientific literature can synthesise findings across thousands of publications, potentially compressing research timelines that once spanned years into a matter of weeks.

This convergence has been mirrored by parallel advances in laboratory automation. Cloud laboratories and robotic experimentation platforms now allow researchers to design experiments computationally and have them executed remotely with minimal human intervention. Taken together, these developments have democratised access to sophisticated biological research, extending capabilities once limited to elite laboratories to a much broader community of academic, commercial, and even amateur researchers. While this democratisation carries substantial scientific and economic benefits, it also underlies the central concern of this paper: capabilities that lower the barrier to legitimate innovation may

simultaneously lower the barrier to malicious misuse (Future of Life Institute, 2025).

Dual-Use Risks and the Bioterrorism Threat Landscape

The concept of "dual-use research of concern" predates the AI era, referring to legitimate scientific work that could be repurposed to cause significant harm, such as gain-of-function research on pathogens. What AI introduces is not necessarily a new category of risk, but an amplification of existing ones. Independent assessments have found that AI systems, including general-purpose language models and specialised biological design tools, can in some cases assist users in navigating technical obstacles that previously required tacit expert knowledge, such as troubleshooting laboratory procedures (Bengio et al., 2025). Structured red-team exercises conducted by policy research organisations have likewise concluded that AI tools could meaningfully reduce certain operational barriers associated with planning a large-scale biological attack, although researchers caution that the overall evidence base remains limited and that many barriers, such as physical acquisition of materials and successful weaponisation, persist regardless of informational assistance (Mouton et al., 2024). It is important to note that the primary risk identified across these assessments concerns the erosion of the tacit knowledge barrier rather than the wholesale removal of technical barriers. Physical infrastructure, specialised equipment, and hands-on laboratory skill remain significant constraints on any actor seeking to develop a biological weapon. Nevertheless, policymakers have treated the trend seriously enough to prompt new evaluation regimes: benchmarks such as the WMDP framework were developed specifically to measure whether AI systems possess and can transmit hazardous biological knowledge, allowing developers to identify and reduce such capabilities before public release (Li et al., 2024). Complementary work has focused on strengthening downstream safeguards, including improved screening of nucleic acid synthesis orders, so that even if an AI system provides design assistance, the physical realisation of a dangerous sequence can be flagged before synthesis occurs.

Beyond the technical dimension, the threat landscape must also account for actor diversity. Historically, biological weapons programmes required state-level resources; contemporary concern instead centres on the possibility that AI could enable small, non-state groups or even lone individuals to approach capabilities once reserved for well-resourced state programmes (National Security Commission on Emerging Biotechnology [NSCEB], 2024). This shift in the risk profile, from a small number of highly resourced state actors to a potentially larger population of less-resourced actors, is precisely what has driven the recent surge of policy attention toward AI-biosecurity governance.

Ethical Considerations

The governance of dual-use AI and biotechnology sits at the intersection of several competing ethical commitments. The first is the principle of scientific openness: modern biomedical progress has depended heavily on the free exchange of data, methods, and findings, and restricting publication or access risks slowing legitimate research that could save lives, particularly in pandemic preparedness and rare-disease treatment. The second is

the precautionary principle, which holds that when an activity carries a risk of severe or irreversible harm, the burden of proof for safety should rest with those advocating for the activity, even absent full scientific certainty. Reconciling these two commitments requires a case-by-case, risk-proportionate approach rather than a categorical choice between openness and restriction.

A second ethical tension concerns responsibility and accountability across a diffuse set of actors. AI model developers, biotechnology firms, academic researchers, cloud-laboratory providers, and national regulators each hold partial responsibility for preventing misuse, yet no single actor controls the entire pipeline from model training to physical synthesis. This diffusion of responsibility creates a risk of ethical gaps in which each actor assumes that safeguards will be enforced elsewhere in the chain. Addressing this gap requires clearer allocation of responsibility, for instance through mandatory model evaluations prior to release, verified customer screening at synthesis providers, and institutional biosafety review for AI-assisted research proposals.

A third consideration involves equity. Biosecurity restrictions, if poorly designed, risk disproportionately burdening researchers in lower-resource settings who may lack the infrastructure to satisfy stringent compliance requirements, while large, well-resourced laboratories and corporations can absorb such costs more easily. An ethically sound governance regime must therefore ensure that safety measures do not simply entrench existing inequalities in global scientific capacity, but instead extend biosafety capacity-building alongside restriction.

Global Biosecurity Governance Frameworks

The foundational instrument of international biosecurity governance remains the Biological Weapons Convention (BWC) of 1972, which prohibits the development, production, and stockpiling of biological weapons. The BWC, however, lacks a formal verification mechanism, and its provisions were drafted decades before the emergence of AI-enabled biological design tools, leaving significant interpretive gaps regarding computational and AI-driven contributions to weapons development. National-level responses have begun to fill part of this gap. In the United States, the 2023 Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence directed federal agencies to establish standardised evaluations of AI systems for hazardous biological capabilities, and a subsequent 2024 National Security Memorandum extended this mandate to classified evaluation of frontier models (Bengio et al., 2025).

Beyond government action, industry and multi-stakeholder initiatives have emerged as an important, if voluntary, layer of governance. Leading AI developers have adopted internal frontier-safety frameworks that commit to pre-deployment testing for biological and chemical uplift risks, drawing on structured red-teaming and benchmark evaluations before releasing new models publicly. Multi-stakeholder biosecurity forums have similarly convened AI developers, biosecurity experts, and synthesis-screening providers to coordinate best

practices across the life-sciences supply chain, including recommendations for AI-resilient screening of nucleic acid synthesis orders (Future of Life Institute, 2025).

Despite this progress, significant gaps remain. Governance efforts are concentrated in a small number of wealthy nations, creating an uneven global patchwork in which model developers or biotechnology firms operating outside these jurisdictions face few binding obligations. Voluntary industry commitments, while valuable, lack independent enforcement mechanisms and may be inconsistently applied across companies and over time. Moreover, the pace of AI capability development continues to outstrip the pace of treaty negotiation and domestic legislation, meaning that governance frequently responds to risks only after they have already materialised in deployed systems (National Security Commission on Emerging Biotechnology, 2024).

Balancing Innovation and Risk: Toward Adaptive Governance

Addressing the dual-use dilemma at the intersection of AI and biotechnology requires governance that is both adaptive and proportionate. First, mandatory pre-deployment evaluation of frontier AI models for biological uplift risk should be extended beyond voluntary commitments into binding regulatory requirements, applied consistently across major AI-developing jurisdictions rather than left to individual companies' discretion. Second, nucleic-acid synthesis screening should be strengthened and harmonised internationally, ensuring that orders for potentially hazardous genetic sequences are flagged regardless of where the request originates, closing loopholes that currently allow circumvention through jurisdiction-shopping.

Third, international coordination should be strengthened through existing treaty architecture rather than the creation of entirely new institutions, which are often slow to negotiate. Expanding the mandate of BWC review conferences to explicitly address AI-enabled biological risks, alongside technical support from bodies such as the World Health Organization, would allow existing diplomatic infrastructure to adapt more quickly than establishing a new convention from scratch. Fourth, investment in biosafety and biosecurity capacity-building in lower-resource countries is essential to prevent governance frameworks from simply displacing risk to jurisdictions with weaker oversight, while also ensuring that the benefits of AI-enabled biotechnology are shared more broadly rather than concentrated in wealthy nations.

Finally, cultivating a culture of responsible research conduct among scientists, students, and AI developers is a necessary complement to formal regulation. Institutional biosafety committees, responsible-conduct training that explicitly addresses AI-assisted research, and clear reporting channels for dual-use concerns can help ensure that safeguards are internalised as professional norms rather than experienced merely as external compliance burdens. Together, these measures represent a layered, defence-in-depth approach: no single safeguard is likely to be sufficient on its own, but overlapping technical, institutional, and legal measures can meaningfully raise the barriers to misuse while preserving the scientific

openness that drives legitimate innovation.

Conclusion

The convergence of artificial intelligence and biotechnology represents one of the most consequential developments in contemporary science, carrying immense promise for medicine, agriculture, and public health alongside genuine and evolving risks of catastrophic misuse. This paper has argued that current governance structures, though improving, remain fragmented, largely voluntary, and reactive relative to the pace of technological change. A sustainable path forward requires adaptive, multi-layered governance: binding evaluation requirements for frontier AI systems, strengthened and harmonised synthesis screening, revitalised international treaty coordination, equitable capacity-building, and a strong professional culture of responsibility among scientists and developers. Only through such a comprehensive and anticipatory approach can the global community hope to capture the extraordinary benefits of AI-enabled biotechnology while safeguarding against its most severe potential harms.

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ARTIFICIAL INTELLIGENCE IN PHYSICAL EDUCATION: TRANSFORMING TEACHING, ASSESSMENT, PERSONALISED LEARNING AND SPORTS PERFORMANCE

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Abstract

Artificial Intelligence (AI) is rapidly transforming educational practices by enabling personalised learning, automated assessment, predictive analytics and data-informed decision-making. Physical Education (PE), traditionally characterised by practical instruction, physical activity, motor development, skill acquisition and performance assessment, is also beginning to experience the influence of AI-enabled technologies. Developments in machine learning, computer vision, wearable technologies, predictive analytics and generative AI have created new possibilities for monitoring physical activity, analysing movement patterns, providing personalised feedback, assessing motor skills and supporting sports performance. The present paper examines the emerging role of Artificial Intelligence in Physical Education, with particular emphasis on its applications in teaching and learning, physical fitness assessment, skill acquisition, personalised learning, sports performance analysis and injury prevention. It also critically examines the challenges associated with AI integration, including data privacy, algorithmic bias, technological inequality, teacher preparedness, ethical concerns and the potential overdependence on technology. The paper argues that Artificial Intelligence should be regarded as an augmentative technology rather than a replacement for Physical Education teachers. Meaningful integration requires appropriate teacher preparation, institutional infrastructure, ethical data governance and pedagogically sound implementation. The paper concludes that a human-centred approach to Artificial Intelligence can strengthen Physical Education by combining technological capabilities with the professional judgement, empathy, motivation and pedagogical expertise of teachers.

Keywords: *Artificial Intelligence, Physical Education, Machine Learning, Computer Vision, Wearable Technology, Sports Analytics, Personalised Learning, Physical Fitness*

1. Introduction

Physical Education occupies an important position within the educational process because of its contribution to the physical, cognitive, emotional and social development of learners. Unlike many other academic disciplines, Physical Education combines theoretical understanding with active participation, movement, motor development, physical fitness and skill performance. It provides learners with opportunities to develop healthy lifestyles, cooperation, discipline, leadership, self-confidence and an appreciation of lifelong physical activity. Traditionally, Physical Education teaching has relied extensively on teacher demonstrations, direct observation, guided practice, repetition, performance assessment and

immediate verbal feedback.

The rapid development of Artificial Intelligence has created new possibilities for enhancing these conventional approaches. Artificial Intelligence refers broadly to computational systems capable of performing tasks that involve processes commonly associated with human intelligence, including learning from data, recognising patterns, making predictions, classifying information and generating responses. Recent advances in machine learning, computer vision, natural language processing, sensor technologies and generative AI have expanded the potential applications of AI across educational and sporting environments.

The integration of AI into Physical Education is particularly significant because physical activity generates large amounts of observable and measurable information. Movement patterns, exercise intensity, heart rate, speed, acceleration, repetitions, body position and performance outcomes can potentially be captured through cameras, wearable sensors and other digital technologies. AI systems can process such information rapidly and identify patterns that may not be immediately apparent through conventional observation.

For example, computer-vision technologies can analyse movement captured through video and potentially provide information about posture, body alignment, joint movement and technique. Similarly, wearable technologies can generate continuous data concerning physical activity and exercise intensity, which can subsequently be analysed using AI. Such applications may provide teachers with additional evidence for instructional decision-making and enable learners to receive more immediate and personalised feedback.

However, the introduction of AI into Physical Education also raises important pedagogical and ethical questions. Physical Education is not simply concerned with measuring physical performance. It is also concerned with motivation, enjoyment, interpersonal relationships, confidence, participation, cooperation and holistic development. Excessive reliance on technological measurement could potentially undermine these fundamental purposes. Consequently, the integration of AI should be guided by educational objectives and human values rather than by technological capability alone.

The present paper therefore examines the emerging role of Artificial Intelligence in Physical Education and considers its potential applications, benefits, limitations, ethical implications and future directions. Particular attention is given to the principle that AI should support teachers and learners without displacing the human dimensions of Physical Education.

2. Objectives of the Paper

The present paper aims to:

a) Examine the role and applications of Artificial Intelligence in Physical Education, particularly in teaching, learning, assessment, fitness monitoring and sports performance.
b) Explore the potential benefits and challenges associated with the integration of Artificial Intelligence into Physical Education.

c) Propose a human-centred framework for the effective, ethical and pedagogically appropriate integration of Artificial Intelligence in Physical Education.

3. Methodology

The present study adopts a conceptual and narrative review approach. Relevant scholarly literature, academic publications and policy documents relating to Artificial Intelligence, educational technology, Physical Education, sports analytics, wearable technologies, personalised learning and AI-supported assessment were considered in developing the arguments presented in the paper.

The literature was examined thematically to identify major areas in which Artificial Intelligence can contribute to Physical Education. Particular attention was given to AI-supported teaching and learning, fitness and skill assessment, personalised physical activity, sports performance analysis, injury prevention and the ethical implications of collecting and analysing learner data.

The purpose of the review is not to report findings from a primary empirical investigation but to synthesise existing knowledge and develop a conceptual understanding of the opportunities and challenges associated with Artificial Intelligence in Physical Education. The discussion also seeks to identify areas in which further empirical research is required.

4. Understanding Artificial Intelligence in Physical Education

Artificial Intelligence in Physical Education can be conceptualised as the application of intelligent computational technologies to collect, analyse, interpret and utilise information related to physical activity, movement, fitness, learning and sports performance. The purpose of such applications is not necessarily to automate the entire educational process but to provide additional information and decision-support mechanisms for teachers, learners and coaches.

Machine learning represents one important technological component of AI. Machine-learning systems can identify patterns in large datasets and subsequently classify information or generate predictions. In Physical Education, such systems may be used to examine fitness trends, classify movement patterns, analyse performance data or identify changes in activity levels over time.

Computer vision represents another significant application. Computer-vision systems enable computers to interpret visual information obtained from photographs or video recordings. In Physical Education, this technology can potentially be used to analyse body posture, movement trajectories, joint positions, balance and sports techniques. Such applications may provide learners with visual feedback concerning their performance and allow teachers to supplement direct observation with technology-assisted analysis.

Wearable technologies also have considerable relevance to AI-supported Physical Education. Smartwatches, fitness trackers and other sensor-based devices can collect information relating to physical activity, heart rate, steps, movement intensity and exercise duration. AI systems can analyse these data to identify activity patterns and provide personalised

feedback. When appropriately implemented, such technologies may enable learners to become more aware of their own physical activity and progress.

Predictive analytics constitutes another important area. By analysing historical and current performance data, AI systems may identify trends and estimate potential future outcomes. In sports settings, predictive analytics can contribute to workload management, performance analysis and injury-risk assessment. Nevertheless, predictions should be interpreted cautiously because they are probabilistic rather than absolute.

Generative AI has introduced another dimension to the discussion. Generative AI systems can assist Physical Education teachers in preparing lesson plans, instructional materials, assessment questions, rubrics, activity variations and differentiated learning resources. However, AI-generated information must be critically evaluated by teachers because such systems may occasionally produce inaccurate, inappropriate or contextually unsuitable content.

5. Applications of Artificial Intelligence in Physical Education

5.1 AI-Supported Teaching and Learning

Artificial Intelligence can supplement conventional Physical Education teaching by providing learners with additional opportunities to understand, practise and analyse physical skills. Traditional Physical Education instruction commonly involves teacher demonstration followed by student practice and teacher feedback. AI can potentially extend this process by providing technology-mediated feedback during or after practice.

For example, an AI-supported video-analysis system could record a learner performing a particular movement and analyse aspects of the performance such as body alignment, movement sequence and posture. The learner may then compare the recorded movement with a desired technique and identify areas requiring improvement. This approach can potentially encourage learners to become more reflective and independent in their learning.

AI can also support theoretical aspects of Physical Education. Conversational AI systems can provide explanations of sporting rules, exercise principles, training concepts, nutrition-related educational information and theoretical components of the curriculum. Such systems may provide learners with immediate access to supplementary explanations outside conventional classroom interaction.

Nevertheless, AI-supported instruction should not replace teacher demonstration, supervision or interpersonal interaction. Particularly during practical activities, the teacher remains responsible for ensuring safety, appropriate technique and meaningful participation.

5.2 Personalised Learning in Physical Education

Personalisation is one of the most promising educational applications of Artificial Intelligence. Learners differ considerably in their physical fitness, motor ability, previous sporting experience, motivation, confidence and preferred modes of participation. Consequently, a uniform activity prescribed for an entire class may not always address individual differences effectively.

AI can potentially analyse learner performance and provide differentiated recommendations. A learner who is developing fundamental movement skills may require basic activities and additional practice, whereas a more advanced learner may benefit from increasingly complex activities. AI-supported systems can potentially assist teachers in identifying these differences and designing appropriate learning experiences.

Personalised learning should not, however, be reduced to automated assignment of exercises. The teacher must consider the broader educational context, including learner interests, social relationships, motivation and emotional factors. AI can provide information, but professional judgement remains essential in determining how that information should influence teaching.

5.3 AI-Based Physical Fitness Assessment

Physical fitness assessment is an important component of Physical Education. Traditional fitness assessment generally involves specific tests administered at particular intervals, with teachers recording and interpreting the results. Although such assessment remains valuable, AI and wearable technologies can potentially provide more continuous information about physical activity.

AI systems can analyse information concerning activity levels, exercise intensity, movement frequency, heart-rate patterns, repetitions, running speed and other measurable indicators. When such information is collected over an extended period, it may allow teachers and learners to identify trends rather than relying exclusively on isolated assessment results.

For example, instead of merely recording that a learner completed a particular number of repetitions during a fitness test, an AI-supported system could examine changes in performance over several weeks. This longitudinal perspective may provide teachers with more meaningful information for planning subsequent activities.

However, physical fitness should not be evaluated solely through numerical indicators. Motivation, enjoyment, effort, participation and individual circumstances are also relevant. AI-based measurements should therefore complement rather than replace holistic assessment.

5.4 Computer Vision and Movement Analysis

Computer vision may become one of the most influential applications of Artificial Intelligence in Physical Education. Human movement is complex, and teachers often have to observe several learners simultaneously. Technology-assisted movement analysis may provide an additional means of examining performance.

AI-based video systems can potentially identify body positions, movement trajectories and patterns of coordination. In activities such as running, jumping, throwing, gymnastics and selected team sports, these systems may assist in identifying technical characteristics of movement.

For example, during a basketball shooting activity, computer vision could potentially analyse the coordination of the lower limbs, trunk and upper limbs. During running, it could analyse stride characteristics and body posture. Such information may help learners understand technical aspects of performance that are difficult to identify through ordinary observation.

Nevertheless, AI-generated movement analysis should not be regarded as infallible. Camera position, lighting, occlusion, clothing and variations in individual movement can influence the accuracy of computer-vision systems. Consequently, teacher interpretation remains necessary.

6. Artificial Intelligence and Sports Performance Analysis

The use of data analytics has become increasingly important in competitive sport, and some of its principles can potentially be adapted to educational Physical Education. AI can process large quantities of performance information and identify patterns relating to speed, endurance, workload, movement efficiency, positioning and tactical decisions.

In team sports, AI-supported analytics may potentially examine player positioning, movement patterns and interactions during practice or competition. In athletics, AI may contribute to the analysis of running mechanics, performance progression and training patterns. Such information may help teachers and coaches make more evidence-informed decisions.

However, educational Physical Education should not simply replicate elite sporting environments. Competitive performance is only one dimension of Physical Education. School and higher-education programmes also aim to promote health, enjoyment, participation, social development and lifelong physical activity. Therefore, sports analytics should be applied in ways that support broader educational objectives.

7. Artificial Intelligence for Injury Prevention

Injury prevention represents another potential application of AI in Physical Education and sports training. Physical activity involves varying degrees of physical stress, and inappropriate training loads or incorrect movement patterns may increase the possibility of injury.

AI systems can potentially analyse training load, movement patterns, exercise intensity, fatigue indicators and changes in performance. Patterns associated with increased risk may then be identified, allowing teachers or coaches to consider whether an activity should be modified.

However, injury prediction is highly complex. An AI-generated prediction should not be interpreted as a medical diagnosis or definitive determination of injury risk. Where injury or medical concerns arise, appropriate health professionals should be consulted. AI should function primarily as a decision-support mechanism rather than as a substitute for professional medical assessment.

8. Artificial Intelligence and Student Motivation

Student motivation is central to successful Physical Education. Although some learners are naturally enthusiastic about physical activity, others may experience anxiety, low confidence, lack of interest or fear of comparison with peers. AI-supported systems may contribute to motivation by providing personalised goals, progress feedback and adaptive challenges.

Gamification represents one possible approach. Learners may receive achievement indicators,

progress feedback or individually appropriate challenges. Personalised targets may also help learners perceive improvement in relation to their own previous performance rather than exclusively comparing themselves with classmates.

However, excessive technological monitoring may have unintended consequences. Constant measurement of performance could create pressure, anxiety or unhealthy competition among some learners. Therefore, motivation-oriented AI applications should prioritise enjoyment, self-improvement and healthy participation rather than excessive emphasis on performance metrics.

9. Generative AI for Physical Education Teachers

Generative Artificial Intelligence can provide considerable support for teachers in planning and instructional preparation. A teacher can use generative AI to develop preliminary lesson plans based on learning outcomes, learner age, class size, available facilities and lesson duration. AI can also assist in developing assessment questions, rubrics, worksheets, reflective activities and differentiated learning experiences.

Generative AI may be particularly valuable when teachers need to adapt activities to different ability levels. For example, a teacher may request alternative versions of an activity for beginner, intermediate and advanced learners. AI can also assist in producing theoretical explanations that complement practical activities.

Nevertheless, the teacher must remain the final authority regarding instructional content. AI-generated resources should be reviewed for factual accuracy, curriculum alignment, cultural appropriateness, inclusivity and safety. The role of the teacher therefore changes from simply creating every resource manually to critically evaluating, adapting and contextualising AI-generated materials.

10. Advantages of Artificial Intelligence in Physical Education

The potential advantages of Artificial Intelligence in Physical Education extend across teaching, assessment, learning and performance. AI can support personalised instructional experiences by identifying individual differences among learners. It can facilitate faster analysis of performance data and potentially provide more detailed feedback concerning movement and fitness. Wearable technologies combined with AI can enable more continuous monitoring of physical activity, while computer vision can provide new possibilities for analysing movement technique.

AI can also reduce certain administrative burdens on teachers. Tasks involving data organisation, preliminary analysis, assessment preparation and resource development may be partially supported by AI. This may allow teachers to devote more time to direct interaction with learners, coaching, motivation and pedagogical decision-making.

The greatest educational value of AI, however, lies not in automation itself but in its capacity to provide information that can support better decisions. When appropriately integrated, AI may help teachers understand learner progress more comprehensively and design more responsive learning experiences.

11. Challenges Associated with Artificial Intelligence in Physical Education

Despite its potential benefits, the integration of Artificial Intelligence into Physical Education presents substantial challenges. One of the most significant concerns involves data privacy. Physical Education technologies may collect information about students' physical activity, movement, performance and potentially biometric characteristics. Institutions must therefore establish clear policies governing data collection, storage, access, consent and retention.

Algorithmic bias is another important concern. AI systems learn from data, and if their training data do not adequately represent diverse populations, their outputs may be less accurate for particular groups. Physical Education environments are characterised by considerable diversity in body structure, physical ability, age, gender, cultural background and movement patterns. AI systems must therefore be evaluated for fairness and inclusivity.

Technological inequality may also limit the equitable adoption of AI. Well-resourced institutions may have access to advanced cameras, wearable devices, software and high-speed connectivity, whereas other institutions may lack even basic digital infrastructure. Uncritical adoption of technology could consequently increase existing educational inequalities.

Teacher preparedness represents another major issue. Physical Education teachers require sufficient AI literacy to understand the capabilities and limitations of AI systems. Professional development should therefore focus not only on operating digital tools but also on interpreting AI outputs, recognising potential errors, understanding data privacy and making ethically responsible decisions.

There is also a risk of overdependence on technology. Physical Education is fundamentally concerned with physical participation and human interaction. If learners spend excessive time interacting with screens or devices, the technology intended to promote physical activity could paradoxically reduce active engagement. A balanced approach is therefore essential.

Finally, AI systems are not always accurate. Errors may occur because of inadequate training data, environmental conditions, technical limitations or unusual movement patterns. Consequently, AI-generated assessments should be regarded as evidence to be interpreted rather than unquestionable conclusions.

12. Ethical Considerations

Ethical considerations should occupy a central position in discussions concerning AI in Physical Education. Learners should understand what data are being collected, why they are being collected and how those data will be used. Institutions should ensure appropriate consent and establish mechanisms for protecting student information.

The principle of data minimisation is particularly relevant. Institutions should collect only information that is genuinely necessary for clearly defined educational purposes. The use of student data for unrelated purposes should be avoided.

Transparency is equally important. Teachers and learners should be able to understand, at an appropriate level, how an AI system reaches or generates its recommendations. When AI contributes to assessment, students should not be subjected to opaque automated decisions

without meaningful human review.

Human oversight is therefore essential. Teachers should retain responsibility for important educational decisions, particularly those concerning student participation, assessment, safety and well-being. AI should function as a supportive technology within a human-centred educational framework.

13. The Changing Role of the Physical Education Teacher

The emergence of AI does not eliminate the need for Physical Education teachers. Instead, it has the potential to redefine aspects of their professional role. Traditionally, teachers have been responsible for demonstrating skills, organising activities, observing performance and providing feedback. In an AI-supported environment, teachers may increasingly become facilitators who interpret data, design learning experiences, evaluate AI-generated information and provide personalised guidance.

The human element remains particularly important because AI cannot fully understand the social and emotional dimensions of learning. A teacher can recognise that a learner is anxious, discouraged, socially isolated or lacking confidence. Such contextual understanding cannot necessarily be derived from movement data or fitness scores.

Consequently, the future Physical Education teacher is likely to require a combination of pedagogical expertise, physical-activity knowledge and AI literacy. The teacher's professional judgement will remain central even as technology increasingly supports data collection and analysis.

14. A Human-Centred Framework for AI Integration in Physical Education

A human-centred framework can provide a useful conceptual foundation for integrating Artificial Intelligence into Physical Education. The process should begin with pedagogy, meaning that the intended learning outcome should determine whether AI is appropriate. Technology should not be introduced merely because it is available.

The second dimension is data. Once an educational purpose has been established, only relevant and necessary data should be collected. Appropriate privacy, consent and security measures must accompany this process.

The third dimension is AI-based analysis. Artificial Intelligence can process the collected information and identify patterns, generate feedback or produce recommendations. These outputs should then move to the fourth dimension, which is human interpretation.

Teachers should interpret AI-generated information in relation to the learner's broader educational context. Finally, the fifth dimension is pedagogical action, in which teachers and learners use the interpreted information to modify practice, instruction or learning activities.

The conceptual process can therefore be expressed as:

Pedagogical Purpose → Data Collection → AI Analysis → Teacher Interpretation → Pedagogical Action → Improved Learning

This model emphasises that technology is positioned within the educational process rather than placed at its centre. The ultimate purpose remains learner development.

15. Implications for Physical Education Teacher Education

The growing influence of Artificial Intelligence has important implications for Physical Education teacher education programmes. Future teachers should acquire a foundational understanding of AI and its applications in education and sport. They should also develop the ability to interpret fitness data, understand wearable technologies, critically evaluate AI-generated information and recognise the limitations of automated assessment.

AI literacy should include an understanding of data privacy, algorithmic bias, ethical decision-making and responsible use of generative AI. Prospective teachers do not necessarily need advanced programming skills; rather, they need sufficient technological and critical literacy to determine when AI is educationally appropriate and how its outputs should be interpreted.

Teacher education institutions can therefore integrate AI-related activities into methodology courses, assessment courses and practical teaching experiences. Such preparation can ensure that future Physical Education teachers are not merely consumers of AI technologies but informed professionals capable of using them responsibly.

16. Future Directions

The future integration of Artificial Intelligence into Physical Education is likely to involve increasingly sophisticated combinations of computer vision, wearable technologies, machine learning and generative AI. Real-time movement analysis may become more accessible, allowing learners to receive immediate feedback during skill practice. Intelligent wearable systems may provide more comprehensive information concerning physical activity and training patterns.

AI may also contribute to more inclusive Physical Education by helping teachers adapt activities to individual capabilities and learning requirements. Generative AI may support the development of differentiated instructional materials, while predictive analytics may assist teachers and coaches in understanding performance trends.

Nevertheless, future research should move beyond simply demonstrating that AI can be used in Physical Education. Researchers should investigate whether and under what conditions AI actually improves learning, motivation, participation and physical development. Empirical research should examine the validity and reliability of AI-based assessment, teacher acceptance, student perceptions, ethical implications, accessibility and long-term educational outcomes.

There is also a need for research conducted in diverse educational contexts. Much of the technological development in AI and sport occurs within well-resourced environments. Research in schools, colleges and teacher education institutions with varying levels of infrastructure is necessary to determine how AI can be implemented equitably.

17. Conclusion

Artificial Intelligence presents significant opportunities for the development of Physical Education. Through machine learning, computer vision, wearable technologies, predictive

analytics and generative AI, technology can potentially support personalised learning, fitness assessment, movement analysis, sports performance and instructional planning.

At the same time, AI should not be viewed as a technological solution to every challenge in Physical Education. The discipline is fundamentally concerned with human development through physical activity. Motivation, enjoyment, social interaction, confidence, cooperation, discipline and teacher-student relationships cannot be adequately represented through numerical data alone.

The appropriate future is therefore not one in which Artificial Intelligence replaces the Physical Education teacher but one in which AI augments the professional capabilities of the teacher. AI can perform computationally intensive tasks, identify patterns and provide information, while teachers provide interpretation, empathy, motivation, contextual understanding and pedagogical leadership.

The successful integration of AI will ultimately depend on the quality of the relationship between technology and pedagogy. When implemented responsibly, ethically and inclusively, Artificial Intelligence can become a valuable instrument for strengthening Physical Education. The central objective should remain unchanged: using available knowledge, technology and human expertise to help learners become physically literate, healthy, confident and lifelong participants in physical activity.

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ARTIFICIAL INTELLIGENCE AND FUTURE EDUCATION

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Abstract

Artificial Intelligence (AI) is emerging as a transformative force in education, reshaping the ways in which teaching, learning, assessment and educational management are conceived and implemented. The integration of AI into educational systems has the potential to move beyond traditional, teacher-centred approaches towards more personalized, adaptive, inclusive and technology-enabled learning environments. AI-powered tools can support educators in designing customized learning materials, analysing student performance, identifying learning gaps, automating routine assessment tasks and providing timely and individualized feedback. At the same time, intelligent tutoring systems, adaptive learning platforms, virtual assistants, generative AI and other emerging technologies are creating new possibilities for enhancing student engagement, creativity, critical thinking and lifelong learning.

The future of education is likely to be increasingly characterized by human–AI collaboration, where technology complements rather than replaces the role of teachers. AI can assist educators in making data-informed decisions and developing learner-centred instructional strategies, while teachers continue to provide the human elements of education, including mentorship, emotional support, ethical guidance, creativity and social interaction. AI also offers significant opportunities for inclusive and equitable education through speech recognition, language translation, assistive technologies and personalized learning support for learners with diverse educational needs.

This paper explores the transformative role of Artificial Intelligence in shaping the future of education, with particular emphasis on emerging opportunities, pedagogical innovations, challenges and future implications. It argues for a balanced approach that combines technological advancement with human values, ethical principles, institutional preparedness and teacher empowerment. The study highlights the need for appropriate policies, digital infrastructure, AI literacy and strong institutional support to ensure that Artificial Intelligence contributes to innovative, inclusive, sustainable and future-ready education systems.

Keywords: Artificial Intelligence, Future and Education.

INTRODUCTION:

The rapid advancement of Artificial Intelligence (AI) is transforming almost every sector of society and education is emerging as one of the most significantly influenced domains. AI has evolved from a technological innovation into a powerful instrument capable of reshaping the way knowledge is created, delivered, accessed, assessed and applied. The emergence of intelligent tutoring systems, adaptive learning platforms, generative AI, automated assessment, learning analytics and AI-powered educational applications is challenging conventional approaches to teaching and learning and creating new possibilities for future education.

The emergence of generative AI has further expanded the possibilities for future education. AI-enabled systems can provide students with individualized explanations, learning resources, practice activities, feedback and opportunities for collaborative and self-directed learning. For educators, AI can function as a supportive tool for developing instructional materials, designing assessments, analysing learning outcomes and addressing diverse learner requirements. Thus, the future educational landscape is likely to involve increasing collaboration between human intelligence and artificial intelligence rather than the replacement of educators by technology.

The theme **"Artificial Intelligence and Future Education"** therefore provides an important platform for examining the transformative relationship between AI and education. The present paper aims to explore the emerging applications of Artificial Intelligence in teaching and learning, examine its potential to reshape educational practices and identify the opportunities and challenges associated with its integration. It also seeks to highlight the changing roles of teachers and learners and the importance of developing AI-enabled educational environments that remain human-centred, inclusive, ethical and equitable.

Through scholarly discussion and exchange of ideas, the study seeks to contribute to a deeper understanding of how Artificial Intelligence can support innovative and future-ready education while preserving human values and educational principles. The effective integration of AI will ultimately depend not only on technological advancement but also on appropriate policies, digital infrastructure, teacher preparedness, institutional support, ethical frameworks, and a commitment to ensuring quality education for all.

SIGNIFICANCE OF THE STUDY:

The rapid development of Artificial Intelligence (AI) is bringing significant changes to the educational landscape and creating new possibilities for the future of teaching and learning. The integration of AI into education is no longer limited to technological experimentation; it is increasingly becoming an important component of educational planning, pedagogy, assessment and institutional development. In this context, studying the significance of Artificial Intelligence for future education is essential for understanding how emerging technologies can contribute to quality, equitable, personalized and sustainable learning.

The study is also significant in understanding the changing role of teacher's in future educational environments. The increasing use of AI does not necessarily imply the replacement of teachers. Instead, it encourages a shift towards meaningful human–AI collaboration. Understanding this changing professional role is important for developing appropriate teacher education and continuous professional development programs that prepare educators to use AI confidently, critically, and responsibly. Another important significance of the study lies in examining the ethical and social dimensions of AI in education. Concerns related to data privacy, cybersecurity, algorithmic bias, academic integrity, misinformation, intellectual property, digital dependency, and unequal access to technology require careful consideration.

Finally, the study is significant in preparing learners for an increasingly AI-driven world. Future education must equip students not only with subject knowledge but also with digital competence, AI literacy, creativity, problem-solving ability, critical thinking, adaptability, collaboration, and ethical awareness. Thus, the study provides a meaningful foundation for researchers, educators, policymakers, institutions, and learners to understand and responsibly shape the future of education in the age of Artificial Intelligence.

ISSUES AND CHALLENGES OF AI IN THE FUTURE EDUCATION SYSTEM:

Artificial Intelligence (AI) is transforming future education, but it also brings several issues and challenges that need careful attention. Here are the major ones explained clearly:

1. ***Lack of Human Interaction:*** Education is not just about information- it includes emotions, motivation, and values; Overuse of AI may reduce teacher-student bonding in turn students may miss emotional support and guidance.
2. ***Bias in AI Systems:*** AI tools depend on the data they are trained on - If data is biased, AI can give unfair or discriminatory outcomes, which may affect grading, recommendations, or opportunities.
3. ***Data Privacy and Security:*** AI systems collect large amounts of student data (performance, behaviour, personal details); Risk of data breaches or misuse which concerns about student privacy protection.
4. ***High Cost and Infrastructure:*** Implementing AI requires: Advanced technology; Internet access; Maintenance costs many schools (especially in rural areas) may not afford it.
5. ***Ethical Concerns:*** Who is responsible for AI decisions; is it fair to let AI grade students? Issues of accountability and transparency.
6. ***Digital Divide:*** Not all students have equal access to devices or internet which creates inequality between urban and rural learners, some students may be left behind.
7. ***Job Displacement Fears:*** Some worry AI may replace teachers, fear of job loss or reduced roles; However, AI is more likely to assist rather than replace teachers.
8. ***Accuracy and Reliability:*** AI is not always perfect which can give wrong or misleading information; in turn students may trust incorrect outputs blindly.

9. ***Teacher Training and Adaptation:*** Teachers need new skills to use AI effectively, lack of proper training can lead to ineffective use of AI tools, resistance to change among educators.
10. ***Overdependence on Technology:*** Students may rely too much on AI tools, reduced critical thinking and problem-solving skills; leads to less independent learning.

While AI offers many benefits, these challenges must be addressed through: Strong policies; Teacher training; Ethical use of technology; Equal access for all students. The goal should be to use AI as a support tool, not a replacement for human education.

ROLE OF ARTIFICIAL INTELLIGENCE IN FUTURE EDUCATION SYSTEM:

Artificial Intelligence (AI) can assist in teaching and learning process in many ways by saving time, improving teaching quality and supporting students more effectively.

Here are some key ways:

1. ***Automating Routine Tasks:*** AI can handle repetitive work like: Grading objective tests (MCQs, quizzes)**;** checking assignments for grammar and plagiarism; which gives teachers more time to focus on teaching and interacting with students.
2. ***Personalized Learning:*** AI helps create customized learning experiences by: Adapting lessons based on each student's level; suggesting extra practice for weak areas, which ensures every student, learns at their own pace.
3. ***Student Performance Analysis:*** AI tools can: Track student progress; identify learning gaps; Predict which students may need extra help, so that teachers can provide targeted support.
4. ***Virtual Teaching Assistants:*** AI-powered chatbots can: Answer students' common questions; Provide 24/7 support outside classroom hours, which improves student engagement.
5. ***Smart Content Creation:*** AI can help teachers to generate lesson plan; create question papers and worksheets; provide summaries of complex topics, which reduces preparation time.
6. ***Administrative Support:*** AI helps with: attendance tracking; scheduling; managing records and reports, which reduces paperwork.
7. ***Language Translation and Accessibility:*** AI tools can translate content into different languages; convert text to speech for better accessibility; which helps diverse learners.
8. ***Improving Classroom Engagement:*** AI can make classes more interactive by using quizzes, games and simulations; supporting multimedia teaching methods.

INSTITUTIONAL SUPPORT FOR AI INTEGRATION IN FUTURE EDUCATION:

For AI to be successfully implemented in future education, institutions (schools, colleges, universities, and governments) must provide strong support in multiple areas.

1. ***Infrastructure Development:*** Proper digital infrastructure is essential: High-speed internet; Smart classrooms; Access to AI tools and platforms, without infrastructure, AI integration cannot be effective.

2. ***Teacher Training and Professional Development:*** Teachers must be trained to: Use AI tools effectively; Integrate AI in teaching methods, workshops & training programs are necessary.
3. ***Policy and Strategic Planning:*** Institutions should develop clear AI policies and frameworks. Guidelines must include: Ethical use of AI; Data privacy and security, a long-term vision ensures systematic implementation.
4. ***Curriculum Integration:*** AI should be included in the curriculum: Basic AI literacy for all students; Advanced AI topics for higher education, helps students become future-ready.
5. ***Collaboration and Partnerships:*** Collaboration with: technology companies; research organizations; Ed Tech platforms, helps in accessing latest innovations and expertise.
6. ***Monitoring and Evaluation:*** Continuous evaluation of AI implementation: measure student performance; Assess effectiveness of AI tools, ensures improvement and accountability.
7. ***Funding and Investment:*** Institutions need financial support for: Purchasing AI tools; Training programs; Research and development, Government and private sector funding plays a key role.
8. ***Inclusivity and Accessibility:*** AI tools should be accessible to all students: Rural and urban learners; Students with disabilities; Promotes equity in education.
9. ***Data Protection and Privacy:*** Strong policies for: student data protection; secure storage and usage, prevents misuse of sensitive information.
10. ***Ethical and Responsible Use:*** Institutions must ensure: Fairness (no bias in AI systems); Transparency; Responsible usage by students and teachers, builds trust in AI systems.

Strong institutional support ensures that AI in future education is: effective, ethical and Inclusive, without proper planning, training, and infrastructure, AI cannot achieve its full potential in transforming education.

AI-DRIVEN TOOLS IN FUTURE EDUCATION:

AI-driven tools are software applications or systems that use Artificial Intelligence techniques (such as machine learning, natural language processing, and data analysis) to automate, enhance and personalize future teaching and learning processes. AI-driven tools are applications that use AI technology to support, improve and personalize education by analysing data and providing intelligent solutions. AI-driven tools are software or applications that use Artificial Intelligence in future education to improve teaching and learning processes.

1. ***Chabot's & Virtual Assistants:*** Answer student queries instantly; Available 24/7 for doubt clearing; Help in administrative tasks like schedules and reminders. Example: AI chatbots used in school portals.
2. ***Automated Grading Tools:*** Automatically check: assignments; quizzes; objective tests in turn saves teachers' time and ensures quick results.
3. ***Intelligent Tutoring Systems:*** Provide personalized teaching to students; Adapt lessons based on student performance. Give instant explanations and feedback. Example: AI tutors that help to solve maths problems step-by-step.
4. ***Content Creation Tools:*** Generate notes; summaries; question papers, which help both students and teachers save time.

5. ***Gamified Learning Platforms:*** Use AI to create: educational games; interactive quizzes, which makes learning fun and engaging.
6. ***Language Learning Tools:*** Improve: speaking; pronunciation and grammar, provide real-time corrections.
7. ***Learning Analytics Platforms:*** Analyse student data to track progress; identify weak areas, which help teachers make better decisions.
8. ***Assistive AI Tools (Inclusive Education):*** Help students with disabilities: Text-to-speech; Speech-to-text; AI translators, which ensure equal access to learning.
9. ***Adaptive Learning Platforms:*** Adjust difficulty level automatically which provide customized learning paths for each student.
10. ***AR/VR-Based Learning Tools:*** Combine AI with virtual reality and augmented reality, which provide real-life simulations for better understanding.

AI-driven tools are transforming future education system by making it: Personalized Efficient and Interactive. They support both students and teachers, but must be used responsibly for best results.

FUTURE IMPLICATIONS OF AI IN EDUCATIONAL DEVELOPMENT:

Artificial Intelligence improves educational quality by making learning **personalized, efficient, inclusive and interactive in future**. It not only supports students in better understanding concepts but also helps teachers deliver more effective education.

However, the successful adoption of AI in future education cannot depend solely on technological advancement. Issues related to data privacy, algorithmic bias, ethical use of AI, digital inequality, cyber security, academic integrity and the changing role of teachers require careful consideration. AI should therefore be viewed as a tool that complements human intelligence rather than replaces teachers. Human interaction, creativity, critical thinking, empathy, communication and social-emotional development will remain essential components of meaningful education.

1. ***Intelligent Tutoring System:*** AI-powered tutors provide 24/7 guidance. Students can learn anytime without waiting for teachers provide instant explanations improve understanding.
2. ***Automated Assessment and Feedback:*** AI can quickly evaluate assignments and tests provide; instant feedback reduces teachers' workload, which helps students' correct mistakes faster.
3. ***Individualized Learning:*** AI adapts lessons based on each student's learning speed and ability. Students get customized content and practice questions, which helps both slow learners and advanced learners.
4. ***Data-Driven Insights:*** AI analyses student performance data. Identifies weak areas; Helps teachers provide targeted support, which improves overall academic outcomes.
5. ***Accessibility and Inclusion:*** AI supports students with different needs. Speech-to-text and text-to-speech tools; Helps students with disabilities, which breaks language barriers.
6. ***Enhanced Teaching Methods:*** Teachers can use AI tools to improve their teaching strategies. Smart lesson planning; Use of simulations, visuals and interactive content, which makes better classroom engagement.
7. ***Time Efficiency:*** Automates administrative tasks like attendance, grading, scheduling, so that teachers get more time to focus on teaching.

8. ***Virtual Learning and Smart Classrooms:*** AI enables modern digital learning environment. Virtual classrooms; Chabot's for student queries gives Interactive and engaging learning experience.

CONCLUSION:

Artificial Intelligence is emerging as a transformative force in the future of education, with the potential to reshape teaching, learning, assessment and educational administration. The integration of AI-based technologies can facilitate personalized learning, provide intelligent and timely feedback, support educators in routine academic tasks and enable data-driven decision-making. By adapting learning content to individual learners' needs, abilities, and progress, AI can contribute to more flexible, inclusive and learner-centered educational environments.

The future education system is likely to be characterized by a collaborative model in which **teachers, learners and AI systems work together**. To realize this vision, educational institutions and policymakers must develop appropriate ethical frameworks, strengthen digital infrastructure, provide continuous professional development for teachers, and ensure equitable access to AI-enabled learning opportunities. Furthermore, future research should examine the long-term educational, social and psychological impacts of AI across diverse learning contexts.

In conclusion, Artificial Intelligence has the potential to make education more personalized, accessible, efficient and responsive to the needs of future generations. Nevertheless, the goal should not be to create an education system that is simply more automated, but one that is **more human-centered, equitable, ethical and effective**. The future of education will depend not on how extensively AI replaces existing practices, but on how responsibly and intelligently it is integrated with human expertise to enhance the overall quality of learning.

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RETHINKING ASSESSMENT IN THE AGE OF GENERATIVE AI: FROM PRODUCT-BASED EVALUATION TO PROCESS-ORIENTED LEARNING

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Abstract

The rapid emergence of generative artificial intelligence (GenAI) is challenging conventional approaches to assessment in education. For decades, educational assessment has relied substantially on written assignments, essays, reports, presentations, examinations, and other products intended to demonstrate students' knowledge and skills. The widespread availability of generative AI tools capable of producing sophisticated text, solving problems, generating presentations, translating content, writing code, and providing feedback has complicated the relationship between student performance and the products submitted for assessment. This development raises fundamental questions concerning academic integrity, validity, authorship, originality, learning outcomes, and the role of teachers. This review paper examines how generative AI necessitates a shift from predominantly product-oriented assessment towards process-oriented, authentic, dialogic, and AI-aware assessment. An integrative review of recent literature, international educational frameworks, and emerging research on GenAI in higher education was undertaken. The review indicates that GenAI can support learning through personalized feedback, explanation, brainstorming, revision, and formative assessment; however, uncritical use may encourage cognitive dependency, reduce opportunities for independent reasoning, and make conventional take-home assignments less reliable indicators of individual learning. The paper argues that the appropriate educational response is not simply to prohibit AI or attempt to detect its use, but to redesign assessment so that students demonstrate the processes through which learning occurs. A conceptual framework for AI-era assessment is proposed, comprising authentic tasks, process documentation, critical engagement with AI, oral defence, reflection, iterative feedback, and human judgement. The paper concludes that assessment in the AI era should move from evaluating only the final product to evaluating the learner's thinking, decision-making, application, reflection, and responsible interaction with AI.

Keywords: *generative artificial intelligence, assessment, artificial intelligence in education, authentic assessment, process-oriented assessment, academic integrity, higher education, AI literacy*

Introduction

Assessment is one of the central components of the educational process. It provides evidence of students' learning, informs instructional decisions, communicates achievement, and contributes to certification and progression. Conventional assessment systems have generally

been designed on the assumption that the submitted product represents the learner's individual knowledge, understanding, reasoning, and ability.

The emergence of generative artificial intelligence (GenAI) challenges this assumption. Contemporary GenAI systems can generate essays, reports, summaries, presentations, computer programs, images, lesson plans, mathematical explanations, and other forms of academic output. Since the public emergence of ChatGPT in late 2022, higher education institutions across the world have therefore been reconsidering assessment practices.

Recent systematic reviews demonstrate the rapid expansion of research on GenAI in higher education. Qian (2025), for example, reviewed pedagogical applications of GenAI in higher education and identified a rapidly developing field encompassing teaching, learning, assessment, feedback, and student support. A broader systematic review of 103 empirical studies published through 2025 similarly found that GenAI was being used across learning support, communication, assessment and feedback, pedagogical design, analytics, programming, and professional education. Importantly, the review concluded that educational benefits depend substantially on the surrounding pedagogy, assessment design, and verification practices rather than on the technology alone.

The emergence of GenAI consequently presents not simply a technological problem but an assessment problem.

If an assignment can be generated substantially by AI, can the submitted product still provide valid evidence of the student's learning? If AI can provide feedback, should students be prohibited from using it, or should they be taught to use it critically? If AI detection systems are imperfect, should institutions rely on them to determine academic misconduct?

These questions suggest that education needs to rethink the underlying philosophy of assessment.

The central argument of this review is that the AI era requires a movement from product-oriented assessment towards process-oriented, authentic, reflective, and AI-aware assessment.

Objectives of the Review

The review was guided by the following objectives:

1. To examine the impact of generative AI on conventional educational assessment.
2. To identify opportunities and challenges associated with AI-supported assessment.
3. To examine the limitations of traditional product-oriented assessment in the AI era.
4. To explore emerging approaches to process-oriented and authentic assessment.
5. To propose a conceptual framework for assessment in AI-enabled education.

Methodology

This paper adopts an integrative narrative review approach. Recent scholarly literature on generative AI, higher education, teaching and learning, assessment, academic integrity, and educational technology was examined alongside international frameworks and policy-oriented literature.

Particular attention was given to systematic reviews and empirical literature published after

the emergence of widely accessible GenAI systems. The literature was thematically synthesized under five areas: GenAI and assessment, opportunities, challenges, assessment redesign, and AI-era assessment competencies.

The review does not constitute a statistical meta-analysis. Its purpose is conceptual synthesis and the development of a framework that can inform assessment practice and future empirical research.

Generative AI and the Changing Nature of Assessment

Traditional assessment has frequently focused on the final product. A student submits an essay, project report, assignment, presentation, or solution, and the teacher evaluates the quality of that product.

GenAI complicates this model because the relationship between the learner and the final product can no longer be assumed.

For example, a student may:

- independently generate an essay;
- use AI to brainstorm ideas;
- use AI to improve grammar;
- ask AI to generate an initial draft;
- substantially rewrite AI-generated content;
- ask AI to analyse data;
- use AI to solve a problem and reproduce the solution; or
- submit largely AI-generated work.

These different forms of AI engagement may produce superficially similar final products but represent substantially different learning processes.

Consequently, the final product alone may provide insufficient evidence of learning.

This is one of the most important implications of generative AI for assessment.

Opportunities Presented by Generative AI

The emergence of GenAI should not be interpreted exclusively as a threat. When appropriately integrated, AI can enhance formative assessment and learning.

Personalized Feedback: AI can provide rapid feedback on writing, explanations, structure, language, and problem-solving. Students can use such feedback iteratively rather than waiting for teacher comments.

Formative Assessment: Teachers can use AI to generate questions, quizzes, scenarios, examples, and differentiated learning activities. AI can therefore support continuous assessment.

Adaptive Learning: GenAI can provide alternative explanations based on learners' needs. A student who does not understand a concept can request another explanation, example, analogy, or level of difficulty.

Assessment Accessibility: AI-enabled translation, speech recognition, text generation, and alternative representations may support learners with diverse linguistic and accessibility

needs.

Development of Higher-Order Thinking: GenAI can potentially support higher-order thinking when students are required to critique, verify, compare, improve, or challenge AI-generated outputs.

Recent meta-analytic evidence indicates that GenAI can produce positive effects on university students' learning outcomes, including academic achievement and higher-order thinking, although effects vary according to contextual and methodological factors.

Challenges to Conventional Assessment

Academic Integrity: One of the most immediate concerns is unauthorized AI-assisted academic work.

The availability of GenAI makes it increasingly difficult to distinguish between a student's independent work and AI-generated content solely from the final submission.

However, attempting to solve this problem exclusively through prohibition or surveillance may be inadequate.

Validity of Assessment: Assessment validity concerns whether an assessment actually measures what it claims to measure. If a writing assignment is intended to assess students' ability to construct arguments, but AI generates much of the argument, the assessment may no longer measure the intended competency. The problem is therefore not simply cheating; it is potentially a problem of construct validity.

Reliability of AI Detection: AI-detection systems have attracted considerable attention, but their reliability and fairness remain contested. False positives can create serious consequences when students are incorrectly suspected of using AI. Therefore, AI detection should not become the sole basis for high-stakes academic decisions.

Cognitive Dependency: Excessive reliance on AI may reduce opportunities for students to practise independent writing, problem-solving, reasoning, and knowledge construction. If students consistently outsource difficult cognitive tasks, they may complete assignments successfully without developing the underlying competencies.

Loss of Metacognition: Learning involves not only producing answers but also understanding how one arrived at those answers. If AI performs much of the cognitive process, students may have fewer opportunities to monitor, evaluate, and regulate their own thinking.

This is particularly important because recent evidence suggests that the effects of GenAI on learning are not uniformly positive. A 2025 meta-analysis reported positive effects on several learning outcomes but found no statistically significant effect on metacognition.

From Product-Oriented to Process-Oriented Assessment

Process-oriented assessment evaluates how learning develops rather than focusing exclusively on the final outcome.

A process-oriented assessment may require students to submit:

1. initial ideas;

2. research questions;
3. source-selection decisions;
4. drafts;
5. AI interactions where permitted;
6. revisions;
7. feedback received;
8. reflection on changes; and
9. final conclusions.

This approach creates an **audit trail of learning**.

The teacher can therefore evaluate not merely *what* the student produced but *how* the student developed it.

Process-oriented assessment is especially appropriate for research projects, case studies, portfolios, business plans, laboratory investigations, lesson planning, design projects, and dissertations.

Authentic Assessment in the AI Era

Authentic assessment requires students to perform meaningful tasks resembling real-world professional practice.

This approach becomes particularly important because AI is already part of professional environments.

For example, commerce students may be asked to analyse a business case using AI as an optional analytical assistant and then critically evaluate the AI's recommendations.

Management students could develop a strategic plan and identify situations where AI-generated recommendations should be accepted, modified, or rejected.

Teacher education students could develop an AI-supported lesson plan and justify their decisions concerning AI use, student privacy, assessment, and pedagogical appropriateness.

Such assessment reflects the realities of contemporary professional practice.

The goal is therefore not necessarily to assess whether students can work **without AI**, but whether they can work **responsibly and competently with AI**.

AI Literacy as an Assessment Outcome

AI literacy should itself become an educational outcome.

Students should demonstrate their ability to:

Recognize AI systems and their applications.

Understand how AI systems operate at an appropriate level.

Use AI tools effectively.

Evaluate AI-generated information.

Create with AI where appropriate.

Navigate AI ethically and responsibly.

These dimensions are consistent with contemporary conceptualizations of AI literacy.

Assessment can therefore directly measure AI competence rather than treating AI use as

something external to the curriculum.

The Role of the Teacher

The role of the teacher also changes.

In conventional assessment, the teacher primarily acts as:

Designer → Examiner → Evaluator

In an AI-enabled assessment environment, the role becomes:

Designer → Facilitator → Critical Evaluator → Mentor → Verifier

The teacher must design assessments that require genuine intellectual engagement and determine whether AI use enhances or undermines learning.

UNESCO's AI Competency Framework for Teachers emphasizes human-centredness, ethics, AI foundations and applications, AI pedagogy, and AI for professional learning. It also organizes teacher competencies through the progression levels **Acquire, Deepen, and Create**.

This framework has important implications for assessment because teachers themselves need sufficient AI competence to design, implement, and evaluate AI-aware learning tasks.

A Proposed Framework for AI-Era Assessment

Based on the literature reviewed, this paper proposes an **AI-Era Process-Oriented Assessment Framework** comprising seven interconnected elements.

1. Authentic Task

Assessment should involve meaningful problems rather than tasks that can easily be completed through generic AI generation.

2. Learning Process

Students should document important stages of their work, including planning, research, drafting, testing, revision, and reflection.

3. Responsible AI Engagement

Where AI use is permitted, students should explicitly disclose how AI was used and explain its contribution.

4. Critical Verification

Students should evaluate AI-generated information for accuracy, relevance, bias, completeness, and credibility.

5. Human Judgement

Assessment should require students to make decisions that cannot simply be delegated to AI.

6. Oral or Interactive Defence

Short oral examinations, presentations, viva voce, demonstrations, or teacher–student discussions can provide additional evidence that students understand their submitted work.

7. Reflection

Students should explain what they learned, what they changed, what AI contributed, where AI failed, and what decisions they made independently.

The framework can be represented as:

Authentic Problem
↓
Independent Thinking + AI Interaction
↓
Critical Evaluation and Verification
↓
Revision and Human Judgement
↓
Final Product
↓
Oral Defence + Reflection

This model does not eliminate traditional assessment. Instead, it repositions the final product within a broader evidence base.

Rethinking Assessment Practices

Several practical changes can be implemented.

a) **From Essays to Evidence-Based Inquiry:** Instead of simply asking students to write essays, teachers can require them to formulate questions, analyse evidence, critique AI outputs, and defend conclusions.
b) **From One-Time Assignments to Iterative Assessment:** Students can submit multiple stages of work rather than a single final product.
c) **From Recall to Application:** Assessment should increasingly require students to apply concepts to unfamiliar and authentic situations.
d) **From Answer Production to Reasoning:** Students should explain **why** they selected a particular answer or strategy.
e) **From AI Prohibition to AI Transparency:** Institutions should establish clear rules distinguishing acceptable, restricted, and prohibited AI use.
f) **From Surveillance to Pedagogy:** Rather than depending primarily on AI-detection software, assessment design should make meaningful learning visible.

Implications for Higher Education

The transformation of assessment requires institutional change.

a) Universities should develop clear AI assessment policies that define acceptable uses of AI across disciplines.
b) Faculty development is equally important. Teachers need professional learning concerning prompt design, AI limitations, assessment validity, academic integrity, data privacy, and AI-supported pedagogy.
c) Assessment regulations should also recognize disciplinary differences. AI use appropriate for computer science or business analytics may differ from AI use in language learning, teacher education, or professional ethics.

d) Recent systematic reviews indicate that GenAI implementation in higher education remains uneven and that innovative applications and evidence-based implementation are still developing.
e) Institutions should consequently avoid adopting one universal AI policy for all assessment contexts.

Implications for Teacher Education

Teacher education institutions have a particularly important responsibility because future teachers will design assessment for the next generation of learners.

Student teachers should therefore learn to:

- design AI-resistant and AI-inclusive assessments;
- distinguish learning objectives from assessment products;
- evaluate AI-generated information;
- develop authentic assessment tasks;
- use formative AI feedback responsibly;
- identify appropriate levels of AI assistance;
- protect learner data;
- promote academic integrity; and
- assess AI literacy itself.

Teacher education curricula should consequently include AI-aware assessment design as a component of professional competence.

Future Research Directions

The review identifies several priorities for future research.

a) First, empirical studies are required to compare product-oriented and process-oriented assessment in terms of validity, reliability, learning outcomes, and student engagement.
b) Second, research should examine the effects of AI-supported assessment on critical thinking, creativity, metacognition, self-regulated learning, and academic motivation.
c) Third, researchers should develop reliable instruments for measuring AI literacy and AI competence among students and teachers.
d) Fourth, longitudinal studies are needed to determine whether regular AI use strengthens or weakens students' independent cognitive abilities.
e) Fifth, research should investigate assessment models appropriate for different disciplines and educational levels.
f) Finally, greater attention should be given to developing institutional AI assessment policies based on pedagogy rather than technology alone.

Conclusion

Generative artificial intelligence is forcing education to reconsider one of its most fundamental assumptions: that the final product submitted by a learner necessarily represents the learner's own knowledge and intellectual work.

The appropriate response is unlikely to be either unrestricted AI use or complete prohibition. Both approaches fail to address the deeper educational issue.

The more fundamental response is to redesign assessment.

Assessment in the AI era should increasingly value authentic problem-solving, critical thinking, evidence evaluation, reflection, communication, human judgement, and responsible interaction with AI. The final product should remain important, but it should become one component of a broader body of evidence demonstrating learning.

The proposed process-oriented model—Authentic Task → Learning Process → AI Engagement → Critical Verification → Human Judgement → Final Product → Oral Defence and Reflection—provides one possible pathway for achieving this transformation.

The central educational principle is therefore:

When artificial intelligence can increasingly produce answers, education must place greater emphasis on the learner's ability to question, evaluate, justify, apply, create, and reflect.

The future of assessment should not be about determining whether students can avoid AI. It should be about determining whether students can think effectively in a world where AI is available.

In this sense, generative AI should be regarded not merely as a threat to assessment, but as an opportunity to move education towards more authentic, process-oriented, competency-based, and human-centred assessment.

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USE OF ARTIFICIAL INTELLIGENCE AND AUTOMATED ADAPTIVE LEARNING IN EDUCATION

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Artificial intelligence as become an integral part of everyday learning at everywhere, by making learning more active, and also interactive, personalized and deeply engaging, AI based learning empowered the very base of learning activities in helping learners to build knowledge and digital skills through modern education technology which supports various learning needs, not only educational institutes are so eager to promote AI powered learning, but also different communities, government initiatives and non-governmental agencies are all combined together to work collectively in the direction of improving quality of education through digitalization,

When AI first gained its importance, then it was the time to greet with a mixture of excitement and uneasiness. information spread and swing between bold promises of personalized learning experience of every student and the motivator role of instructor. on the other hand, there was a cautious warning that machine would replace teachers or it will undermine education altogether, but for parents, teachers and learners it felt as something foundational and assured the ways and means of rapid changing, without being aware of where it might lead. Today it has become inseparable part of modern society. turned into actual need of the hour and a common source of means of communication in the process of building societies and imparting knowledge.

After few years on the popularity of AI becoming more familiar, then AI is no longer a distance future or a passing trend: it is already woven into everyday learning from language practice app to tools that can help teachers plan their lessons, teaching more effectively and get back the responses of feedback, it suddenly transformed the very basic nature of teaching and learning activities, now the real challenge is not whether to use AI, but how to make use it responsibly and so fairly in the ways that genuinely improve learning tasks for everyone, who are deeply engaged in learning process.

A CHANGE THAT AI BRINGS INTO THE FIELD OF EDUCATION:

Education has always adopted to new tools from textbooks to calculators and then to the internet, each innovation has prompted debate about what students should learn and how useful in bringing remarkable changes in learning activities, now it's time to adopt AI, it feels different partly because of its speed and scale. The tools powered by large language models can generate text, hold conversations and provide instant feedback in ways that were unthinkable, in the matter of decade, it usually an incredibly changed the very mode of learning experience. In language learning, especially, uptake has been rapid learners are using AI to practice conversations, explore new vocabulary or draft piece of writing . teachers are

experimenting with AI to save time on routine tasks, create materials or support assessment. For many years, these tools offer a welcome sense of opportunity, in bringing rapid change and unthinkable speed of quick learning strategies.

But this moment of change has also surfaced real concerns, if a student can ask AI to write an essay, how do we know, what they can really do ?, if AI models are trained mainly on certain kind of language, whose voices are being amplified, whose are being ignored? and if access to good technology is uneven, who risks being left behind?, these questions do not have simple answers, but they do point to the need for a clear set of values to guide, how AI is used in learning. to tailor the different needs of the learners, adopt to their learning ways, and rightly adjust to them in a way to help and to inspire in connection with one's learning tasks are concerned, as well focused with their individual speed of learning.

A PROMISED AND PERSONALIZED MEANS OF LEARNING

A strong reason that AI has attracted so much attention is its potential to make learning more personal. In traditional classrooms, it can be difficult to tailor activities to every learner's needs, AI systems by contrast, it can adopt tasks and feedback based on individual progress, offering extra practice where it is needed or moving faster when a learner is ready, to leap beyond one's expectation. For someone learning a new language, this can be particularly powerful. AI tools can act as patient conversation partners allowing learners to practice speaking without fear of embarrassment. They can highlight patterns in mistakes, suggest alternative expressions or help learners notice how language works. for many, this kind of low-pressure practice can build confidence and motivation, boost not only in learning but also fulfill perfect sort of confidentiality.

AI can also help learners to become more independent by helping them set goals monitor their progress and reflect on their learning strategies, technology can encourage habits, that last beyond a single course or classroom in this sense. AI has the potential to support lifelong learning rather than replace human teaching. Crucially these benefits are strongest, when AI is used to complement, not substitute human interaction, teachers remain essential as guides, mentors and motivators to handle the roles that depend on empathy, cultural understanding and professional development.

FACTOR OF RISKS IN USING AI

Beside these opportunities, it has been posing equal risks. one of the most discussed bias AI systems learn from existing data, and that data reflects social and cultural inequalities. In language learning, this can mean that certain accents, dialects or ways of expressing ideas are treated as more 'correct' than others. For learners who use non- standard varieties of English or who are still developing fluency, this can have real consequence. An AI tool might misinterpret their writing as low quality or even machine generated reinforcing unfair judgments, left unchecked, this risk narrowing our understanding of language and discouraging learners whose voices matter. There are also concerns about privacy and surveillance, many AI tools rely on collecting large amounts of user data for school and

families, questions about who controls that data, how it is stored and how it might be used in the future are increasingly urgent. Perhaps most worrying is the potential for AI to widen existing inequalities, if high-quality tools and training are available only to well-resourced schools or learners. The gap between those who benefit from AI and those who do not grow in this sense. AI not automatically inclusive inclusion which must be redesigned and defended.

SUPPORTS AND PROMOTES LEARNER-CENTRIC ACTIVITIES

Responding to these challenges require more than technical solutions, it calls for a human-centered approach, that puts learners' wellbeing and agency first. This means treating AI as a tool to endorse human goals not as an authority that defines them. But in putting practice a human -centered approach, which fosters critical engagement with AI teachers and learners, are invited to question AI outputs, discuss their limitations and use them as starting points for deeper thinking rather than final answers, this kind of engagement help build digital literacy and prepares learners to navigate a world, where AI- generated content is increasingly common. It also means being accurate and responsible, AI systems can produce convincing responses without explaining how they arrived at them, when something goes wrong, when information is inaccurate, based on harmful humans must remain accountable. Transparency oversight and clear ethical guidelines are therefore essential in its proper execution.

SUPPORTING TEACHERS THROUGH FOSTER COLLABORATIVE PROBLEM-SOLVING

Teachers plays a central role in shaping how AI is experienced in the classroom, it's their enormous experience and greater interest which shapes AI, of course many are already experimenting with these tools often on their own initiative. At the same time, many feel under prepared for ethical and pedagogical questions AI rises, all these gap mattered, without support of teachers, it may feel pressure to either ban AI, outright or embrace it, uncritically neither response serves learners well, or what teachers need in time. it is all training and trust opportunities to explore how AI fits with their subject, their students and their performance level that becomes the most deterministic values. Professional development that focuses on critical evaluation - not just how to use a tool but when and why to use it - can make a real difference clear policies on acceptable use and academic integrity can also reduce anxiety and create a sense of collective responsibility rather than individual risk. (Encouragingly many teachers see AI as a threat to their profession, but as a choice to refocus on, what makes teaching human building relationships, supporting collaboration and helping learners, make sense of easily comprehending almost complex ideas into simple terms of easy assimilation.)

SPECULATIONS BEYOND USING AI TECHNOLOGY

The helpful way to approach AI in education is to reach down and better ask questions, before adopting a new tool, schools and institutions can speculate over. why are

we using AI? what are the problems we are trying to solve and what kind of outcomes matter for learners ?, how will we use it responsibly? What safeguards are in place around ethics inclusion and data? what tools make sense?, and so on. Once those principles are clear starting with purpose, rather than products helps ensure that technology serves educational values rather than driving them away out of one's reach.

LEARNING CHANGES AND ITS TRANSFORMATION

AI will continue to evolve, and education will continue to adapt, the choice made now - about access, training, ethics and accountability - will shape how this technology affects learners for years to come. The challenge is not to choose between innovation and tradition, but to bring them into the conversation, in molding learners properly and more effectively with the lasting effect of unprecedented learning experience, and then by leading with curiosity, care and a commitment to inclusion, educators and leaders can help and ensure that AI supports learning in ways that are fair meaningful and deeply human.

AI and its role is rapidly expanding, tools which are provided by AI leads to trends of transformation enhance learning experience and improved educational outcomes, it seems to have vast and promising, a personalized, efficient and accessible means of education. Ultimately what remains is not, what AI can do, but what kind of education we want to create if we keep people at the centre, technology can become a powerful ally rather than a distraction- one that helps learners find their voices not lose them, brings out a perfect terms of confidentiality in terms of learning, performance and righty leading into the pathway of success.

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ARTIFICIAL INTELLIGENCE INNOVATION AND SUSTAINABLE DEVELOPMENT FOR VIKSIT BHARAT: OPPORTUNITIES, CHALLENGES, AND POLICY PERSPECTIVES

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Abstract

Artificial Intelligence (AI) has emerged as a disruptive technology capable of expediting economic growth, improving governance, and fostering sustainable development. Within the framework of India's aspiration for Viksit Bharat (Developed India) by 2047, AI-driven innovation may significantly contribute to fostering inclusive growth, environmental sustainability, and social fairness. This article analyzes the function of AI in critical industries like agriculture, healthcare, education, energy, urban development, and government. The study employs secondary data and theme analysis to investigate the role of AI in enhancing economic productivity, resource efficiency, and service delivery, while also tackling sustainability issues. The results indicate that AI can substantially aid Sustainable Development Goals (SDGs) via intelligent resource management, data-informed decision-making, and inclusive digital transformation. Nonetheless, challenges pertaining to the digital divide, ethical governance, talent deficiencies, and data security require resolution. The study indicates that strategic policy support, capacity enhancement, and responsible AI frameworks are crucial for harnessing AI innovation to realize the goal of Viksit Bharat.

Keywords: *Artificial Intelligence, Viksit Bharat, sustainable development, digital transformation, SDGs, inclusive growth*

Introduction

India's Viksit Bharat 2047 envisions the nation as a mature economy distinguished by elevated income levels, technical preeminence, environmental sustainability, and social inclusivity. Realizing this vision necessitates the incorporation of sophisticated technologies that augment productivity, optimize resource allocation, and enhance governance frameworks. Artificial Intelligence (AI) has acquired significance among emerging technologies for its capacity to analyze extensive datasets, automate intricate procedures, and facilitate evidence-based decision-making (NITI Aayog, 2018).

Artificial intelligence innovation can revolutionize conventional development paradigms by facilitating precision agriculture, advanced healthcare systems, tailored education, optimized energy management, and strategic urban planning. Sustainable development necessitates the equilibrium of economic growth, environmental conservation, and social equality. The amalgamation of AI with sustainability goals can assist India in tackling significant issues

such as climate change, resource depletion, demographic strain, and regional inequalities.

The notion of AI for sustainable development corresponds with the United Nations Sustainable Development Goals (SDGs), which prioritize inclusive economic growth, environmental conservation, and enhanced quality of life. In the Indian context, utilizing AI for development must also confront obstacles such as digital disparity, skill deficiencies, data governance, and ethical considerations. This study investigates the impact of AI innovation on advancing sustainable development and its significance for realizing the national goal of Viksit Bharat.

Methodology

The research relies on a qualitative analysis of secondary data obtained from government policy documents, academic journals, reports from international organizations, and industry publications. A thematic content analysis was employed to investigate the role of AI in key development sectors and to discern potential, problems, and policy implications pertinent to sustainable development in India.

AI and Sustainable Development: Sectoral Applications

Artificial Intelligence is being integrated across multiple sectors to improve efficiency, reduce resource wastage, and enhance service delivery.

Table shows Sector-wise Applications of AI for Sustainable Development

Sector	AI Applications	Sustainability Impact
Agriculture	Crop monitoring, yield prediction, precision irrigation, pest detection	Efficient resource use, increased productivity, reduced chemical usage
Healthcare	Disease prediction, telemedicine, diagnostic imaging, health data analytics	Improved access, early diagnosis, reduced healthcare costs
Education	Personalized learning, adaptive assessments, digital tutoring systems	Inclusive education, improved learning outcomes
Energy	Smart grids, demand forecasting, renewable energy optimization	Energy efficiency, reduced carbon emissions
Urban Development	Smart traffic management, waste management, urban planning analytics	Reduced congestion, improved urban sustainability
Governance	Predictive analytics, digital public services, fraud detection	Transparent administration, efficient service delivery

The table delineates the sector-specific applications of Artificial Intelligence (AI) and its impact on sustainable results. The table illustrates AI's role as a cross-sectoral enabling technology that enhances economic efficiency, promotes social inclusion, and safeguards environmental protection—three fundamental pillars of sustainable development crucial for realizing the vision of Viksit Bharat.

In the agricultural industry, AI technologies, including satellite images for crop monitoring, machine learning models for yield prediction, precision irrigation systems, and early pest detection tools, assist farmers in making data-driven decisions. These applications enhance the utilization of water, fertilizers, and pesticides, consequently diminishing input expenses and ecological harm. Effective resource utilization enhances agricultural output and farmer income while fostering long-term soil health and ecological equilibrium.

In the healthcare sector, artificial intelligence facilitates disease prediction, medical imaging analysis, telemedicine services, and extensive health data analytics. Predictive algorithms facilitate the early identification of illness risks, whilst AI-assisted diagnostics enhance the precision and expediency of medical decision-making. AI-driven telemedicine technologies enhance healthcare accessibility in remote and underprivileged areas, mitigating geographical differences. These approaches enhance public health outcomes and reduce healthcare costs, hence improving social welfare and system efficiency.

In the education industry, AI-powered personalized learning platforms evaluate student performance and modify instructional content based on individual learning requirements. Adaptive assessment systems detect learning deficiencies and deliver tailored support, whilst digital tutoring systems furnish ongoing academic aid. These innovations enhance educational inclusivity and learner-centricity, hence enhancing learning outcomes and decreasing dropout rates, especially among marginalized populations.

In the energy sector, artificial intelligence is essential for enhancing energy generation, distribution, and consumption efficiency. Smart grid solutions employ artificial intelligence to equilibrate electricity supply and demand instantaneously, therefore reducing transmission losses. AI-driven forecasting enhances the assimilation of renewable energy sources, including solar and wind, which are intrinsically variable. These applications improve energy efficiency, diminish reliance on fossil fuels, and facilitate reduced carbon emissions, so aiding climate change mitigation objectives.

The urban development sector gains advantages from AI applications in intelligent traffic management, waste management optimization, and data-informed urban planning. AI-driven traffic systems alleviate congestion through the dynamic management of traffic lights and routing. Advanced garbage management systems enhance collection timetables and resource reclamation. Urban analytics enhance land-use planning and infrastructure development, leading to more livable, resource-efficient, and environmentally sustainable urban areas.

In governance, AI improves administrative efficiency via predictive analytics, automated public service provision, and fraud detection mechanisms. AI-driven solutions assist governments in forecasting service requirements, identifying anomalies in financial transactions, and optimizing citizen services via chatbots and digital interfaces. These technologies enhance transparency, mitigate corruption, and provide expedited and more accessible public service delivery, ultimately bolstering institutional efficacy.

The table illustrates that AI transcends a singular area, operating as a revolutionary

instrument across various sectors. AI greatly contributes to sustainable development by enhancing efficiency, broadening access to important services, minimizing resource wasting, and facilitating evidence-based decision-making. The integration of its sectors is essential for attaining equitable economic growth, social inclusion, and environmental sustainability in alignment with the national goal of Viksit Bharat.

Economic Growth and Innovation Potential

Artificial Intelligence is anticipated to substantially augment India's economic expansion by improving productivity, stimulating innovation, and generating new job possibilities. Industry estimates suggest that AI might significantly enhance India's GDP by increasing efficiency in manufacturing, logistics, finance, and services (PwC India, 2020). The emergence of AI startups and digital innovation ecosystems bolsters entrepreneurship and enhances India's standing in the global knowledge economy.

Simultaneously, AI-driven automation is altering the work landscape, generating a need for new competencies in data science, machine learning, digital operations, and AI ethics. The shift to a knowledge-based economy corresponds with the long-term goals of Viksit Bharat, which prioritizes technology leadership and high-value jobs.

Social Inclusion and Human Development

A primary advantage of AI is its capacity to facilitate inclusive growth. AI-driven digital platforms enhance accessibility to banking, education, healthcare, and governmental services for marginalized people. In rural regions, AI-driven advice systems furnish farmers with instantaneous data regarding meteorological conditions, market valuations, and agronomic management techniques.

AI-powered language translation and voice-activated interfaces facilitate the surmounting of literacy and linguistic obstacles, hence promoting broader engagement in digital services. These solutions mitigate regional and social disparities, which is crucial for attaining equitable development in India.

Table shows AI Contributions to Social Inclusion

Area	AI Intervention	Development Outcome
Rural Development	AI-based agricultural advisory, weather alerts	Increased farmer income and resilience
Financial Inclusion	AI credit scoring, digital payment analytics	Expanded access to formal finance
Public Services	AI chatbots, automated grievance systems	Faster and accessible citizen services
Language Accessibility	AI translation and voice assistants	Inclusion of non-English users

Environmental Sustainability

Artificial intelligence is crucial in tackling environmental issues through facilitating data-driven environmental monitoring and resource management. Satellite-based artificial

intelligence systems are employed for monitoring deforestation, assessing air quality, and managing water resources. Predictive models assist authorities in formulating catastrophe response and climate adaption measures.

In the energy sector, artificial intelligence enhances the integration of renewable energy sources, including solar and wind, by predicting fluctuations in demand and supply. Intelligent waste management systems and pollution monitoring instruments also aid in the development of sustainable urban environments. These applications bolster India's climate obligations and objectives for environmental sustainability.

Challenges and Ethical Concerns

Notwithstanding its potential, the widespread implementation of AI poses numerous problems. The digital gap persists as a significant issue, as inequitable access to internet connectivity and digital infrastructure may marginalize rural populations from AI-enabled services. Deficiencies in expertise in innovative technologies also hinder the acceleration of AI implementation across many sectors.

Concerns regarding data privacy and security are becoming increasingly significant, as AI systems depend on extensive amounts of personal and institutional data. Ethical concerns, including algorithmic bias, transparency, and accountability, necessitate resolution via suitable legislative frameworks. Moreover, job loss due to automation necessitates proactive reskilling and workforce transfer initiatives.

Table shows Key Challenges in AI-driven Sustainable Development

Challenge	Implication	Policy Need
Digital divide	Unequal access to AI benefits	Expansion of digital infrastructure
Skill gap	Shortage of AI professionals	Large-scale reskilling and education programs
Data privacy concerns	Risk of misuse and surveillance	Strong data protection laws
Ethical risks	Bias and lack of transparency	Responsible AI governance frameworks

Policy Implications for Viksit Bharat

Realizing the complete potential of AI for sustainable development necessitates a synchronized policy strategy. National efforts like Digital India, Skill India, and the National Strategy for Artificial Intelligence establish a robust framework for AI adoption. Nonetheless, additional investment in research and development, public-private collaborations, and innovation ecosystems is essential.

Enhancing capabilities through higher education, vocational training, and ongoing skill development will be essential for cultivating a workforce prepared for the future. Implementation of ethical AI norms and stringent data governance procedures is essential to establish trust and responsibility. Inclusive policies that emphasize rural connectivity and

regional digital infrastructure will guarantee that the advantages of AI are accessible to all segments of society.

Conclusion

Artificial Intelligence possesses the capacity to act as a significant catalyst for attaining sustainable development and fulfilling the goal of Viksit Bharat. Its applications in agriculture, healthcare, education, energy, urban management, and governance can augment productivity, boost service delivery, and foster environmental sustainability. The effective incorporation of AI into the development framework necessitates tackling difficulties associated with digital access, competencies, ethics, and data security. A comprehensive strategy that integrates technology advancement with inclusive policy and accountable governance would empower India to leverage AI as a catalyst for sustained economic growth, social equity, and environmental sustainability.

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POLICY AND ETHICAL CHALLENGES IN ARTIFICIAL INTELLIGENCE: FRAMEWORKS FOR RESPONSIBLE GOVERNANCE

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Abstract

Artificial intelligence has moved from a specialized research pursuit to a general-purpose technology embedded in decisions that touch employment, healthcare, criminal justice, and public administration. This rapid diffusion has outpaced the policy and institutional structures originally designed to govern narrower, less consequential technologies, producing a widening gap between technical capability and ethical or regulatory oversight. This paper examines the central policy and ethical challenges raised by artificial intelligence and evaluates the frameworks that have emerged in response. Drawing on an analysis of recurring ethical concerns, including algorithmic bias, data privacy, opacity in automated decision-making, diffused accountability, and labour market disruption, the paper argues that these problems are not simply technical failures but reflect deeper tensions between innovation incentives and public protection. It then reviews four influential governance instruments: the European Union's Artificial Intelligence Act, the OECD AI Principles, UNESCO's Recommendation on the Ethics of Artificial Intelligence, and the United States National Institute of Standards and Technology's AI Risk Management Framework. Comparing these instruments reveals a shared normative vocabulary cantered on transparency, fairness, human oversight, and accountability, alongside substantial divergence in enforceability, scope, and institutional design, ranging from the European Union's binding, risk-tiered regulation to the voluntary, principles-based approach favoured in the United States. The paper contends that no single framework is sufficient by itself; effective governance instead requires layering binding legal obligations for high-risk applications with flexible technical standards and international ethical norms. It concludes by proposing design principles for responsible AI governance, including proportionate regulation, interoperable standards, meaningful human oversight, and sustained multilateral cooperation, and argues that policymakers must treat AI governance as an evolving, iterative process rather than a fixed regulatory endpoint. Ultimately, the paper suggests that durable AI governance depends less on selecting a single ideal instrument than on deliberately coordinating binding law, technical standards, and international norms so that each compensates for the others' structural limitations.

Keywords: artificial intelligence, AI governance, AI ethics, AI policy, algorithmic accountability, algorithmic bias, AI regulation

1. Introduction

Artificial intelligence (AI) no longer occupies a narrow corner of computer science laboratories. It now screens job applicants, sets prices, flags fraudulent transactions, assists medical diagnosis, moderates online speech, and, increasingly, informs decisions made by courts and government agencies. The scale and speed of this diffusion is unusual even by the standards of prior general-purpose technologies such as electricity or the internet, because AI systems can be retrained, redeployed, and scaled across sectors with comparatively little marginal cost once the underlying models exist (National Institute of Standards and Technology [NIST], 2023). This combination of reach and speed has created a policy environment in which regulators, ethicists, and technologists are frequently reacting to capabilities that have already been deployed at scale, rather than anticipating them.

The result is what many scholars describe as a governance gap: a mismatch between the pace of technical innovation and the pace at which legal, ethical, and institutional structures can adapt (Jobin, Ienca, & Vayena, 2019). This gap is not merely an inconvenience. Left unaddressed, it allows harms such as discriminatory hiring algorithms, opaque credit-scoring systems, and unaccountable content-moderation decisions to become entrenched before oversight mechanisms exist to correct them. At the same time, overly rigid or premature regulation risks stifling beneficial innovation, entrenching incumbent firms that can absorb compliance costs, and pushing development toward jurisdictions with weaker safeguards (Bradley, 2025).

This paper addresses two interlinked questions. First, what are the principal ethical and policy challenges that artificial intelligence raises for governments, organizations, and society? Second, what frameworks have been developed to address these challenges, and how well do they succeed in reconciling innovation with responsible oversight? The paper proceeds in five parts. Section two examines the ethical challenges associated with AI, including bias, privacy, transparency, accountability, and labour displacement. Section three turns to the policy-level obstacles that complicate governance, such as regulatory fragmentation and the pacing problem. Section four reviews four influential governance frameworks in detail. Section five offers a comparative analysis of these frameworks, and section six proposes an integrated model for responsible AI governance before the paper concludes.

2. Ethical Challenges in Artificial Intelligence

Ethical concerns about AI are not new, but their practical stakes have grown as AI systems have moved from experimental settings into decisions that materially affect people's lives. This section surveys five recurring categories of ethical concern that appear, in some form, across nearly every major governance framework reviewed later in this paper.

2.1 Algorithmic Bias and Discrimination

AI systems learn patterns from historical data, and historical data often encodes existing social inequalities. When a hiring algorithm is trained on a company's past recruitment decisions, or a risk-assessment tool is trained on historical policing records, the system can

reproduce and even amplify the biases embedded in that history, while presenting its output with a veneer of mathematical objectivity (Floridi & Cowls, 2019). UNESCO's Recommendation on the Ethics of Artificial Intelligence directly addresses this risk, calling on AI developers and deployers to make continuous efforts to minimize and avoid the reinforcement of discriminatory outcomes across the lifecycle of a system (UNESCO, 2021). The challenge for policymakers is that bias is rarely intentional and rarely visible from the outside; it typically requires technical auditing, disaggregated performance testing across demographic groups, and ongoing monitoring rather than a one-time certification.

2.2 Privacy and Data Governance

Contemporary AI systems, particularly large-scale machine learning models, are trained on vast quantities of data, much of it personal or behavioural. This creates tension between the data-hungry nature of effective AI and long-standing privacy norms that emphasize consent, purpose limitation, and data minimization. The same training data that improves a model's accuracy can also make it possible to infer sensitive attributes about individuals who never consented to that use, or to reconstruct fragments of the original training data itself. Effective governance therefore requires treating data protection not as a separate compliance exercise but as an integral part of AI system design (OECD, 2019).

2.3 Transparency and Explainability

Many of the most capable AI systems, particularly deep learning models, function as effective black boxes: their internal decision logic is difficult even for their designers to fully articulate. This opacity becomes an ethical problem when AI outputs affect consequential decisions, such as loan denials, parole recommendations, or medical diagnoses, because affected individuals may have no meaningful way to understand, contest, or appeal the outcome. Transparency and explainability appear as core values in nearly every governance framework examined in this paper, though the frameworks differ in how much explanatory detail they actually require in practice (NIST, 2023; UNESCO, 2021).

2.4 Accountability and Autonomous Decision-Making

As AI systems take on a greater share of decision-making, it becomes harder to identify who is responsible when something goes wrong. Responsibility is distributed across data providers, model developers, the organizations that deploy the system, and, in some cases, the end users who rely on its output. This diffusion of responsibility can produce what has been called an accountability gap, in which no single actor feels fully answerable for harmful outcomes. Governance frameworks generally respond to this problem by assigning differentiated obligations to distinct actors across the AI lifecycle, for example distinguishing between the obligations of an AI system's provider and those of the organization that deploys it (European Parliament and Council of the European Union, 2024).

2.5 Labor Displacement and Socioeconomic Impact

Beyond individual harms, AI raises broader societal concerns about the future of work, the concentration of economic power among firms that control the most capable models and the

computing infrastructure to train them, and the environmental cost of large-scale model training. These concerns are less amenable to case-by-case technical fixes and instead require deliberate policy choices about taxation, social safety nets, competition policy, and workforce transition support. Ethical frameworks increasingly recognize this dimension: UNESCO's Recommendation, for instance, explicitly links AI ethics to labor market policy, education, and environmental sustainability rather than treating AI ethics as a purely technical or individual-rights matter (UNESCO, 2021).

3. Policy Challenges in AI Governance

Recognizing an ethical concern is not the same as being able to regulate it effectively. This section examines four structural challenges that complicate the translation of ethical principles into workable policy.

3.1 Regulatory Fragmentation and Jurisdictional Divergence

Different jurisdictions have adopted markedly different regulatory philosophies. The European Union has pursued binding, horizontal legislation in the form of the Artificial Intelligence Act, which classifies AI systems into risk tiers and imposes correspondingly graduated obligations (European Parliament and Council of the European Union, 2024). The United States, by contrast, has relied more heavily on voluntary frameworks, sector-specific rules, and state-level legislation, such as Colorado's consumer protection statute governing high-risk AI systems (AI21, 2025). This divergence creates compliance complexity for organizations operating across borders and raises the possibility of regulatory arbitrage, in which AI development gravitates toward jurisdictions with the lightest obligations, regardless of where the resulting harms are ultimately felt.

3.2 The Pacing Problem: Innovation versus Regulation

Legislative processes are inherently slower than the iterative development cycles typical of AI research, where new model capabilities can emerge within months. By the time a regulation is drafted, negotiated, and enacted, the technology it targets may have already evolved in ways the drafters did not anticipate. This pacing problem pushes many governments toward principles-based or risk-based frameworks that describe outcomes and obligations in technology-neutral terms, rather than prescribing specific technical requirements that would quickly become obsolete (NIST, 2023). The trade-off is that flexible, principles-based language can be harder to enforce consistently, since terms like fairness or appropriate human oversight require interpretation on a case-by-case basis.

3.3 Enforcement and Institutional Capacity

Even well-designed rules are only as effective as the institutions charged with enforcing them. Assessing whether a high-risk AI system meets its stated obligations often requires technical expertise that many regulatory bodies do not yet possess in sufficient depth, along with access to information about proprietary training data and model architecture that companies are frequently reluctant to disclose. The EU AI Act attempts to address this by establishing a dedicated AI Office within the European Commission alongside national

competent authorities, but the broader challenge of building durable technical capacity inside regulatory agencies remains a persistent constraint across most jurisdictions (K&L Gates, 2026).

3.4 Global Coordination and Geopolitical Competition

AI governance is also entangled with geopolitical competition. Governments view leadership in AI as a strategic economic and even military asset, which creates incentives to prioritize domestic AI industry growth over stringent international coordination. Non-binding international instruments, such as the OECD AI Principles and UNESCO's Recommendation, have achieved broad multilateral endorsement precisely because they impose no binding obligations, but this same feature limits their capacity to constrain state or corporate behavior when economic or security interests are at stake (Bradley, 2025). Building durable international cooperation on AI governance therefore requires reconciling the shared interest in avoiding a race to the bottom on safety with the competitive pressures that discourage unilateral restraint.

4. Frameworks for Responsible AI Governance

A range of governance instruments has emerged over the past several years, differing in legal status, geographic scope, and level of technical specificity. This section reviews four of the most influential frameworks.

4.1 The European Union Artificial Intelligence Act

Formally adopted as Regulation (EU) 2024/1689, the AI Act is the first comprehensive, horizontally applicable law regulating artificial intelligence by a major global economy (European Parliament and Council of the European Union, 2024). The Act organizes AI systems into four risk categories: unacceptable risk, which is prohibited outright and includes practices such as government-run social scoring; high risk, which is permitted but subject to extensive obligations around risk management, data governance, documentation, transparency, and human oversight; limited risk, which triggers narrower transparency obligations, for instance disclosing that a user is interacting with an AI system; and minimal risk, which faces no obligations under the Act (European Commission, 2024). Enforcement is phased in through 2026 and beyond, and penalties for noncompliance are calculated as a percentage of a company's global annual turnover, giving the regulation meaningful teeth (White & Case LLP, 2024). Because the Act applies to any organization placing AI systems on the EU market regardless of where that organization is headquartered, it is widely expected to exert a so-called Brussels Effect, encouraging multinational companies to adopt EU-compliant practices globally rather than maintain separate systems for different markets (ModelOp, 2024).

4.2 OECD AI Principles

Adopted in 2019 and updated in 2023 and 2024, the OECD AI Principles were the first intergovernmental standard on AI, subsequently endorsed by the G20 and adopted, formally or informally, by dozens of countries beyond the OECD's own membership (Bradley, 2025).

The Principles articulate five values-based commitments, including inclusive growth, human-centered values and fairness, transparency, robustness and safety, and accountability, along with five recommendations directed at policymakers, covering areas such as investment in trustworthy AI research and international cooperation (OECD, 2019). Unlike the EU AI Act, the OECD Principles are non-binding; their influence operates through the normative and reputational weight of intergovernmental endorsement, and through their role as a common reference vocabulary that later, more binding instruments have drawn upon, including the language later reflected in the NIST framework and the EU AI Act itself (VerityAI, 2026).

4.3 UNESCO Recommendation on the Ethics of Artificial Intelligence

Adopted unanimously by UNESCO's 193 member states in November 2021, the Recommendation on the Ethics of Artificial Intelligence is the first global standard-setting instrument dedicated specifically to AI ethics (UNESCO, 2021). It is grounded in four core values, respect for human rights and human dignity, environmental and ecosystem flourishing, ensuring diversity and inclusiveness, and living in peaceful, just, and interconnected societies, from which it derives ten operating principles, including proportionality, safety, privacy, transparency, and accountability. What distinguishes the Recommendation from narrower technical standards is its extensive set of policy action areas, which translate broad ethical values into concrete guidance across domains such as data governance, gender equality, education, health, and environmental sustainability (UNESCO, 2021). Like the OECD Principles, the Recommendation is non-binding, but it carries significant normative weight given its near-universal adoption and its explicit mandate for UNESCO to support member states in conducting ethical impact assessments and readiness assessments.

4.4 NIST AI Risk Management Framework

Released in January 2023 by the United States National Institute of Standards and Technology, the AI Risk Management Framework, or AI RMF, is a voluntary, technology-neutral framework intended to help organizations incorporate trustworthiness considerations throughout the design, development, and deployment of AI systems (NIST, 2023). The framework is organized around four core functions: Govern, which establishes organizational culture and accountability structures for AI risk; Map, which identifies the context and potential risks of a given AI system; Measure, which analyzes and tracks identified risks using appropriate metrics; and Manage, which allocates resources to treat and monitor risk on an ongoing basis (Securiti, 2023). Because it was developed through an open, consensus-based process involving both public and private sector input, the AI RMF has been widely adopted as a practical reference point by organizations seeking to operationalize the more abstract commitments found in instruments like the OECD Principles, even though it carries no independent legal force.

4.5 Complementary Technical Standards

Alongside these four frameworks, technical standards bodies have developed certifiable

management-system standards that give organizations an auditable pathway to demonstrate responsible AI practices. ISO/IEC 42001, published in December 2023, is the first international standard against which an organization's AI management system can be third-party certified, using a plan-do-check-act cycle broadly similar to established quality and information-security management standards (Lumaris Consulting, 2025). Standards of this kind occupy an important middle position between binding law and purely voluntary ethical commitments: certification is optional, but once an organization pursues it, the resulting obligations are concrete and independently verifiable, which can help bridge the gap between high-level principles and day-to-day operational practice.

5. Comparative Analysis: Convergence and Divergence Across Frameworks

Reviewing these frameworks together reveals a striking degree of convergence at the level of stated values. Transparency, fairness, human oversight, accountability, and safety appear, in some form, in every instrument examined above, echoing a broader pattern identified in comparative studies of AI ethics guidelines, which have found that most published guidelines around the world converge on a similar small set of core principles even when they originate from very different institutional and cultural contexts (Jobin, Ienca, & Vayena, 2019). This convergence suggests that, at the level of what AI governance should value, there is more global agreement than public debate often implies.

The divergence emerges instead at the level of enforceability and institutional design. The EU AI Act sits at one end of a spectrum, using binding law, risk-tiered obligations, and turnover-based penalties to compel compliance. The OECD Principles and UNESCO Recommendation sit at the other end, relying on normative influence, peer pressure among member states, and voluntary alignment rather than legal compulsion. The NIST AI RMF and ISO/IEC 42001 occupy an intermediate position: the RMF is voluntary but operationally detailed, while ISO/IEC 42001 is voluntary but independently auditable through third-party certification. No single point on this spectrum is straightforwardly superior. Binding regulation offers stronger guarantees of compliance but is slower to adapt and harder to achieve multilaterally; voluntary frameworks are more adaptable and easier to gain broad international buy-in for, but their ultimate effectiveness depends heavily on organizations' good-faith engagement, which cannot be assumed uniformly across a global market (Elevate Consulting, 2026).

A second axis of divergence concerns scope. The EU AI Act and NIST AI RMF are primarily oriented toward organizational and technical risk management, focusing on what a provider or deployer of an AI system must do. UNESCO's Recommendation, by contrast, extends further into societal and structural concerns, including gender equity, environmental sustainability, and labor markets, treating AI governance as inseparable from broader social policy rather than as a self-contained technical compliance domain. This difference in scope reflects different institutional mandates, an economic regulator such as the European Commission naturally emphasizes market obligations, whereas a body such as UNESCO naturally emphasizes human rights and cultural and social dimensions, but it also means that no existing framework, taken alone, addresses the full range of ethical challenges identified

in section two of this paper.

6. Toward an Integrated Model of Responsible AI Governance

Given this landscape, the strongest case is not for choosing among these frameworks but for treating them as complementary layers of a single governance architecture. Four design principles follow from the analysis above.

First, regulation should be proportionate to risk rather than uniform across all AI applications. The EU AI Act's tiered structure, whatever its implementation challenges, reflects the correct underlying insight: a spam filter and a system used to make parole recommendations should not face the same regulatory burden, and treating them identically would either over-regulate low-risk innovation or under-regulate high-stakes applications.

Second, binding legal obligations and voluntary technical standards should be explicitly linked rather than developed in isolation. When a regulation such as the EU AI Act references conformity with recognized standards as a route to demonstrating compliance, it allows technical bodies to keep pace with fast-moving capabilities while giving legal force to the resulting requirements. Expanding this kind of cross-referencing between binding law and instruments such as the NIST AI RMF or ISO/IEC 42001 would help address the pacing problem described in section three.

Third, meaningful human oversight must be built into high-stakes systems as a structural requirement, not an afterthought. This means ensuring that human reviewers have both the authority and the practical capacity, including sufficient time, information, and expertise, to meaningfully review and override automated decisions, rather than treating human sign-off as a symbolic formality layered on top of a decision that has already effectively been made by the system.

Fourth, international cooperation should be pursued incrementally, through shared technical vocabulary and mutual recognition of standards, rather than through attempts to negotiate a single binding global treaty in the near term. The convergence of values documented across the OECD, UNESCO, EU, and NIST instruments provides a foundation for this kind of interoperability, even where formal legal harmonization remains politically out of reach. Over time, consistent use of shared definitions, for example around what constitutes a high-risk AI system, can reduce compliance fragmentation even without a single unified regulator.

7. Conclusion

Artificial intelligence presents a genuinely difficult governance problem: it is a general-purpose technology whose applications span nearly every sector of the economy and public life, it evolves faster than most legislative processes can accommodate, and its harms are often diffuse, probabilistic, and difficult to attribute to any single actor. This paper has argued that the ethical challenges raised by AI, spanning bias, privacy, transparency, accountability, and broader socioeconomic disruption, are best understood not as isolated technical defects but as manifestations of a deeper structural gap between innovation incentives and public protection. The governance frameworks reviewed here, the EU AI Act, the OECD AI Principles, UNESCO's Recommendation, and the NIST AI Risk Management Framework, each address part of this gap, and their shared normative vocabulary suggests a genuine, if incomplete, global consensus on what responsible AI governance should value. What remains unresolved is how to translate that consensus into governance architecture that is simultaneously enforceable, adaptable, and internationally coordinated. Meeting that challenge will likely require exactly the kind of layered approach outlined in this paper,

combining proportionate binding regulation for high-risk applications, interoperable technical standards, structurally meaningful human oversight, and patient, incremental international cooperation. AI governance, in this sense, should be understood not as a problem to be solved once but as an ongoing institutional practice that must evolve alongside the technology it seeks to govern.

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ARTIFICIAL INTELLIGENCE IN ECONOMICS EDUCATION: TRANSFORMING TEACHING, LEARNING AND SKILL DEVELOPMENT

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Abstract

Artificial Intelligence (AI) is rapidly reshaping the landscape of higher education, and economics education is no exception. This conceptual paper examines how AI technologies are transforming the teaching and learning of economics, with particular reference to the Indian higher-education context. Economics, as a discipline built on abstract theory, quantitative reasoning and data-driven analysis, offers fertile ground for AI-enabled tools such as intelligent tutoring systems, adaptive learning platforms, natural-language explainers, data-visualisation and machine-learning applications, and automated assessment engines. Drawing on recent empirical and bibliometric literature including large-scale student surveys, systematic reviews of adaptive learning, and cross-national studies of generative-AI perception the paper synthesises evidence on five broad themes: AI in the teaching of economic concepts and models; AI-enabled personalised and adaptive learning; the use of AI for economic data analysis; AI's contribution to skill development, including critical thinking, digital literacy and employability; and AI-supported assessment and learning analytics. The paper further considers the changing role of economics teachers, from content deliverers to AI-supported facilitators, and examines challenges such as the digital divide, algorithmic inaccuracy, overdependence on AI tools, academic integrity concerns and inadequate teacher preparedness. Ethical considerations relating to data privacy, bias and equitable access are also discussed. Two supporting exhibits a comparative table of recent empirical findings and a conceptual framework diagram are provided to ground the discussion in current evidence. The paper concludes by proposing strategies for the responsible and effective integration of AI into economics education and by outlining implications for preparing learners for an increasingly AI-driven economy.

Keywords: *Artificial Intelligence, economics education, adaptive learning, skill development, learning analytics, higher education*

1. INTRODUCTION:

Economics education has traditionally relied on lectures, textbooks and problem sets to build competence in theory, models and quantitative reasoning. The emergence of Artificial Intelligence (AI) encompassing machine learning, natural-language processing and intelligent tutoring systems is now altering how economic concepts are taught, how students learn, and how learning is assessed. The scale of this shift is no longer speculative: successive HEPI/Kortext Student Generative AI Surveys of UK undergraduates found that the proportion of students using generative-AI tools in some form rose from 66% in 2024 to 92% in 2025 (Freeman, 2025) and to 95% by December 2025, with use specifically for assessed

work rising from 53% to 88% and then to 94% over the same period (Stephenson & Armstrong, 2026). A global study of 23,218 students across 109 countries similarly found widespread early adoption of ChatGPT, alongside persistent concerns about its reliability for classroom learning (Ravšelj et al., 2025). Economics, given its heavy reliance on data, modelling and analytical reasoning, is particularly well positioned to be reshaped by these tools.

In the Indian higher-education context, the National Education Policy (NEP) 2020 explicitly calls for the integration of technology, including AI, to enable personalised, flexible and outcome-oriented learning. Universities and colleges are consequently experimenting with AI-based tutoring platforms, chatbots, adaptive learning software and AI-assisted data-analysis tools within economics curricula. However, this transition is uneven, shaped by infrastructural constraints, teacher readiness and concerns regarding academic integrity.

This paper adopts a conceptual approach, synthesising recent empirical, bibliometric and survey-based literature to examine how AI is transforming economics teaching, learning and skill development. It further identifies the opportunities, challenges and ethical issues associated with this transformation and offers strategies for responsible integration. The paper is guided by the following objectives: (1) to examine the role of AI in transforming economics teaching and learning; (2) to identify major applications of AI in economics education; (3) to analyse AI's contribution to students' analytical, digital, critical-thinking and employability skills; (4) to examine opportunities and challenges of AI integration; and (5) to suggest strategies for effective and responsible AI use in economics education.

2. AI AND ECONOMICS EDUCATION: EVIDENCE BASE:

Economics as a discipline combines abstract theoretical reasoning with empirical, data-intensive analysis, making it a natural fit for AI-supported pedagogy. AI systems can explain complex theories and models such as market equilibrium, elasticity, game theory or macroeconomic identities through interactive, conversational and example-based explanations tailored to a learner's existing understanding. Unlike a static textbook, an AI tutor can rephrase an explanation, generate additional worked examples, or simplify technical language on demand, allowing students to engage with difficult concepts at their own pace.

A growing body of empirical and bibliometric research substantiates this shift. A bibliometric analysis of 561 articles on AI-driven adaptive learning published between 2014 and 2024 across 68 countries found a sustained upward publication trend, with the United States contributing the largest share of research output (38.15% of articles) and a clear shift toward outcome-focused, higher-education-oriented adaptive learning in recent years (Kang et al., 2025). A systematic review of AI-powered adaptive learning implementations similarly concluded that such systems measurably enhance student engagement and academic performance, particularly in quantitative and STEM-adjacent disciplines, although infrastructural and computational-bias constraints continue to limit wider adoption (Pinela-Cárdenas et al., 2025). Table 1 summarises key findings from this recent literature relevant to

economics and cognate quantitative disciplines.

Study	Context / Sample	Key Finding
Freeman (2025) HEPI/Kortext	UK undergraduates, N = 1,041 (survey run Dec 2024)	Any generative-AI tool use rose from 66% (2024) to 92% (2025); use for assessments rose from 53% to 88%.
Stephenson & Armstrong (2026) HEPI/Kortext	UK undergraduates, N = 1,054 (survey run Dec 2025)	Any AI tool use reached 95%; 94% used GenAI for assessed work; direct copy-pasting of AI text into assessments rose to 12% (from 8% in 2025, 3% in 2024).
Ravšelj et al. (2025) PLOS ONE	Global, N = 23,218 students, 109 countries	ChatGPT rated effective for AI literacy and content creation but less useful for numeracy, decision-making and critical-thinking development.
Blahopoulou & Ortiz-Bonnin (2025)	Spanish university, N = 737 undergraduates	High ChatGPT prevalence; users significantly more supportive of AI integration in teaching methods than non-users.
Kang, Liu & Zhang (2025)	Bibliometric analysis, 561 articles, 68 countries (2014–2024)	Upward publication trend; research focus shifting toward outcome-based adaptive learning in higher education.
Pinela-Cárdenas et al. (2025)	Systematic literature review of AI-adaptive learning systems	AI-driven adaptive systems improve engagement and performance, especially in online and STEM/quantitative settings.
Elsayed et al. (2026)	Dental undergraduates, survey response rate 57%	ChatGPT was the most-used AI tool (81.5%); 78% saw educational value, 78% cited privacy/data-security concerns.

Table 1. Selected recent empirical and bibliometric findings on AI in higher education relevant to economics teaching and learning

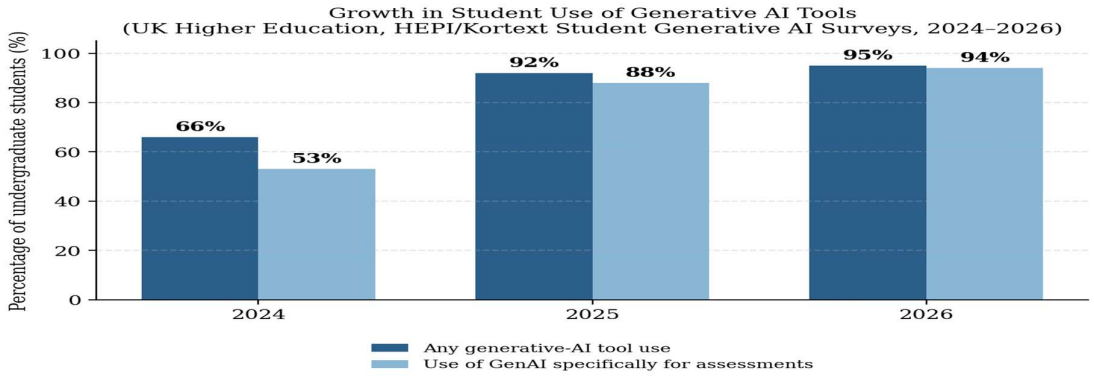

Figure 1. Growth in student use of generative AI tools, UK higher education, 2024–2026 (Freeman, 2025; Stephenson & Armstrong, 2026; HEPI/Kortext Student Generative AI Surveys)

Beyond concept explanation, AI supports simulation-based learning, where students can model the effects of policy changes a change in interest rates, a tax, or a tariff and observe simulated outcomes, deepening their intuition for cause-and-effect relationships in economic systems. AI-driven visualisation tools also help translate abstract mathematical relationships, such as demand and supply curves or production-possibility frontiers, into dynamic, manipulable graphics. Importantly, the evidence above suggests AI does not replace the theoretical rigour of economics teaching; rather, it acts as a scaffold that makes theory more accessible, especially for students who struggle with quantitative or abstract reasoning, while remaining less reliable for higher-order critical-thinking support (Ravšelj et al., 2025).

3. APPLICATIONS OF AI IN ECONOMICS EDUCATION:

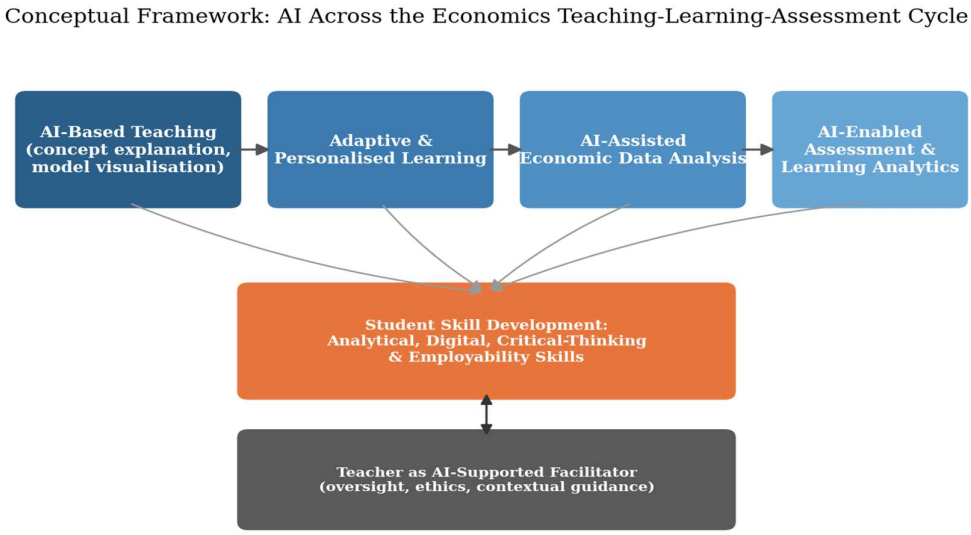

Figure 2. Conceptual framework: AI applications across the economics teaching-learning-assessment cycle

As Figure 2 illustrates, AI applications in economics education can be organised as a cycle running from teaching, through personalised learning and applied data analysis, to assessment and analytics all mediated by teacher facilitation and feeding into student skill development. First, intelligent tutoring and conversational AI systems (such as AI chatbots and large language model-based assistants) provide on-demand explanations, answer conceptual queries and generate practice questions on topics ranging from microeconomic theory to macroeconomic policy. These tools are available beyond classroom hours, supporting self-paced learning.

Second, adaptive learning platforms use algorithms to track individual student performance and adjust the difficulty, sequence and content of learning materials accordingly. For

economics students with varying levels of quantitative preparedness, such platforms can provide differentiated pathways offering additional foundational material to those who need it while allowing advanced learners to progress to more complex topics. Bibliometric evidence indicates that adaptive-learning research has grown steadily over the past decade and is increasingly oriented toward outcome-focused applications integrated with higher education (Kang et al., 2025).

Third, AI-enabled data-analysis tools are increasingly central to economics education, given the discipline's empirical orientation. Machine-learning-based software can assist students in cleaning, visualising and interpreting large economic datasets for instance, analysing inflation trends, labour-market data or trade statistics thereby building applied econometric and data-literacy skills that extend beyond traditional statistical software.

Fourth, AI supports simulation and gamified learning environments, such as virtual markets or policy simulators, where students experiment with economic decision-making and observe the consequences of their choices in a risk-free environment. Fifth, AI-based writing and research-assistance tools help students structure economic arguments, summarise literature and improve academic writing, though their use raises important questions of originality and academic integrity: the share of UK students directly copy-pasting AI-generated text into assessed work rose from 3% in 2024 to 8% in 2025 and 12% in 2026 (Stephenson & Armstrong, 2026), underscoring the growing scale of this concern.

Finally, AI is being embedded into learning-management systems to provide instructors with dashboards summarising class-wide performance trends, common misconceptions and engagement patterns, enabling more targeted teaching interventions. Collectively, these applications indicate that AI's role in economics education spans content delivery, personalised learning, applied data analysis, experiential simulation and administrative support for teaching.

4. AI AND SKILL DEVELOPMENT:

A central promise of AI in economics education lies in its contribution to skill development beyond disciplinary content knowledge. Analytical skills are strengthened as students use AI-assisted tools to interpret real-world economic data, identify patterns and test hypotheses, moving beyond rote memorisation of theory toward applied reasoning. Working with AI-based data platforms also builds digital literacy, as students become familiar with data visualisation, basic coding logic, and the interpretation of algorithmically generated outputs competencies increasingly demanded in economics-related careers. Table 2 maps the principal AI applications discussed in Section 3 onto the specific skill outcomes they support.

AI Application	Primary Skill Developed	Illustrative Economics Example
Intelligent tutoring / conversational AI	Conceptual understanding, self-directed learning	On-demand explanation of price elasticity or market equilibrium
Adaptive learning platforms	Personalised pacing, foundational competency	Differentiated practice paths for quantitative/mathematical economics
AI-based data-analysis	Data literacy, applied	Interpreting inflation, trade or

tools	econometric reasoning	labour-market datasets
Simulation & gamified platforms	Problem-solving, strategic decision-making	Virtual market or fiscal-policy simulators
AI writing/research assistants	Academic synthesis (with integrity caveats)	Structuring literature summaries and arguments
Automated feedback & learning analytics	Formative self-assessment, employability readiness	Auto-graded problem sets and performance dashboards

Table 2. Mapping of AI applications in economics education to student skill outcomes

AI can also foster critical thinking, provided it is used reflectively rather than passively. This caveat matters empirically: the global student survey by Ravšelj et al. (2025) found ChatGPT was perceived as effective for improving AI literacy, digital communication and content-creation skills, but comparatively less useful for numeracy, decision-making and the development of critical-thinking skills themselves. This suggests that when students are required to evaluate, question or fact-check AI-generated explanations rather than accept them uncritically, they develop the ability to assess the reliability, bias and limitations of algorithmic information a skill of growing importance in an information-saturated economy but this outcome is not automatic and depends on deliberate instructional design. Similarly, engaging with AI-driven simulations of policy or market scenarios cultivates problem-solving skills, as students must interpret ambiguous outcomes and justify their economic reasoning.

From an employability perspective, exposure to AI tools during economics education mirrors the technological environment students are likely to encounter in careers spanning finance, public policy, consulting, data analytics and research. Familiarity with AI-assisted data interpretation, forecasting tools and automated reporting systems can therefore enhance graduates' readiness for AI-augmented workplaces. However, these benefits depend on how AI is integrated pedagogically: unstructured or unsupervised use risks fostering superficial engagement rather than deep skill development a risk borne out by survey evidence that a meaningful minority of students submit AI-generated text with little or no editing (Freeman, 2025) underscoring the need for deliberate instructional design that pairs AI tools with reflective, guided learning activities.

5. OPPORTUNITIES AND BENEFITS:

The integration of AI into economics education offers several notable opportunities. Personalisation is perhaps the most significant, as AI enables instruction to be tailored to individual learning paces, prior knowledge and areas of difficulty, addressing the wide heterogeneity typically found in large economics classrooms; bibliometric evidence indicates that outcome-focused, personalised adaptive learning is an increasingly prominent direction within this research field (Kang et al., 2025). AI also expands access to learning support, offering round-the-clock tutoring assistance that can partially compensate for limited teacher-student ratios in resource-constrained institutions reflected in survey data showing students value the 24/7 accessibility and time-saving benefits of AI tools above most other features (Blahopoulou & Ortiz-Bonnin, 2025).

AI enhances engagement through interactive simulations, gamified exercises and real-time feedback, which can make traditionally abstract or mathematically demanding topics more approachable. For instructors, AI-generated learning analytics offer valuable insight into class-wide trends, enabling early identification of struggling students and more efficient allocation of teaching effort. Additionally, AI supports scalability, allowing quality educational resources such as adaptive practice sets or automated feedback to be delivered consistently across large and diverse student cohorts, which is particularly relevant to mass higher-education systems such as India's.

6. CHALLENGES AND ETHICAL ISSUES:

Despite these opportunities, several challenges accompany AI integration in economics education. The digital divide remains a significant concern, as unequal access to devices, reliable internet connectivity and digital skills can widen existing educational disparities rather than narrow them, particularly across rural and under-resourced institutions. Concerns about accuracy and reliability also persist: cross-national and dental-education studies alike report that a large share of both students and faculty flag data privacy and output reliability as leading concerns even where adoption is high for example, 78% of health-sciences students who used AI tools also cited privacy and data-security concerns (Elsayed et al., 2026) requiring careful teacher oversight and verification of AI-generated economic content.

Overdependence on AI tools poses a further risk: if students rely excessively on AI for explanations, calculations or written work, foundational understanding and independent reasoning skills may be undermined. Closely related is the challenge of academic integrity, as AI-based writing and problem-solving assistance can blur the line between legitimate learning support and unauthorised assistance, complicating assessment design and plagiarism detection a concern made concrete by survey findings that the share of students submitting AI-generated text directly, with little or no editing, has climbed steadily in successive years (3% in 2024, 8% in 2025, 12% in 2026) (Stephenson & Armstrong, 2026).

Teacher preparedness is another critical challenge, as many economics educators have not received formal training in AI tools, limiting effective and pedagogically sound integration; only a minority of students report that their institution actively encourages AI use, suggesting policy and training lag behind actual adoption (Freeman, 2025). Ethical considerations add further complexity, including concerns about student data privacy, algorithmic bias in AI-generated content, transparency in how AI systems arrive at conclusions, and equitable access to AI-enabled resources across institutions of varying resource levels. Addressing these challenges requires coordinated institutional policy, teacher training and thoughtful pedagogical design rather than ad hoc adoption of AI tools.

7. RECOMMENDATIONS:

To ensure effective and responsible integration of AI in economics education, this paper recommends: (1) structured faculty-development programmes to build teacher competence and confidence in using AI tools pedagogically; (2) clear institutional guidelines on acceptable AI use in assignments and assessments to safeguard academic integrity; (3) blended pedagogical models that combine AI-assisted learning with teacher-led critical

discussion, ensuring AI supplements rather than replaces conceptual instruction; (4) investment in digital infrastructure and equitable access initiatives to mitigate the digital divide; and (5) the incorporation of AI literacy and ethical-use modules within economics curricula, so that students learn to use AI tools critically and responsibly.

8. CONCLUSION: Artificial Intelligence is transforming economics education across teaching, learning, assessment and skill development, offering meaningful opportunities for personalisation, engagement and analytical skill-building. However, realising these benefits requires deliberate, ethically grounded integration that addresses challenges of access, accuracy, overdependence and teacher preparedness. As economics graduates increasingly enter an AI-driven economy, economics education itself must model responsible, critical and reflective engagement with AI, positioning teachers not as replaced content deliverers but as essential facilitators guiding students toward deeper, more resilient economic understanding.

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ACADEMIC STRESS, STUDENT WELL-BEING AND THE ROLE OF ARTIFICIAL INTELLIGENCE

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Abstract

Academic stress is a growing concern in education, arising from examinations, heavy workload, competition, parental expectations, fear of failure, and career uncertainty. While moderate stress may motivate students, excessive stress can negatively affect their physical, psychological, emotional, social, and academic well-being. The emergence of Artificial Intelligence (AI) has created new opportunities for education through personalised learning, immediate feedback, academic assistance, and study support. However, excessive dependence on AI, information overload, technology-related pressure, reduced human interaction, and concerns about academic integrity may create additional stress. This paper examines the causes and impact of academic stress, the role of AI in learning, and the opportunities and challenges of AI-supported education. It highlights the importance of teachers, parents, institutions, and students in promoting responsible AI use, healthy learning habits, supportive relationships, and balanced assessment. AI should support rather than replace teachers and human interaction. When used responsibly, AI can reduce unnecessary academic burden, promote personalised learning, improve student engagement, and contribute to a positive and well-being-oriented educational environment.

Keywords: *Academic Stress, Student Well-being, Mental Health, Artificial Intelligence, AI in Education, Examination Stress, Student Engagement, Personalised Learning, Stress Management*

1. Introduction

Education plays an important role in the intellectual, emotional, social, and personal development of students. However, increasing expectations for academic achievement, competitive examinations, skill development, and career success can create considerable pressure. As a result, academic stress has become a major concern among students.

Academic stress refers to the physical and psychological pressure associated with educational responsibilities and expectations. While moderate stress may motivate students, excessive stress can negatively affect their well-being and learning.

Student well-being includes physical health, emotional stability, confidence, meaningful relationships, and satisfaction with learning and life. Excessive academic stress can therefore affect students' overall well-being and academic performance.

The rapid development of **Artificial Intelligence (AI)** is changing the educational

environment. AI can support personalised learning, provide explanations and feedback, generate practice activities, and assist students with study planning. However, excessive dependence on AI, technology-related pressure, information overload, and concerns about future skills may create additional challenges.

Therefore, understanding the relationship between **academic stress, student well-being, and AI** is important for developing a supportive, responsible, and effective learning environment.

2. Understanding Academic Stress

Academic stress occurs when students perceive that the demands of their academic environment are greater than their available resources to manage them. The experience of stress differs from student to student. A particular academic challenge may motivate one student but overwhelm another.

Academic stress may be temporary, such as stress before an examination, or prolonged, such as continuous pressure caused by heavy academic workload or persistent expectations of high achievement.

In the digital era, students also face **technology-related academic pressure**. They may be expected to use online learning platforms, digital resources, educational applications, AI tools, and other technologies. When students lack adequate digital literacy, technology that is intended to support learning may itself become a source of stress.

2.1 AI and Academic Stress

Artificial Intelligence can influence academic stress in two different ways.

AI can reduce stress by:

- Providing personalised explanations.
- Giving immediate feedback.
- Helping students organise study materials.
- Supporting revision and practice.
- Explaining difficult concepts in different ways.
- Assisting students with language and communication.
- Supporting students who need additional learning assistance.
- Helping teachers identify learning difficulties.

At the same time, AI can contribute to stress through:

- Fear of technological change.
- Excessive dependence on AI.
- Pressure to use AI tools.
- Fear of academic dishonesty accusations.
- Information overload.
- Reduced confidence in one's own abilities.
- Uncertainty about future employment and AI-related changes.
- Competition between students who use technology differently.

Therefore, AI should be introduced in a manner that supports students rather than creating

another layer of academic pressure.

3. Common Signs of Academic Stress

Academic stress does not always appear in the same form in every student. Some students may openly express their worries, while others may hide their difficulties. Teachers, parents, and peers therefore need to recognise the common behavioural, emotional, physical, and academic signs of stress.

Common signs include:

- Anxiety and excessive worrying
- Difficulty concentrating
- Lack of motivation
- Irritability and mood changes
- Sleep disturbances
- Headaches and fatigue
- Procrastination
- Fear of examinations or failure
- Withdrawal from friends and activities
- Reduced academic performance

In an AI-supported learning environment, another important indicator may be **technology-related anxiety**. Students may feel uncomfortable when they are expected to use unfamiliar AI tools or may become anxious about whether their work is considered original.

4. Major Causes of Academic Stress

4.1 Examination and Assessment Pressure

Examinations are one of the most common sources of academic stress. Students may worry about obtaining high marks, disappointing parents or teachers, or failing to achieve their desired academic goals.

AI can potentially support examination preparation by providing practice questions, revision activities, explanations, and personalised feedback. However, excessive dependence on AI-generated answers may reduce independent preparation and create uncertainty about actual learning.

4.2 Heavy Academic Workload

Assignments, projects, practical work, presentations, examinations, and other academic requirements can create considerable workload.

AI can assist students in organising information, generating study plans, explaining concepts, and supporting revision. When appropriately used, these functions can reduce unnecessary workload. However, students should not use AI simply to complete all academic tasks without engaging in the learning process.

4.3 Parental Expectations

Unrealistic expectations regarding marks, ranks, or career choices can increase academic pressure. Constant comparison with other students may negatively affect self-esteem.

The availability of AI and digital learning tools may sometimes increase parental expectations. Parents may assume that because AI tools are available, students should always achieve better results. Therefore, parents need to understand that technology is a learning support and not a substitute for effort, practice, or individual development.

4.4 Competition

Competition for higher marks, admissions, scholarships, and employment opportunities can create anxiety among students.

The growth of AI may introduce another dimension of competition. Students may compare their ability to use AI tools and digital technologies. Healthy competition can encourage learning, but excessive comparison may increase stress.

4.5 Fear of Failure

Fear of failure can become a significant source of stress. Students may associate academic failure with personal failure.

AI should be used to create a **safe learning environment** in which students can practise, make mistakes, receive feedback, and try again. AI-supported formative learning can potentially help students view mistakes as part of the learning process.

4.6 Poor Time Management

Students who do not plan their academic activities effectively may postpone tasks until deadlines approach.

AI-based planning tools can assist students in organising tasks, preparing study schedules, setting reminders, and dividing larger activities into manageable steps. However, students should remain responsible for their own schedules rather than depending completely on automated systems.

4.7 Uncertainty about Future Careers

Students may experience stress because of uncertainty regarding higher education, employment, career choices, and financial security.

The rapid development of AI has increased discussions about the changing nature of employment. Students may worry about whether certain occupations will be affected by automation. Therefore, education should focus on developing creativity, critical thinking, communication, problem-solving, collaboration, digital literacy, and ethical awareness.

5. Impact of Academic Stress on Student Well-being

Academic stress affects students in multiple dimensions.

5.1 Psychological and Emotional Well-being

Excessive academic stress may contribute to anxiety, persistent worry, irritability, low confidence, and emotional exhaustion. AI may support emotional well-being indirectly by reducing certain academic difficulties. For example, personalised explanations and additional practice may help students who are struggling with a particular concept. However, AI should not be considered a replacement for professional counselling or human emotional support. Students experiencing serious emotional difficulties require appropriate support from

teachers, counsellors, parents, and qualified professionals.

5.2 Physical Well-being

Stress can affect sleep, appetite, energy levels, and general physical health. Excessive screen use associated with digital and AI-supported learning may also interfere with healthy routines if students do not maintain appropriate balance. Students therefore need adequate sleep, physical activity, recreation, and breaks from digital devices.

5.3 Academic Performance

Excessive stress can interfere with concentration, memory, motivation, and problem-solving. Consequently, students may perform below their actual potential.

AI-supported personalised learning may help students understand difficult concepts at their own pace. However, learning improves when AI assistance is combined with active thinking, practice, discussion, and teacher guidance.

5.4 Social Well-being

Highly stressed students may reduce their interaction with friends and family. Excessive use of AI and digital technologies can potentially contribute to reduced face-to-face interaction. Therefore, educational institutions should ensure that AI-supported learning is balanced with collaborative learning, classroom discussion, group activities, sports, arts, and social interaction.

5.5 Student Engagement

Well-being and engagement are closely connected. Students who feel anxious, exhausted, or disconnected may participate less actively in classroom activities. AI can increase engagement when it provides interactive learning experiences, personalised activities, simulations, immediate feedback, and opportunities for exploration.

5.6 Self-esteem and Self-confidence

Continuous academic comparison and repeated experiences of perceived failure can affect students' self-esteem. AI should be used to strengthen students' confidence rather than replace their thinking. Teachers should encourage students to use AI as a **learning partner or support tool**, while ensuring that students develop the ability to analyse, evaluate, create, and solve problems independently.

6. AI and the Learning Process

Artificial Intelligence has the potential to transform the learning process. AI-based educational tools can provide explanations at different levels, generate practice exercises, support personalised learning, and provide immediate feedback. For example, a student who finds a mathematical concept difficult can ask an AI tool for an explanation using simple language, request additional examples, and practise similar problems. The student can then discuss the concept with the teacher and classmates.

AI can support:

- Personalised learning
- Adaptive practice

- Immediate feedback
- Revision and examination preparation
- Language learning
- Accessibility and inclusion
- Generation of practice questions
- Brainstorming and idea development
- Learning-resource organisation
- Individualised explanations

However, AI-generated information may not always be accurate or appropriate. Students therefore need **critical digital literacy** to verify information, identify errors, compare sources, and make informed judgments.

The goal should not be to allow AI to do the learning for students. Instead, AI should help students **learn better, think deeper, and become more independent learners**.

7. Strategies for Managing Academic Stress

7.1 Effective Time Management

Students can prepare realistic study schedules and divide large tasks into smaller, manageable activities. AI tools may assist in creating study plans and organising tasks. However, students should review and adapt these plans according to their actual needs.

7.2 Mindfulness and Relaxation

Simple mindfulness exercises, deep breathing, meditation, and relaxation activities can help students manage anxiety and improve attention. AI may provide guided relaxation exercises or reminders for breaks, but these tools should complement rather than replace healthy human support.

7.3 Physical Activity

Regular physical activity, sports, walking, yoga, and stretching can support physical and emotional well-being. Students should maintain a healthy balance between screen-based learning and physical activity.

7.4 Adequate Sleep and Healthy Habits

Adequate sleep is essential for concentration, memory, emotional regulation, and overall health. Students should avoid prolonged late-night use of digital devices and AI tools, particularly before examinations.

7.5 Supportive Teacher–Student Relationships

Teachers have an important role in reducing unnecessary academic pressure.

AI cannot replace the empathy, encouragement, understanding, and personal relationship provided by a teacher. The teacher remains central to creating a psychologically safe classroom.

7.6 Counselling and Psychological Support

Educational institutions should provide accessible counselling services.

AI-based conversational systems may provide general information or learning support, but

they should not replace qualified counsellors or mental-health professionals.

7.7 Peer Support

Collaborative learning, peer tutoring, and group activities can reduce feelings of isolation and promote a sense of belonging.

Students can also work together to discuss appropriate and ethical uses of AI.

7.8 Balanced Assessment Practices

Assessment should focus not only on marks but also on learning progress, skills, creativity, application, and improvement.

In the age of AI, assessment should increasingly emphasise:

- Critical thinking
- Problem-solving
- Oral explanation
- Application of knowledge
- Creativity
- Reflection
- Project-based learning
- Collaborative activities
- Demonstration of individual understanding

Such approaches can reduce the pressure associated with traditional examinations while also discouraging meaningless dependence on AI-generated responses.

8. Responsible and Ethical Use of AI in Education

The effective use of AI requires clear principles.

8.1 AI as a Support Tool

Students should use AI to understand concepts, practise skills, generate ideas, receive feedback, and explore alternative explanations.

8.2 Maintaining Academic Integrity

Students should not submit AI-generated work as their own without appropriate acknowledgement where required. Educational institutions should clearly communicate their expectations regarding responsible AI use.

8.3 Verification of Information

Students should understand that AI can produce inaccurate or incomplete information. Important information should be checked using textbooks, academic sources, teachers, and reliable references.

8.4 Protecting Privacy

Students and teachers should avoid entering confidential, personal, or sensitive information into AI systems.

8.5 Maintaining Human Interaction

Technology should support relationships rather than replace them. Classroom discussion, teacher guidance, peer interaction, and collaborative learning remain essential.

8.6 Developing AI Literacy

Students should be taught how AI works at an appropriate level, including its possibilities, limitations, ethical issues, bias, privacy concerns, and responsible use.

9. Role of Teachers in Promoting Student Well-being and Responsible AI Use

Teachers are among the most important adults in students' educational lives. They can identify early signs of stress and create classroom conditions that support well-being.

Teachers can:

- Maintain a positive and respectful classroom climate.
- Avoid unnecessary comparison between students.
- Provide clear instructions and realistic deadlines.
- Encourage questions and active participation.
- Give constructive rather than discouraging feedback.
- Teach study skills and time-management strategies.
- Encourage participation in sports, arts, and co-curricular activities.
- Introduce AI tools responsibly and purposefully.
- Teach students how to verify AI-generated information.
- Encourage critical thinking rather than passive acceptance of AI responses.

A teacher who understands both the emotional needs of learners and the opportunities and limitations of AI can transform the classroom into a **supportive, innovative, inclusive, and well-being-oriented learning environment**.

10. Role of Parents and Educational Institutions

Parents should encourage effort, perseverance, and learning rather than focusing exclusively on marks. They should listen to students' concerns and avoid excessive comparison.

Parents should also understand that AI is a tool for learning and should not be used to impose unrealistic expectations on children.

Educational institutions have a responsibility to create a culture of well-being and responsible technology use. Schools and colleges can organise:

- Counselling programmes
- Stress-management workshops
- AI-literacy programmes
- Digital-well-being activities
- Mindfulness programmes
- Sports and cultural programmes
- Life-skills education
- Responsible-AI awareness programmes

Institutions should establish clear and age-appropriate guidelines for the use of AI in assignments, projects, assessments, and research.

11. AI as a Tool for Personalised and Inclusive Learning

One of the major educational possibilities of AI is personalised learning.

Students differ in their prior knowledge, learning speed, interests, language abilities, and

learning needs. AI-supported systems can potentially provide different explanations and practice activities according to individual requirements.

For example:

- A student can request a simpler explanation of a difficult concept.
- Another student can ask for advanced examples.
- A language learner can practise vocabulary and communication.
- A student can receive additional practice after making mistakes.
- Teachers can use AI to develop differentiated learning materials.

Such possibilities can help reduce frustration and increase students' confidence.

However, personalised AI support should be combined with teacher observation. Teachers understand the social, emotional, cultural, and classroom context of learners in ways that automated systems may not fully understand.

12. Towards a Well-Being-Oriented and AI-Enabled Education System

The purpose of education should extend beyond examination results. A successful education system should help students develop knowledge, skills, confidence, emotional resilience, social responsibility, healthy relationships, digital competence, and ethical awareness.

Academic achievement and well-being should not be viewed as competing goals. AI can contribute to both when it is used appropriately.

A well-being-oriented and AI-enabled education system should therefore focus on:

Human Values + Teacher Support + AI Technology + Critical Thinking + Student Well-being

AI should reduce unnecessary academic burden rather than increase it. It should provide opportunities for learning rather than encourage shortcuts. It should support teachers rather than replace them. Most importantly, technology should remain subordinate to the broader educational goal of developing responsible, capable, creative, and emotionally healthy human beings.

13. Conclusion: Academic stress can significantly affect student well-being and learning. While moderate pressure may motivate students, excessive stress can negatively affect their psychological, emotional, physical, social, and academic well-being.

Artificial Intelligence (AI) offers opportunities for personalised learning, immediate feedback, study support, and better understanding of difficult concepts. However, overdependence on AI, technology-related anxiety, information overload, academic dishonesty, and reduced human interaction may create additional challenges.

Therefore, AI should be used **responsibly, ethically, and as a support tool rather than a replacement for teachers or human interaction**. Teachers, parents, and educational institutions should guide students in using AI critically while promoting counselling, digital well-being, academic integrity, and healthy learning habits.

Ultimately, AI can contribute to a **positive, effective, and well-being-oriented education system** when guided by human values, teacher expertise, and responsible use.

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E-LEARNING: IMPORTANCE, SCOPE, OPPORTUNITIES, CHALLENGES AND IT'S ROLE IN MODERN EDUCATION

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Abstract

E-Learning has emerged as an important component of modern education with the rapid development of digital technologies and electronic devices. It refers to the process of teaching and learning through computers, smartphones, tablets, the internet and digital learning platforms. E-Learning enables learners to access educational content, attend online classes, communicate with teachers, participate in learning activities and complete assessments irrespective of time and place. It has expanded the boundaries of conventional education by making learning more flexible, accessible, interactive and learner-centred. The scope of E-Learning includes school education, higher education, teacher education, distance education, skill development, corporate training, mobile learning, virtual learning, online assessment and lifelong learning. It supports self-paced learning, independent learning, digital literacy, creativity, communication and collaboration. However, challenges such as inadequate internet connectivity, lack of digital devices, limited face-to-face interaction, technical difficulties, online distractions, excessive screen time and the digital divide can affect its effectiveness. Therefore, successful E-Learning requires appropriate infrastructure, digitally competent teachers, quality learning resources and effective pedagogical practices. This paper examines the meaning, importance, scope, role, advantages, challenges and future possibilities of E-Learning in modern education and emphasizes that digital learning should complement rather than completely replace traditional classroom education.

Keywords: *E-Learning, Digital Education, Online Learning, Educational Technology, Virtual Learning, Digital Literacy, Lifelong Learning.*

Introduction

Education is a continuous process through which individuals acquire knowledge, develop skills, cultivate values and prepare themselves for personal, social and professional life. The development of science and technology has brought significant changes in the educational system. In the twenty-first century, information and communication technologies have become an important part of teaching, learning, communication and assessment. Consequently, educational institutions are increasingly integrating digital technologies into conventional teaching practices.

Traditional education mainly depends on face-to-face interaction between teachers and

students within a physical classroom. Although classroom-based education continues to be important, technological development has created new opportunities for learning beyond physical boundaries. One of the most significant developments in this context is Electronic Learning or E-Learning. E-Learning allows students to access educational materials through computers, smartphones, tablets and internet-based platforms. Learners can attend live or recorded classes, read e-books, watch educational videos, participate in online discussions, submit assignments and undertake assessments. This flexibility has made E-Learning useful for learners with different educational needs, interests, abilities and learning speeds.

E-Learning also provides opportunities for individuals who cannot regularly attend conventional educational institutions because of geographical or other circumstances. At the same time, the role of teachers has changed. Teachers increasingly function as facilitators, mentors, guides and learning designers rather than simply transmitting information.

However, technology alone cannot ensure effective education. Teacher guidance, motivation, interaction, practical experience and human relationships remain essential. Therefore, meaningful integration of E-Learning with traditional teaching is necessary to create an effective, inclusive and learner-centred educational environment.

Meaning and Concept of E-Learning

E-Learning stands for **Electronic Learning**. It refers to a method of teaching and learning that uses electronic devices and digital technologies. Computers, laptops, smartphones, tablets, internet connections and online learning platforms are commonly used to facilitate E-Learning.

In simple terms, **E-Learning is the process of learning through electronic and digital technologies**. It enables learners to access educational content, attend online classes, communicate with teachers and classmates, participate in discussions, complete assignments and undertake assessments without always being physically present in a classroom.

E-Learning can take different forms, including live online classes, recorded lectures, digital textbooks, educational applications, virtual classrooms and learning management systems. Mobile learning enables students to access educational content through smartphones and tablets, while virtual learning environments provide digital spaces for teaching, communication and assessment.

E-Learning is not merely the electronic presentation of traditional teaching materials. Effective E-Learning involves the planned integration of technology, educational content, pedagogy, learner interaction and assessment to achieve educational objectives. It can also encourage learners to take greater responsibility for their own education by allowing them to search for information, review lessons, access supplementary resources and learn according to their own pace.

Thus, E-Learning represents an important development in educational practice because it extends learning opportunities beyond the limitations of time, location and conventional classroom structures.

Importance of E-Learning in Modern Education

E-Learning has become increasingly important because it provides flexibility, accessibility and diverse learning opportunities. One of its major advantages is flexibility in terms of time and place. Students can access learning materials according to their convenience and circumstances. Recorded lectures and digital resources enable learners to review content whenever necessary.

E-Learning also provides access to a wide range of educational resources. Ebooks, digital libraries, educational videos, presentations, online articles and other materials can supplement prescribed textbooks and classroom teaching. Multimedia resources such as videos, animations, graphics, simulations and quizzes can make learning more interesting and understandable.

Another important feature is self-paced learning. Students differ in their learning abilities and speeds. E-Learning enables students to repeat lessons, review difficult topics and progress according to their individual requirements. It can therefore support learner-centred education.

E-Learning also contributes to the development of digital skills. Students learn to use digital devices, online platforms and information resources, which are increasingly important for higher education and employment. Online platforms further enable communication and collaboration between teachers and students through discussions, video conferences, messages and collaborative activities. E-Learning supports continuous and lifelong learning because individuals can acquire knowledge and skills at different stages of life. It can also support educational continuity when regular classroom teaching becomes difficult. Thus, E-Learning has become an important component of modern education by promoting flexibility, accessibility, independent learning and digital competency.

Scope of E-Learning

The scope of E-Learning is very broad and extends across different levels and forms of education. In school education, online classes, digital textbooks, educational videos, digital worksheets and interactive activities can supplement classroom instruction. In higher education, colleges and universities can provide online courses, virtual classrooms, recorded lectures, digital libraries and other electronic academic resources.

E-Learning has an important role in teacher education. Pre-service teachers can use online resources for academic study, while practising teachers can participate in webinars, workshops, online training programmes and professional development activities. Distance education is another major area in which ELearning provides opportunities for students who cannot be physically present at educational institutions.

The scope of E-Learning also extends to skill development. Learners can participate in vocational, technical and professional courses through online platforms. Organisations can use E-Learning for corporate training, employee development and workplace learning. Mobile learning provides educational opportunities through smartphones and tablets, while virtual learning environments provide online classrooms and digital learning spaces.

Online assessment is another growing area. Tests, quizzes, assignments and feedback can be conducted through digital platforms. E-Learning also supports lifelong learning by providing individuals with opportunities to continue learning according to their academic, personal and professional needs. Therefore, its scope extends from formal education to professional training, skill development and lifelong learning.

Role of E-Learning in Modern Teaching and Learning

E-Learning has changed the way teachers teach and students learn. It provides opportunities to move from teacher-dominated instruction towards more active and learner-centred approaches. Students can supplement classroom instruction with digital textbooks, educational videos, presentations and other online resources.

E-Learning supports self-directed learning by enabling students to explore topics independently, search for information and review learning materials. It also encourages active participation through online discussions, quizzes, assignments, presentations and collaborative projects. Digital technologies can provide different forms of learning materials and allow students to progress according to their abilities and requirements.

The role of teachers in E-Learning is also significant. Teachers guide students in selecting appropriate learning resources, explain difficult concepts, provide feedback and motivate learners. They also design learning activities and monitor student participation. Thus, technology does not eliminate the need for teachers; instead, it can strengthen their role as facilitators and mentors.

E-Learning also supports blended learning, which combines face-to-face classroom teaching with online learning. This approach provides the benefits of direct teacher-student interaction together with the flexibility and resource availability of digital learning. Online assessments can further help teachers identify areas of difficulty and provide timely feedback.

Therefore, E-Learning is not simply a technological development. It can contribute to meaningful changes in teaching methods, student participation, learning resources and assessment practices.

Role of Learning in Modern Education

Learning is the central purpose of education. Modern learning is not limited to memorizing information but focuses on the development of knowledge, skills, attitudes, creativity, critical thinking and problem-solving abilities. E-Learning can contribute to these objectives when it is supported by appropriate teaching methods.

Learning helps students acquire knowledge and understand concepts. Digital resources provide opportunities to explore topics beyond classroom textbooks. Modern education also emphasizes communication, collaboration, critical thinking, problem-solving and digital skills. E-Learning can provide activities that support the development of these competencies.

Digital tools can promote creativity by enabling students to prepare presentations, projects, videos and other learning products. E-Learning also encourages independent learning because students can search for information and manage their learning activities. In a rapidly

changing society, lifelong learning is increasingly important, and digital platforms provide opportunities for continuous learning and professional development.

Learning also contributes to social development by encouraging communication, cooperation, confidence and interaction. Modern education should prepare students for higher education, employment and changing social conditions. Digital learning resources can provide information in different formats and support learners with diverse educational needs.

Thus, the purpose of modern education should be the holistic development of learners. E-Learning can support this objective when technology is integrated with sound pedagogy and appropriate teacher guidance.

Advantages of E-Learning

E-Learning provides several advantages to students, teachers and educational institutions. It provides flexibility by allowing learners to access educational content according to their time and circumstances. It also improves accessibility because digital resources can be accessed from different locations. Self-paced learning enables students to progress according to their individual learning speed and revisit difficult concepts when required.

E-Learning can make learning more interactive through multimedia content such as videos, animations, presentations and quizzes. Learners can access courses and educational resources beyond their geographical location, thereby increasing educational opportunities. It can also save time and reduce certain expenses associated with travel and physical learning resources.

Another important advantage is quick feedback. Online quizzes and assessments can provide immediate results and help students understand their performance. Regular use of digital platforms can improve digital competency, which is increasingly important in education and employment.

E-Learning also supports lifelong learning. Individuals can acquire new knowledge and skills at different stages of life according to their academic and professional needs. It can provide learning continuity when regular classroom attendance is difficult. These advantages make E-Learning an effective complement to conventional educational practices.

Disadvantages and Challenges of E-Learning

Despite its advantages, E-Learning has several limitations and challenges. One major concern is the reduction of face-to-face interaction. Direct interaction between teachers and students plays an important role in communication, motivation and social development, and this interaction may be limited in an online environment.

Technical problems can also affect learning. Poor internet connectivity, power interruptions, device problems and software difficulties may interrupt online classes and activities. The digital divide is another important challenge because not all learners have equal access to smartphones, computers, reliable internet and other digital facilities.

E-Learning requires learners to possess self-discipline, motivation and timemanagement skills. Students who require continuous personal supervision may find online learning difficult. Some subjects also require laboratory work, fieldwork and hands-on activities that cannot always be fully provided through digital platforms.

Excessive screen time may cause tiredness and reduced concentration. Online distractions such as social media, games and entertainment can affect students' attention. Teachers and students also require adequate digital literacy to use ELearning platforms effectively.

Furthermore, the quality and reliability of online content may vary, requiring students to receive appropriate guidance.

Therefore, E-Learning requires proper planning, teacher preparation, institutional support, digital infrastructure and equitable access to technology.

Conclusion and Future Perspectives

E-Learning has transformed modern education by making learning more flexible, accessible, interactive and learner-centred. Through computers, smartphones, tablets and internet-based platforms, students can access online classes, digital resources, virtual classrooms, assignments and assessments beyond the physical classroom. Its scope extends from school and higher education to teacher education, distance education, skill development, corporate training, mobile learning and lifelong learning.

E-Learning can promote independent learning, creativity, communication, collaboration and digital competency. However, challenges such as the digital divide, technical problems, lack of face-to-face interaction, limited practical experiences, online distractions and excessive screen time must be addressed. Effective E-Learning requires appropriate infrastructure, trained teachers, quality digital content and continuous learner support.

The future of education should not be based on replacing teachers or traditional education with technology. Instead, **blended learning**, which combines digital technology with face-to-face teaching, can provide the benefits of both approaches. Teachers remain essential for academic guidance, motivation, feedback, emotional support and human interaction.

In conclusion, E-Learning should be used as a **means of improving education rather than an end in itself**. When technology is meaningfully integrated with sound pedagogy, qualified teachers and active learner participation, it can contribute to a more flexible, inclusive, engaging and lifelong learning environment.

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***Format:** This version is structured as an **International Conference paper**, with **exactly 10 main sections**, continuous paragraph writing without bullet/sub-points, an abstract below 300 words, keywords, and APA-style references.*

INTEGRATION OF ARTIFICIAL INTELLIGENCE TO CHALLENGES AND QUALITY DEVELOPMENT IN HIGHER EDUCATION: AN ANALYSIS

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Abstract

Artificial Intelligence (AI) is rapidly transforming teaching and learning processes in the higher education system worldwide. My research paper is "Integration of Artificial Intelligence to Challenges and Quality Development in Higher Education: An Analysis". Methods: I analyse AI tools, systems, and applications for quality education in higher education through international reports, national policy documents, research articles, and descriptive and analytical studies using secondary data. Findings reveal that AI-based systems can be used to facilitate the teaching process, make it more effective and enhance student engagement and personalised learning paths. My research paper also addresses challenges such as inadequate infrastructure, lack of faculty training, high cost of development processes and privacy of data have been hindrances to the successful implementation of AI, particularly in the developing environment. My study concludes that AI can be transformative in terms of quality education in higher institutions of learning, and strategic planning, capacity-building, and ethical governance can be used to bring a more inclusive, student-centred and future-ready learning environment. At the institutional level, AI can be used to support data-driven planning, curriculum optimisation, and student retention, which can directly lead to quality improvement and SDG-4 goals.

Keywords: *Artificial Intelligence (AI), Higher Education, Teaching-Learning Practices, Quality Education*

Introduction:

Artificial Intelligence (AI) has brought significant transformations to higher education. Artificial Intelligence has become one of the most effective tools to develop teaching-learning practices in higher education institutions worldwide. The integration of AI in higher education supports adaptive learning, automated assessments, predictive analytics, virtual tutoring systems, and high-tech student services. The application of AI in the teaching-learning process of higher education is increasing to enhance the quality of instruction, personalized learning process and enhancement of academic decision-making. AI technologies in education will contribute considerably to Sustainable Development Goal 4 (Quality Education) because it has the potential to increase access and learning outcomes. The National Education Policy (NEP) 2020 focuses on digital transformation and proposes that higher education institutions implement emerging technologies like AI to support innovation, quality improvement, and global competitiveness. The level of AI

implementation in Indian higher education is not homogeneous, as a significant number of institutions do not have an appropriate digital infrastructure, skilled faculty, and a detailed plan of action. Artificial Intelligence affects the quality of teaching-learning and existing challenges and opportunities in higher education.

Literature Review

1. Bobula (2024), It has provided an understanding of context, facilitated the generation of language, offered multilingual support, and enabled adaptability for various educational purposes.
2. Baidoo-Anu and OwusuAnsah (2023) state that generative AI can create digital content—including humanlike text, images, video, and audio—by analysing patterns in existing data. Two categories of interest are generative adversarial networks (GANs) and generative pre-trained transformers (GPT).
3. Tenakwah (2023): The emergence of generative AI models such as GPT-2 and GPT-3 has broadened the scope of AI in educational contexts.
4. Richardson and Clesham (2021): The various institutions responded to AI in different ways; some still show reluctance in adopting the technology due to factors such as institutional inertia, risk aversion, and doubts about AI reliability.

Scope of The Study

AI-powered Teaching and Learning

- The integration of Artificial Intelligence into education marks the beginning of a new era, positively affecting both teachers and learners. Among its various contributions, improved accessibility stands out as the most significant. AI-based learning platforms are evolving and taking the initiative in creating educational content tailored to individual learners, providing specific context for each course, and making real-time instructional materials available during the learning process. The AI-powered chatbot can immediately respond to students' inquiries, offer in-depth explanations of concepts, point out additional resources, provide personal tutoring, assist with assignments, prepare students for standardised tests, and act as a therapist during mental distress, all at once, functioning like virtual teaching assistants.

Developing Student Engagement Through AI

- AI integration in education not only improves student engagement but also provides interactive and immersive learning experiences that ultimately boost motivation and academic outcomes. The use of AI-based tools has significantly expanded the reach of education by introducing virtual and augmented reality, which provide access to interactive experiences that surpass traditional teaching methods. The application of Generative AI (GenAI) in the classroom is a key factor, as it not only cultivates learners' motivation but also attracts them through constantly changing learning strategies and adaptive pathways. AI has been widely utilised in education to create learning

environments that are both supportive and stimulating, enabling students to feel more confident in their abilities and reducing anxiety about learning.

Statement of the Problem

Problem of my research paper " **Integration of Artificial Intelligence to Challenges and Quality Development in Higher Education: An Analysis ".**

Objectives of the Study

1. To find out the integration of AI in teaching and learning practices in higher education.
2. To find out the challenges faced by higher education institutions in applying AI.
3. To find out the impact of AI on quality learning outcomes in higher education.
4. To find out the future implications of AI for higher education.

Methodology

My research paper has taken a descriptive and analytical research method to address my paper. It is based on secondary data to explore the integration of Artificial Intelligence (AI) in teaching and learning practices in higher education institutions. My research methodology includes reviewing the available literature, international reports, policy documents, and institutional data to find out how AI can be integrated to develop the quality of higher education.

My research paper identified secondary data applicable to AI in higher education institutions.

1. Survey and analytical papers related to teaching-learning innovation of AI in higher education.
2. Peer-reviewed academic journals on educational technology and higher education.
3. International Reports from (UNESCO, OECD, WEF) focusing on AI and education.
4. Indian educational bodies such as UGC, AICTE, and Ministry of Education reports.
5. Publications about AI trends in the industry.
6. EdTech platforms and case studies (e.g., Coursera, SWAYAM)

Finding of The Study

My research paper uses qualitative content analysis and comparative thematic analysis to interpret the collected data. The interpretation relies on the synthesis of information from research articles on AI-enabled learning tools and student performance, documents on Indian higher education digitalisation, data on global AI adoption, Challenges such as training gaps, infrastructure, and data privacy and opportunities for AI-driven quality development.

Objective 1: To find out the integration of AI in teaching-learning practices in higher education

Conceptual Representation of AI Integration in Higher Education

SL. No	ITEMS	LEVEL OF INTEGRATION
1	Student Level AI Use	Very High
2	Faculty Level AI Readiness	High
3	Institutional AI Adoption	High
4	Policy & Governance Support	Moderate
5	Infrastructure & Digital Capacity	Moderate

Table 1: Conceptual Representation of AI Integration in Higher Education

The secondary data reveal that adaptive learning systems, automated assessment systems, AI chat bots, plagiarism detection tools, and predictive analytics are all AI tools that are becoming more popular within institutions of higher learning worldwide. In India, NEP 2020 focuses on the incorporation of digital, as well as AI-based tools in higher education. AICTE (2023) and EdTech industry analyses indicate that colleges are increasingly integrating AI-based learning management systems and virtual assistants to help instructors in classrooms. AI utilisation varies between urban and rural institutions.

Conceptual Representation of AI Integration in Higher Education: student-level AI uses in very high level. Faculty-level AI Readiness is at a high level of integration. Institutional AI Adoption is at a high level of integration. Policy & Governance Support in moderate level of integration. Infrastructure & Digital Capacity in moderate level of integration.

AI tools are improving the delivery of instruction and student interaction; colleges that have weaker infrastructure continue to be left behind and need more robust digital ecosystems to ensure complete integration of AI.

Objective 2: To find out the challenges faced by higher educational institutions in applying AI

SL. No	Challenges faced by Higher Education	LEVEL OF CHALLENGES
1	High Cost of AI Adoption	Very High
2	Lack of Digital Infrastructure	High
3	Shortage of AI Trend Faculty	High
4	Tata Privacy & Security Concern	Very High
5	Faculty Resistance to Change	Moderate
6	Lack of AI Govt. Policies	High
7	Limited Training Capacity Building	High

Table-2: Challenges faced by Higher Education Institutions in developing AI

Challenges faced by Higher Education Institutions in developing AI, from most significant to the use of AI. High Cost of AI Adoption is very high. Lack of Digital Infrastructure is high. Shortage of AI-trained faculty is high. Tata Privacy & security concerns are very high. Faculty Resistance to Change is moderate. Lack of AI government support is high. Limited Training Capacity Building is at a high level. Higher Education Institutions have listed AI as their strategic priority, which indicates an opportunity to develop more strategic planning.

Objective 3: To find out the impact of AI on quality learning outcomes in higher education.

SL. No	Impact of AI on Quality Education	LEVEL OF INTEGRATION
1	Personalized Learning	Very High

2	Student Engagement & Motivation	High
3	Assessment & Feedback Quality	Very High
4	Academic Performance & Recantation	Moderate
5	Inclusivity & Accessibility	Moderate
6	Employability & Skill Development	Very High
7	Institutional Quality Enhancement	Moderate

Table. 3: Impact of AI on Quality Education and Student Learning Outcomes

AI-based personalised learning is a highly effective way of improving learning outcomes. These features are useful in raising the benchmarks of education standards. AI is positively correlated with the quality of education, enhancing personalisation and advancements in feedback systems. The impact of AI on Quality Education and Student Learning Outcomes, Personalised Learning is very high. Student Engagement & Motivation is high. Assessment & Feedback Quality is very high. Academic Performance & Retention is moderate. Inclusivity & Accessibility is moderate. Employability & Skill Development is very high. Institutional Quality Enhancement is moderate.

Objective 4: To find out the future implications of AI for higher education.

The future of AI in Indian higher education is promising, presenting numerous opportunities to enhance learning experiences and institutional efficiencies. Artificial intelligence can reshape higher education into more customised, creative and student-oriented. NEP 2020 in India is concerned with digital transformation and creates new opportunities for AI-based skill development, smart classrooms, and hybrid learning models. Artificial Intelligence can facilitate informed decision-making, enhance the capacities of research, and innovate the ways of teaching. AI has enormous opportunities to transform the education system into a more flexible, effective, and competitive system across the world.

Conclusion

The global and Indian trends reflect the accelerated creation of AI technologies, including adaptive learning systems, intelligent tutoring, automated assessment, learning analytics and virtual labs. These technologies enhance the quality of instruction, lessen the workload of the faculty, and facilitate individualised and student- centred learning, resulting in improved engagement, understanding of concepts, and academic performance. At the institutional level, AI can be used to support data-driven planning, curriculum optimisation, and student retention, which can directly lead to quality improvement and SDG-4 goals. AI-based innovation, including smart classes, predictive analytics, virtual campuses and smart academic systems, has massive potential in the future of higher education. With proper implementation, AI can revolutionise higher education.

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ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION: EMERGING INNOVATIONS, RESEARCH PERSPECTIVES AND CASE STUDIES WITH SPECIAL REFERENCE TO KARNATAKA

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Abstract

Artificial Intelligence (AI), particularly Generative Artificial Intelligence (GenAI), has emerged as one of the most influential technological developments shaping contemporary higher education. Unlike earlier educational technologies that primarily supported the delivery and management of information, generative AI systems can produce explanations, questions, text, code, images and other forms of academic content. This development is transforming the relationship between teachers, students and educational resources and is compelling higher education institutions to reconsider established approaches to teaching, learning, assessment and research. The rapid expansion of these technologies has created significant opportunities for personalised learning, pedagogical innovation, academic productivity and research support, while simultaneously raising concerns regarding academic integrity, accuracy, privacy, equity, overdependence and human agency. This paper examines the emerging role of Artificial Intelligence in higher education, with particular reference to Karnataka. It reviews recent literature on AI-enabled teaching and learning, AI literacy, faculty adoption, assessment, research and institutional governance, with particular attention to studies published during 2024–2026. The paper argues that the educational value of AI does not arise simply from access to sophisticated technological tools but from the quality of pedagogical and institutional practices surrounding their use. Recent systematic reviews and meta-analyses indicate that GenAI can positively influence academic achievement, language skills, motivation and higher-order thinking, although its effects vary according to the learner, discipline, duration, instructional context1327 and manner of implementation. The paper further examines emerging case-study eviden1328-ce and identifies implications for higher education institutions in Karnataka. It concludes that institutions should move from a technology-centred model of AI adoption towards a human-centred model in which AI augments, rather than replaces, the intellectual, pedagogical and ethical functions of teachers and researchers.

Keywords: *Artificial Intelligence, Generative AI, Higher Education, Educational Innovation, AI Literacy, Pedagogy, Research, Academic Integrity, Karnataka*

I. Introduction

The pursuit of quality and relevance has remained at the centre of higher-education reform

across the world. Universities and colleges are increasingly expected to cultivate critical thinking, creativity, problem-solving ability, research competence, innovation and lifelong learning rather than merely transmit established knowledge. At the same time, rapid technological change is altering the skills required by graduates and the ways in which knowledge is produced, accessed and evaluated. Within this changing environment, Artificial Intelligence has emerged as one of the most consequential technologies influencing the future of education. Reviews of the wider field show that AI in education has developed from earlier applications such as intelligent tutoring, prediction and adaptive systems towards a much broader ecosystem of generative and conversational technologies (Zawacki-Richter et al., 2019; Bond et al., 2024; Wang et al., 2024).

The emergence of Generative Artificial Intelligence has accelerated this transformation considerably. The public availability of systems such as ChatGPT has brought sophisticated language-generation capabilities into everyday academic life. Students can use such systems to obtain explanations, generate examples, practise questions, improve language, explore ideas and obtain programming assistance. Teachers can employ them for lesson planning, preparation of learning resources, formative feedback and assessment design, while researchers can use AI-enabled systems for literature exploration, coding assistance, transcription and language refinement. Baig and Yadegaridehkordi (2024), in a systematic review of 57 studies, found that ChatGPT applications in higher education were already extending across academic staff, students, researchers and non-academic users. Bhullar et al. (2024) similarly identified academic integrity, learning environments, student engagement and scholarly research as major clusters in the emerging literature.

The transformation is different from the introduction of earlier educational technologies because generative AI can participate directly in the production of apparently original academic content. This has created what UNESCO describes as a teacher-AI-student dynamic, requiring a reconsideration of teachers' roles and competencies (Miao & Cukurova, 2024). The issue is therefore not simply whether AI should be available in universities, but how it should be integrated into educational processes without weakening human agency, academic standards and intellectual development.

Recent literature shows both promise and uncertainty. Chen and Cheung (2025), in a systematic review and meta-analysis of 57 studies and 97 effect estimates, reported positive effects of GenAI on language skills, academic achievement, affective-motivational outcomes and higher-order thinking, although they found no statistically significant effect on metacognition. Sun and Zhou (2024), using a meta-analytic approach involving 28 articles, 65 independent studies and 1,909 participants, likewise examined the effect of GenAI on college students' academic achievement. At the same time, Jensen et al. (2025) caution that many early claims about GenAI in higher education were stronger than the available evidence warranted. The emerging evidence therefore calls for neither uncritical enthusiasm nor outright rejection, but systematic and context-sensitive educational research.

The question is particularly significant for India and for Karnataka. Karnataka combines a large higher-education ecosystem with a strong technology sector, start-up culture and research-oriented industries. This provides favourable conditions for experimentation with AI-enabled education, but it also creates a responsibility to ensure that technological adoption is accompanied by faculty competence, student AI literacy, equitable access and appropriate governance. The present paper therefore examines AI in higher education as an educational transformation and considers how research and innovation can contribute to responsible implementation in Karnataka.

II. Theoretical Framework and AI Competency

Education is fundamentally a human process involving knowledge, judgement, relationships, motivation, values and social interaction. Consequently, the educational significance of AI cannot be understood solely through the technical capabilities of AI systems. Bond et al. (2024), in a meta-systematic review of AI in higher education, call for greater ethics, collaboration and methodological rigour in the field. Their observation is important because technological capability can easily become the starting point of educational decision-making, whereas sound educational practice requires the learning objective to remain primary.

UNESCO's AI Competency Framework for Teachers provides a useful conceptual basis for this transition. Miao and Cukurova (2024) identify fifteen competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. The framework moves discussion beyond the narrow question of whether teachers can operate an AI tool and instead considers whether they understand its pedagogical, ethical and professional implications. For students, Miao, Shiohira, and Lao (2024) similarly propose twelve competencies across human-centred mindset, ethics of AI, AI techniques and applications, and AI system design.

AI competence is becoming an important bridge between access and responsible use. Delcker et al. (2024), examining 634 first-year students, found that attitudes towards AI significantly explained intended use of AI tools and that perceived benefits influenced students' perception of AI systems as potential cooperation partners. In a complementary study, Delcker, Heil, and Ifenthaler (2025) developed an evidence-based instrument for assessing teachers' AI competence and showed that AI competence comprises multiple dimensions that are not necessarily equally developed. These findings suggest that providing AI tools without developing the competence to use them critically may produce uneven or superficial adoption.

The theoretical implication is that AI should not replace pedagogy but should be subordinated to it. A teacher may prohibit AI during an initial problem-solving exercise because independent reasoning is itself the learning objective, while subsequently allowing AI to critique the student's solution. The technology remains the same, but its educational meaning changes according to the pedagogical purpose. Qian (2025) similarly argues that GenAI needs to be examined through its pedagogical applications, while Wang et al. (2024)

demonstrate that AI in education encompasses diverse applications and research traditions rather than one uniform technological model.

The human-centred approach is especially important because AI can simultaneously expand and constrain learner agency. Students can receive rapid explanations and personalised assistance, but excessive dependence can reduce opportunities for independent reasoning. Nasr et al. (2026), in a systematic review of GenAI and critical thinking in higher education, highlight precisely this tension between AI-assisted performance and authentic intellectual effort. The objective should therefore be to develop students who can use AI intelligently without surrendering their capacity to question, evaluate and create.

III. AI-Enabled Teaching, Learning, Assessment and Research

Generative AI has introduced new possibilities for teaching and learning by enabling students to obtain immediate explanations and alternative representations of academic concepts. A student who finds a particular explanation difficult can request a simpler explanation, a worked example, an analogy or a set of practice questions. Such interaction can provide additional support outside conventional classroom hours. Qian (2025) identifies creativity, critical thinking, learning autonomy and prompt literacy as important emerging themes in the pedagogical application of GenAI.

Systematic evidence indicates that the effects of GenAI are not uniform. Chen and Cheung (2025) found positive effects across several learning outcomes, but no significant effect on metacognition. Daniel (2025), reviewing 158 studies published between 2021 and 2024, similarly reports substantial attention to cognitive, technical and interpersonal skills. These findings suggest that AI can support learning when it is embedded in appropriate instructional designs, but it does not automatically develop self-regulation or disciplinary judgement.

Personalisation is one of the most promising applications. AI systems can provide additional explanations and practice opportunities to learners with different levels of prior knowledge. Heil et al. (2025), studying 223 students across three higher-education institutions, found that students' AI competence significantly influenced how they evaluated different GenAI tools for learning and assessment. The finding is important because it suggests that the value students obtain from AI depends partly on their own competence and not merely on the sophistication of the tool.

The transformation of assessment is equally significant. Xia et al. (2024), in a scoping review of 32 empirical studies, argue that assessment needs to be reconsidered in order to cultivate self-regulated learning, responsible learning and integrity. Mao et al. (2024) likewise examine the opportunities and challenges created by GenAI for educational assessment. Fischer et al. (2024), studying students' use of GenAI in a written assessment, found that students' use of AI could neglect critical-thinking dimensions when writing became primarily a generation task. These findings point towards assessment designs that require explanation, reflection, demonstration and application rather than merely submission of polished text.

Academic integrity is not simply a problem of detecting AI-generated text. It is also a

question of what universities value as evidence of learning. Kofinas et al. (2025) examine the impact of GenAI on the integrity of authentic assessments and demonstrate why assessment design itself must evolve. Cotton et al. (2024) similarly argue that academic integrity needs to be reconsidered in the context of generative systems. The challenge is therefore to design assessment in which students demonstrate intellectual ownership, reasoning and application even when AI is permitted as a support tool.

AI is also changing academic research. Researchers can employ AI to assist with literature exploration, coding, transcription, data organisation and language editing. However, research remains fundamentally dependent on judgement: identifying meaningful problems, selecting methods, evaluating evidence and interpreting results cannot simply be delegated to a generative system. Baig and Yadegaridehkordi (2024) note the expanding use of ChatGPT by researchers, while Bhullar et al. (2024) identify scholarly research as a major theme in the literature. Responsible research practice therefore requires verification of AI-generated information against authoritative sources and transparency concerning substantive AI assistance.

The classroom and research environment consequently require a new balance. AI should be used where it adds cognitive or pedagogical value, while activities whose educational purpose is independent reasoning should retain meaningful human effort. This distinction allows institutions to move from the question 'Can AI perform this task?' to the more important question 'What kind of learning occurs when AI performs this task?'.

IV. Research, Innovation and Case Studies

The conference theme of research, innovation and case studies is particularly relevant because the field is moving from conceptual discussion towards evidence of implementation. Belkina et al. (2025), in a systematic review of empirical case studies, found that GenAI implementation in higher education spans disciplines, participant groups, locations and research methods, but also identified shortages of empirical evidence on innovative uses. The study's use of the Conversational Framework and SAMR model illustrates the importance of examining not only whether AI is used but how deeply it changes pedagogical practice.

A useful case pattern is the use of AI as a learning assistant rather than an answer generator. Students can first attempt a problem independently, use AI to obtain hints or alternative explanations, verify the response against textbooks or scholarly sources, and finally revise their own solution. This model preserves learner agency while exploiting the speed and flexibility of AI. Sandu, Gide, and Elkhodr (2024), in an Australian higher-education case study, examined the role and impact of ChatGPT in educational practice and demonstrated the importance of considering both opportunities and pedagogical limitations.

A second case concerns assessment. Fischer et al. (2024) studied an experiential exercise involving postgraduate management students in which students reflected on their use of AI during a written assessment. Such an approach converts AI from an invisible source of assistance into an explicit object of reflection. Students are required to explain what they used

AI for, what they accepted or rejected, and how they evaluated the resulting content. This provides an alternative to assessment strategies that focus exclusively on detection.

A third case involves student AI competence. Delcker et al. (2024) demonstrated that students' attitudes and perceived benefits influence their use of AI tools. Heil et al. (2025) further showed that students with different levels of AI competence evaluate tools differently. Together, these findings suggest that institutions should not assume that students will automatically become effective AI users simply because tools are available to them. AI literacy needs to be deliberately incorporated into academic programmes.

A fourth case is faculty development. Baggia, Tratnik, and Brezavšček (2026), in a systematic review and meta-analytic study of university teachers' perceptions and practices with GenAI, demonstrate the importance of understanding faculty attitudes and actual use. Delcker et al. (2025) similarly show that teacher AI competence has multiple dimensions. Faculty development therefore needs to extend beyond demonstrations of individual applications towards pedagogical experimentation, ethical reflection, assessment redesign and discipline-specific practice.

These cases have direct relevance for Karnataka. Engineering and technology-oriented institutions can use AI in project-based learning, programming, design, research and technical communication, while teacher-education institutions can examine AI-supported pedagogy and AI literacy. However, innovation should be documented systematically. An institutional pilot should specify the educational problem, define the role of AI, collect evidence of student and faculty experiences, evaluate outcomes and document limitations. Such an approach transforms isolated experimentation into research-informed institutional learning.

The most important lesson from emerging case studies is that successful AI implementation is pedagogical rather than merely technological. The 2026 systematic review by Razami et al. (2026) shows the expanding role of GenAI in learning analytics and decision support, while Bacalso et al. (2026) demonstrate the growing importance of institutional approaches to GenAI management. The direction of travel is therefore from individual experimentation towards institutionally supported ecosystems of responsible use.

V. Challenges, Ethics, Equity and Institutional Governance

The benefits of AI cannot be separated from its risks. One of the most immediate concerns is academic integrity. Bittle and El-Gayar (2025) identify academic integrity as a major research area in the emerging GenAI literature, while Kangwa (2025) examines factors that can support a balance between academic integrity and effective use of GenAI. These studies suggest that blanket prohibition is unlikely to provide a sustainable solution. Institutions need clear expectations regarding acceptable assistance, disclosure and authorship, alongside assessment designs that reward genuine understanding.

Another concern is accuracy. Generative AI systems can produce fluent but incorrect information. The problem is particularly serious in higher education because students may interpret linguistic confidence as factual reliability. Jensen et al. (2025) demonstrate why

early claims about GenAI should be examined critically rather than accepted at face value. AI literacy must therefore include source verification, cross-checking and awareness of hallucination and uncertainty.

Equity represents another major challenge. Access to devices, connectivity, digital skills and premium AI services is uneven. Eddine, Gide, and Al-Sabbagh (2026), in a systematic evidence mapping study of GenAI and digital-divide phenomena in higher education, highlight the importance of examining AI adoption through the lens of digital equity. For Karnataka, this is particularly relevant because institutions differ substantially in infrastructure and student populations. AI-enabled education should not create an additional divide between students who can access sophisticated tools and those who cannot.

Privacy and data governance also require careful consideration. Students and faculty may unknowingly submit personal, institutional or research-sensitive information to external AI platforms. Institutional guidelines therefore need to address data protection, confidentiality, acceptable platforms and responsible handling of AI-generated material. UNESCO (Miao & Cukurova, 2024) places ethics, human agency, accountability and protection of rights at the centre of teacher AI competence, while Bacalso et al. (2026) show that institutional governance is becoming a distinct research and policy area.

Assessment presents a particularly complex governance problem. Luo (2024) critically examines how universities have framed the originality problem in GenAI assessment policies, while Kofinas et al. (2025) show that authentic assessment itself is affected by GenAI. The challenge is not simply to find a perfect detection mechanism. Rather, institutions need permission to redesign, iterate and experiment. The assessment problem is therefore partly pedagogical and partly institutional.

There is also a risk of cognitive overdependence. If students routinely delegate explanation, writing, problem-solving and idea generation to AI, the technology may gradually replace precisely those cognitive activities that higher education seeks to cultivate. Nasr et al. (2026) identify this tension in their review of GenAI and critical thinking. Responsible adoption therefore requires a principle of purposeful use: students should use AI where it expands learning opportunities, but retain meaningful responsibility for reasoning, judgement and creation.

Institutional governance should consequently be adaptive rather than static. Qian (2026) examines emerging institutional policy approaches to governing GenAI and shows the movement towards support ecosystems rather than simple prohibition. Tan (2026) similarly synthesises factors influencing AI adoption and proposes a framework for understanding adoption beyond technological availability. Institutions should therefore combine policy, faculty development, student education, assessment reform and ongoing evaluation.

VI. Implications for Karnataka and Conclusion

Karnataka occupies a distinctive position in India's educational and technological landscape. Its universities and colleges coexist with a large technology sector, a strong start-up

ecosystem and a substantial pool of engineering and scientific talent. This environment provides considerable opportunities for educational experimentation with Artificial Intelligence. At the same time, technological proximity does not automatically produce educational readiness. Institutions require faculty members who understand AI, students who can use it critically, and administrators capable of establishing appropriate governance frameworks.

The first implication is the need for systematic faculty development. Professional learning should move beyond demonstrations of popular AI tools and address AI-supported pedagogy, assessment redesign, ethical considerations, verification strategies and discipline-specific applications. The work of Delcker et al. (2025), Miao and Cukurova (2024), and Baggia et al. (2026) indicates that teacher competence is multidimensional and should therefore be developed through sustained professional learning rather than isolated workshops.

The second implication is student AI literacy. Students need to understand not only how to use AI but also how AI works at a conceptual level, what its limitations are, how bias and misinformation can occur, how to protect data, and when AI assistance is academically appropriate. Miao, Shiohira, and Lao (2024) provide a useful competency framework for this purpose, while Delcker et al. (2024) and Heil et al. (2025) demonstrate empirically why differences in AI competence matter for student use and evaluation of AI tools.

The third implication concerns assessment. Higher education institutions should progressively complement conventional written assignments with authentic tasks involving oral defence, reflection, design, experimentation, problem-solving and demonstration. Xia et al. (2024), Fischer et al. (2024), Mao et al. (2024) and Kofinas et al. (2025) collectively indicate that assessment must evolve because GenAI has changed the relationship between submitted products and individual intellectual effort.

The fourth implication is research and innovation. Karnataka's institutions can make a significant contribution by conducting empirical studies of AI-supported teaching, student AI competence, faculty adoption, assessment transformation and institutional governance. Recent reviews repeatedly identify the shortage of rigorous implementation evidence (Belkina et al., 2025; Qian, 2025). Local research is therefore essential because educational effects are shaped by language, discipline, institutional culture, socioeconomic conditions and technological access.

The fifth implication is university-industry collaboration. Karnataka's technology companies and start-ups can collaborate with universities to develop educational applications, faculty-development programmes and student innovation projects. Such collaboration should, however, remain guided by educational objectives, transparency and public interest rather than by technological novelty alone. The state's technological strength should be converted into educational leadership through evidence-based experimentation and responsible governance.

The literature reviewed indicates that Artificial Intelligence is no longer a distant technological possibility for higher education. It has already become part of teaching, learning, assessment and research. The central challenge is therefore not whether higher education should engage with AI, but how it should do so responsibly and meaningfully. Recent systematic reviews and empirical studies show that AI can contribute positively to

learning outcomes and educational productivity, but its benefits are strongly dependent on pedagogical design, AI competence, verification, assessment practices and institutional context (Chen & Cheung, 2025; Qian, 2025; Baggia et al., 2026).

Ultimately, the future of higher education should not be understood as a contest between artificial intelligence and human intelligence. AI can process information, generate possibilities and provide rapid assistance; human beings provide judgement, values, empathy, creativity and responsibility. For Karnataka to emerge as a leader in AI-enabled higher education, the objective should therefore not be simply to become an early adopter of AI technologies. It should aspire to become a responsible innovator in AI-enabled education, demonstrating how technological capability can be combined with human agency, academic integrity, equity and educational purpose.

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EXAMINING THE READINESS–ADOPTION NEXUS: A SYSTEMATIC NEEDS ASSESSMENT OF ARTIFICIAL INTELLIGENCE INTEGRATION AMONG SCIENCE FACULTY IN HIGHER EDUCATION INSTITUTIONS

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Abstract

The growing pace of development of the field of Artificial Intelligence (AI) is changing the manner in which pedagogical processes in higher education take place, particularly in the science-related disciplines. This paper examines awareness, usage, AI and science faculty member perceptions of AI training requirement by the structured needs assessment survey. In March 2026, a total of 50 faculty members across the spectrum of scientific disciplines took part in the study. The findings show that most of the participants possess the basic understanding of AI, yet, their conceptual and practical understanding of AI is still low. AI is used by the majority of faculty members for academic writing, information gathering, and content creation. Nonetheless, the majority of respondents had a favorable opinion of AI since it is thought to improve productivity in research, efficiency, and student interaction. Training problems, a lack of institutional support, ethical concerns, and ignorance of educational and specialized AI technologies are other impediments that have been highlighted. This study indicates that there is a strong demand for structured faculty development programs. This will involve ethics, discipline-focused applications, and practical training. These results are significant because they emphasize that in order to successfully integrate AI in science education, a methodical capacity-building process is required. The study adds to the body of knowledge on AI-assisted pedagogy and offers some potential policy and career development implications for higher education.

Keywords: *Artificial Intelligence, Science Faculty Development, Higher Education Pedagogy, AI Integration in Teaching, Faculty Training Needs, Educational Technology Adoption*

Introduction

The integration of Artificial Intelligence (AI) into higher education has seen a transformative change which in turn has influenced teaching, learning, and assessment as well as research in many fields. There is no doubt that the use of AI can have a significant impact on performance and outcomes, especially in science education where the complexity of the content and volume of data can make it difficult to achieve optimum results. Furthermore, we observe the use of machine learning and natural language processing to help develop personalised study plans, and the use of intelligent tutoring systems and other AI based applications to release administrative staff time and for in-depth data analysis (Zawacki-

Richter et al., 2019; Holmes et al., 2022). The emergence of the new technology and even the global trend that is moving towards digital and blended learning spaces, only added to the popularity of AI in education. The faculty members will not only be called upon to acquire new teaching methods, but also new technologies in the teaching methods. However, the willingness, awareness, and ability of the faculty are key to successful introduction of AI in higher education (Bond et al., 2023). It is more significant when it comes to science education, where the processes of visualization, simulation and analysis should be engaged, which can lead to the comprehension of more complicated scientific phenomena (Zawacki-Richter et al., 2019). Despite that we see a growth in interest toward AI, what we have instead is a gap which has developed between the put forth promise of AI technologies and the real-world application of AI in higher education. Also, it is reported that in large part our educators are still lacking in terms of the expertise, training, and what we may term institutional will to put AI into practice in the classroom (UNESCO, 2023). Also, we see that issues of ethics, data privacy, and academic integrity have come to the fore as we report an increased adoption of generative AI systems (Kasneci et al., 2023) (Figure 1). The policy measures, like the National Education Policy (NEP) 2020, which presents the idea of the use of technology in the teaching and learning process, explain the digitalization of education in India. The policy is based on the need to further professionally develop the faculty members in the provision of digital skills and innovative pedagogical skills to them. However, the readiness of the faculty members to use AI technologies in their teaching process is among the factors that will have to be studied in a systematic way (NEP, 2020 and Alshorman, 2024). Science faculty are vital in nurturing future researchers, professionals and innovators. What they bring to the table in terms of successful application of AI to the teaching process greatly improves the student experience and performance (Luckin et al., 2016). There are a wide range of possible applications for AI in science education, such as creating interactive simulations, providing immediate feedback, data-informed instruction, and research. Furthermore, note that the use of AI is not widespread and is largely contingent upon experiences of the past, institutional arrangements and the perceived value of the AI (Selwyn, 2022).

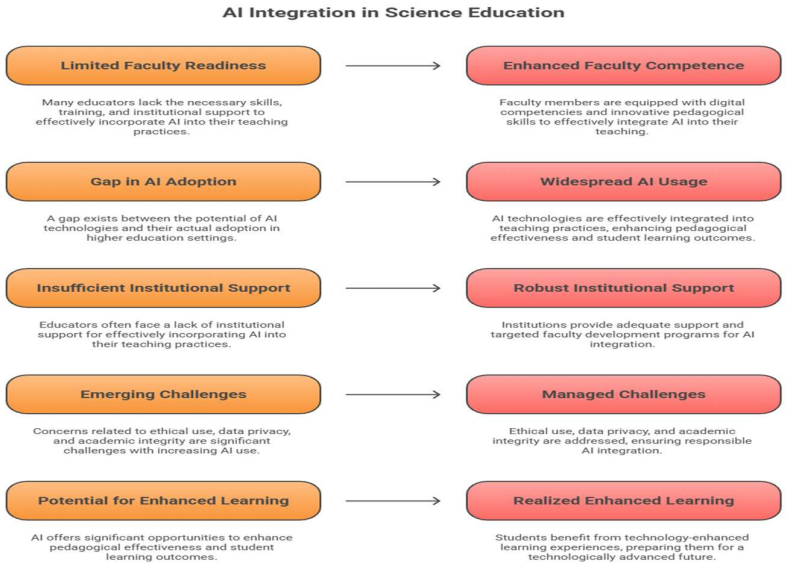

Figure 1: This figure illustrates the transition from existing challenges to desired outcomes in AI integration within science education. It highlights gaps in faculty readiness, adoption, and institutional support, while emphasizing the potential for enhanced teaching effectiveness, widespread AI usage, and improved learning outcomes through targeted training, ethical practices, and strengthened institutional frameworks (Sourced: Napkin AI).

With regard to this, there is a need for extensive research on the current knowledge, understanding and application of AI in science faculty. The study on needs assessment is very useful in identifying the gaps in faculty competency and the needed skills to bridge the gaps for preparing Specialized Training Programs in faculty development. The empirical results of these studies suggest the possibility of informing institutional strategies and the policy decisions based on technology, as put forward by Darayseh (2023) and Almasri (2024).

The current study will focus on the opinions of higher education science faculty regarding the application of AI, as well as its problems and practices. The study will provide a comprehensive picture of teachers' preparedness to employ AI in the classroom by examining faculty awareness, use patterns, attitudes, and impediments. Additionally, it outlines the precise domains in which professional development and training are necessary (Ofosu and others, 2024).

Specifically, the work could be implemented in the current education system where the teacher's role has been transformed from an information provider to technology-assisted learning facilitator (Mah et al., 2024). The current study's conclusions will be relevant to the body of research on artificial intelligence in education and offer some useful ideas for creating faculty development initiatives. Finally, building the capacity of faculties to implement AI in science education will play a key role in enhancing the quality of science teaching and equipping students for future technological advancements (Najjar et al., 2025 and Kim et al., 2025).

In addition, the integration of AI into science education must be viewed not only as a technological upgrade but as a pedagogical transformation that redefines the teacher–student relationship. Recent scholarship emphasizes that effective AI adoption requires a dual focus on technical proficiency and pedagogical innovation, ensuring that faculty can adapt AI tools to diverse instructional contexts rather than applying them superficially (Zawacki-Richter et al., 2019).

Instructors, then, should focus on reflective practice as part of faculty development efforts, and engage in critical reflection on the impact of AI on curriculum design, assessment methods, and student engagement. Also, institutional policies need to prioritize equity and inclusivity in the implementation of AI, taking into account issues such as accessibility and the digital divide (Holmes et al., 2022). The interdisciplinary nature of AI education, along with ongoing professional development, will build sustainable ecosystems where AI is used to inspire innovation, not just add to the pedagogical toolkit. This comprehensive strategy will not just improve the quality of science teaching but also help students to become critical

and flexible thinkers in the world of complex technologies. In conclusion, the successful integration of AI into education demands a harmony of values and vision, making sure that its use adds to the larger-than-that of higher education.

Methodology

The study adopted a descriptive survey design to assess the awareness, usage, perceptions, and training needs related to Artificial Intelligence among science faculty members in higher education.

Participants

The study involved around 50 faculty members from various science disciplines, including life sciences, physics, engineering and allied fields. Participants were drawn from different higher education institutions, ensuring diversity in academic backgrounds and teaching experiences.

Data Collection/Survey design

The present study employed a descriptive cross-sectional survey design to systematically investigate the awareness, usage patterns, perceptions, and training needs related to Artificial Intelligence (AI) among science faculty members in higher education.

Research Design

A quantitative research approach was adopted to obtain measurable insights into faculty engagement with AI. The descriptive design was considered appropriate as it enables the analysis of existing conditions without manipulation of variables, thereby providing a realistic representation of current practices and perceptions.

Instrument Development

Data were collected using a structured questionnaire specifically designed for the study. The instrument was developed based on an extensive review of recent literature on AI in higher education and faculty competency frameworks. It comprised multiple sections, including:

- Demographic profile of respondents
- Awareness and conceptual understanding of AI
- Current usage of AI tools in teaching, research, and assessment
- Perceived benefits of AI integration
- Challenges and barriers to AI adoption
- Training needs and professional development preferences

The questionnaire primarily included close-ended items, such as multiple-choice questions and five-point Likert scale statements (ranging from strongly disagree to strongly agree), to ensure consistency and ease of quantitative analysis (Figure 2).

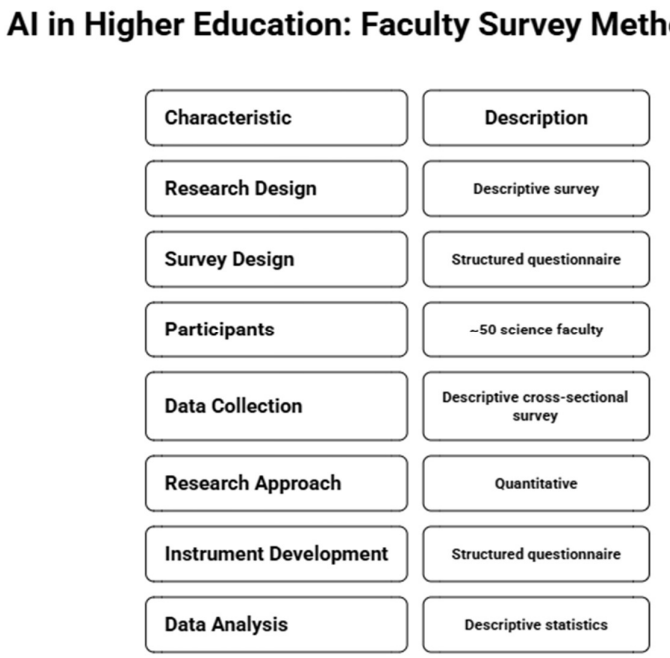

Figure 2: Faculty survey methodology flowchart

Data Analysis

The collected data were analyzed using descriptive statistical techniques, including frequency distribution and percentage analysis. The analysis focused on identifying trends in awareness, usage patterns, perceived benefits, and challenges associated with AI integration.

Results and Discussion

The study findings (collected in the month of March, 2026 as shown in Figure 3) are valuable data on the present situation in the use of AI among faculty members in higher education science. The results show that although the overall knowledge about AI is present, the level of knowledge differs considerably among the participants. The majority of the faculty are in the initial phases of AI implementation, mainly utilizing it in simple academic activities like content creation and information search.

The analysis also shows that there is a positive view of AI, and the faculty sees it as a possible source of increased teaching effectiveness, better student interaction, and research-facilitating activities. Nevertheless, awareness-to-implementation is still incomplete because of various issues, such as a lack of training, the absence of knowledge about AI tools, ethical issues, and institutional barriers.

The results discussion is used to identify the disparity between the perceived potential and actual use of AI in the teaching practices. It highlights the importance of faculty development programmes that are structured, based on hands-on training, application of discipline-specific training and ethical issues. These results are in line with the recent literature that emphasized the significance of capacity building and institutional support in the advancement of AI

integration in education.

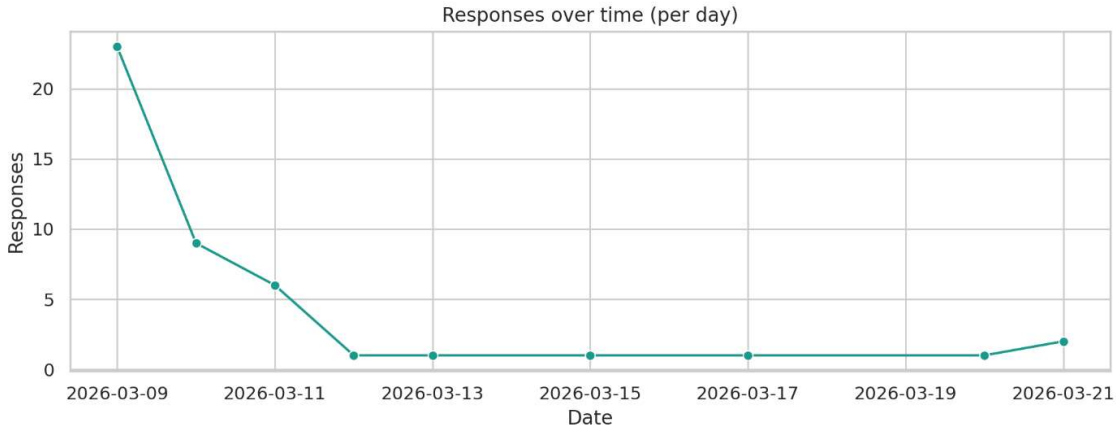

Figure 3: This figure illustrates the distribution of survey responses collected over time on a daily basis. A sharp peak in responses is observed at the beginning of the data collection period, indicating high initial participation. This is followed by a rapid decline, with responses stabilizing at a minimal level for the remaining days. A slight increase toward the end suggests a marginal resurgence in engagement, possibly due to reminders or follow-up efforts. Overall, the trend reflects strong early interest followed by reduced participant activity over time.

The various reasons faculty members use AI tools that provide multiple answers are shown in Figure 4. The most common usage of AI is in research aid, which means that academics mostly employ it to support scholarly and academic research. The creation of lecture notes and diagrams/visuals, which indicate a significant desire to improve instructional materials and classroom presentation, closely follow this. The fact that a sizable percentage of respondents use AI to create multiple-choice questions and explain complex ideas further demonstrates how it may be used to simplify content and support assessment design. Additionally, notable applications that highlight the function of AI in the assessment process include the generation of question papers and assignment design.

Conversely, a smaller number of participants used AI to get student feedback, which means that it is not widely used in personalized learning interactions. Very few respondents indicated that they did not use AI at all, which proves that AI tools have become accepted and integrated by many faculty members. On the whole, the results indicate that AI is mostly used in content creation, supporting instruction, and assessment related tasks in higher education. The results also indicate growing acceptance of AI among science faculty, although its integration into core teaching and learning practices is still in the early stages.

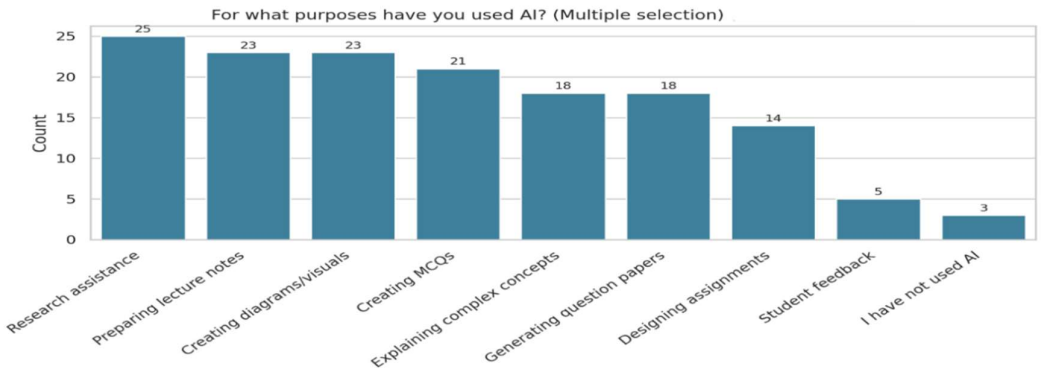

Figure 4: Factors Driving AI Tool Usage in Science Education

There is a strong tendency to utilize some of these more well-known platforms, according to the bar chart in Figure 5 that displays the trajectory of respondents' use of different AI tools. The top option is ChatGPT, and Google Gemini comes in second, both of which show how popular general-purpose AI applications are. Additionally, we observe that AI-based plagiarism detection software is widely used, which is why academic integrity in teaching and research is so crucial. The interactive and assessment-based technologies are also presented by other tools, such as AI quiz generators and simulation-based applications, which might show people's interest in them. In the meantime, in the case of Microsoft Copilot and other less widely used services, the use of AI in general is more diverse.

The findings from the survey are a bit confusing because the survey was not limited – it gave the respondent a number of answers to pick from, and so the respondent will not be using just one tool, but a combination of AI tools based on his or her requirements. Overall, the use of AI tools is fairly extensive, varied and shows an overall trend of using the general-purpose tools the most and more specific tools the least. This tendency implies that despite the growing amount of awareness about AI, the usage of the tools aimed at science instruction and the domain-specific application is not extensive.

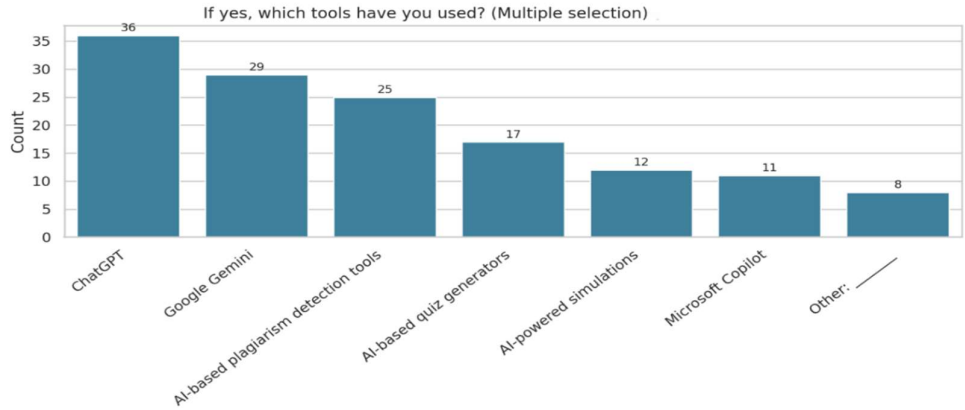

Figure 5: AI tools usage by Science Faculties of Higher Education

This bar chart (Figure 6) reflects participants' interest in learning about different AI

applications within education and research. It highlights a strong preference for tools that support academic processes, such as literature review, interactive presentations, and research writing assistance. Equally important are applications that enhance teaching practices, including creating animations or simulations in science, lesson planning, and rubric-based evaluation. Data analysis, citation management, and laboratory demonstration support also feature prominently, showing a balance between research and pedagogy. Meanwhile, automated question paper generation, instant feedback systems, and formative assessment design represent emerging but less prioritized areas of exploration.

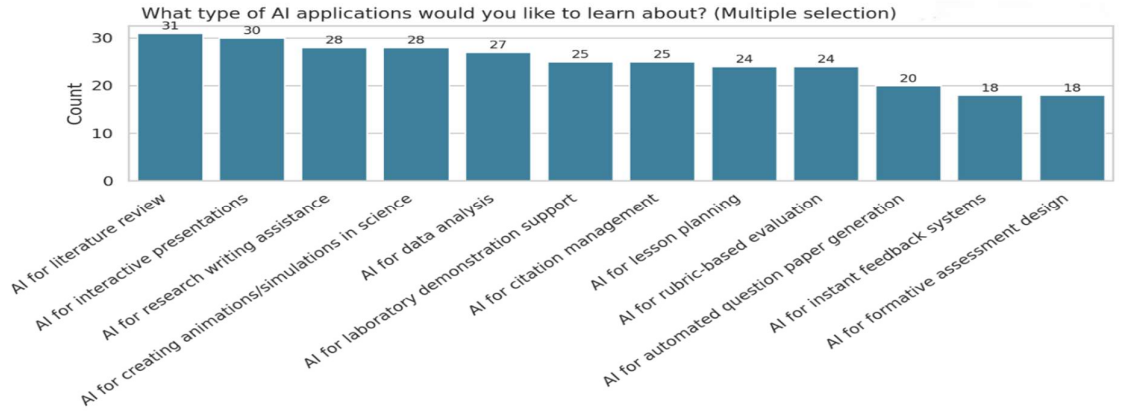

Figure 6: Participants' interest in learning about different AI applications

In this chart (Figure 7), the major issues expected in the implementation of AI in education and research are outlined. The ethical and data privacy considerations emerge as one of the key concerns, representing the concerns regarding the responsible usage and protection of personal data. The threat of plagiarism and the absence of proper training underscore the necessity of proper guidelines and skill building between the teachers and the students. The tendency of students to rely too heavily on AI tools leads to concerns about the decline in critical thinking. Real barriers like inadequate infrastructure and constraining institutional policies only complicated integration. All in all, the chart highlights that despite the opportunities that AI has to offer, its implementation must be thoroughly planned, ethically protected, and supported by supportive institutional frameworks.

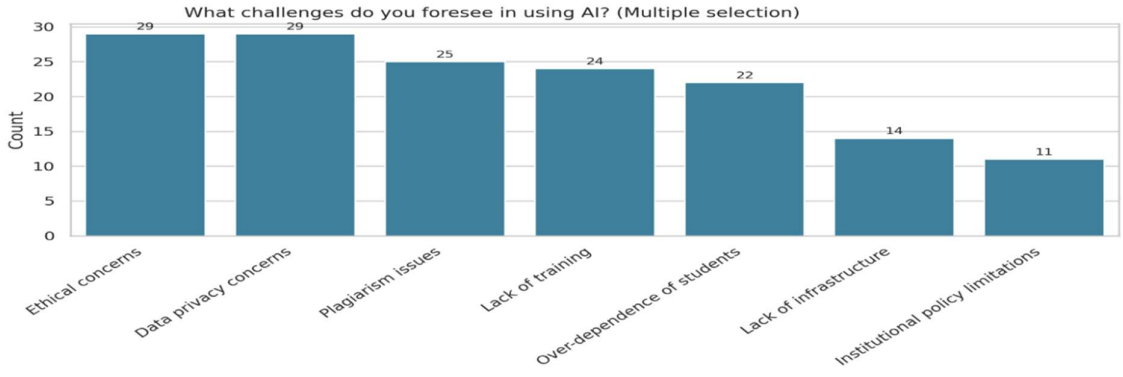

Figure 7: Key challenges anticipated in adopting AI within education and research

Whether participants like AI tools customized for their specific discipline?

The chart (Figure 8) illustrates responses to whether AI tools should be customized for specific disciplines. A clear majority expressed strong support, indicating recognition of the value of discipline-specific solutions in enhancing relevance and effectiveness. The smaller proportion of "Maybe" reflects cautious interest, suggesting some participants want to explore potential benefits before committing. Very few respondents opposed the idea, showing limited resistance to tailored AI adoption. Overall, the data emphasizes a growing demand for specialized AI applications that align closely with academic and professional contexts, reinforcing the importance of designing tools that address unique disciplinary needs and challenges.

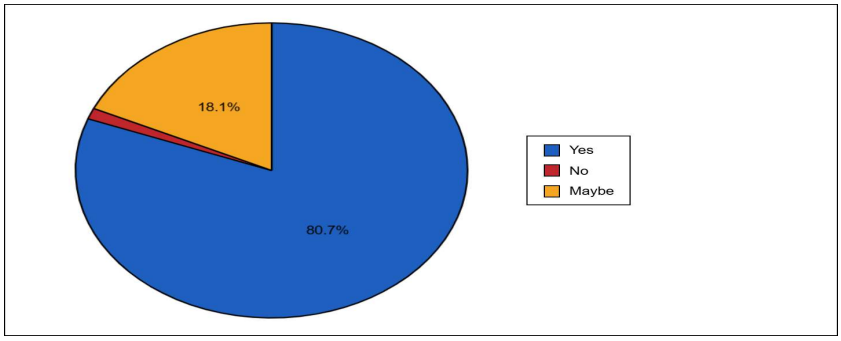

Figure 8: AI tools customized for their specific discipline

Participants interest in type of training programme:

The chart (Figure 9) highlights participants' preferences for different types of AI training programmes. The strongest interest lies in hands-on workshops, reflecting a desire for practical, immersive experiences that build confidence in using AI tools. Faculty development programmes (FDPs) focused on AI in science education also attract significant attention, showing the importance of structured academic training. Certification courses appeal to those seeking formal recognition of skills, while continuous mentoring support, though less prioritized, underscores the value of sustained guidance. Overall, the chart suggests that participants favor interactive and applied learning formats, complemented by structured and credentialed opportunities for professional growth.

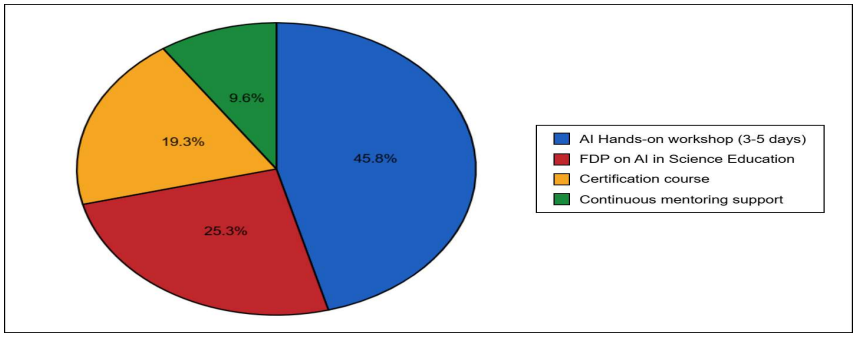

Figure 9: Participants' preferences for different types of AI training programmes

The heatmap (Figure 10) illustrates the relationship between interest levels in learning about AI applications and preferred training modes. It shows that those who are extremely or highly interested tend to favor offline and online formats, with blended learning receiving moderate attention. Online training emerges as a strong preference among highly and moderately interested participants, suggesting flexibility and accessibility are valued. Offline training appeals to those seeking structured, in-person engagement, while blended learning attracts fewer respondents overall. The chart highlights that enthusiasm for AI learning is closely tied to mode of delivery, with online and offline approaches driving the strongest engagement.

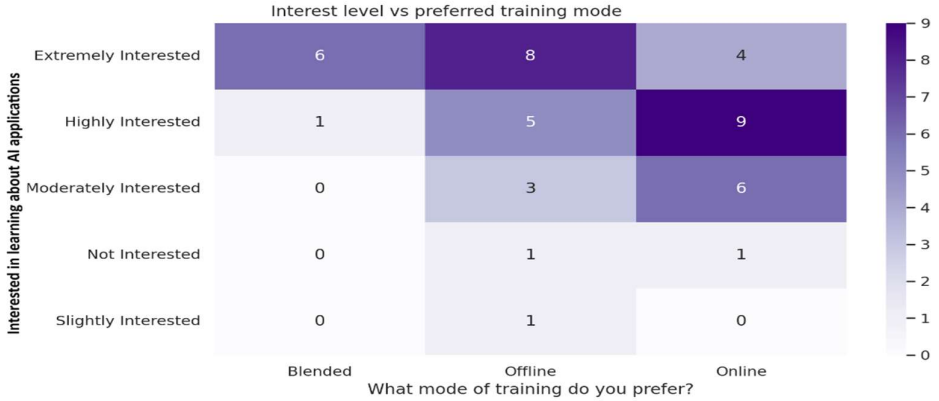

Figure 10: Relationship between interest levels in learning about AI applications and preferred training modes.

The heatmap (Figure 11) illustrates how different academic disciplines view the idea of customizing AI tools for their specific needs. Across most fields, there is a clear preference for discipline-specific customization, with strong support evident in areas such as education, physics, chemistry, and general science. Some disciplines, like geology, show more uncertainty, leaning toward "Maybe," while opposition is minimal overall. The "Other disciplines" category reflects the highest enthusiasm, suggesting diverse fields outside traditional sciences see strong value in tailored AI solutions. Overall, the chart emphasizes widespread interest in customization, reinforcing the importance of designing AI tools that align with disciplinary contexts.



Figure 11: Disciplinary Perspectives on AI Tool Customization

The heatmap (Figure 12) explores the connection between awareness of artificial intelligence and the frequency of AI tool usage in teaching. It reveals that individuals with moderate awareness are the most active users, particularly in occasional contexts, while those with high awareness also show consistent engagement. Very high awareness corresponds to both occasional and regular use, though in smaller numbers, suggesting depth of expertise among a selected group. Low awareness aligns with minimal adoption, highlighting the need for training and exposure. Overall, the chart demonstrates that awareness strongly influences usage patterns, with moderate and high levels driving the greatest participation.

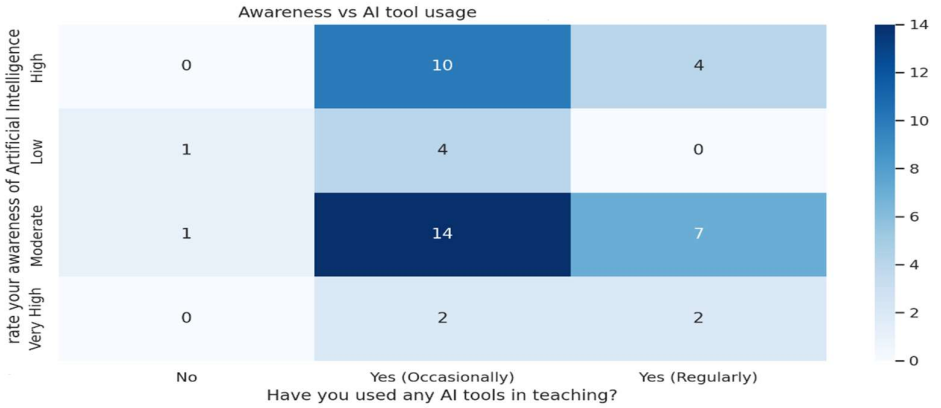

Figure 12: Awareness Levels and AI Tool Usage in Teaching

Conclusion

This study highlights that faculty members in higher education are generally aware of artificial intelligence (AI) and hold positive attitudes toward its potential in science education. However, its current use remains limited, with most applications focused on content creation and research support rather than teaching, assessment, or personalized learning. Despite this, faculty recognize AI's potential to improve teaching efficiency, student engagement, and research productivity.

The findings identify several barriers to effective AI integration, including limited knowledge and technical skills, ethical concerns, and insufficient institutional support. These challenges emphasize the need for structured faculty development programs that provide discipline-specific training, hands-on experience, and guidance on the ethical use of AI. Participants also expressed a strong interest in AI tools designed specifically for science education, indicating that context-specific solutions are more valuable than generic applications.

Policy document as NEP 2020 is a positive step towards the use of digital technology in education, but this requires teachers and staff to be well trained and equipped, and for the institution to be prepared to invest in infrastructure, technical support, and further staff development. Enhancing these capabilities will empower teachers and educators to use AI seamlessly in learning and applications.

The study also highlights the need for building communities of practice to encourage

collaborative learning experiences, where educators can share their experiences, create new teaching methods, and discuss the implications of AI for education. This co-operation fosters confidence, cross learning and a spirit of continuous improvement in educational practice.

Finally, incorporating ethical literacy and digital responsibility into faculty training is crucial for the responsible and transparent use of AI. Higher education institutions can effectively leverage AI as a valuable educational tool by adopting a balanced perspective that integrates institutional support, professional development, ethical considerations, and collaborative innovation. These priorities, if met, will help improve science education, improve the quality of teaching, and help students get ready for a world that is rapidly changing and technology-driven.

Conflict of Interest

There is no conflict of interest.

Funding

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Clinical Trial Number

No clinical trial number.

Ethics, Consent to Participate, and Consent to Publish declarations: Not Applicable

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT: A PATHWAY TOWARDS COMPETENT, REFLECTIVE AND FUTURE-READY TEACHERS

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Abstract

Teacher education and professional development are essential for ensuring the quality, effectiveness, and relevance of education in a rapidly changing world. The responsibilities of teachers have expanded considerably due to technological advancement, changing learner characteristics, inclusive education, competency-based learning, emerging pedagogies, and increasing expectations from educational institutions and society. A teacher is no longer only a provider of information but also a facilitator, mentor, researcher, reflective practitioner, collaborator, and lifelong learner. This paper examines the significance of teacher education and continuous professional development in preparing teachers to meet contemporary educational demands. It discusses the relationship between pre-service teacher education and professional learning throughout the teaching career. Particular attention is given to pedagogical competency, digital competency, assessment literacy, classroom management, communication, reflective practice, research skills, collaboration, and professional ethics. The paper also examines professional development approaches such as mentoring, workshops, seminars, peer learning, action research, professional learning communities, online learning, and reflective practice. Challenges such as workload, limited institutional support, insufficient follow-up, unequal access to professional learning, technological barriers, and the gap between theoretical preparation and classroom practice are discussed. The paper proposes a continuous and integrated framework in which teacher education institutions, schools, universities, educational authorities, and teachers work collaboratively to promote professional growth. It argues that professional development should be sustained, context-sensitive, practice-oriented, collaborative, and supported by institutional leadership. The paper concludes that strengthening teacher education and professional development can contribute to competent and confident teachers, improved teaching practices, better learner engagement, and sustainable educational quality.

***Keywords**: Teacher Education, Professional Development, Teacher Competency, Teacher Educators, Reflective Practice, Digital Pedagogy, Lifelong Learning, Quality Education*

1. Introduction

Education is a powerful means of developing individuals and transforming society. Although curriculum, infrastructure, technology, textbooks, and educational policies are important components of an education system, the teacher remains one of its most influential elements. Teachers translate curriculum objectives into meaningful classroom experiences and influence learners through their knowledge, attitudes, values, communication, creativity, and

professional behaviour.

The nature of teaching has changed significantly in recent years. Learners have access to information through digital platforms, social media, educational applications, virtual resources, and other technological sources. Consequently, teachers are expected to guide learners in understanding, analysing, evaluating, and applying information rather than simply transmitting facts. Contemporary classrooms also include learners with varied abilities, interests, backgrounds, learning preferences, and educational requirements.

These developments make effective teacher education particularly important. Teacher education should prepare prospective teachers with a strong foundation in subject knowledge, pedagogy, educational psychology, assessment, classroom management, technology, research, and professional ethics. At the same time, initial teacher preparation cannot provide all the knowledge and competencies required throughout a teacher's career. Continuous professional development is therefore essential.

Professional development enables teachers to update their knowledge, learn innovative practices, reflect on their classroom experiences, collaborate with colleagues, and respond to emerging educational challenges. Teacher education and professional development should consequently be viewed as parts of a continuous professional journey rather than as two unrelated activities.

2. Understanding Teacher Education

Teacher education is a systematic process of preparing individuals for effective participation in the teaching profession. It includes theoretical understanding, practical experience, professional attitudes, pedagogical skills, research orientation, and opportunities for reflection.

An effective teacher education programme should develop several dimensions of teacher competence. The first is content knowledge, which enables teachers to understand the subject they teach. The second is pedagogical knowledge, which helps teachers decide how content can be presented and learned effectively. The third is knowledge about learners, including their cognitive, emotional, social, and developmental characteristics.

Teacher education must also provide opportunities to connect theory with practice. Prospective teachers need exposure to real classrooms through observation, demonstration lessons, practice teaching, school internship, community engagement, and reflective activities. These experiences help student teachers understand that classroom teaching involves responding to actual learners and situations rather than merely following theoretical principles.

Research orientation is another important dimension. Student teachers should be encouraged to identify educational problems, collect information, analyse evidence, and consider possible solutions. Developing this habit during teacher preparation can contribute to a culture of inquiry and continuous improvement.

3. Professional Development as a Continuous Process

Professional development refers to the ongoing learning undertaken by teachers to improve their professional knowledge, skills, attitudes, and practices. It can occur through formal and informal experiences.

Formal professional development may include workshops, seminars, conferences, refresher programmes, faculty development programmes, certificate courses, and online courses. Informal professional learning may occur through professional reading, peer discussions, classroom experimentation, mentoring, observation of colleagues, participation in professional communities, and reflection.

Professional development is most meaningful when it is connected with teachers' actual needs. A general programme delivered to all teachers may have limited impact if it does not address their classroom realities. Effective professional learning should therefore consider the subject taught, level of education, experience of teachers, learner characteristics, institutional context, and current educational challenges.

Professional development should also extend beyond attendance. The success of a programme should be reflected in changes in professional knowledge, classroom practices, teacher confidence, collaboration, and learner experiences.

4. Changing Role of the Teacher

The twenty-first-century teacher performs multiple roles. Teachers are facilitators who create opportunities for learners to actively construct knowledge. They are mentors who guide learners academically and personally. They are classroom managers who establish positive and inclusive learning environments. They are assessors who collect evidence of learning and use it to provide feedback. They are researchers who investigate classroom issues and explore solutions.

Teachers are increasingly becoming technology-enabled educators. However, technology should not be considered an objective by itself. The purpose of using technology should be to enhance learning, accessibility, engagement, creativity, collaboration, and understanding.

Teachers must also become lifelong learners. Educational knowledge changes continuously, and teachers need the willingness and ability to update themselves. Professional curiosity is therefore an important characteristic of an effective teacher.

5. Essential Competencies for Contemporary Teachers

Teacher education and professional development should focus on a broad range of competencies.

5.1 Pedagogical Competency

Teachers should be able to select appropriate teaching strategies based on learning objectives, subject matter, learner characteristics, and classroom conditions. They should be familiar with active learning, experiential learning, collaborative learning, inquiry-based learning, problem-solving, and other learner-centred approaches.

5.2 Digital Competency

Teachers require the ability to identify, evaluate, create, and use digital resources appropriately. Digital competency includes online teaching, digital content creation, multimedia resources, virtual learning environments, online assessment, and responsible use of emerging technologies.

5.3 Assessment Competency

Teachers need to understand different forms of assessment and use assessment information to improve learning. Formative assessment, constructive feedback, diagnostic assessment, self-assessment, and peer assessment can support learner development.

5.4 Communication Competency

Effective communication helps teachers explain concepts clearly and establish positive relationships with learners, parents, colleagues, and the community.

5.5 Inclusive Education Competency

Teachers should be prepared to respond to learner diversity. They need strategies for supporting learners with different abilities, backgrounds, interests, and learning requirements.

5.6 Reflective Competency

Reflection allows teachers to examine what worked, what did not work, and why. Reflective teachers are more likely to modify their practices based on experience and evidence.

5.7 Research Competency

Teachers with research skills can systematically investigate classroom challenges and develop evidence-informed solutions. Action research can be particularly useful in this regard.

6. Role of Teacher Educators in Professional Development

Teacher educators have a significant influence on the professional development of prospective teachers. Their role is not limited to teaching the prescribed curriculum. They should create an environment that promotes questioning, discussion, experimentation, reflection, collaboration, and research.

Teacher educators should model the pedagogical practices they expect student teachers to adopt. If teacher educators demonstrate learner-centred teaching, technology integration, collaborative activities, formative assessment, and reflective practice, student teachers can experience these approaches directly.

Mentoring is another important responsibility. During practice teaching and internship, prospective teachers may face difficulties related to lesson planning, classroom management, communication, assessment, or learner engagement. Constructive guidance from teacher educators can help them address these challenges.

Teacher educators themselves also require professional development. They need to remain familiar with contemporary developments in curriculum, pedagogy, educational technology, research methodology, assessment, and teacher education.

7. Major Approaches to Professional Development

7.1 Workshops and Seminars

Workshops and seminars can introduce teachers to new educational ideas and practical strategies. Their effectiveness increases when participants have opportunities to practise the newly learned skills and receive feedback.

7.2 Mentoring

Mentoring creates a supportive relationship between experienced and less experienced teachers. A mentor can provide guidance on classroom management, lesson planning, assessment, communication, and professional responsibilities.

7.3 Peer Learning

Teachers possess valuable professional knowledge based on their classroom experiences. Peer learning enables them to share successful practices, discuss challenges, observe one another, and collaboratively develop solutions.

7.4 Reflective Practice

Reflection can be encouraged through teaching diaries, reflective journals, peer feedback, self-evaluation, classroom observation, and professional discussions. Reflection transforms everyday teaching experiences into opportunities for learning.

7.5 Action Research

Action research enables teachers to investigate problems in their own classrooms. For example, a teacher may identify low learner participation as a concern, introduce a collaborative learning strategy, collect evidence, analyse the results, and reflect on the effectiveness of the intervention.

7.6 Professional Learning Communities

Professional learning communities provide teachers with regular opportunities to work together towards improving teaching and learning. Such communities can promote shared responsibility, professional dialogue, collaboration, and evidence-based decision-making.

7.7 Online Professional Learning

Online learning has increased access to professional development. Teachers can participate in webinars, online courses, virtual conferences, digital communities, and professional discussion forums. This flexibility can support teachers who face geographical or scheduling limitations.

8. Technology and Teacher Professional Development

Technology has transformed both teacher education and professional development. Digital platforms can provide access to educational resources, professional networks, research literature, online courses, virtual classrooms, and collaborative learning environments.

Teachers need to understand not only how technology works but also when and why a particular technology should be used. Effective technology integration requires alignment between learning objectives, pedagogy, content, and the technological tool.

Emerging technologies, including artificial intelligence, are also influencing education.

Teachers require professional learning to understand their educational possibilities, limitations, ethical dimensions, privacy considerations, academic integrity concerns, and responsible use.

Technology should support teachers rather than eliminate the human dimension of teaching. Empathy, communication, mentoring, motivation, ethical judgement, and interpersonal relationships remain central to education.

9. Challenges in Professional Development

Several challenges can limit the effectiveness of teacher professional development.

One major challenge is time. Teachers often have academic, administrative, assessment, co-curricular, and institutional responsibilities. Finding sufficient time for sustained professional learning can therefore be difficult.

A second challenge is the theory-practice gap. Professional development may have limited impact when it presents theoretical information without demonstrating how it can be implemented in actual classrooms.

A third challenge is limited follow-up. Teachers may attend a training programme but receive little support when attempting to apply new strategies. Follow-up mentoring and peer support can help overcome this problem.

Another challenge is unequal access. Teachers may differ in their access to technology, professional networks, financial resources, and development opportunities.

There can also be a lack of motivation if professional development is perceived as an obligatory activity rather than a meaningful opportunity for professional growth. Institutions should therefore create a positive culture in which learning is valued and encouraged.

10. Institutional Leadership and Professional Growth

Educational leadership has an important role in creating conditions for professional development. Principals and institutional leaders can encourage teachers to participate in professional learning, conduct research, share innovative practices, collaborate with colleagues, and reflect on their work.

Institutions can establish regular academic discussions, peer observation, demonstration lessons, mentoring systems, research forums, professional learning communities, and technology-based learning initiatives.

Professional development should be integrated into institutional academic planning. Teachers should be given adequate opportunities to participate in relevant programmes and implement what they learn.

Recognition is also important. Teachers who contribute through research, innovation, mentoring, development of teaching resources, or professional activities should be encouraged and appreciated. A supportive institutional culture can transform professional development from an occasional activity into a sustained practice.

11. Strengthening Collaboration Between Teacher Education Institutions and Schools

Teacher education institutions and schools should work closely together. School internship is

one important mechanism for connecting theoretical preparation with classroom practice. However, collaboration can extend beyond internship.

Teacher education institutions can support schools through professional development programmes, action research, demonstration lessons, academic consultations, resource development, and collaborative research. Schools can provide teacher educators with valuable insights into emerging classroom needs and challenges.

Such partnerships can benefit both student teachers and practising teachers. Student teachers gain authentic professional experiences, while practising teachers gain access to academic expertise, research, and professional learning opportunities.

12. A Proposed Framework for Continuous Professional Development

A sustainable professional development framework can be organised around five interconnected stages:

Stage 1: Identify Professional Needs

Teachers and institutions should identify areas requiring development through self-assessment, classroom observation, learner feedback, peer discussion, and institutional priorities.

Stage 2: Plan Professional Learning

Based on identified needs, suitable activities such as workshops, mentoring, peer learning, courses, action research, or online programmes should be selected.

Stage 3: Implement Learning

Teachers should apply newly acquired knowledge and skills in authentic educational settings.

Stage 4: Reflect and Collaborate

Teachers should examine the outcomes of implementation and discuss their experiences with colleagues or mentors.

Stage 5: Evaluate and Improve

Professional development should be evaluated based on changes in teacher competence, teaching practices, learner engagement, and educational outcomes. The results should inform the next cycle of professional learning.

This cyclical model can establish professional development as an ongoing process of improvement.

13. Recommendations

Based on the discussion, the following recommendations are proposed:

Teacher education programmes should provide a stronger connection between educational theory and classroom practice.

Professional development should be continuous rather than occasional.

Programmes should be designed according to teachers' actual professional needs.

Teacher education institutions should strengthen mentoring and reflective practice.

Teachers should be encouraged to undertake classroom-based action research.

Schools should develop professional learning communities that encourage collaboration.

Digital competency and responsible use of emerging technologies should form an important part of teacher professional development.

Teacher educators should receive regular opportunities for professional development and research.

Educational institutions should provide adequate time, infrastructure, resources, and leadership support for professional learning.

Professional development programmes should include follow-up activities to support classroom implementation.

Collaboration between teacher education institutions and schools should be strengthened through joint research, workshops, internships, and professional learning activities.

Professional development should be evaluated based on meaningful changes in teaching practice rather than merely on participation or attendance.

14. Conclusion

Teacher education and professional development are fundamental to the development of an effective and sustainable education system. The contemporary teacher operates in an environment characterised by technological change, learner diversity, curriculum transformation, new pedagogical approaches, and increasing expectations. These changes require teachers to continuously develop their professional competencies.

Teacher education provides the foundation for entering the profession, but professional learning must continue throughout the teacher's career. Pedagogical competence, digital literacy, assessment skills, communication, classroom management, inclusive practices, research orientation, reflective practice, and professional ethics should all form part of continuous professional development.

Professional development is most effective when it is meaningful, sustained, collaborative, practice-oriented, and supported by institutional leadership. Workshops and seminars can introduce new ideas, but lasting professional growth requires opportunities for mentoring, peer learning, reflection, action research, professional collaboration, and implementation.

Teacher educators have an equally important role. They should act as mentors, facilitators, researchers, and role models while continuously updating their own professional knowledge. Strong partnerships between teacher education institutions and schools can further reduce the gap between theory and practice.

The future of education depends significantly on the quality and preparedness of teachers. Investment in teacher education and professional development is therefore an investment in learners, institutions, and society. A professionally competent teacher can create an environment where learners are encouraged to think critically, communicate effectively, collaborate with others, solve problems, use technology responsibly, and become lifelong learners.

Thus, teacher education and professional development should not be understood as separate or temporary activities. They represent a continuous professional journey from initial teacher

preparation to lifelong professional learning. Building strong systems that support this journey can contribute to competent, confident, reflective, innovative, and future-ready teachers and, ultimately, to improved quality of education.

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AUGMENTED REALITY FOR GEOMETRY TEACHING: TRANSFORMING MATHEMATICS LEARNING IN THE DIGITAL AGE

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Abstract

The rapid advancement of digital technologies has transformed teaching and learning practices across educational institutions. Among these innovations, Augmented Reality has emerged as a powerful educational tool that enhances students' understanding by integrating virtual objects into real-world environments. Geometry, one of the most visual branches of mathematics, often presents challenges to students due to its abstract concepts and spatial reasoning requirements. Augmented Reality addresses these challenges by enabling learners to visualize and interact with three-dimensional geometric figures in real time. Augmented Reality-based learning environments improve students' conceptual understanding, engagement, motivation, and problem-solving abilities. Teachers can use AR applications to demonstrate geometric shapes, transformations, symmetry, and measurement in an interactive and learner-centered manner. The integration of Augmented Reality aligns with the objectives of the National Education Policy (NEP) 2020, which emphasizes experiential learning, digital literacy, and technology-enabled education. Despite its numerous advantages, successful implementation requires adequate infrastructure, teacher training, and access to digital resources. This paper discusses the concept of Augmented Reality, its applications in geometry teaching, educational benefits, challenges, and implications for teacher education.

Keywords: *Augmented Reality, Geometry Teaching, Mathematics Education, Digital Learning, Visualization, Teacher Education.*

Introduction

Geometry is a fundamental branch of mathematics that develops logical reasoning, spatial visualization, and analytical thinking. However, many students find geometry difficult because they struggle to visualize two-dimensional and three-dimensional figures using traditional teaching methods. Chalk-and-board instruction and static textbook diagrams often fail to represent complex geometric relationships effectively.

Augmented Reality offers an innovative solution by overlaying digital information, animations, and three-dimensional models onto the real environment through smartphones, tablets, or Augmented Reality -enabled devices. Students can observe, rotate, enlarge, and manipulate geometric objects, making learning more interactive and meaningful. Augmented Reality bridges the gap between abstract mathematical concepts and real-life experiences,

thereby improving students' understanding and retention.

Concept of Augmented Reality

Augmented Reality is an emerging educational technology that integrates computer-generated digital content with the real-world environment in real time. It overlays virtual elements such as three-dimensional (3D) models, images, animations, videos, audio, and text onto physical objects or surroundings, creating an interactive and engaging learning experience. Unlike **Virtual Reality (VR),** which immerses users in a completely computer-generated environment, Augmented Reality enhances the existing physical environment by blending digital information with the real world. This allows users to interact simultaneously with both real and virtual objects through smartphones, tablets, computers, or Augmented Reality -enabled devices such as smart glasses.

In the field of education, Augmented Reality has gained significant attention because of its ability to transform traditional teaching into an interactive and learner-centered process. It enables students to visualize complex concepts that are difficult to understand through textbooks or conventional classroom instruction. By presenting information in a realistic and dynamic manner, Augmented Reality encourages students to explore, observe, manipulate, and experiment with learning materials, thereby promoting active participation and meaningful learning.

In mathematics education, particularly in geometry, Augmented Reality helps students understand abstract concepts by converting two-dimensional textbook diagrams into interactive three-dimensional models. Learners can rotate, zoom, and examine geometric figures such as cubes, prisms, pyramids, cones, cylinders, spheres, triangles, and polygons from different perspectives. This enhances spatial visualization, conceptual understanding, and mathematical reasoning while reducing misconceptions related to geometric shapes and relationships.

Furthermore, Augmented Reality supports experiential, inquiry-based, and constructivist learning approaches by allowing students to discover mathematical concepts through exploration rather than rote memorization. It increases learner engagement, motivation, and curiosity by providing immediate visual feedback and interactive experiences. Teachers can use Augmented Reality applications to create collaborative learning activities, demonstrations, and problem-solving tasks that make mathematics more enjoyable and relevant to real-life situations.

With the increasing availability of mobile devices and educational applications, Augmented Reality has become an effective digital tool for promoting innovative teaching practices. Its integration into mathematics education aligns with the objectives of the **National Education Policy (NEP) 2020,** which advocates technology-enabled learning, digital literacy, experiential education, and the development of 21st-century skills among learners. As educational institutions continue to adopt digital technologies, Augmented Reality has the

potential to revolutionize geometry teaching by making learning more visual, interactive, engaging, and effective.

Applications of AR in Geometry Teaching

Augmented Reality has numerous applications in geometry classrooms. It enables students to visualize three-dimensional solids such as cubes, cones, cylinders, pyramids, prisms, and spheres from different perspectives, thereby improving their spatial understanding. Teachers can demonstrate concepts such as symmetry, rotations, reflections, translations, and dilations using interactive Augmented Reality models that allow learners to observe transformations in real time.

Augmented Reality also supports the teaching of fundamental geometric concepts, including triangles, circles, polygons, angles, and coordinate geometry, through dynamic visualizations. Students can manipulate virtual geometric figures by rotating, enlarging, and examining them from multiple viewpoints. This interactive approach helps learners understand the relationships between shapes, dimensions, and geometric properties more effectively than traditional static diagrams. By connecting abstract concepts with visual and hands-on experiences, Augmented Reality enhances conceptual understanding, develops spatial reasoning skills, and encourages active participation in mathematics learning. As a result, students gain a deeper understanding of geometry and retain concepts more effectively.

Benefits of Augmented Reality in Geometry Teaching

The integration of Augmented Reality into geometry teaching offers numerous educational benefits that significantly improve the quality of mathematics instruction and student learning outcomes. By combining digital technology with real-world experiences, Augmented Reality creates an engaging and interactive learning environment that promotes conceptual understanding, active participation, and meaningful learning.

One of the most significant benefits of Augmented Reality is its ability to **enhance visualization.** Geometry involves the study of shapes, sizes, angles, dimensions, and spatial relationships, which many students find difficult to imagine using only textbook illustrations or blackboard drawings. Augmented Reality enables learners to visualize three-dimensional geometric figures such as cubes, prisms, pyramids, cylinders, cones, and spheres in a realistic manner. Students can rotate, enlarge, shrink, and observe these objects from different perspectives, helping them understand their properties, dimensions, and relationships more effectively.

Another important advantage is that Augmented Reality **increases student engagement and motivation**. Traditional geometry lessons often rely on static diagrams and teacher explanations, which may reduce students' interest and participation. Augmented Reality transforms the classroom into an interactive learning environment where students actively explore mathematical concepts through hands-on experiences. The use of animations, interactive models, and real-time visualizations makes learning enjoyable and encourages students to participate enthusiastically in classroom activities.

Augmented Reality also **improves conceptual understanding** by bridging the gap between abstract mathematical ideas and concrete visual experiences. Many geometry concepts, such as symmetry, transformations, surface area, volume, coordinate geometry, and three-dimensional visualization, become easier to understand when students can manipulate virtual models. Instead of memorizing formulas and definitions, learners develop a deeper understanding by observing how geometric properties change through exploration and experimentation.

Furthermore, Augmented Reality contributes to the development of **higher-order thinking skills.** Students are encouraged to analyze geometric relationships, compare different figures, investigate patterns, solve problems, and draw logical conclusions. Such activities promote critical thinking, logical reasoning, creativity, decision-making, and mathematical problem-solving abilities, which are essential competencies for the twenty-first century.

Another major benefit is the promotion of **active and experiential learning**. Augmented Reality shifts the classroom from a teacher-centered approach to a learner-centered approach by encouraging students to explore concepts independently. Learners become active participants rather than passive recipients of information, leading to greater confidence, curiosity, and self-directed learning.

Augmented Reality also supports **collaborative learning** by enabling students to work together in pairs or small groups to explore geometric concepts, solve mathematical problems, and discuss their observations. Such collaborative activities enhance communication skills, teamwork, peer learning, and knowledge sharing, thereby creating a more inclusive and interactive classroom environment.

An additional advantage of Augmented Reality is its ability to provide **immediate visual feedback**. Students can instantly observe the results of manipulating geometric objects, allowing them to identify errors, correct misconceptions, and refine their understanding without waiting for teacher intervention. Immediate feedback improves learning efficiency and helps learners build accurate mathematical concepts.

Moreover, Augmented Reality can **reduce mathematics anxiety** by presenting geometry concepts in an engaging and less intimidating manner. Students who usually struggle with abstract mathematical ideas often gain confidence when they can interact with visual representations and learn through exploration rather than rote memorization. This positive learning experience increases their interest in mathematics and improves academic performance.

Finally, the use of Augmented Reality contributes to the development of **digital literacy and technological competence,** which are essential skills in modern education. Students become familiar with educational technologies while simultaneously learning mathematical concepts, preparing them for future academic and professional environments where digital tools play an important role.

Augmented Reality serves as an effective instructional tool for geometry teaching by enhancing visualization, improving conceptual understanding, increasing student motivation, promoting active and collaborative learning, developing higher-order thinking skills, providing immediate feedback, reducing mathematics anxiety, and fostering digital competencies. These benefits make Augmented Reality a valuable innovation for creating engaging, effective, and learner-cantered mathematics classrooms.

Role of Teachers in Integrating Augmented Reality for Geometry Teaching

Teachers play a pivotal role in the successful integration of Augmented Reality into geometry instruction. Although Augmented Reality provides innovative and interactive learning opportunities, its educational effectiveness largely depends on how teachers plan, implement, and facilitate learning experiences. Teachers act not only as instructors but also as facilitators, mentors, and technology integrators who guide students in using Augmented Reality meaningfully to achieve the intended learning outcomes.

One of the primary responsibilities of teachers is to **select appropriate Augmented Reality applications and digital resources** that align with the mathematics curriculum, learning objectives, and students' developmental levels. Since numerous Augmented Reality applications are available, teachers should evaluate them based on their educational value, ease of use, curriculum relevance, and ability to enhance conceptual understanding. The selected tools should support specific geometry topics such as polygons, circles, three-dimensional solids, coordinate geometry, symmetry, transformations, surface area, and volume.

Effective **lesson planning** is another essential responsibility of teachers. Augmented Reality should not replace conventional teaching methods but rather complement them. Teachers should design learner-centered lessons that integrate Augmented Reality activities with classroom discussions, demonstrations, practical exercises, group work, and problem-solving tasks. Well-planned Augmented Reality lessons encourage students to observe, explore, manipulate, and analyze geometric figures while relating mathematical concepts to real-life situations. Such integration helps students develop a deeper conceptual understanding and improves long-term retention of knowledge.

Teachers also serve as **facilitators of active learning** by encouraging inquiry, exploration, and discovery. Instead of merely explaining geometric concepts, teachers can guide students to investigate properties of shapes, identify patterns, test mathematical relationships, and draw conclusions independently. This inquiry-based approach promotes critical thinking, creativity, logical reasoning, and problem-solving skills while making geometry learning more engaging and meaningful.

Another important responsibility is to **create collaborative learning environments.** Teachers can organize students into pairs or small groups to complete Augmented Reality - based activities, solve geometric problems, and discuss their observations. Collaborative learning encourages communication, teamwork, peer interaction, and knowledge sharing,

enabling students to learn from one another while strengthening their mathematical understanding.

Teachers must also ensure the **responsible and ethical use of technology** in the classroom. Students should be guided on the appropriate use of Augmented Reality applications, digital devices, and online resources while maintaining academic integrity and digital citizenship. Teachers should establish clear classroom guidelines to ensure that technology is used as a learning tool rather than a source of distraction.

Continuous **assessment and feedback** are equally important. Teachers should observe students' participation during Augmented Reality activities, assess their conceptual understanding through questioning, assignments, projects, and practical tasks, and provide immediate feedback to correct misconceptions. Both formative and summative assessment strategies can be employed to evaluate the effectiveness of Augmented Reality -based learning experiences and monitor students' progress.

To successfully implement Augmented Reality in mathematics classrooms, teachers need **continuous professional development.** They should participate in workshops, training programmes, webinars, faculty development programmes (FDPs), and professional learning communities to enhance their technological knowledge and pedagogical skills. Familiarity with emerging educational technologies enables teachers to design innovative instructional strategies and confidently integrate Augmented Reality into classroom practice.

Finally, teachers play a significant role in promoting the objectives of the **National Education Policy (NEP) 2020,** which emphasizes technology-enabled learning, experiential education, digital literacy, critical thinking, and competency-based education. By effectively integrating Augmented Reality into geometry teaching, teachers can create learner-centered classrooms that foster curiosity, creativity, collaboration, and conceptual understanding.

In conclusion, teachers are the key drivers of successful Augmented Reality integration in geometry education. Their expertise in selecting appropriate digital resources, designing engaging learning experiences, facilitating inquiry and collaboration, providing timely feedback, promoting ethical technology use, and continuously upgrading their professional competencies determines the effectiveness of Augmented Reality in enhancing students' mathematical learning.

Challenges

Despite its advantages, several challenges limit the widespread adoption of Augmented Reality in schools.

Many educational institutions lack adequate technological infrastructure, including smartphones, tablets, high-speed internet, and Augmented Reality -compatible devices.

Some teachers may have limited knowledge and confidence in using Augmented Reality applications effectively. The cost of purchasing digital devices and educational software may also be a barrier for many schools.

Additionally, excessive dependence on technology may distract students if Augmented

Reality activities are not properly planned and monitored. Therefore, balanced integration of technology with sound pedagogical practices is necessary.

Implications for Teacher Education

Teacher education institutions should prepare future mathematics teachers to effectively integrate Augmented Reality into classroom teaching. B.Ed. and M.Ed. programmes should include training on digital pedagogy, educational technologies, and Augmented Reality -based instructional design.

Pre-service teachers should receive practical experience in designing Augmented Reality -supported lesson plans and classroom activities. Workshops, seminars, and hands-on training can enhance teachers' confidence and technological competence. Such initiatives will help future teachers create engaging and student-cantered mathematics classrooms.

Conclusion

Augmented Reality is transforming geometry teaching by making mathematical concepts more visual, interactive, and meaningful. It enables students to explore geometric relationships through immersive experiences that promote deeper understanding, engagement, and critical thinking. Although challenges related to infrastructure, cost, and teacher preparedness remain, the educational benefits of Augmented Reality outweigh its limitations. With appropriate teacher training, institutional support, and effective implementation, Augmented Reality can significantly enhance the quality of mathematics education. As educational systems increasingly adopt digital technologies in line with NEP 2020, has the potential to become an essential tool for developing conceptual understanding and improving students' achievement in geometry.

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ANALYZING THE PERCEPTION OF TEACHERS AND STUDENTS ON THE ROLE OF AI BASED TOOLS IN PHYSICS TEACHING AND LEARNING

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Abstract

AI technology can be an effective tool in teaching Physics. Furthermore, AI technology offers enormous possibilities to enhance teaching effectiveness, thereby helping the students to visualize a concept involving the organization of content and engage with them and so on. The present study aims to analyze the perception of teachers and students regarding the use of AI-Based tools in Physics teaching-learning. This research involved the use of quantitative descriptive research design 20 teachers and 40 students. Two sets of structured questionnaires containing 15 statements each were administered to elicit responses on the usefulness and effectiveness of AI-based applications in the Physics teaching-learning process. Teacher responses were being measured on a five-point agreement scale while student responses were recorded on a five-point frequency scale. The frequency, percentages, total score, mean, standard deviation and one-sample t test analysis were done. The results signify that teachers have a positive perception, with item-wise mean scores falling between 4.60 and 5.00. The students showed favourable perceptions with mean scores between 4.28 and 4.93, particularly in the areas of an AI-supported feedback, sequential presentation, visualisation, interest in classroom, and ease of learning. The one-sample t-test findings further reveal that the overall perceptions of both teachers and students were significantly above the neutral level. The research indicates that AI can be used in known ways to help with Physics teaching by enhancing visualization, content generation, feedback, engagement and learning.

Keywords: *Artificial Intelligence, AI-Based Tools, Physics Teaching, Physics Learning, Teachers' Perception, Students' Perception, AI in Education, Technology-Enhanced Learning.*

I. INTRODUCTION

Physics learning involves the understanding of the relationship between a theory, its mathematical formulation, a physical phenomenon, and its applications. Numerous Physics concepts involve events that cannot be witnessed in the classroom; thus, some appropriate methods of teaching became all the more important. Though traditional explanations,

textbooks, diagrams and laboratory activities continue to underpin how we teach Physics, new digital technologies have opened up extra possibilities for representing and explaining complex scientific concepts. AI is the crucial technological development within education for the 21st century. Teachers can use AI-based applications to help them prepare instructional materials, images, organize information, presentations, feedback, and simplify complex content. In Physics education, such capabilities may prove particularly useful as visualizations, animations, simulations and structured explanations can help make connections between scientific abstract principles and observable situations. Tools including generative AI, intelligent feedback systems, AI-supported presentation systems, and information-analysis systems are beginning to enter the bigger educational technology ecosystem.

The educational worth of AI, on the other hand, doesn't just lie in the availability of these tools, but also in their perception and use by teachers and students. Teachers significantly influence how the technology will be used in class. Teacher's attitude towards technology is important as the overall classroom environment is shaped according to the habitual behaviour of students. How they perceive AI applications can affect whether they're willing to use it for lesson preparation, visualization, presentation, explanation, and feedback. In the same way, the perception of students is important since whether students find the instructional process comprehensible, engaging, useful and supportive of their learning needs is closely associated with effective technology-supported learning. The implementation of AI also raises questions about the quality and appropriateness of educational content used, time spent on AI-supported lessons, relevance of materials generated, and balancing technology-supported teaching with human teacher-student interactions. As a result, analyzing perceptions from both ends of the teaching-learning system helps to understand better about the involvement of AI based tools in teaching Physics.

In this context, the current study analyzes teacher and student perceptions of AI-based tools in the teaching-learning of Physics. The study evaluates teachers' opinions about the use of AI tools for content generation, visualization, structuring, presentation and feedback while students' feedback gives us an idea of their experience of'n AI supported Physics teaching-learning process in terms of comprehension, interest, conceptual clarity, tasks and feedback. The study will help in understanding how AI-based tools are perceived and the potential educational opportunities they offer through examining both ends of the World Physics classroom.

II. REVIEW OF LITERATURE

Fadillah and colleagues (2024) researched on high school students' perception of using ChatGPT in Physics. The research was conducted on167 students and with the help of a survey, which will examine students' perceptions regarding effectiveness, clarity, consistency of information and contribution of ChatGPT in understanding Physics concepts. The students generally had a positive perception of ChatGPT, especially in terms of learning Physics in a

more fun way, deepening conceptual understanding, and correcting misconceptions. There were significant differences of perception based on gender and academic level, though duration of ChatGPT use resulted in no significant overall difference. The findings are crucial for the present study as ones' perception is an important dimension in studying the educational role of AI-based tools in Physics.

A study by **Duc, Phuong, and Nguyen (2024)** examined high school teachers' perception and use of Artificial Intelligence in Physics. A mixed-method approach was used by the researchers who surveyed 82 Physics teachers to examine their awareness, attitude and current use of AI in Teaching. This study focused on using AI to improve the quality of Physics education within a competency-based educational paradigm. The present research is highly relevant as the teacher-oriented approach indicates the importance of studies relating to teachers' perceptions regarding the use of AI in Physics classrooms. The research also serves as a relevant base for how teachers' awareness and attitudes can influence the practical uses of AI-based educational tools.

Kestin et al. (2025) conducted a randomized controlled trial of college students to compare AI-supported tutoring and active learning classroom instruction regarding effectiveness and perceptions. The study investigated both educational learning results and students' perceptions when an AI-tutor better delivers the instructional content. The research reveals important evidence that AI can do more than just act as a source of information if designed around relevant pedagogical principles. The findings are relevant to the present study in that it says students' experiences and perceptions need to be assessed, along with the effectiveness. The research further reveals that the AI tools pedagogical design is an essential determining factor of the value of an AI application.

In a study by **Dahlkemper, Lahme, and Klein, carried out in (2023**), 102 university Physics students had assessed the scientific accuracy and language quality of ChatGPT answers to Physics comprehension questions. According to the researchers, students would sometimes assign similar linguistic quality scores to the ChatGPT responses despite inaccuracies, incomplete explanations, or outright misleading explanations from ChatGPT that were given similar ratings as human responses. The study thus raised a significant issue about students' inability to detect errors in AI-generated Physics material. The results are important for this study because we should verify and critically evaluate positive perceptions of AI tools. According to the study, teachers must guide the students to use AI as a support tool for learning instead of accepting the explanation given by AI.

Wattanakasiwich, Kaewkhong, and Katwibun (2025) employed Rogers' Diffusion of Innovation theory to study Physics instructors' acceptance and use of generative AI for Physics education. The researchers created different survey instruments for instructors who used generative AI and for instructors who did not. They applied the stages through which instructors develop awareness, attitudes, decisions, implementation practices, and continued adoption of an innovation. Particularly relevant to the present research survey is this study of

Physics teachers that examines instructors' acceptance of generative AI and reveals important aspects of their implementation. Due to this focus on teachers, this study is an important complement to studies that focus on students. Moreover, it highlights that the integration of AI does not merely involve the technology but also how educators perceive, decide and enact it in classrooms.

Research Gap:

The examined research articles have confirmed that the interest in AI-supported Physics education is on the rise; however, this interest is being curbed by several aspects that need to be investigated further. Previous research has examined students' views of one tool, ChatGPT, and teacher acceptance of generative AI, and previous systematic reviews show not much research has been conducted on teachers and long-term pedagogical investigations. Furthermore, recent assessments indicate that AI research in Physics education is still fragmented across content areas, pedagogical functions and evaluation approaches. Consequently, the current study adds to the existing literature by studying the perceptions of both teachers and students together, with a focus on a wider range of AI-based tools. In particular, it will study their perceived usefulness for Physics teaching and learning.

III. OBJECTIVES OF THE STUDY

The main objective of the research study is stated as follows:

1. To study the perception of teachers on the use of AI-based tools in teaching Physics
2. To evaluate students' views on AI-based tools in Physics learning
3. To identify the perceived usefulness of AI-based tools for visualization, content presentation, conceptual understanding, and classroom engagement in Physics.
4. To compare teacher and student perceptions of the role of AI-based tools in classroom Physics teaching and learning.
5. To find out if the general opinions of the teachers and students towards AI based tools are significantly higher than the neutral level.

IV. RESEARCH METHODOLOGY

Research Design

The Study employed a descriptive survey research design with a quantitative approach, combining descriptive and inferential statistics to analyse the perceptions of teachers and students regarding the role of AI-based Tools in Physics teaching and learning. The study examined the perceived usefulness, effectiveness, clarity, engagement, visualisation, feedback and learning support of specific AI-based applications in the Physics teaching-learning process.

Sampling:

A purposive sampling technique was used to select respondents who had direct exposure to AI-based tools in physics instruction. The total sample consisted of 60 respondents - 20 teachers and 40 students. Inclusion criteria were: (i) Teachers currently teaching with prior experience of using AI- based tools for lesson preparation or classroom instruction, and (ii)

Students who had attended Physics sessions conducted with AI-based tools. Teachers' responses were collected through a structured opinion questionnaire and student responses through a separate structured questionnaire on their learning experience with AI-based tools in Physics.

Research Instrument:

Data was collected using two structured questions. The questionnaire about Teachers' Opinion on AI-Based Tools in Physics Teaching comprised 15 statements about teachers' perception of AI like Gemini AI, Cloud AI, Napkin AI, OpenArt-AI, NotebookLM, Gamma AI, Quanda, and Copilot. The Strongly Agree scale rated their responses from 5 to Disagree from 1.

The survey which is Students' Opinion on AI-Based Tools in Physics Teaching has 15 statements. The response options ranged from Always (5) to Never (1), with several options in between. The statements were about learning with ease, interest in the classroom, clarity of concept, visualization, sequencing of content, feedback, interaction, and content development when taught through AI based instruction. The questionnaire contained some negatively worded statements, which were appropriately considered in the scoring and interpretation of the overall perception measure.

Data Collection:

Data were collected through structured questionnaires administered to the selected teachers and students. Participation depends on the availability of the respondents for the study and the responses were recorded in a code format for further analysis. The dataset of teachers has gender coding, and that of students has respondent names and responses to the questionnaire.

Scoring Procedure:

The responses for the questionnaire to teachers were given scores from 5 to 1, where 5 was given to Strongly Agree and 1 to Disagree. The items scores for the students' questionnaire were from 5 to 1, where always receive 5 and never receive 1. The total and mean score item-wise was calculated from which the level of perception of the respondents for the statement was calculated.

For the student statements that were negatively worded, reverse scoring was applied before deriving any overall perception measure, so that higher scores consistently represented a more favourable perception of AI-based teaching and learning

Data Analysis:

The researchers analysed the collected data using frequency, percentage, total score, mean and standard deviation. The demographic distribution of respondents is described using frequency and percentage and respondents' total scores and mean values on the items of the questionnaire are used.

To see whether teachers and students' responses are significantly different from the neutral midpoint of a five-point scale, we applied a one-sample t-test. A neutral test value of 3.00 was taken. The significance level was set at 0.05. The results were interpreted according to t-

value degrees of freedom and level of significance.

Ethical Aspects:

Respondents' information was used only for academic research purposes. Responses of the individual participants will be kept confidential and the analysis is presented in an aggregated form.

V. ANALYSIS AND INTERPRETATIONS

Demographics:

Table 1: Gender-wise Distribution of Students

Gender	Frequency (N)	Percentage (%)
Male	15	37.5
Female	25	62.5
Total	**40**	**100.0**

Table 1 shows the gender-wise distribution of 40 student respondents. It was noted that 15 students (37.5%) were male and 25 students (62.5%) were female. As a result, female respondent students were slightly over 2/3rd of the total sample. The distribution shows the student sample consisted of more female students.

Table 2: Gender-wise Distribution of Teachers

Gender	Frequency (N)	Percentage (%)
Male	5	25.0
Female	15	75.0
Total	**20**	**100.0**

Table 2 shows how the 20 teachers were distributed based on gender. Of all the respondents, male teacher share was 25.0% while the female teacher share was 75.0% The female sample was mostly represented in the survey by 75 percent of the respondents while the male sample was 25 percent. Consequently, the teacher sample had more female teacher representation.

Opinion on AI-Based Tools in Physics Teaching:

Table 2: Teachers Opinion Calculation

Sl. No.	Statement	Strongly Agree (5)	Agree (4)	Uncertain (3)	Strongly Disagree (2)	Disagree (1)	Total Score	Mean
1	Gemini AI generated videos quickly and efficiently.	18	2	0	0	0	**98**	**4.90**
2	The style and colors in the Gemini AI generated images met my	16	4	0	0	0	**96**	**4.80**

	expectations.							
3	Cloud AI helped analyze and simplify my data efficiently.	14	6	0	0	0	**94**	**4.70**
4	Napkin AI helped structure my thoughts better.	19	1	0	0	0	**99**	**4.95**
5	OpenArt-AI saved me time in producing creative visuals.	20	0	0	0	0	**100**	**5.00**
6	OpenArt-AI helped visualize abstract concepts creatively.	16	4	0	0	0	**96**	**4.80**
7	NotebookLM helped connect different ideas effectively.	20	0	0	0	0	**100**	**5.00**
8	NotebookLM helped me retain information better.	14	6	0	0	0	**94**	**4.70**
9	The design templates offered by Gamma AI were effective.	16	4	0	0	0	**96**	**4.80**
10	Gamma AI saved me time in presentation creation.	19	1	0	0	0	**99**	**4.95**

11	Gamma AI slideshow layout matched my expectations.	12	8	0	0	0	**92**	**4.60**
12	The explanations given by Quanda were easy to understand.	20	0	0	0	0	**100**	**5.00**
13	NotebookLM provided relevant insights based on my inputs.	17	3	0	0	0	**97**	**4.85**
14	Copilot provided clear and constructive feedback.	18	2	0	0	0	**98**	**4.90**
15	Copilot identified areas that genuinely needed improvement.	19	1	0	0	0	**99**	**4.95**

Teachers have shown a positive perception toward the AI-based tools. Responses for the 15 statements recorded mean scores that ranged from a low of 4.60 to a high of 5.00. This indicates that responses were concentrated in the Strongly Agree and Agree categories. The OpenArt-AI Tool, NotebookLM, and Quanda scored the highest mean score of 5.00 for the statements saved me time creating creative visuals, ability of NotebookLM to seamlessly connect different ideas, and explanations given by Quanda were easy to understand. All 20 individuals strongly agreed to these statements. After that, with 4.95, Napkin AI assisting with structuring thought processes, Gamma AI saving time in making presentations, and Copilot targeting real areas needing change were next in line. The teachers had the least expectation from the Gamma AI slideshow layout, with a mean of 4.60. Overall, the teachers' responses indicate an exceptionally favorable perception of the selected AI- based tools. Quanda obtained the highest tool- specific rating (100%), followed by Napkin AI (99%),

Copilot (98.5%) Opener AI (98%) and Gemini AI and NotebookLM (97% each). Gamma AI also received a highest rate in 95.7% while Cloud AI obtained 94%, Thus teachers perceived the AI tools particularly useful for explanation, creative visualization, Idea organization, feedback, presentation development and connecting information.

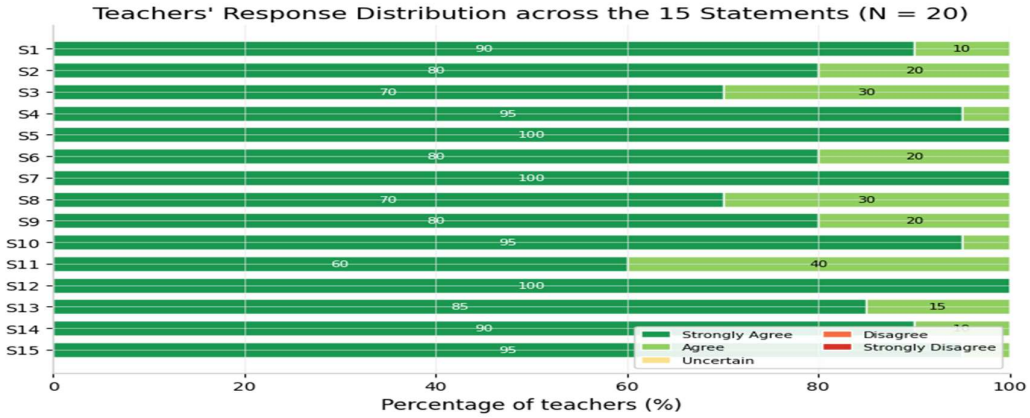

Figure 1: Percentage Distribution of Teachers' Responses across the 15 Statements

Graphical Analysis: Figure 1 shows that teachers' responses Were concentrated entirely in the Strongly Agree and Agree categories, with zero responses in Uncertain Disagree, or Strongly Disagree for all 15 statements. The proportion of Strongly agree ranged from 60% (S11-Gamma AI slideshow layout) to a unanimous 100% (S5- OpenArt- AI saving time, S7- Notebook LM connecting ideas and S12- Quanda's easy explanations). The graph visually confirms the uniformly high intensity of teachers' agreement.

Table 2: Students Opinion Calculation

Sl. No.	Statement	Always (5)	Often (4)	Sometimes (3)	Rarely (2)	Never (1)	Total Score	Mean
1	Sessions conducted using AI applications in Physics instruction makes learning easier.	24	16	0	0	0	**184**	**4.60**
2	Learning increases through AI based tools in Physics as compared to usual classroom.	19	21	0	0	0	**179**	**4.48**
3	AI based tools in Physics provides more activities.	22	17	0	1	0	**180**	**4.50**

4	Use of AI based tools in Physics makes the sessions more interesting.	24	16	0	0	0	**184**	**4.60**
5	AI based tools in Physics helps in making concepts more concrete.	15	23	0	2	0	**171**	**4.28**
6	AI based tools make images, videos and animations long lasting and enhance learning.	24	16	0	0	0	**184**	**4.60**
7	Concepts become clear through the teachers' AI-based illustrations and explanation.	22	18	0	0	0	**182**	**4.55**
8	Use of simple language and vocabulary in AI based intervention makes the learner comprehend concepts easily.	20	20	0	0	0	**180**	**4.50**
9	Contents of the AI based tools in Physics instruction were sequentially linked and helped student in learning the concepts step by step.	30	10	0	0	0	**190**	**4.75**
10	Questions asked by the teacher during the presentation were not relevant to the objectives identified to be	26	13	0	1	0	**184**	**4.60**

	achieved.							
11	Practice questions asked by the teacher helped the student to know his/her performance as feedback was given by the teacher immediately.	21	16	1	2	0	**176**	**4.40**
12	More time was taken by the teacher to complete the AI based tools in Physics presentation when compared to traditional class lecture.	27	12	1	0	0	**186**	**4.65**
13	Face to face interaction of teacher and students following AI-based instruction did not affect learning.	22	16	0	0	2	**176**	**4.40**
14	Contents presented as part of AI based tools in Physics were not in accordance to the prescribed syllabus.	25	15	0	0	0	**185**	**4.63**
15	AI analyzed feedback helps strengthen the structure of the content.	37	3	0	0	0	**197**	**4.93**

According to students, who recorded a mean score between 4.28 and 4.93, the perception of AI-based tool in Physics learning is positive. The statement which had a highest mean of 4.93 was that AI-analyzed feedback enhances the content structure which had a response of Always by 37 students and often by 3. The linking of AI-based instructional content sequentially had the mean of 4.75 which was the next highest mean. This implies that students find the AI-supported content to be useful for understanding concepts sequentially.

An average of 4.60 was obtained for the statement of making learning easier, making the session more interesting, learning through images videos and animations, and the statement about questions asked during presentation. The statement that AI-based tools assist in making the concepts of Physics concrete was scored the lowest at 4.28, which is still quite good.

Students responded favourably to all positive worded statements, with agreement (Always and often ranging from 9 2.5% to 100%. The strongest endorsement was for AI analysed feedback strengthening content structure (92.5% always, mean 4.93), followed by the sequential Linking of AI-based content supporting step-by-step learning (75% always, mean 4.75). On positively worded items, negative responses rarely or never were almost negligible. (≤5%)

The negatively worded items, however, reveal important areas of concern that must be read in reverse: 97.5% of students agreed that AI-based presentations took more time than traditional lectures, 100% agreed that content was not fully aligned with the prescribed syllabus, and 97.5% are agreed that some questions asked during a presentation were not relevant to the objectives. These results indicate that while students find AI-supported Physics learning engaging, clearer, and better structured teachers must exercise greater control over the time management, syllabus alignment and relevance of AI-generated questions.

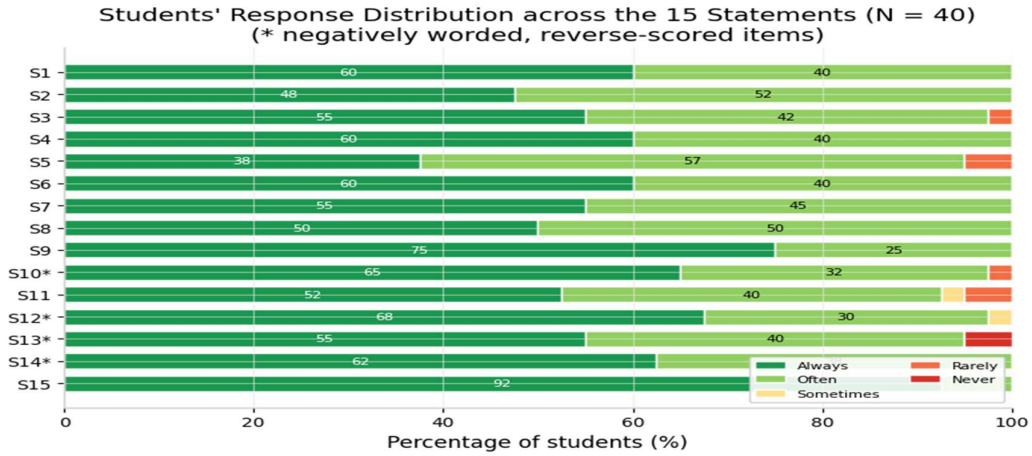

Figure 2: Percentage Distribution of Students' Responses across the 15 Statements

Graphical analysis: Figure 2 shows that students' responses to the positively worded statements were concentrated in the Always and Often categories, with negative responses (Rarely/Never) not exceeding 5% on any positively worded item. The strongest endorsement Was for S15 (AI analyzed feedback strengthens content structure), with 92.5% responding Always followed by S9 (sequentially linked content) at 75.0% Always. The negatively worded items (S10*, S12*, S13*, S14*) also attracted high agreement (62.5%- 67.5% Always), which- because these items are reverse scored- visually flags areas of concern: time consumption of AI-based presentations, partially mismatch with the prescribed syllabus, and occasional irrelevance of questions to lessen objectives.

Hypothesis Testing:

A one-sample t-test was used to determine whether teachers and students have a significantly positive perception of AI-based tools in teaching and learning Physics. The test value for the five-point scale was taken as the neutral value of 3.00. In the calculation of the overall perception score, negatively worded statements were reverse-coded. The significance level

that was adopted was 0.05.

H_{o1}: There is no significant positive perception among teachers regarding the use of AI based tools in Physics teaching.

H_{o2}: There is no significant positive perception among students regarding the use of AI-based tools in Physics.

Table 1: One-Sample t-Test of Teachers' Perception towards AI-Based Tools in Physics Teaching

Variable	N	Mean	SD	Test Value	t-value	df	Sig. (2-tailed)	Result
Teachers' overall perception	20	4.813	0.105	3.00	77.177	19	<0.001	Significant

The overall mean perception score on a scale of the teachers was 4.813 (SD = 0.105) indicating a value higher than neutral (3.00). A t-value of 77.177 in the one-sample t-test with 19 degrees of freedom was significant ($p < 0.001$). The teachers' perception of AI-based tools in Physics teaching was significantly positive. H_o1 was rejected.

Table 2: One-Sample t-Test of Students' Perception towards AI-Based Tools in Physics Learning

Variable	N	Mean	SD	Test Value	t-value	df	Sig. (2-tailed)	Result
Students' overall perception	40	3.727	0.119	3.00	38.724	39	<0.001	Significant

After reverse-scoring the negative items, the overall perception score of the students was 3.727 (SD = 0.119). The average was greater than the neutral value of 3.00. According to the one-sample t-test results, t-value is 38.724 with 39 degrees of freedom which is significant ($p < 0.001$. The result showed that students have significantly positive perceptions towards the use of AI-based tools in the learning of Physics. H_o2 was rejected.

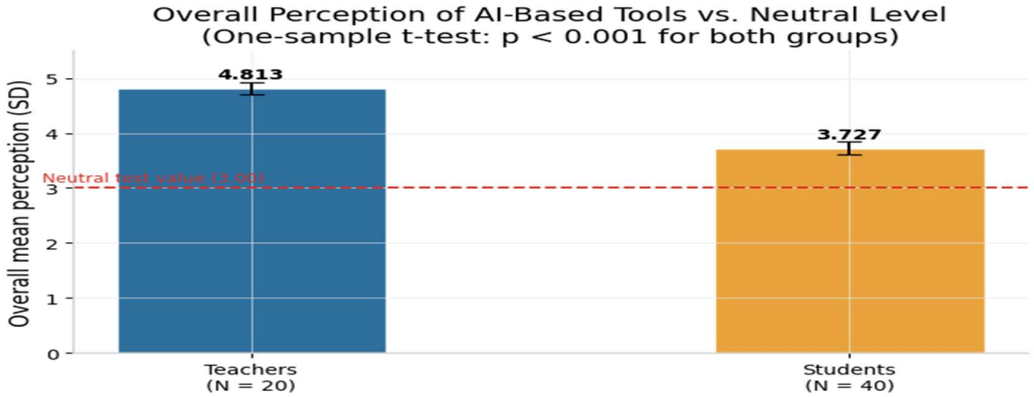

Figure 6: Overall Perception of Teachers and Students against the Neutral Level

Graphical Analysis: figure 3 compares the overall mean perception of teachers (4.813 ±0.105) and students (3.727± 0.119) with the neutral test value of 3.00. Both bars lie substantially above the neutral line, consistent with the significant one sample t-test results ($p< 0.001$ for both groups). The visible gap between the two bars shows the teacher hold a markedly stronger positive perception than students, whose overall score is moderated by the reverse- scored negative items. The results show that both teachers and students have

perceptions significantly higher than the neutral level with the teachers having a very high overall perception. The findings of this study lend statistical credence to the positive impact of AI-based tools in Physics teaching and learning.

VI. CONCLUSION

The current study examined perception of teachers and students regarding AI based tool usage in Physics teaching-learning. As noted above, the study took into account both teacher and student perspectives which led to a wider understanding of the role of AI in Physics. The study demonstrates that teachers and students generally perceive AI-based tools as valuable supplementary resources For Physics teaching and learning. AI based tools were perceived highly favorably by the teachers. The average scores for the items are ranging from 4.60 to 5.00. Among teachers, the strongest perception were associated with Quanda for comprehensible explanations, Napkin AI and NotebookLM for highely effective structuring ideas and supporting retention, Copilot for feedback and improvement identification, Openart AI and Gemini AI emerged as the strongest assets for visualization in Physics teaching, these findings suggest that the pedagogical value of AI is not uniform across applications: rather, different tools appear to support distinct dimensions of physics instruction. Teachers especially praised AI's ability to generate visual materials, organize ideas, save time, connect ideas, enhance presentations and provide constructive feedback. The incorporation of AI-based educational applications into Physics teaching can serve as a beneficial instructional aid for teachers. Students indicated that their perceptions of AI-supported Physics learning were also favorable. The mean scores for 15 statements ranged from 4.28 to 4.93. From the students' perspective, the strongest perceived benefit was associated with AI- supported feedback, followed by the sequential organization of instructional content, visualisation through images, videos and animations, increased Classroom interest, and easier learning. these findings indicate that AI-supported Physics instructions may be particularly valuable when it is integrated with pedagogical strategies that make abstract concepts more accessible, organize learning progressively, and provide timely feedback. The hypothesis testing also revealed that the overall perceptions of teachers and students were significantly more than neutral. Thus, the one-sample t-test findings provided statistical confirmation for the positive perceptions identified in the research. The findings, taken together, indicate that participants in both groups have a positive attitude towards an AI-based tool and see it as a potential complement to conventional physics teaching and learning.

Nonetheless, the data does not suggest that the AI can substitute the instructor. Instead of seeing AI-based tools as instructional material, teachers remain the protagonists in choosing information, directing pupils, checking information, encouraging interaction and enhancing technology according to their pedagogic goals and the prescribed curriculum. The findings further suggest that the effectiveness of AI in Physics education depends not simply on the availability of AI technology but on the pedagogical alignment between the particular AI tool and the instructional function for which it is employed. The successful integration will depend on effective pedagogical use, suitable teacher guidance, and critical evaluation of AI-generated content. The positive reports from both teachers and students present a good basis for further research on the effective and responsible use of AI in Physics education.

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A STUDY ON MATHEMATICS TEACHERS' ATTITUDES TOWARDS APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN THE TEACHING PROCESS OF MATHEMATICS

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Abstract

Artificial Intelligence (AI) is emerging as an important technological innovation in education, particularly in mathematics teaching and learning. AI-based applications can support mathematics teachers in lesson planning, personalized learning, automated assessment, identification of learning difficulties, generation of mathematical problems, visualization of abstract concepts, and provision of immediate feedback. The present study was undertaken to examine the attitudes of mathematics teachers towards the applications of Artificial Intelligence in the teaching process of mathematics in Karnataka. A descriptive survey method was adopted for the study. The sample consisted of 600 mathematics teachers selected from different schools of Karnataka through a representative sampling procedure. The independent variables considered were Gender, Locale, Management of School and Teaching Experience. An Artificial Intelligence Applications in Mathematics Teaching Attitude Scale developed by the investigator was used for data collection. Mean, Standard Deviation, independent-samples t-test and one-way ANOVA (F-test) were employed for analysis. The findings indicated that mathematics teachers generally possessed a favourable attitude towards the applications of AI in mathematics teaching. Significant differences were found with respect to gender, locale, school management and teaching experience. The findings are discussed in relation to previous studies on teachers' attitudes towards AI and educational technology. The study recommends systematic AI literacy programmes, hands-on training, ethical guidelines and institutional support for mathematics teachers.

Keywords: *Artificial Intelligence, Mathematics Teaching, Teachers' Attitude, AI Applications, Mathematics Education, Teacher Education, Karnataka.*

1. Introduction:

Artificial Intelligence has become one of the most influential technological developments in contemporary education. AI refers broadly to computational systems capable of performing tasks that traditionally require human intelligence, including learning, reasoning, prediction, language processing, pattern recognition and decision-making. The rapid development of generative AI, intelligent tutoring systems, adaptive learning platforms and automated assessment tools has created new possibilities for classroom teaching.

Mathematics is a particularly suitable subject for the application of AI because mathematical learning involves problem solving, logical reasoning, pattern recognition, symbolic

manipulation, visualization and continuous assessment. AI-based systems can provide individualized practice, generate problems at different levels of difficulty, offer step-by-step explanations, identify common errors and provide immediate feedback to learners. AI can also assist teachers in preparing lesson plans, worksheets, quizzes and remedial activities.

However, the successful integration of AI into mathematics education depends considerably upon teachers' attitudes, technological competence, confidence, perceived usefulness and awareness of ethical issues. Teachers who perceive AI as useful and manageable are more likely to experiment with AI-supported teaching strategies, whereas teachers who perceive AI as complicated, unreliable or threatening may be reluctant to use it.

The introduction of AI into education also raises concerns related to academic integrity, accuracy of mathematical explanations, student dependence on technology, privacy, algorithmic bias, teacher autonomy and the possibility of inappropriate use of generative AI. Consequently, studying teachers' attitudes is essential for developing appropriate policies and professional development programmes.

In Karnataka, schools differ considerably in terms of geographical location, management structure, technological facilities and teachers' professional experience. Therefore, it is important to examine whether mathematics teachers' attitudes towards AI differ according to gender, locale, school management and teaching experience.

2. Need and Significance of the Study:

The integration of AI into mathematics teaching is not merely a technological issue; it is also a pedagogical and professional issue. Mathematics teachers need to understand how AI can complement—not replace—their professional judgment.

The present study is significant for the following reasons:

1) It provides an understanding of mathematics teachers' attitudes towards AI applications.

2) It identifies differences in attitudes across important demographic and professional variables.

3) It can help educational administrators plan AI-oriented teacher professional development.

4) It provides evidence for strengthening digital and AI literacy among mathematics teachers.

5) It can support teacher education institutions in incorporating AI pedagogy into mathematics-method courses.

6) It may assist policymakers in developing responsible AI implementation strategies.

7) It can identify groups of teachers who may require additional training and technological support.

8) It contributes to the growing literature on AI integration in mathematics education in the Indian context.

3. Statement of the Problem:

"A Study on Mathematics Teachers' Attitudes Towards Applications of Artificial Intelligence in the Teaching Process of Mathematics."

4. Objectives of the Study:

The study was undertaken with the following objectives:

1) To study the overall attitude of mathematics teachers towards applications of AI in the teaching process of mathematics.

2) To find out whether there is a significant difference in the attitude of male and female mathematics teachers towards applications of AI.

3) To find out whether there is a significant difference in the attitude of mathematics teachers belonging to rural and urban locales towards applications of AI.

4) To find out whether there is a significant difference among mathematics teachers working under different school managements with respect to their attitude towards applications of AI.

5) To find out whether there is a significant difference among mathematics teachers with different levels of teaching experience with respect to their attitude towards applications of AI.

6) To compare the findings of the present study with the findings reported in earlier studies concerning teachers' attitudes towards AI and educational technology.

5. Hypotheses of the Study:

The following null hypotheses were formulated:

1) **$H_0$1:** There is no significant difference between male and female mathematics teachers in their attitudes towards applications of AI in mathematics teaching.

2) **$H_0$2:** There is no significant difference between rural and urban mathematics teachers in their attitudes towards applications of AI in mathematics teaching.

3) **$H_0$3:** There is no significant difference among mathematics teachers working in different types of school management in their attitudes towards applications of AI in mathematics teaching.

4) **$H_0$4:** There is no significant difference among mathematics teachers with different levels of teaching experience in their attitudes towards applications of AI in mathematics teaching.

6. Operational Definitions:

Artificial Intelligence: For the purpose of the present study, Artificial Intelligence refers to computer-based systems and applications that can perform tasks involving learning, prediction, language processing, problem generation, feedback, personalization and decision support, and which may be used to support mathematics teaching and learning.

Applications of AI in Mathematics Teaching: These include AI-supported lesson planning, generation of mathematical questions, personalized learning, intelligent tutoring, automated assessment, feedback, identification of students' learning difficulties, mathematical visualization, problem-solving support and creation of teaching-learning resources.

Attitude: Attitude refers to the degree of favourable or unfavourable disposition of mathematics teachers towards the use and application of Artificial Intelligence in the teaching process of mathematics.

7. Methodology:

7.1 Research Method:

The descriptive survey method was employed for the present investigation because the study aimed to determine the existing attitudes of mathematics teachers towards applications of AI in mathematics teaching.

7.2 Population:

The population comprised mathematics teachers working in secondary and higher secondary schools in Karnataka.

7.3 Sample:

A sample of 600 mathematics teachers was selected from different parts of Karnataka. Teachers representing different genders, locales, school managements and levels of teaching experience were included.

7.4 Variables:

The following variables were considered:

Variable	Categories
Gender	Male, Female
Locale	Rural, Urban
School Management	Government, Aided, Private
Teaching Experience	Below 5 years, 5–10 years, Above 10 years

8. Tool Used

Artificial Intelligence Applications in Mathematics Teaching Attitude Scale (AIAMTAS)

For the purpose of the study, an **Artificial Intelligence Applications in Mathematics Teaching Attitude Scale (AIAMTAS)** was developed by the investigator.

The scale may consist of **40 statements** covering the following dimensions:

1) Perceived usefulness of AI in mathematics teaching
2) Ease of using AI applications
3) AI-supported lesson planning
4) Personalized mathematics learning
5) AI-assisted assessment and feedback
6) Mathematical problem-solving support
7) Visualization and representation
8) Remedial and enrichment teaching
9) Teacher confidence in using AI
10) Ethical and responsible use of AI

The items were rated on a five-point Likert scale ranging from strongly agree to strongly disagree. Higher scores indicated a more favourable attitude towards AI applications in mathematics teaching.

For the final research report, the investigator should report the actual values of content validity, reliability and pilot-study results obtained for the instrument.

9. Statistical Techniques:

The following statistical techniques were employed:

1) Mean
2) Standard Deviation
3) Independent-samples t-test
4) One-way ANOVA (F-test)

The level of significance was fixed at **0.05**.

10. Analysis and Interpretation:

Objective 1: To study the overall attitude of mathematics teachers towards applications of AI in mathematics teaching.

Table – 2: Overall Attitude of Mathematics Teachers Towards Applications of AI

Variable	N	Mean	SD	Level
AI Applications in Mathematics Teaching Attitude	600	148.26	14.82	Favourable

The obtained mean attitude score of 148.26 with a standard deviation of 14.82 indicates that mathematics teachers, as a group, possessed a favourable attitude towards applications of AI in mathematics teaching. The finding suggests that teachers generally recognize the potential of AI to support lesson preparation, personalized learning, assessment, feedback, mathematical visualization and problem-solving activities.

At the same time, a favourable attitude should not be interpreted as evidence that teachers are already highly competent in using AI. Attitude and actual classroom implementation are distinct constructs and should be examined separately.

1) Hypothesis-1: There is no significant difference between male and female mathematics teachers in their attitudes towards applications of AI in mathematics teaching.

Table – 3: Difference Between Male and Female Mathematics Teachers in Attitude Towards AI

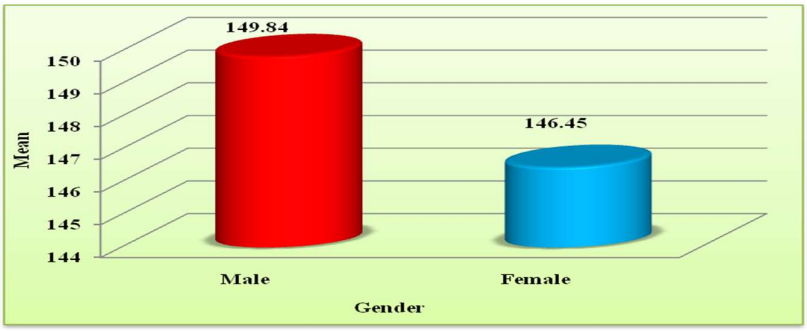
Gender	N	Mean	SD	t-value	Significance
Male	320	149.84	14.36	2.73	Significant at 0.01
Female	280	146.45	15.18		

The mean attitude score of male mathematics teachers **(**149.84) was higher than that of female mathematics teachers (146.45). The obtained t-value of **2.73** is statistically significant at the 0.01 level.

Therefore, $H_0$1 is rejected. There is a significant difference between male and female mathematics teachers in their attitudes towards applications of AI in mathematics teaching.

The result indicates that gender may be associated with differences in exposure to, confidence in or perceived usefulness of emerging technologies. However, gender alone should not be regarded as a determinant of AI competence. Access to professional development and opportunities for hands-on experience may be more important explanatory factors.

Graph – 2: Comparison of the Difference Between Male and Female Mathematics Teachers in Attitude Towards AI



2) $H_0$2: There is no significant difference between rural and urban mathematics teachers in their attitudes towards applications of AI in mathematics teaching.

Objective - 3: To find out whether there is a significant difference between rural and urban mathematics teachers in their attitudes towards applications of AI.

Table – 4: Difference Between Rural and Urban Mathematics Teachers

Locale	N	Mean	SD	t-value	Significance
Rural	300	145.91	15.24	3.76	Significant at 0.001
Urban	300	150.61	13.94		

The mean attitude score of urban mathematics teachers (150.61) was higher than that of rural mathematics teachers (145.91). The obtained t-value of 3.76 is significant at the 0.001 level. Hence, H02 is rejected. There is a significant difference between rural and urban mathematics teachers in their attitudes towards AI applications.

The comparatively higher attitude among urban teachers may be associated with greater exposure to digital technologies, better access to internet facilities, professional development programmes and AI-enabled educational resources. The finding also highlights the importance of reducing the digital divide between rural and urban schools.

Graph – 3: Comparison of the Difference Between Rural and Urban Mathematics Teachers



3) $H_0$3: There is no significant difference among mathematics teachers working in different types of school management in their attitudes towards applications of AI in mathematics teaching.

Table – 5: Attitude of Mathematics Teachers According to School Management

Management	N	Mean	SD
Government	250	145.72	15.16
Aided	150	148.36	14.21

Private	200	151.42	13.76
Total	**600**	**148.26**	**14.82**

Table – 6: ANOVA of Attitude Scores According to School Management

Source of Variation	SS	df	MS	F	Significance
Between Groups	3521.84	2	1760.92	8.24	Significant at 0.001
Within Groups	127604.16	597	213.74		
Total	131126.00	599			

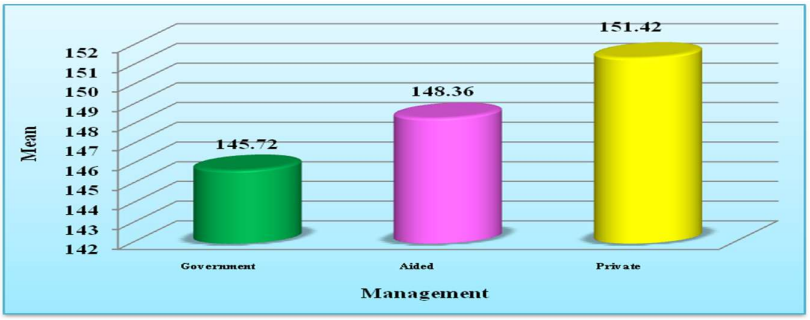
The mean scores show that mathematics teachers working in private schools obtained the highest mean (151.42), followed by aided-school teachers (148.36) and government-school teachers (145.72).

The obtained F-value of 8.24 is significant at the 0.001 level. Therefore, H03 is rejected. There is a significant difference among mathematics teachers belonging to different school managements.

The difference may be related to variations in technological infrastructure, institutional policies, access to digital platforms, training opportunities and organizational encouragement for technology integration.

A post-hoc test would be desirable in the final statistical analysis to determine specifically which management groups differ significantly from one another.

Graph – 4: Comparison of the Attitude of Mathematics Teachers According to School Management



5) Teaching Experience-wise Comparison:

Objective – 5: To find out whether there is a significant difference among mathematics teachers with different levels of teaching experience.

Table – 7: Attitude of Mathematics Teachers According to Teaching Experience

Teaching Experience	N	Mean	SD
Below 5 years	180	152.31	13.42
5–10 years	210	149.08	14.16
Above 10 years	210	144.21	15.72
Total	**600**	**148.26**	**14.82**

Table – 8: ANOVA of Attitude Scores According to Teaching Experience

Source of Variation	SS	df	MS	F	Significance
Between Groups	6418.72	2	3209.36	15.28	Significant at 0.001
Within Groups	125307.28	597	209.90		

Total	131726.00	599			

The mathematics teachers with less than five years of experience obtained the highest mean attitude score (152.31), followed by teachers with 5–10 years of experience (149.08). Teachers with more than 10 years of experience obtained the lowest mean (144.21). The obtained F-value of 15.28 is significant at the 0.001 level. Hence**,** H04 is rejected. Thus, there is a significant difference among mathematics teachers with different levels of teaching experience in their attitudes towards AI applications.

The finding may indicate that younger or less-experienced teachers have had greater exposure to contemporary digital technologies during their pre-service and early professional education. However, experienced teachers possess valuable pedagogical expertise, and targeted AI professional development could help them integrate emerging technologies effectively.

Graph – 5: Comparison of the Attitude of Mathematics Teachers According to Teaching Experience



6) Summary of Hypothesis Testing:

Table – 9: Summary of Results of Hypotheses

Hypothesis	Statistical Value	Result	Decision
Gender	t = 2.73	Significant	H01 Rejected
Locale	t = 3.76	Significant	H02 Rejected
School Management	F = 8.24	Significant	H03 Rejected
Teaching Experience	F = 15.28	Significant	H04 Rejected

The results demonstrate statistically significant differences across all four selected variables.

7) Discussion of Findings in Relation to Previous Studies

The present study found that mathematics teachers generally have a favourable attitude towards AI applications in mathematics teaching. This finding is broadly consistent with the emerging international literature showing that teachers tend to recognize the potential usefulness of AI while simultaneously expressing concerns about reliability, ethics, privacy and professional preparedness.

Studies examining teachers' acceptance of AI and educational technologies have frequently reported that perceived usefulness, ease of use, technological confidence and institutional supportinfluence teachers' willingness to adopt AI-supported tools. The favourable overall attitude observed in the present study is therefore consistent with the broader technology-acceptance literature.

The present finding of a significant gender difference should be interpreted cautiously. Some technology-adoption studies have reported gender differences in technology confidence or acceptance, while other studies have found that such differences become smaller when

access, training and prior experience are controlled. Thus, the present finding supports the existence of a difference in the sample but does not establish gender as the underlying cause.

The significant rural–urban difference is particularly important in the Karnataka context. The higher mean score of urban teachers is consistent with research highlighting the role of digital access, infrastructure, connectivity and professional development in technology adoption. The finding suggests that AI implementation policies should not focus solely on software procurement; they must also address infrastructure and teacher capacity in rural schools.

The significant difference according to school management is also consistent with the broader observation that institutional resources and organizational support influence educational technology integration. Private schools may have greater access to digital platforms and technology-oriented training, although the actual situation can vary substantially from institution to institution.

The significant difference according to teaching experience is consistent with studies suggesting that teachers' prior exposure to digital technologies can influence their acceptance of emerging technologies. The higher attitude among less-experienced teachers may reflect greater familiarity with digital environments. Nevertheless, experienced teachers should not be viewed as resistant to innovation. With appropriate professional development, their substantial pedagogical experience can be combined with AI competencies to produce effective AI-supported mathematics teaching.

Importantly, international research on generative AI in education also indicates that positive attitudes coexist with concerns about accuracy, academic integrity, data privacy, bias and overdependence on technology. Therefore, favourable attitudes alone cannot guarantee effective or responsible implementation.

8) Major Findings:

The major findings of the study were:

1) Mathematics teachers demonstrated an overall **favourable attitude** towards applications of AI in mathematics teaching.

2) Male mathematics teachers showed a significantly higher attitude score than female mathematics teachers.

3) Urban mathematics teachers showed a significantly higher attitude than rural mathematics teachers.

4) Significant differences were found among teachers working in government, aided and private schools.

5) Private-school mathematics teachers recorded the highest mean attitude score.

6) Teachers with less than five years of experience obtained the highest attitude score.

7) Teachers with more than ten years of experience obtained the lowest mean attitude score.

8) Teaching experience produced a statistically significant difference in teachers' attitudes.

9) The findings indicate that exposure, infrastructure, institutional support and professional development may play important roles in teachers' attitudes towards AI.

10) The findings broadly correspond with the emerging literature emphasizing perceived usefulness, technological readiness, access and professional development as important factors in AI adoption.

9) Educational Implications:

The findings have several implications for mathematics education.

1) AI Literacy Programmes: Teacher education institutions should introduce structured AI literacy programmes for mathematics teachers covering both basic and advanced applications.

2) Hands-on Training: Training should move beyond theoretical lectures and provide practical experience with AI-based lesson planning, mathematical problem generation, assessment and feedback.

3) Rural–Urban Digital Equity: The difference between rural and urban teachers indicates the need for improved connectivity, devices, digital resources and AI training in rural schools.

4) Professional Development for Experienced Teachers: Special programmes should be organized for experienced mathematics teachers to demonstrate how AI can complement their existing pedagogical knowledge.

5) Ethical AI Use: Teachers should be trained to evaluate AI-generated mathematical content for correctness and to understand issues related to privacy, bias, copyright, academic integrity and student data.

6) AI as a Supporting Tool: AI should be positioned as a supportive pedagogical tool rather than a replacement for the mathematics teacher**.** Teachers should retain responsibility for instructional decisions, mathematical validation and student assessment.

10) Recommendations

Based on the findings, the following recommendations are made:

1) Karnataka's school education system should develop systematic AI-in-education professional development programmes.

2) Mathematics teachers should receive hands-on training in generative AI and intelligent mathematics applications.

3) Rural schools should receive priority in improving digital infrastructure and connectivity.

4) Teacher education curricula should include AI-supported mathematics pedagogy.

5) Schools should develop institutional guidelines for responsible AI use.

6) Teachers should be trained to verify AI-generated mathematical solutions before classroom use.

7) AI tools should be used to support differentiated and personalized mathematics learning.

8) Professional learning communities should be created for teachers to share successful AI-supported mathematics teaching practices.

9) Experienced teachers should be encouraged to combine their pedagogical expertise with new AI tools.

10) Future research should investigate the relationship between teachers' attitudes and their **actual classroom use of AI**.

11) Limitations of the Study

1) The study was limited to mathematics teachers in Karnataka.
2) The sample consisted of 600 teachers and therefore the findings should be generalized cautiously.
3) The study focused on attitude rather than actual classroom implementation.
4) The investigation considered only four demographic/professional variables.
5) The study used self-reported responses, which may be affected by social desirability.
6) AI technologies are rapidly changing; consequently, teachers' attitudes may change as exposure and institutional policies develop.

12) Suggestions for Further Research

Future studies may be undertaken on:

1) AI competency of mathematics teachers.
2) Effectiveness of AI-assisted mathematics teaching.
3) Teachers' perceptions of generative AI in mathematics education.
4) AI literacy among B.Ed. and M.Ed. teacher trainees.
5) Relationship between AI attitude and actual AI usage.
6) AI-based personalized learning in mathematics.
7) Effectiveness of ChatGPT or other generative AI tools in mathematics problem solving.
8) AI and mathematical creativity among secondary school students.
9) Ethical concerns regarding AI use in mathematics assessment.
10) Comparative studies of AI adoption among mathematics, science, language and social science teachers.

13) **Conclusion:** The present study examined mathematics teachers' attitudes towards applications of Artificial Intelligence in the teaching process of mathematics. The findings indicate that mathematics teachers in Karnataka generally possess a favourable attitude towards AI. However, significant differences were found according to gender, locale, school management and teaching experience. The findings emphasize that successful AI integration cannot be achieved simply by making AI tools available to schools. Teachers require appropriate technological infrastructure, professional training, pedagogical guidance and ethical frameworks. The rural–urban difference particularly highlights the importance of equitable access to digital resources. AI has considerable potential to transform mathematics education by supporting personalized learning, automated feedback, problem generation, assessment, visualization and remedial instruction. Nevertheless, the mathematics teacher remains central to the teaching-learning process. The most desirable approach is therefore not teacher replacement but teacher–AI collaboration, in which AI performs supportive

computational and content-generation functions while teachers provide pedagogical judgment, mathematical validation, emotional support and classroom leadership.

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ARTIFICIAL INTELLIGENCE AS A CATALYST FOR CRITICAL INQUIRY AND HISTORICAL THINKING IN SOCIAL SCIENCE EDUCATION: PREPARING SMART TEACHERS FOR CULTURALLY RESPONSIVE CLASSROOMS

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Abstract

As Artificial Intelligence (AI) progresses at a rapid speed, it offers a transformative opportunity to reinvent social science teaching and learning from passive content delivery to building critical inquiry and advanced historical thinking skills. This concept paper looks at how AI can play a powerful role in supporting students' capacities to locate evidence, explain events in their context, verify several views, and draw inferences or conclusions and how AI might support teachers in building culturally responsive classrooms that value and respect different learner identities. In the context of historical thinking and culturally responsive pedagogy, the paper explores how AI tools can offer pedagogical affordances for document-based inquiry, virtual and augmented realities to create living historical experiences, intelligent tutoring systems that support Socratic dialogue, and learning analytics tools as real-time sources of feedback on argumentation and source evaluation. The technologies have notable potential in tackling some of the longstanding problems in secondary social studies classrooms: the limited access to primary sources, the challenge to see processes of socio-economic and political development, and the difficulty of engaging students, particularly when teaching in large or resource-limited groups. Simultaneously, the paper critically reviews the risks that lie in the uncritical adoption of AI, such as 'algorithmic bias', 'cultural misrepresentation in training data', 'loss of teacher professional judgment', and 'closing the digital divide'. It calls for purposeful teacher professional learning programmes that weave together what is known as Technological Pedagogical Content Knowledge (TPACK) with critical awareness of AI, ethical considerations, and culturally sustaining practices. This can help a teacher to assess the output of AI tools, collaboratively develop learning activities that are relevant for the context and ensure their facilitation is human-centred, enabling student voice and community knowledge to be heard. The discussion points towards the implications of the discussion for Indian teacher education and secondary curricula, focusing on the alignment with national goals of holistic, multi-disciplinary and equitable learning. The paper concludes that AI is only a true facilitator of "historical thinking" and "critical inquiry" when teachers are viewed and strengthened as "culturally responsive learning designers" instead of "technological consumers of learning". This approach is a direct contribution towards the vision of the conference 'Smart Teachers for a Smart and Inclusive Future'.

Keywords: *Artificial intelligence in education; Historical thinking; Critical inquiry; Social science pedagogy; Culturally responsive pedagogy; Teacher professional development; Ethical AI integration*

I. Introduction

The incorporation of the concepts of artificial intelligence (AI) in education has gained momentum all over the world, leading to the radical transformation of education pedagogy, curriculum design, and teacher preparation. The vision of Future Ready Citizens has now been explicitly stated in the National Education Policy 2020 (NEP 2020) in India as Artificial Intelligence, machine learning and data science as important subjects to prepare next-generation citizens. Multi-disciplinary education that integrates technological skills, or abilities, with critical thinking, creativity, and moral awareness is promoted (Ministry of Education, 2020). The vision is to extend the use of AI beyond efficiency initiatives into a paradigm shift in the way students learn, and their teachers teach, particularly within the realms of the social sciences and humanities.

However, secondary social science and history education has still been beset by several difficulties in India even if policy measures express such a vision. Teaching is typically still focused on the memorisation of facts, timelines and events, and little focus is on the learning of the historical thinking skills of sourcing, contextualisation, corroboration and the development of evidence-based interpretations. In addition, various factors such as large class size, differences in student backgrounds and the scarcity of resources result in students becoming disengaged and lacking insight into how the curriculum applies to their real-life experiences, particularly in state boards like the Council of Higher Secondary Education (CHSE) in Odisha.

The potential and challenges of generative AI to tackle these issues are great. On the other hand, the potential of AI tools to scaffold complex cognitive processes, offer personalised feedback, develop different materials, and simulate abstract phenomena to make them more concrete is inevitable. The ability of AI tools to scaffold complex cognitive processes, offer personalised feedback, develop different versions of materials, and simulate abstract processes that would make them more concrete is inevitable. However, over-dependence on AI may lead to superficial usage of the technology, adopting fabricated or biased information, and a decrease in students' ability to think for themselves. The American Historical Association (2025), in the Guiding Principles for Artificial Intelligence in History Education, asserts that, in the age of AI, historical thinking is still required--and cannot be performed perfectly by AI. Generative tools must complement and not supplant the historical thinking skills and habits that allow students to analyse evidence, interpret it within multiple viewpoints, and draw their own conclusions.

This paper investigates an important gap between these developments: how, at the same time, AI can serve as an engine for critical inquiry and historical thinking in the study of social science and teachers' preparedness to adopt AI tools in culturally responsive ways in this discipline. This aim is to explore the pedagogical opportunities of using AI to enhance historical thinking skills, recognise the required professional knowledge and skills for teachers, and offer guidelines on how teacher training should develop further to meet the

technological integration needs for cultural and equity responsiveness.

The importance of this inquiry is that it directly contributes to the theme of the conference 'Shaping smart teachers for a smart future'. This conceptual paper provides practical implications for the teacher education programmes in India, like B.Ed. and M.Ed. course curricula, teacher in-service training under DIKSHA and NCERT schemes, and execution of secondary curriculum in boards like CHSE Odisha. Thereafter, in this introduction, the present paper develops an integrated theoretical framework based on the concepts of historical thinking, culturally responsive pedagogy, and Technological Pedagogical Content Knowledge (TPACK). Following this introduction, an integrated theoretical setting is provided based on the concepts of historical thinking, culturally responsive pedagogy, and Technological Pedagogical Content Knowledge (TPACK). The following sections explore the affordances and challenges of AI for educators, teacher preparation requirements, ethical and equity concerns, and policy implications, and finally, recommendations for research and practice are considered.

II. Theoretical and Conceptual Framework

Integrating artificial intelligence (AI) into the field of social science education demands a comprehensive theoretical framework that not only embraces the disciplinary thinking of social science educators but also considers cultural diversity, technological affordances, and accountable and anti-marginal perspectives on new technologies in the curriculum. This section merges four interrelated frameworks to formulate one overarching perspective to consider AI as a catalyst for historical thinking in culturally responsive classrooms.

Historical thinking is a disciplinary core that serves as the basis for meaningful social studies content. The six ideas (evidence, significance, continuity and change, cause and consequence, historical perspectives, and the ethical dimension) that Seixas and Morton (2013) present are interconnected, and they work to help students develop to the level of sophisticated interpretation and judgment. These ideas focus on the active building of historical knowledge by critically assessing historical sources, identifying multiple perspectives from history and examining the moral context of historical events. In an age of generative AI, when the ability to write a story or make up a historical voice is swiftly acquired by large language models, such as the one employed by ChatGPT, these disciplinary ways of thinking are more critical than ever for discerning true inquiry from mere meanderings and imagination.

Culturally responsive pedagogy (CRP) includes strategies for using the technological tools on behalf of diverse learners, not as a reinforcement of dominant culture. Gay (2010) describes CRP as instruction that draws on the cultural knowledge, previous experiences and styles of performance of the varied student population to enhance and personalise learning. Ladson-Billings (1995) also stresses the cultivation of the students' cultural competence along with academic and critical consciousness. There has been recent scholarship that has considered how to extend the CRP in a technology-enhanced learning (TEL) or AI-facilitated learning context, noting that teachers should question whether espoused AI-generated content affirms

or marginalises students' cultural identities and community knowledge systems.

The model of how teachers combine technology and pedagogy and content is the Technological Pedagogical Content Knowledge (TPACK) model. Mishra and Koehler (2006) view TPACK as an interweaving of three bodies of knowledge: Technological Knowledge, Pedagogical Knowledge, and Content Knowledge. This framework is developing in the realm of generative AI. The centrality of teacher agency in TPACK is also shared in emerging conceptions, such as Human-Centric AI Pedagogy, which integrates AI-specific skills and capabilities, such as prompt engineering, critical analysis of AI outputs, human-AI collaboration, and ethical considerations (Zhou et al., 2026). These extensions highlight that skilful incorporation of AI needs more than technical proficiency, and involves a nuanced pedagogical judgment that relies on disciplinary and cultural contexts.

AI in human rights work can be understood from critical and decolonisation angles that add a dose of caution to the frameworks. More attention has been placed on how AI systems, predominantly trained with Western data and epistemologies, can continue to cause algorithmic bias, cultural misrepresentation, and epistemic injustice (Jarvis & Silano, 2026). In contexts of education, especially in the Global South, there is a greater focus on culturally sustaining and decolonial approaches that value and respect local knowledge systems, recognise data sovereignty, and enable the meaningful and active involvement of marginalised communities in the design and utilisation of AI tools and practices.

Combining all of these visions, this study suggests a combination of perspectives that sees the use of AI as a facilitator only when integrated with the TPACK-informed, culturally responsive and critically reflective approaches that the teacher utilises. In this lens, the focus extends beyond the Learning Standards to include evaluations of the properties of the tools and their affordances related to the Big Six concepts of historical thinking as well as their connections to students' cultural resources, and their ability to enhance or impede Epistemic Justice. This comprehensive strategy serves as a foundation for the next examination of the affordances of AI, the teacher preparation systems, and policy recommendations in secondary social science education in India. This holistic framework will be used to examine the affordances of AI, teacher preparation systems, and policy implications in Indian secondary social science education.

IV. Building Smart Teachers: Reframing Professional Development for the Integration of AI in a Culturally Responsive Way

The impact of AI on social science education is yet to be fully realised if no systematic investment is made in teacher education. However, there are substantial gaps in pre-service and in-service teacher training in AI literacy, especially in social sciences and humanities in India. The current National Education Policy 2020 has highlighted that both new technologies and interdisciplinary teaching should be utilised in the education system, but the application of these perspectives among teacher training schools has been uneven. The upkeep of technology integration as a secondary issue instead of a key pedagogical skill has

been prevalent in the curriculum of many B.Ed. and M.Ed. programs; only recently has the integration of AI as a core component in in-service platforms like DIKSHA been introduced (Ministry of Education, 2020). Teachers of social science, particularly those of history under the state board like CHSE Odisha, typically do not receive specific guidance on how to effectively engage with generative AI tools to shape students' critical thinking and an understanding of historical concepts.

To be well prepared, there should be a well-defined set of competencies among what "smart teachers" ought to possess. These skills build upon and integrate the Technological Pedagogical Content Knowledge (TPACK) framework, encompassing the critical understanding of how AI systems create knowledge and how to question their biases, limitations, and understandings of privacy, to the prompting skills needed to tailor AI systems to meet the demands of a specific task, and how to assess AI output for its accuracy, cultural representation, and pedagogical value, while co-designing culturally responsive lessons with AI tools and focusing on students' lived experiences and community knowledge. These skills need to be built in a way that ensures teachers have agency – not replaced by AI.

There are several models that appear to have the potential to develop these capacities through professional development. Any training will be more successful when focusing on the content-specific uses of AI rather than generic AI training sessions. Content-specific uses of AI will be better suited than general use of AI training. Communities of practice promote ongoing pedagogical innovation as teachers plan, execute, and review lessons enhanced with AI together. Using Action research cycles and integrating the use of AI in micro-teaching sessions, teachers are able to place in the field forms of tools like generative platforms for source analysis and/or simulation-based activities and receive structured feedback from them. Reflective frameworks similar to what is done with tools such as CulturAIEd support educators to reflect systematically on how their AI-generated content is aligned with students' cultures, and how to intentionally adapt it for inclusivity.

These approaches need to be scaled and lie with the teacher educators and key institutions. The Regional Institutes of Education (RIEs), along with B.Ed. and M.Ed. programmes, DIKSHA and the Central Institute of Educational Technology (CIET-NCERT) have a unique opportunity in building context-responsive modules, as they would be able to link technology with critical aspects and culturally sensitive approaches. While there is an increasing awareness concerning the need within educational institutions, more attention needs to be paid to the application of AI in the humanities and social science segments. There are several instances from the CIET-NCERT recently where they started looking into AI in education that are examples of that.

Balancing the efficiency AI provides (like quick lesson planning, differentiation, and feedback generation) with the pedagogical judgment and cultural responsiveness needed for meaningful learning is the key to professional development. If educators are willing to look at how AI can be leveraged as an adaptive tool for them to use, undeniably, rather than a way to

'teach deals', they can benefit from the affordances of the technology and maintain the essential human, ethical, and disciplinary elements in the learning process, which can never be replaced by technology.

V. Challenges, risks and equity considerations

The affordances of artificial intelligence for improving historical thinking and students' engagement are considered here, with their immense challenge to social studies education that requires thoughtful consideration. Generative AI systems often introduce inaccuracies in the past and fabricate sources and culturally biased representations. As the American Historical Association (2025) states, AI may produce "more believable but less accurate changes in the past that are not supported by factual evidence. This problem of possible cultural inaccuracies is more severe in the Indian context where one has to deal with culturally diverse traditions (like Jainism, Buddhism) and history (like local ones) which might be inaccurately interpreted by models trained solely on Western data.

Ethical issues aren't limited to the accuracy of content. AI tools in classrooms pose challenges of data privacy if students' interactions with generative tools aren't made secure and consented for storage or analysis. Also, there is the fear of more scrutiny being conducted with the use of learning analytics—a system of monitoring student behaviour and performance in real time. Fundamentally, excessive dependency on AI could reduce critical thinking skills in students and the teacher professional autonomy needed to curb cognitive overload. On the most basic level, this heavy reliance on AI may strip students of their ability to think critically and form a sense of professional autonomy from teachers, which could cause mental overload. Some pedagogical research questions are generated with little pedagogic judgment shown by the teacher or little intellectual effort asked from the students when AI is used to create lessons, assessments or feedback.

Equity is also a critical consideration. There are major digital divides in Indian schools, especially in states like Odisha where a lack of devices, internet connectivity, and a consistent electricity supply make it difficult to access digital resources. Language support is another major missing link, as a lot of language-generation AI tools fail to perform well in Indian languages like Odia, which has a minimal presence in classrooms that are run in Odia, which is where students are at a disadvantage. If AI-enabled pedagogies are not targeted strategically, they could exacerbate rather than bridge inequities between communities and within our nation's secondary schools. If left to chance, the introduction of AI-supported pedagogies can increase inequities between secondary schools in the community and well-resourced private and government schools.

AI systems today primarily represent a Western epistemological picture inscribed in their training data, from a decolonial standpoint. This concerns epistemic injustice, through which the local knowledge systems and ways of knowing are marginalised or misrepresented (Jarvis & Silano, 2026). The demand for contextually appropriate and culturally responsive AI applications, grounded in meaningful involvement of Indian educators, historians and

community.

To mitigate these risks, conscious actions can be taken while ensuring that human-AI collaboration retains teacher autonomy. Teachers need to be not just evaluators and adapters of AI-generated content but primarily active agents of questioning and interrogation, to tweak, transform and customise the output of AI to fit local cultural and curricular settings, and remain responsible for instruction decisions throughout the process as active participants. A focus on critically understanding AI literacy, ethical considerations, and culturally appropriate adaptation is crucial for professional development. In fact, using AI is not a standalone process, but requires teachers to become adept at navigating thoughtful partnerships with AI where student autonomy, equity, and the integrity of a discipline are maintained.

VI. Implications for Policy, Curriculum, and Teacher Education in India

The potential benefits of using artificial intelligence as a catalyst for critical thinking and historical thinking must be realised with coordinated action in teacher education and in school curricula and educational policy. The need at the level of teacher preparation is to have a critical understanding of AI literacy within the framework of culturally responsive pedagogies and disciplinary thinking in B.Ed./M.Ed. courses. Pre-service teachers need to practice using sustained efforts in designing, testing, and modifying AI-integrated lessons in SSS, paying focus on elements of bias, representation, and student agency. There is a need to invest more time in modular and subject-specific in-service professional development platforms with technological skills and pedagogical skills based on best practices and reflections, taking the cultural context into consideration, with CIET-NCERT playing a pivotal role in it.

The school curriculum level should include clear articulation of how AI can be used responsibly in the learning of social science in the frameworks that have been prepared by the NCERT and state boards like CHSE Odisha. This includes incorporating learning outcomes for AI-generated historical content evaluations, source analysis and simulation with AI tools, and critical digital citizenship development. AI should be integrated into the curriculum from early to late classes as a helpful tool in developing historical thinking concepts, not an add-on.

Similarly, policy initiatives are needed. The Ministry of Education should set guidelines for the use of generative AI in humanities and social science education that ensure that this technology is respected in the following aspects: Data privacy, Truthfulness of generated content and Academic integrity. There is a need to invest more into building more culturally relevant, multilingual AI tools that align with Indian languages and knowledge systems. Teachers should also be encouraged to drive change, and policy should establish ways for teachers to test, record, and share the ways in which they are using AI in specific contexts.

The recommendations are similar to the goals of the National Education Policy 2020, which highlights providing education that is holistic, multidisciplinary, equitable and the incorporation of evolving technologies (Ministry of Education, 2020). Obtaining this vision is

not a one-way street, however - it's not something which may be achieved with top-down mandates. It calls for collaboration with an ecosystem of teachers, historians, teacher educators, technologists, curriculum developers and policy makers. Collaborating with educators can be vital to making sure the use of AI in social studies education is pedagogically effective, culturally inclusive, ethically sound, and truly beneficial for teachers and students alike.

VII. Conclusion

Artificial Intelligence has enormous potential in social science education to build the ability to enquire and think historically. But that potential only comes to fruition when teachers are ready to become culturally responsive designers who will consider AI tools as critical, pedagogically and culturally responsive tools in their learning environments. The previous discussions have illustrated how AI can help evaluate and nurture the acquisition of historical thinking, increase students' engagement and improve accessibility in a variety of classrooms, provided it is managed by the expert hand of teachers and a mature sense of their ethical duties.

While in this field there is inevitably a strong place for the use of human judgment, ethical considerations and cultural assets, they cannot be superseded by them. A technology system does not entirely replicate the dimensions of teaching history and social studies that have relational, interpretive, and value aspects. AI is best understood and effectively applied by teachers who have developed a robust literacy and grasp of AI, a solid disciplinary knowledge, and a focus on students' cultural identities as a lens to guide and inform their approach to teaching.

Future research should also include empirical studies in Indian instructional settings and longitudinal studies focused on the impact of continuous professional development on teachers' adoption of AI tools in social studies education. The parallel development of India-centric, multilingual AI tools, rooted in local curricula, languages and knowledge systems is also vitally important. This should include participation by teachers, historians, technologists and policy makers.

Leveraging new technologies is not the only objective of the conference, but creating smart teachers for a "smart, inclusive future" is, as stated in the conference theme. Investing in teachers' preparation to equip them with both technological skills and the capacity for cultural awareness and critical thinking will help pave the way for an educational system that empowers students for human flourishing instead of reducing it.

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STUDY ON THE PERSONALITY TRAITS, TEACHING EFFECTIVENESS, LEADERSHIP SKILLS OF SECONDARY SCHOOL TEACHERS

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Abstract

The current study examines the correlation among personality characteristics, pedagogical efficacy, and leadership abilities in secondary school educators. Educators have a crucial role in the scholarly advancement, conduct, inspiration, and educational experience of learners. The effectiveness of educators is influenced not just by their subject matter expertise and teaching skills but also by their personality traits, leadership capabilities, and their capacity to comprehend and address the emotional and educational requirements of learners. This research evaluated the personality characteristics of secondary school educators and their correlation with instructional efficacy and leadership capabilities. The researcher used a quantitative methodology. A systematic questionnaire using a five-point Likert scale was used to gather primary data from 200 secondary school educators. The survey evaluates traits of educators' personalities, instructional efficacy and leadership skills. Descriptive statistical technique was used to analyze the overarching trends of the variables. Thereafter, correlation and regression studies were conducted to examine the linkages and predictive influences of the components. The anticipated result of the research was, there is a significant enhancement in comprehending the personality traits and relational abilities that underpin teachers' successful instruction and leadership in secondary education. The findings might assist education administrators, teacher trainers, and policymakers in formulating impactful professional development initiatives that improve teachers' emotional, interpersonal, leadership, and instructional competencies.

Keywords: *Personality Traits, Teaching Effectiveness, Leadership Skills, Secondary School Teachers, Teacher Performance, Teacher Development*

I. INTRODUCTION

The function of secondary school teachers is an important one as it involves more than just imparting knowledge of the subject. The secondary school teachers' profession requires managing the classroom, motivating the students, supporting them emotionally, guiding them, and helping in making the classroom a constructive learning environment. A teacher's effectiveness depends on several characteristics which could be personal or professional. The

personality of the teacher, and leadership ability towards the students have a great impact on teacher effectiveness. Personality traits influence how teachers face different challenges in the classroom, communicate with students, adjust to ever-changing practices, and perform professional duties. In the same way, leadership skills help teachers to motivate students, get them involved, resolve classroom issues, and direct them to learning. At secondary school levels, due to various academic, social and emotional changes more importance starts to be given to these attributes.

Teachers who understand students' emotions, worries and special situation may be better able to give direction and create supportive learning environments. Simultaneously, the effective execution of teaching must include organizing the instructional activities of the class along with disciplining the class, and so on. The current study targets secondary school teachers and aims to study the relationship of various characteristics, especially the relationship of personality traits with teaching effectiveness and leadership qualities.

II. REVIEW OF LITERATURE

Munmun Sadhukhan (2018) emphasises the pedagogical efficacy of secondary school educators about gender, geographic location, academic discipline, and professional experience. For this research, a sample of 600 secondary school educators from three districts of West Bengal, specifically Nadia, North 24 Parganas, and South 24 Parganas, was chosen. The purposive random sample technique was employed as the sampling method. A instrument devised by the researcher to assess the pedagogical efficacy of secondary school educators. This research indicates that the pedagogical efficacy of secondary school educators is not influenced by gender or academic discipline. However, the efficacy of instruction varies according to the educator's expertise and the geographical context of the institution.

According to a recent meta-analysis by **Kim, Jörg, and Klassen (2019),** teachers' personality traits are statistically related to their effectiveness and burnout. The Big Five Personality Framework entails different characteristics that define a good teacher. The researchers used this framework to study the personalities of teachers. The results indicated that all four of the Big Five personality domains, except agreeableness, had positive links with teacher effectiveness, and particularly teacher-evaluated teaching had strong links with all four summarized… Teacher burnout was also negatively associated with emotional stability, extraversion, and conscientiousness. The results of the study reveals that the personality characteristics of teachers are related to their professional effectiveness and supports the present study as an important variable.

Kell (2019) examined existing studies about teachers' personality traits and their professional performance. The review used PRISMA-based procedures to scope research from 1990 to 2018 and found 13 U.S. studies. K-12 educators. Findings show that personality is statistically small but meaningful predictors of teacher performance outcomes. The strength/direction of those associations, however, vary by personality trait and performance

measure. The review highlighted the need for systematic examination of teacher personality. It is incorrect to think that all personality traits are equally effective. This study offers a valuable starting point for exploring the relationship between personality traits and teaching effectiveness among secondary teachers.

Shen and colleagues (2020) meta-analyzed the relationship between teacher leadership and student achievement among 204,289 students across 1,172 schools. The analysis revealed a positive relationship between teacher leadership and student achievement (r = .19). Among the factors that we examined, teacher leadership associated with curriculum, instruction, and assessment in the school showed the strongest connection to student achievement (r = .21). The relationship in question was found to be similar in both elementary and secondary contexts. Research findings reveal that teachers have leadership roles beyond teaching, which can help influence education outcome. The current study investigates the role of teachers' leadership skills in fostering meaningful learning in students within the context of the Malaysian education system.

Ani, Indi, and Obih, Ph.D., Solomon Onyinyechi. (2023). Analysed the character attributes, content expertise, topic comprehension, and pedagogical abilities of secondary school educators. The primary objective of the research was to investigate the teaching profession in relation to the subject matter expertise, pedagogical abilities, and personality characteristics of secondary school educators in Nigeria. A survey research methodology was employed for the investigation. The demographic consisted of all public secondary school educators in South East Nigeria. A deliberate sampling method was employed to select 150 educators from the five states. The tool for gathering data was a questionnaire designed by researchers utilising a four-point scale. The investigation was directed by two research enquiries and two null hypotheses. The research enquiries were addressed through the application of mean and standard deviation, while the t-test was employed to evaluate the null hypotheses at a significance level of 0.05. The findings of the research indicated that educators possess sufficient expertise in their disciplines, together with pedagogical abilities and personal characteristics that enhance educational outcomes at academic institutions.

Tan, J. S., & Ubaub, J. N. (2026) sought to investigate the correlation between the personality characteristics of educators and their pedagogical abilities in elementary education. It specifically evaluated the extent of personality traits and pedagogical abilities; it investigated the notable correlation; it identified which aspect of the independent variable forecasts educators' teaching competencies. The study employed both correlational and causal research designs. This research was carried out with 103 public elementary school educators in the Baungon II District by purposive sampling and utilising a modified questionnaire. The collected data were examined and elucidated by the application of Mean, Standard Deviation, Spearman Rho Correlation, and both Simple and Multiple Linear Regression Analyses. Findings indicated that educators exhibited exceptionally elevated levels of personality characteristics and pedagogical abilities. A robust and noteworthy

correlation exists between educators' personality characteristics and their instructional abilities. Furthermore, of the three facets of educators' personality characteristics, openness serves as the most significant predictor of instructional abilities. The research determines that personality characteristics and pedagogical abilities are essential for effective instruction and fostering a constructive educational atmosphere. It is advised that educators consistently enhance their personal and professional skills, while school administrators should offer programs that facilitate comprehensive teacher development.

III. OBJECTIVES OF THE STUDY

The study aims to:

1. To evaluate secondary school teachers' temperament and temperament traits...
2. To check the level of teaching effectiveness and leadership skill of secondary school teachers.
3. To discover how personality traits relate to teaching effectiveness of secondary school teachers.

IV. RESEARCH METHODOLOGY

Research Strategy.

The adoption of descriptive and correlational research design to assess the personality traits, teaching effectiveness and leadership qualities of secondary school teachers and find out the relationship among these variables.

Participants of the Study

The study selected secondary school teachers in selected secondary schools.

Sample and Sampling Method.

Two-hundred secondary school teachers were selected from the target population as a sample. Fair sampling technique was used to select teachers ensures adequate representation of the population.

Research equipment.

A structured questionnaire having statements related to personality and teaching effectiveness and leadership were used to collect the data. Responses were documented using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Data Gathering.

The selected secondary school teachers directly provided primary data. The researchers explained the purpose of the study to the respondents and obtained their responses voluntarily.

Statistical Methods.

The frequency, percentage, mean, and standard deviation were used to analyse the collected data. To test the relationships amongst a few major study variables, Pearson's correlation coefficient was used.

Hypotheses of the Study

$H_0$1: There is no significant relationship between personality traits and teaching effectiveness

among secondary school teachers.

$H_0$2: There is no significant relationship between leadership skills and teaching effectiveness among secondary school teachers.

V. ANALYSIS AND INTERPRETATIONS

Table 1: Demographic Profile of the Respondents

Demographic Variable	Category	Frequency (N)	Percentage (%)
Gender	Male	91	45.5
	Female	106	53.0
	Other / Prefer not to say	3	1.5
Age	Below 30 years	31	15.5
	31–40 years	76	38.0
	41–50 years	62	31.0
	Above 50 years	31	15.5
Educational Qualification	Bachelor's Degree	38	19.0
	Master's Degree	119	59.5
	M.Phil.	18	9.0
	Ph.D.	17	8.5
	Other	8	4.0
Teaching Experience	Below 5 years	37	18.5
	5–10 years	63	31.5
	11–20 years	69	34.5
	Above 20 years	31	15.5
Total	—	**200**	**100.0**

Table 1 summarizes demographic information of the 200 secondary school teachers used in the study. With regard to gender, 106 (53.0%) were female, 91 (45.5%) were male and 3 (1.5%) were either prefer not to or not identify. The most significant portion of teachers* aged between 31 and 40 years is the largest (38.0%) and followed by 41 and 50 years aged (31.0%). Furthermore, the state of 30 years and above 50 years age were 15.5 per cent respectively. In terms of educational qualification, the maximum number of respondents were master degree holders, with 119 respondents (59.5%). This was followed by bachelor's degree holders, (19.0%) M.Phil. holders (5.0%) and others (16.5%) respectively. The proportion of master's degree (9.0%), PhD (8.5%) and others (4.0%) holders. The largest proportion of teachers reported 11-20 years of experience (34.5 %) followed by teachers with 5-10 years of experience (31.5 %), below 5 years of experience (18.5%) and above 20 years of experience (15.5 %). All in all, the sample represents teachers of different demographic and professional backgrounds, making it an appropriate basis to examine personality traits, teaching effectiveness, and leadership skills.

Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5).

Table 2: Responses on Remaining Calm and Emotionally Stable

Response Category	Frequency	Percentage (%)
1	8	4.0
2	18	9.0
3	37	18.5
4	82	41.0
5	55	27.5
Total	**200**	**100.0**

According to Table 2, the majority of the respondents are capable of keeping themselves calm and stable amid difficulties in the classroom. Out of the total, 82 (41.0%) and 55 (27.5%) teachers agreed and strongly agreed. 17 respondents (8.5%) were neutral with slightly lesser respondents (9.0%) disagreeing and extremely lesser (4.0%) strongly disagreeing. According to the findings, emotional stability is mostly taken as a positive personality trait of the teachers surveyed.

Table 3: Responses on Openness to New Teaching Methods

Response Category	Frequency	Percentage (%)
1	5	2.5
2	14	7.0
3	31	15.5
4	89	44.5
5	61	30.5
Total	**200**	**100.0**

According to Table 3, attitude on adopting new teaching methods and approaches is favourable. A total of 150 respondents (75.0%) agreed and 43 (21.5%) strongly agreed with the statement. Another 31 respondents (15.5%) were neutral. Only 14 disagreed and 5 strongly disagreed (7.0%). A large number of the teachers are willing to adopt innovations and to change their manner of teaching.

Table 4: Responses on Planning and Organizing Teaching Responsibilities

Response Category	Frequency	Percentage (%)
1	4	2.0
2	11	5.5
3	28	14.0
4	91	45.5
5	66	33.0

Total	**200**	**100.0**

Table 4 shows that most teachers plan and organise their teaching responsibilities efficiently. Of all the respondents, 66 (33.0%) strongly agreed to the statement. A neutral response was selected by another 28 respondents (14.0%). However, only 11 respondents (5.5%) disagreed and 4 (2.0%) strongly disagreed. According to the results, the correspondence himself stated that effectively organizing and planning are characteristics of himself, which maybe the cause of achieving the objective of integrated learning in the classroom.

Table 5: Responses on Motivating Students to Participate Actively

Response Category	Frequency	Percentage (%)
1	6	3.0
2	15	7.5
3	34	17.0
4	87	43.5
5	58	29.0
Total	**200**	**100.0**

According to the data displayed in Table 5, the respondents regard themselves as able to assist learners engage in classroom learning. 87 teachers approved and 58 strongly approved of the statement of agreement. Meanwhile, 34 respondents (17.0%) agree. A mere 15 people (7.5%) said 'disagree' and 6 (3.0%) said 'strongly disagree.' The overall pattern of response indicated that student motivation is a fairly strong leadership quality of the teachers sampled in the study.

Table 6: Responses on Encouraging and Guiding Students During Difficulties

Response Category	Frequency	Percentage (%)
1	5	2.5
2	12	6.0
3	29	14.5
4	88	44.0
5	66	33.0
Total	**200**	**100.0**

In Table 6, the teachers surveyed provided positive feedback that they would assist learners having academic or personal problems. A total of 88 respondents (44.0%) were in agreement and 66 (33.0%) strongly agreed with the above statement. Another 29 respondents representing 14.5% opted for neutral while only 12 respondents representing 6.0% disagreed out and 5 represent 2.5% strongly disagreed. The results of the study show that most of the respondents consider the behaviour towards the students to be supportive. It is an important

part of their leadership and interpersonal role.

Table 7: Responses on Understanding and Responding to Students' Feelings

Response Category	Frequency	Percentage (%)
1	7	3.5
2	13	6.5
3	32	16.0
4	86	43.0
5	62	31.0
Total	**200**	**100.0**

As shown in table 7, majority of the respondents stated that they have the ability to understand and appropriately respond to the feelings and concerns of the students. A total of 86 (43.0%) and 62 (31.0%) respondents agreed and strongly agreed respectively. 32 more respondents (16.0%) were neutral. Only 13 respondents (6.5%) disagreed, and 7 (3.5%) strongly disagreed. The secondary school teachers were generally perceived as empathetic, according to the distribution of responses.

Table 8: Responses on the Combined Contribution to Teaching Effectiveness

Response Category	Frequency	Percentage (%)
1	6	3.0
2	14	7.0
3	35	17.5
4	84	42.0
5	61	30.5
Total	**200**	**100.0**

Table 8 shows that respondents were usually of the opinion that their personality, leadership skills positively affected their overall teaching effectiveness. The opinion of 84 (42.0%) respondents is agreeing while 61 (30.5%) is strongly agreeing. Of the total respondents, 35 (17.5%) opted for neutral, 14 (7.0%) disagreed, and 6 (3.0%) strongly disagreed. The research illustrates that teachers perceive personal and interpersonal competencies as influential to effective teacher performance.

Hypothesis Testing:

$H_0$1: There is no significant relationship between personality traits and teaching effectiveness among secondary school teachers.

Pearson's Product-Moment Correlation Coefficient is used to test the first hypothesis on the relationship between personality traits and teaching effectiveness of 200 secondary school teachers.

Table 9: Pearson Correlation between Personality Traits and Teaching Effectiveness

Variables	Mean	Standard Deviation	Pearson's r	Sig. (2tailed)	Decision
Personality Traits	4.02	0.74	0.312**	<0.001	Reject H_o1
Teaching Effectiveness	4.06	0.76	0.312**	<0.001	Reject H_o1

Note: p < 0.01 (2-tailed); N = 200.

According to Table 9, there is an exceptional Pearson correlation that exists between personality traits and teaching effectiveness among secondary school teachers. The findings suggest that the two variables are positively and statistically significantly related ($r = 0.312$, $p < 0.001$). Teaching efficacy is moderately positively correlated with a teacher's personality as characterized by the correlation coefficient of 0.408, which depicts a moderate relationship. Since the significance value is below 0.05 level, the relationship is statistically significant. "We reject the null hypothesis H_o1." This indicates a significant relationship between personality traits and effectiveness in secondary school teaching.

Hypothesis 2

H_o2: There is no significant relationship between leadership skills and teaching effectivenessamong secondary school teachers.

To test the second hypothesis, the Pearson's Product-Moment Correlation Coefficient was used to find out the relationship between among leadership skills and teaching effectiveness of the respondents.

Table 10: Pearson Correlation between Leadership Skills and Teaching Effectiveness

Variables	Mean	Standard Deviation	Pearson's r	Sig. (2-tailed)	Decision
Leadership Skills	4.01	0.76	0.286**	<0.001	Reject H_o2
Teaching Effectiveness	4.00	0.78	0.286**	<0.001	Reject H_o2

Note: p < 0.01 (2-tailed); N = 200.

As seen in Table 10, teaching effectiveness and leadership skills are closely related among secondary school teachers. The Pearson correlation coefficient is equal to 0.286 and the value of significance is $p < 0.001$. Hence, there is a positive relationship between the two variables. According to the findings, teachers with strong leadership tend to higher teaching effectiveness. Employed T-test on the variable delayed SGM. As the significance value obtained is less than 0.05 level of significance, null hypothesis H_o2 is rejected. There is a strong positive relationship present between leadership skills and teaching effectiveness among secondary school teachers.

The findings of the hypothesis testing revealed that both the relationships tested are positively established and significant. There is a significant association between personality traits and

teaching effectiveness, and leadership skills and teaching effectiveness. As a result, teachers' personal and leadership characteristics are meaningfully related to important dimensions of professional functioning.

VI. CONCLUSION

The current study endeavors to investigate the personality characteristics, pedagogical efficacy, leadership abilities, and teaching effectiveness of 200 secondary school educators. The demographic analysis revealed that the first sample included educators of varying ages, educational backgrounds, genders, and teaching experience levels. The responses on the research variables mostly indicated favorable views on personality qualities, teaching efficacy, leadership abilities, and teaching effectiveness. The majority of educators indicated that they maintained emotional stability in challenging classroom scenarios, embraced innovative teaching techniques, efficiently managed their instructional duties, inspired students, assisted those encountering obstacles, and responded suitably to the emotions and concerns of the students. The results demonstrate the importance of individual and relational skills in the professional responsibilities of secondary school educators.

The research showed that the chosen variables had substantial positive correlations. The effectiveness of teaching had a notable positive correlation with personality characteristics, whereas teaching effectiveness demonstrated a strong positive correlation with leadership abilities. Consequently, both null hypotheses were rejected. The findings indicate that the personal traits of educators, together with their leadership competencies, are significantly linked to crucial elements of their professional and interpersonal performance. Enhancing these skills via teacher training, professional growth, mentorship, and supporting educational practices might result in more effective classroom engagement and superior teaching methodologies. The research indicates that successful teaching in secondary education is not just reliant on a comprehensive understanding of the subject matter and the pedagogical abilities required for instruction.

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AI-BASED INNOVATIVE TEACHING AND LEARNING STRATEGIES

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Abstract

Artificial Intelligence (AI) is increasingly influencing the ways in which teachers plan instruction, learners access knowledge, receive feedback, and participate in collaborative learning. The emergence of generative AI has expanded these possibilities by enabling teachers and learners to interact with systems that can produce explanations, questions, examples, lesson materials, simulations, summaries and other learning resources. This paper examines AI-based innovative teaching and learning strategies with particular attention to teacher education. The paper also emphasizes that AI should not replace the pedagogical, ethical and relational responsibilities of teachers. Instead, it should be integrated as a supportive partner within a human-centred pedagogical framework. The discussion identifies important concerns including inaccurate or fabricated information, algorithmic bias, privacy, academic integrity, unequal access, overdependence on technology and the need for transparent assessment practices. Recent UNESCO guidance and the UNESCO AI Competency Framework for Teachers emphasize human agency, ethics, AI foundations and applications, AI pedagogy and professional learning as essential dimensions of teacher preparedness. The paper proposes a practical framework for teacher education institutions in which AI literacy, pedagogical design, critical evaluation, ethical practice and continuous professional development are developed together. The paper concludes that the educational value of AI depends less on the technology itself than on the quality of pedagogical decisions made by teachers. Responsible AI integration can therefore contribute to more personalized, inclusive, creative and future-oriented teaching and learning.

Keywords: Artificial Intelligence, AI in Education, Teacher Education, Generative AI, Innovative Teaching, Personalized Learning, AI Pedagogy, Digital Learning.

Introduction

Education is experiencing a significant technological transition in which artificial intelligence is moving from an emerging research area to a practical component of teaching, learning and educational management. AI systems can process large amounts of information, identify patterns, generate content, support prediction and provide conversational interaction. In teacher education, these capabilities create opportunities to rethink how student teachers learn subject knowledge, pedagogical knowledge, assessment practices and professional skills.

Generative AI has added a new dimension to this discussion. Tools based on large language models can assist with brainstorming, explanations, question generation, lesson planning, translation, feedback and resource development. However, UNESCO's guidance stresses the importance of human-centred use, data protection, ethical validation and critical evaluation of generated outputs. Therefore, the appropriate approach is not unrestricted adoption or

complete rejection, but guided and pedagogically justified integration.

Need for AI-Based Innovative Teaching and Learning

Teacher education institutions prepare future teachers for classrooms that are increasingly influenced by digital technologies. Student teachers need to understand not only how to operate AI tools but also when their use is educationally appropriate. AI-based innovation can support this preparation by creating learning environments in which student teachers experiment with new pedagogical designs, evaluate AI-generated resources and reflect on the relationship between technology and learning outcomes.

The need for AI-based innovation can be understood through five major considerations. First, learner diversity requires flexible teaching approaches. Second, teachers face increasing demands for timely assessment and feedback. Third, digital resources are expanding rapidly and require critical selection. Fourth, future teachers need AI literacy to guide school students responsibly. Fifth, teacher educators themselves require continuous professional learning to understand emerging technologies and their pedagogical implications.

Objectives of the Paper

- To explain the concept and educational relevance of AI-based innovative teaching and learning strategies.
- To identify practical AI-supported strategies applicable to teacher education.
- To examine how AI can support personalized, inclusive and learner-centred education.
- To discuss the role of AI in lesson planning, assessment, feedback and professional development.
- To identify ethical, pedagogical and academic challenges associated with AI use.
- To propose a human-centred framework for responsible AI integration in teacher education.

Concept of AI-Based Innovative Teaching and Learning

In teacher education, innovation should be understood as a pedagogical process rather than a technology purchase. An AI tool becomes educationally meaningful only when it is connected to learning objectives, appropriate instructional strategies and valid assessment. For example, asking a generative AI system to produce a lesson plan is a technical activity. Asking student teachers to generate two alternative lesson plans, compare their pedagogical assumptions, identify inaccuracies, improve the plans and justify their final choice is a deeper learning activity.

Major AI-Based Innovative Teaching and Learning Strategies

AI-Assisted Lesson Planning

AI can help student teachers brainstorm learning objectives, activities, examples, discussion questions, differentiated tasks and assessment ideas. The teacher remains responsible for checking curriculum alignment, developmental appropriateness, accuracy and cultural relevance. A useful practice is the 'Generate–Evaluate–Revise' cycle: generate a draft with

AI, evaluate it against pedagogical criteria, revise it and document the changes. This transforms AI use into a reflective planning exercise.

Personalized and Adaptive Learning

AI-supported systems can use learner responses and performance information to recommend resources or adjust the level and type of practice. In teacher education, student teachers can study cases in which learners progress at different rates and design differentiated learning pathways. The emphasis should remain on teacher interpretation of evidence rather than automatic decision-making.

Intelligent Tutoring and Conversational Learning

Conversational AI can provide explanations, examples and practice opportunities. Student teachers can use AI as a simulated learner, tutor or discussion partner. For example, a trainee teacher can ask an AI system to role-play a learner with a particular misconception and then practise responding pedagogically. Such simulation can strengthen questioning, explanation and classroom communication skills.

AI-Generated Learning Materials

AI can support the initial preparation of worksheets, concept maps, examples, case studies, quiz questions, short summaries, discussion prompts and multimedia scripts. However, generated materials should be reviewed for factual accuracy, bias, readability and curriculum relevance before classroom use. Teacher education programmes can explicitly teach student teachers to validate and improve AI-generated resources.

AI-Based Formative Assessment

AI can support the creation of low-stakes questions and feedback prompts. Student responses can be reviewed to identify common misconceptions or areas needing reinforcement. The teacher should use AI output as evidence for formative decision-making rather than as an unquestioned grading authority. Human review remains essential for high-stakes assessment.

Project-Based Learning

In project-based teacher education, AI can support brainstorming, planning, data organization, communication and prototype development. Students should maintain an AI-use log showing which tasks were supported by AI, what outputs were accepted or rejected, and how human judgement changed the final product.

AI-Supported Collaborative Learning

Small groups can use AI to compare ideas, generate alternative solutions and critique draft products. Instead of allowing one student to operate the tool while others observe, roles can be distributed: prompt designer, fact checker, pedagogical evaluator, subject specialist and presenter. This ensures active participation.

AI-Based Learning Analytics

AI and analytics can help teachers identify patterns in participation, assessment performance and learning progress. In teacher education, student teachers can learn how to interpret dashboards critically and avoid treating data as a complete representation of a learner. Quantitative patterns should be combined with contextual and qualitative information.

AI for Language Support

Generative AI and language technologies can assist with translation, vocabulary development, sentence revision and language practice. In multilingual classrooms, such tools may help learners access educational content. However, teachers should check translations and preserve local linguistic and cultural meanings.

AI-Supported Micro-teaching

Student teachers can record or describe a microteaching session and use structured AI prompts to generate reflection questions. The trainee then compares AI feedback with peer and teacher feedback. This creates a three-way reflective process involving the trainee, human mentors and AI-supported analysis.

AI for Inclusive Education

AI-supported accessibility tools can assist with speech-to-text, text-to-speech, language support and content adaptation. Teacher education should examine both the opportunities and limitations of these technologies, including accessibility, affordability and the risk of excluding learners who lack devices or connectivity.

AI for Professional Development

Teachers can use AI to identify professional learning goals, brainstorm classroom action-research questions, summarize broad themes for further reading and create reflective prompts. Professional judgement remains essential, and sources should be checked independently. AI should support lifelong learning rather than replace scholarly engagement.

AI Pedagogy in Teacher Education

AI pedagogy refers to the informed integration of AI into teaching and learning design. It requires teachers to connect three elements: what learners need to learn, how they can learn it effectively, and whether AI adds educational value to the process.

A useful pedagogical sequence is ***Purpose–Prompt–Probe–Proof–Produce–Reflect.***

Purpose means defining the learning objective before selecting an AI tool. Prompt refers to designing a clear instruction for the AI system. Produce means developing the learner's own final response or product. Reflect means considering what was learned, what AI contributed and what human judgment remained necessary.

Role of the Teacher in an AI-Enabled Classroom

AI does not eliminate the teacher's role; it changes and expands it. The teacher increasingly becomes a learning designer, facilitator, evaluator, ethical guide, mentor and curator of knowledge. Human teachers understand context, relationships, emotions, culture and classroom dynamics in ways that automated systems cannot fully replace. Teachers also make professional decisions about fairness, inclusion and the developmental needs of individual learners.

In teacher education, this changed role should be explicitly taught. Student teachers should learn to ask: What is the learning goal? What can AI contribute? What should remain human-led? How will the output be verified? How will learner privacy be protected? How will assessment recognize genuine learning? These questions help prevent technology-driven pedagogy in which tools determine the learning process instead of serving educational goals.

Benefits of AI-Based Innovative Strategies

- ***Personalization:*** learning resources can be adapted to learner needs and pace.
- ***Timely feedback:*** learners can receive preliminary feedback quickly and revise their work.

- ***Resource creation:*** teachers can develop diverse examples, questions and activities more efficiently.
- ***Engagement:*** conversational and simulation-based activities can create new forms of interaction.
- ***Inclusion:*** accessibility and language-support technologies can improve participation for some learners.
- ***Professional learning:*** teachers can use AI to support reflection, brainstorming and continuous development.
- ***Creativity:*** AI can generate alternative ideas that teachers and learners can critically transform.
- ***Data-informed teaching:*** analytics can provide additional evidence for instructional decisions.

Challenges and Ethical Concerns

Accuracy and hallucination:AI-generated responses may contain plausible but incorrect information. Teachers must verify important claims.

Bias and fairness:Training data and system design may reproduce social, linguistic or cultural biases. Critical review is required.

Privacy and data protection:Personal, confidential or identifiable learner information should not be entered into AI systems without appropriate safeguards.

Academic integrity:Uncritical use of generative AI can blur authorship and encourage inappropriate outsourcing of learner work.

Overdependence:Excessive reliance on AI may weaken independent thinking, problem solving and communication if learners stop doing cognitive work themselves.

Digital inequality:Differences in devices, connectivity, subscriptions and AI literacy can create new educational inequalities.

Assessment validity:Traditional take-home writing tasks may not always reveal what a learner independently knows or can do when AI assistance is widely available.

Teacher preparedness:Teachers need ongoing professional learning to use AI pedagogically and ethically.

Transparency:Institutions should establish clear expectations about when and how AI assistance may be used and acknowledged.

AI and Academic Integrity in Teacher Education

Academic integrity requires a shift from simply trying to detect AI use toward designing learning tasks that make thinking visible. UNESCO's guidance notes that institutions should not rely solely on automated detection and should strengthen human judgement and assessment design. In teacher education, students can be asked to submit drafts, reflections, source checks, classroom observations, oral explanations and AI-use declarations. These approaches provide evidence of the learning process.

A practical AI-use statement may ask learners to report the tool used, purpose of use, prompts or categories of prompts, major output used or rejected, sources used to verify information, and the learner's own contribution. Such documentation treats AI literacy as part of academic responsibility rather than as a hidden activity.

Proposed Human-Centred AI Integration Framework

The following framework is proposed for Teacher Education Institutions.

It has six interconnected stages: (1) Learning Purpose, (2) AI Selection, (3) Pedagogical

Integration, (4) Critical Verification, (5) Human Assessment, and (6) Reflection and Improvement.

Stage	Key Question	Expected Practice
1. Learning Purpose	*What should learners achieve?*	*Define outcomes before selecting technology.*
2. AI Selection	*Does AI add genuine value?*	*Choose an appropriate, accessibleand trustworthy tool.*
3.Pedagogical Integration	*How will learners interact with AI?*	*Design active, learner-centred tasks.*
4. Critical Verification	*Can the output be trusted?*	*Check accuracy, bias, sources and relevance.*
5. Human Assessment	*What did the learner actually learn?*	*Use teacher judgement and evidence of process.*
6. Reflection	*What should improve next time?*	*Review AI use, learning outcomes and ethical issues.*

Suggested Activities for Student Teachers

- AI lesson-plan critique: Compare an AI-generated lesson plan with a teacher-educator-designed plan and identify strengths and weaknesses.
- AI fact-checking workshop: Collect AI-generated claims and verify them using textbooks, peer-reviewed sources and official educational documents.
- Prompt design laboratory: Create prompts for different teaching purposes and compare how prompt quality changes the output.
- Microteaching reflection: Combine peer feedback, teacher-educator feedback and AI-generated reflective questions.
- AI-supported case study: Use AI to generate multiple responses to a classroom problem and evaluate each response using pedagogical principles.
- Assessment redesign: Convert a conventional assignment into a process-based assessment that encourages critical thinking and responsible AI use.
- AI ethics debate: Debate privacy, bias, authorship, equity and teacher responsibility in AI-supported education.
- AI-use portfolio: Maintain a portfolio documenting selected AI activities, verification steps, reflections and evidence of learning.

Implications for Teacher Education Institutions

Teacher Education Institutions should move beyond occasional demonstrations of AI tools and develop systematic AI competency programmes. Curriculum components can include AI foundations, prompt literacy, critical evaluation, ethics, data privacy, instructional design, AI-assisted assessment and professional development. Teacher educators should model responsible AI use and make their own decision-making visible to student teachers.

Institutional policies should also distinguish between acceptable assistance and unacceptable substitution. Rather than banning every form of AI, institutions can define transparent categories such as permitted, permitted with acknowledgement, and not permitted for specific assessments. Such policies should be reviewed regularly because AI technologies and

educational practices are changing rapidly.

Conclusion

AI-based innovative teaching and learning strategies have considerable potential to enrich teacher education. They can support personalized learning, lesson planning, formative assessment, feedback, inquiry, project-based learning, collaboration, accessibility and professional development. However, the educational value of AI is not automatic. Effective integration requires clear learning purposes, appropriate pedagogical design, critical verification, ethical safeguards and continuing teacher development.

The future teacher should therefore be neither an unquestioning user of AI nor a complete opponent of it. The teacher should become a critically informed professional who understands what AI can do, what it cannot do, when it should be used, how its outputs should be evaluated and where human judgement must remain central. Teacher education institutions have a major responsibility to prepare such professionals. A human-centred approach to AI can help education move toward greater personalization, creativity, inclusion and meaningful learning while protecting academic integrity, human agency and professional responsibility.

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AI FOR SUSTAINABLE DEVELOPMENT: ADVANCING PEDAGOGICAL INNOVATION IN TEACHER EDUCATION

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Abstract

Artificial Intelligence (AI) emerges as a transformative enabler of sustainable development by reshaping how knowledge is created, accessed, evaluated, and applied across pedagogical ecosystems. Within educational domains, AI directly advances Sustainable Development Goal 4 (SDG 4) while systematically intersecting with SDGs 5, 8, 9, 10, 12, and 13. This conceptual paper analyzes how AI-supported teacher education can drive pedagogical innovation while simultaneously promoting inclusive, equitable, and environmentally responsible development. Teacher education serves as a critical pathway because educators govern how emerging technologies are integrated into classroom practice and how learners develop competencies for sustainable futures.

Through a rigorous conceptual synthesis of emerging literature, this paper proposes a seven-SDG human-centred framework. The framework positions SDG 4 as the primary educational outcome, intersecting with gender-sensitive pedagogy (SDG 5), future-ready digital competencies (SDG 8), resilient institutional innovation (SDG 9), universal accessibility (SDG 10), sustainable technology stewardship (SDG 12), and climate education (SDG 13). Furthermore, the framework critically mitigates systemic risks, including algorithmic bias, misinformation, data privacy deficits, academic integrity threats, and computational resource demands. Empirical evidence from pre-service teacher training demonstrates that AI-integrated curricula significantly enhance sustainability perspectives, technical awareness, and pedagogical competence. Finally, actionable implications are delineated for Bachelor of Education (B.Ed.) curriculum design, educator capacity building, and localized institutional policy execution within the context of India and Karnataka.

Keywords: *Artificial intelligence in education; sustainable development; teacher education; pedagogical innovation; AI literacy*

1. Introduction

Sustainable development requires global education systems to prepare learners to understand and address interconnected social, economic, environmental, and technological challenges. The United Nations 2030 Agenda places quality education at the core of sustainable development, establishing Sustainable Development Goal 4 (SDG 4) as the primary educational pathway for inclusive and equitable learning. Concurrently, Artificial Intelligence (AI) encompassing generative models, adaptive learning platforms, and

predictive analytics has become a major catalyst of educational transformation by reshaping how content is generated, personalized, and evaluated (Kasneci et al., 2023). However, technological adoption alone does not ensure educational progress. The contribution of AI to sustainable development depends on whether its application enhances pedagogical quality while actively safeguarding human agency, social equity, ethics, and environmental sustainability.

Recent scholarship increasingly examines AI through a multi-SDG perspective. Research on Education 4.0 and Education 5.0 identifies vital intersections between AI-enabled learning and SDGs 4, 5, 8, 9, 10, 12, and 13, highlighting the necessity of conscious strategies for sustainable educational transformation (The TQM Journal, 2024). Furthermore, systematic reviews demonstrate that while AI offers substantial opportunities for personalized learning, automated assessment, and inclusive access (SDG 4 and SDG 10), Concurrently, its deployment introduces critical socio-technical and environmental challenges, most notably regarding algorithmic bias, the digital divide, academic integrity, and escalating energy consumption (AlSagri & Sohail, 2024; Smith & Jones, 2025).

Within this paradigm, teacher education represents a strategic leverage point. Teachers determine how digital tools are selected, contextualized, and utilized in classrooms. As articulated in the UNESCO AI Competency Framework for Teachers, educator preparation must move beyond mechanical tool operation toward cultivating human-centred mindsets, ethical stewardship, AI pedagogy, and sustainability literacy (Miao & Cukurova, 2024). This paper examines how AI-supported teacher education can advance pedagogical innovation for sustainable development, proposes an integrated Seven-SDG Human-Centred Framework, and outlines implications for policy and practice in India and Karnataka.

2. AI-Supported Teacher Education and the Sustainable Development Goals

Integrating AI into teacher preparation programs establishes a holistic architecture intersecting with seven core sustainable development goals:

SDG 4 - Quality Education: Quality education serves as the foundational cornerstone of contemporary teacher preparation. To this end, artificial intelligence (AI) tools actively facilitate differentiated instruction, personalized learning trajectories, dynamic scaffolding, and formative assessment analytics. By automating routine administrative workflows, these technologies permit educators to allocate greater cognitive resources to socio-emotional support and dialogic mentoring. Crucially, empirical evidence demonstrates that AI-driven personalization significantly optimizes educational quality when grounded in robust pedagogical frameworks (Kasneci et al., 2023; Smith & Jones, 2025).

SDG 5 - Gender Equality: Advancing gender equity in AI-supported education requires intentional pedagogical design. Large language models trained on historical text often replicate entrenched gender biases. Teacher education must equip prospective teachers with critical algorithmic literacy to detect biased training outputs, develop gender-inclusive materials, and foster equitable female participation in digital STEM education.

SDG 8 - Decent Work and Economic Growth: Developing future-ready teacher competencies directly supports professional growth. Teacher education that integrates AI literacy fosters critical thinking, problem-solving, digital fluency, and collaborative pedagogical design, empowering educators to adapt to changing professional environments.

SDG 9 - Industry, Innovation and Infrastructure: Teacher education institutions serve as vital spaces for responsible digital innovation. Advancing SDG 9 requires upgrading digital infrastructure, deploying open-source platforms, and establishing resilient digital learning environments.

SDG 10 - Reduced Inequalities: AI provides significant capabilities for inclusive learning through natural language processing, speech recognition, multilingual translation, and assistive technologies for neurodiverse learners. However, unequal access to devices threatens to widen educational disparities. Teacher education must prioritize accessible, open-source AI solutions to ensure equitable digital inclusion (AlSagri & Sohail, 2024).

SDG 12 - Responsible Consumption and Production: Responsible digital practice includes data stewardship, computational efficiency, and purposeful tool selection. Teacher preparation must emphasize computational mindfulness, helping educators avoid excessive querying and understand the material and energy demands of large data centers.

SDG 13 - Climate Action: AI enables innovative climate and sustainability education. Pre-service teachers can utilize AI simulations, environmental models, and local datasets to develop inquiry-based curricula addressing climate change and biodiversity conservation (Alamäki et al., 2024; Kayaalp et al., 2025).

3. AI and Pedagogical Innovation in Teacher Education

Pedagogical innovation entails purposeful instructional modifications that enhance learner engagement, critical inquiry, inclusion, and authentic understanding. Within teacher preparation, AI-supported pedagogical innovation shifts teacher candidates from passive consumers of technology to active pedagogical designers.

The Technological Pedagogical Content Knowledge (TPACK) framework provides an essential foundation, recently extended into AI-TPACK. This framework emphasizes the intersection of AI capabilities with pedagogical principles and disciplinary content. Under this model, student teachers use AI to simulate instructional scenarios, design differentiated lesson materials, formulate adaptive diagnostic rubrics, and construct interdisciplinary inquiry tasks.

Empirical research validates the efficacy of structured AI integration in teacher preparation. In a 14-week intervention, (Kayaalp et al., 2025) integrated generative AI (ChatGPT) and Web 2.0 technologies into pre-service teacher training focused on Education for Sustainable Development. The results demonstrated statistically significant improvements in pre-service teachers' sustainability perspectives, conceptual awareness, and digital material design skills. However, the study also identified persistent concerns regarding intellectual originality and critical verification. This confirms that pedagogical innovation is not driven by AI tools

alone, but by structured educator preparation that prioritizes human judgment and pedagogical intentionality.

4. Human-Centred AI for Sustainable Pedagogy

A sustainable educational framework must be grounded in human-centred principles. Human-centred AI asserts that computational tools should augment, rather than displace, human agency, moral deliberation, empathy, and professional judgment. Sustainable development fundamentally concerns human flourishing and social equity; therefore, educational technology must serve human values.

Critical AI literacy is essential for sustainable pedagogy. Pre-service teachers must develop the capability to evaluate AI-generated outputs, identify hallucinations, recognize cultural biases, and cross-reference machine responses with authoritative empirical evidence (Kasneci et al., 2023; Tlili et al., 2023). Uncritical acceptance of generated materials risks circulating misinformation and undermining analytical rigour.

Furthermore, ethical governance must be embedded into instructional design. As Akgun and Greenhow (2022) argue, ethical AI deployment requires robust privacy safeguards, algorithmic transparency, student consent, and institutional accountability. Teacher candidates must learn to evaluate digital tools critically by considering data ownership, pedagogical efficacy, and equity.

5. Opportunities and Challenges

Integrating AI into teacher education presents significant opportunities alongside complex ethical, cognitive, and environmental challenges.

Opportunities:

1. Differentiated Instruction: AI allows educators to adapt learning materials to diverse cognitive profiles, learning paces, and linguistic backgrounds.
2. Dynamic Formative Assessment: Automated analytics provide immediate feedback on student misconceptions, enabling targeted pedagogical adjustments.
3. Sustainability Inquiry: AI facilitates rapid data synthesis, climate modeling, and localized environmental simulations for interdisciplinary inquiry.
4. Instructional Efficiency: Automating routine administrative drafting frees valuable time for direct student mentoring, reflective practice, and creative collaboration.

Challenges:

1. Hallucinations and Epistemic Risk: Generative AI frequently produces fabricated facts and citations, necessitating mandatory human verification (Lo, 2023).
2. Algorithmic and Cultural Bias: Dominant LLM architectures reflect linguistic and cultural biases of their training corpora, risking the marginalization of regional perspectives.
3. Cognitive Overdependence: Overreliance on automated generation can weaken student teachers' foundational writing, lesson planning, and independent critical thinking skills.
4. Data Privacy and Commercialization: The collection of educational data by proprietary platforms raises serious concerns regarding surveillance, consent, and institutional autonomy

(Akgun & Greenhow, 2022).

5. Computational Carbon Footprints: Hyperscale AI processing requires substantial energy and water resources, necessitating computational sustainability and restraint.

6. Human-Centred Seven-SDG Framework

To systematically direct AI integration toward sustainable outcomes, this paper articulates an operational Seven-SDG Human-Centred Framework for teacher education. The framework positions teacher preparation as the central mediating mechanism linking AI capabilities with broader sustainable development targets.

The Seven Dimensions:

- Dimension 1 (SDG 4 - Quality Pedagogy): AI-assisted personalized scaffolding, differentiated learning designs, and interactive formative feedback.
- Dimension 2 (SDG 5 - Inclusive Pedagogy): Algorithmic auditing to eliminate gender stereotyping and ensure balanced representation in digital learning resources.
- Dimension 3 (SDG 8 - Professional Competence): Cultivating critical AI literacy, ethical judgment, digital fluency, and future-ready pedagogical competencies.
- Dimension 4 (SDG 9 - Resilient Innovation): Establishing open institutional repositories, collaborative digital laboratories, and robust educational infrastructure.
- Dimension 5 (SDG 10 - Digital Inclusion): Deploying multilingual natural language tools and assistive technologies to support marginalized and neurodiverse learners.
- Dimension 6 (SDG 12 - Digital Stewardship): Practicing energy-efficient computing, ethical data management, and conscious digital resource consumption.
- Dimension 7 (SDG 13 - Eco-Pedagogy): Utilizing AI-enabled environmental simulations and climate data analysis to foster active sustainability competencies.

Core Guiding Principles:

1. Pedagogical Primacy: Educational and sustainability goals must guide technology adoption, not technological availability.

2. Human Agency: The educator retains final evaluative, moral, and pedagogical authority in instructional decisions.

3. Critical Literacy: Mandatory multi-source verification and bias auditing of all AI outputs.

4. Equity and Inclusion: Active deployment of digital resources to reduce socioeconomic and linguistic divides.

5. Socio-Ecological Responsibility: Institutional mindfulness regarding the environmental and societal impacts of computational systems.

7. Contextual Relevance to India and State of Karnataka

The proposed Seven-SDG Human-Centred Framework directly aligns with the strategic mandates of India's National Education Policy (NEP) 2020. NEP 2020 explicitly advocates for technology-enabled pedagogy, multidisciplinary inquiry, competency-based educational structures, and the cultivation of 21st-century skills, while simultaneously prioritizing regional linguistic diversity and socio-economic equity. As a premier national

ecosystem for technological innovation, the state of Karnataka presents a uniquely fertile landscape for teacher education institutions (B.Ed. and M.Ed. colleges) to pioneer sustainable AI pedagogy. However, operationalizing this framework within Karnataka's distinct socio-educational paradigm requires addressing three critical regional imperatives:

Linguistic Inclusivity and Multilingual AI Architectures: Operational deployment must prioritize the development of AI-supported, high-fidelity bilingual and multilingual resources in Kannada and English. This is vital to guarantee deep conceptual clarity and equitable access for student-teachers across both rural and urban locales.

Localized Sustainability Contextualization: AI-assisted project-based learning must be empirically bound to pressing regional ecological vectors. Specifically, curricular modules should leverage AI data analytics to address water resource management in the Cauvery basin, agrarian sustainability and agrarian crisis metrics in Mandya, biodiversity preservation in the Western Ghats, and municipal solid waste management challenges in Bengaluru.

Asymmetric Digital Divide Mitigation: To prevent compounding existing educational disparities, policy execution must prioritize equipping rural and under-resourced teacher training colleges. This requires provisioning localized, open-source AI frameworks, low-bandwidth edge computing tools, and accessible hardware architectures to ensure uniform, statewide pedagogical advancement.

8. Multi-Level Implications for Curriculum, Institutional Governance and Policy

Operationalizing the Seven-SDG Human-Centred Framework necessitates a highly coordinated, systemic reform across the three primary tiers of the teacher education ecosystem: micro-level curricular design, meso-level institutional governance, and macro-level state policy. Transitioning from abstract framework to classroom reality requires executing four strategic imperatives:

Holistic Curricular Transversality (Micro Level): Rather than isolating technological instruction within discrete, standalone computer literacy modules, contemporary Bachelor of Education (B.Ed.) and Master of Education (M.Ed.) programs must systematically embed AI literacy, ethical inquiry, and sustainability paradigms across all core foundational subjects. Field-based practicum requirements should be restructured to mandate that pre-service teachers actively evaluate AI-generated instructional designs, systematically audit algorithmic bias in educational software, and co-create cross-disciplinary, SDG-focused learning modules.

Continuous Professional Capacity Building (Meso Level): The successful translation of this framework depends heavily on the pedagogical readiness of teacher educators. Higher education institutions must establish sustained professional development tracks centered on advanced prompt engineering architectures, empirical output verification protocols, algorithmic risk-mitigation strategies, and the comprehensive redesign of formative assessment mechanisms to withstand generative AI capabilities.

Robust Institutional Governance and Ethical Frameworks (Meso Level): Teacher

education institutions must proactively institute comprehensive institutional policies. These frameworks must clearly delineate guidelines governing data privacy, algorithmic transparency, student disclosure mandates, intellectual property ownership of AI-assisted outputs, and academic integrity. Cultivating a culture of transparent, ethical collaboration prevents ad-hoc, reactive institutional responses to emerging technologies.

Macro-Level Policy Architectures and Structural Support (Macro Level): Broad-scale systemic equity cannot be achieved through institutional isolation. Regulatory and educational governing bodies specifically the National Council for Teacher Education (NCTE) at the national level and the Karnataka State Higher Education Council (KSHEC) at the state level—must provision dedicated financial and infrastructural resources. Policy mandates must prioritize funding for open-source digital infrastructures, high-speed regional connectivity grids, and localized, bilingual digital learning repositories to insulate under-resourced institutions from technological exclusion.

9. Conclusion

This paper demonstrates that Artificial Intelligence (AI) holds immense promise for advancing pedagogical innovation and supporting multifaceted sustainable development. However, technological capabilities alone cannot drive systemic educational transformation. The true pedagogical value of AI is realized only when computational tools are firmly subordinated to human agency, ethical responsibility, educational equity, and ecological stewardship. By introducing the Seven-SDG Human-Centred Framework, this study provides a crucial theoretical bridge connecting technological innovation with sustainable classroom practices. This framework equips teacher preparation programs with a structured paradigm to cultivate educators who are technologically proficient, ethically grounded, and deeply committed to global sustainability goals. Applied to the distinct socio-educational landscapes of India and Karnataka, this approach offers an actionable roadmap to align rapid technological progress with the dual mandates of educational excellence and localized environmental stewardship.

Limitations and Future Research

As a conceptual study, the primary limitation of this paper is the lack of longitudinal empirical validation regarding the framework's real-world classroom implementation. Future research should focus on piloting the Seven-SDG framework within Bachelor of Education (B.Ed.) curricula across Karnataka to measure its direct impact on pre-service teachers' AI literacy and sustainability mindsets. Additionally, empirical investigations are required to assess the technical infrastructure scalability and localized policy challenges associated with integrating AI into diverse educational ecosystems across India.

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ARTIFICIAL INTELLIGENCE IN COMMERCE

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Abstract

Artificial Intelligence (AI) has emerged as one of the most influential technologiestransforming modern commerce. From personalized product recommendations to demand forecasting, dynamic pricing, fraud detection, inventory management, and generative AI- powered content creation, AI is changing how businesses interact with customers and manage commercial operations. The growth of e-commerce and the availability of large volumes of customer and transaction data have accelerated the adoption of AI across the retail and commercial sectors. Research indicates that generative AI alone could create substantial economic value in retail by improving marketing, customer service, sales, and operational efficiency. This paper examines the applications, benefits of AI in commerce. It discusses how AI enables businesses to provide personalized shopping experiences, optimize supply chains, improve decision-making, automate routine activities, and increase productivity. At the same time, AI adoption creates concerns related to data privacy, algorithmic bias, cybersecurity, employment, transparency, and governance. Recent research also shows that although many organizations are experimenting with generative AI, scaling these technologies successfully requires appropriate data infrastructure, skilled employees, governance mechanisms, and clear business objectives.

Keywords: Artificial Intelligence, Commerce, E-commerce, Generative AI, Personalization, Customer Experience, Retail.

1. Introduction

Commerce has undergone significant transformation due to digitization, globalization, smartphones, social media, and e-commerce platforms. Artificial Intelligence has become the next major technological force influencing this transformation. AI refers to computer systems capable of performing tasks that traditionally require human intelligence, including learning, reasoning, prediction, language processing, image recognition, and decision-making. In commerce, AI is increasingly used throughout the business value chain. Retailers and e-commerce companies use AI to understand customer preferences, recommend products, forecast demand, optimize prices, manage inventory, detect fraudulent transactions, and automate customer service. IBM describes AI in retail as a technology that can improve customer experience, business operations, and decision-making across both online and physical stores. The emergence of generative AI has expanded these possibilities. Unlike conventional AI systems that primarily analyse existing data and make predictions, generative AI can produce text, images, product descriptions, marketing materials, summaries, and conversational responses. Consequently, AI is becoming an important

strategic component of modern commerce rather than simply an information-technology investment.

2. Objectives of the Study

The major objectives of this paper are:

2.1 To examine the major applications of AI in commerce.

2.2 To analyse the benefits of AI for businesses and consumers.

2.3 To examine the role of generative AI in contemporary commerce.

3. Applications of AI in Commerce

3.1 Personalized Recommendations

One of the most visible applications of AI in commerce is product recommendation. AI algorithms analyse browsing history, previous purchases, searches, demographic information, and behavioural patterns to predict what products a customer may prefer. ersonalization can help customers discover relevant products while enabling businesses to improve conversion rates and customer engagement. AI-powered recommendation systems are particularly important for large e-commerce platforms that offer thousands or millions of products.

3.2 AI-Powered Customer Service

Chatbots and virtual assistants have transformed customer service. AI systems can answer frequently asked questions, provide product information, track orders, recommend products, and assist customers throughout the purchasing process. Generative AI has made these systems more conversational. McKinsey reports that retailers have experimented with generative-AI-powered shopping assistants that allow customers to search for products and receive personalized assistance using natural language. This development could make conversational interfaces an important future channel for shopping.

3.3 Demand Forecasting and Inventory Management

Maintaining the correct level of inventory is a major challenge for retailers. Excess inventory increases storage and markdown costs, while insufficient inventory can lead to lost sales and dissatisfied customers. AI can analyse historical sales, seasonal patterns, customer behaviour, market trends, weather information, promotions, and other variables to forecast demand. These predictions can help businesses determine how much inventory should be purchased, where it should be stored, and when it should be replenished. AI therefore contributes to a more responsive and efficient supply chain.

3.4 Dynamic Pricing

AI can also support pricing decisions. Dynamic pricing systems analyse factors such as demand, competition, inventory levels, customer behaviour, and market conditions to recommend or automatically adjust prices. When used responsibly, dynamic pricing can help businesses respond to changing market conditions. However, companies must ensure that pricing algorithms do not create discriminatory or unfair outcomes.

3.5 Marketing and Advertising

Marketing is another major area of AI adoption. Machine-learning systems can segment

customers, predict purchasing behaviour, optimize advertising campaigns, identify potential customers, and evaluate campaign performance.

Generative AI additionally allows businesses to create product descriptions, advertisements, email campaigns, social-media content, and visual material more rapidly. Deloitte reports that generative AI adoption in retail and consumer products is particularly relevant to functions involving creativity, interpretation, contextual decision-making, marketing, e-commerce, and customer service.

3.6 Generative AI and Product Content

Generative AI can automate the creation of product descriptions, catalogue information, promotional messages, and other commercial content. This can be particularly useful for companies managing large product catalogues.

Fashion and consumer brands can also use generative AI during product development and marketing. McKinsey notes that generative AI has potential to help fashion businesses improve productivity, accelerate time to market, and enhance customer experiences.

4. Benefits of AI in Commerce

4.1 Improved Customer Experience

4.2 Increased Operational Efficiency

4.3 Better Decision-Making

4.4 Revenue and Productivity Growth

5. Findings

5.1 AI Improve Personalism

5.2 AI Improve Business Decision Making

5.3 AI Supports Inventory and Supply Chain Management

5.4 Customer Service is Enhanced

5.5 Dynamic Pricing is Becoming More Data-Driven

6. Conclusion

Artificial Intelligence is fundamentally changing commerce by transforming how businesses understand customers, manage operations, make decisions, and deliver products and services. Its applications range from recommendation engines and chatbots to demand forecasting, fraud detection, dynamic pricing, marketing automation, and generative AI. The economic potential is considerable. Research from McKinsey, IBM, and Deloitte demonstrates that AI can improve productivity, personalization, customer service, and operational efficiency. Ultimately, successful AI adoption in commerce will not depend solely on having advanced algorithms. Competitive advantage will arise from combining high-quality data, appropriate technology, skilled employees, responsible governance, and a clear understanding of customer needs. AI is best understood not merely as a replacement for human work but as a tool that can augment human capabilities and create new forms of commercial value.

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BRIDGING EDUCATION AND EMPLOYABILITY: RETHINKING SKILL DEVELOPMENT FOR FUTURE-READY LEARNERS

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Abstract

Due to the fast pace of the evolution of work, which is characterized by digitalization, artificial intelligence, automation, globalization, and green transformation, there is a growing demand for competency development rather than knowledge transmission in educational systems. Higher education institutions need to ensure that their students are not only ready for entering the workforce but also for being flexible and lifelong learners, innovators, and responsible citizens in an evolving society. According to the Future of Jobs Report 2025, nearly 40% of the skills related to employment will be changed by 2030, and analytical thinking, resilience, creative thinking, technological skills, and lifelong learning will continue to be among the essential competencies for employers.

In this conceptual paper, the necessity of connecting education and employability via a multidimensional skill development approach is analyzed. Based on the current literature on graduate employability, work-integrated learning, digital competences, and cooperation between universities and industries, it can be stated that graduates' employability cannot only be defined as getting a job but as the ability to develop, apply, adapt and further develop knowledge and skills. According to the recent systematic reviews, the dimensions of graduate employability include communication skills, teamwork, problem-solving, adaptability, learning attitude, digital skills and professional competencies.

The proposed strategies include competence-based curriculum design, experiential and project-based learning, work-integrated learning, digital and AI literacy, entrepreneurial learning, industry-university collaboration, career mentoring, micro-credentials, and lifelong learning. Thus, the paper concludes that the future-ready education will require a multidimensional ecosystem when educational institutions, employers, policy-makers and learners bear equal responsibility for developing competencies.

Keywords: *Skill Development, Employability, Future-Ready Learners, 21st Century Skills.*

Introduction

Education has traditionally been regarded as a means of acquiring knowledge, developing intellectual abilities, and preparing individuals for social and professional life. However, contemporary changes in technology, employment structures, globalization, artificial intelligence, and economic conditions have transformed the expectations placed on educational institutions. Knowledge alone is increasingly insufficient to ensure successful participation in the labour market. Learners need the ability to apply knowledge, solve

unfamiliar problems, communicate effectively, collaborate with others, use technology responsibly, demonstrate creativity, and continuously update their competencies.

The changing nature of employment makes the relationship between **education and employability** particularly important. The World Economic Forum's *Future of Jobs Report 2025* projects significant changes in occupational structures and reports that employers expect 39% of workers' core skills to change by 2030. Analytical thinking remains the most frequently identified core skill, while AI and big data, networks and cybersecurity, technological literacy, creative thinking, resilience, flexibility and lifelong learning are among the skills increasing in importance.

This changing environment creates an important challenge for higher education. Institutions must ensure that curricula remain relevant to changing professional contexts without reducing education to narrow vocational preparation. Education should develop both **technical competencies and human-centred capabilities**. The future workforce will require a combination of digital and technological competencies with communication, creativity, critical thinking, leadership, emotional intelligence, collaboration and adaptability.

Research on graduate employability demonstrates that there is continuing concern about the mismatch between graduate capabilities and labour-market expectations. Osmani et al. found variations between the skills valued by employers and the attributes possessed by graduates, highlighting the importance of aligning higher education with market needs. Similarly, a systematic literature review found that problem-solving, communication, teamwork, adaptability and willingness to learn have remained important employability skills across different periods. Therefore, skill development should be viewed as an integral component of education rather than as an additional activity outside the curriculum.

Education and Employability: The Changing Relationship

Employability is wider than employment. Employment entails the process of getting a job, while employability involves the knowledge, skills, attitude, and capabilities which allow one to gain employment, operate effectively, and move forward in his career. The issue of graduate employability has emerged as an important concern of higher education institutions due to complexities emerging in the labour market. A systematic review on graduate employability and competence development revealed that a mismatch between competencies of graduates and needs of employers is a big issue and that innovation and collaboration in higher education are needed. Moreover, recent studies have indicated that there is no better way to develop employability than by providing authentic professional experiences to learners. According to a 2025 systematic review, practical experiences had the highest level of effectiveness of all other interventions studied, and university-industry collaboration was a necessary condition for successful employability projects. Therefore, educational institutions need to shift from a knowledge-based model to a knowledge-skill-application model.

Dimensions of Skill Development for Future-Ready Learners

1. Digital and Technological Skills

Digitization has altered the skill requirements for nearly all occupational areas. The learners will require digital literacy, information literacy, data literacy, cyber security literacy, and emerging technologies literacy. The importance of AI literacy cannot be overlooked. In addition to learning how to use AI tools, the learners will require an understanding of the limitations, ethical considerations, reliability, privacy issues, and responsible use of AI. According to the World Economic Forum, some of the most rapidly growing skill areas include AI and big data, networks and cyber security, and technological literacy.

2. Communication Skills

Effective communication will remain essential for employability. Graduates must have skills in oral, written, interpersonal and digital communication.

Communication competency facilitates:

- Collaboration
- Leadership
- Organizational communication
- Public speaking
- Negotiation
- Customer service
- Networking

Research on employability consistently identifies communication and interpersonal abilities among important graduate skills.

3. Creativity and Innovation

Innovation involves creativity that allows the learners to come up with new ideas and find various solutions to emerging problems. Innovation in education may foster entrepreneurship and problem-solving skills. Thinking creatively is one of the skills that are supposed to become important in the years ahead.

4. Entrepreneurship and Career Management

The entrepreneurial skills would enable the students to identify opportunities, manage risks, think innovatively, and create jobs. It is imperative that career management skills like self-assessment, career planning, networking, portfolio building, and interview skills be introduced into higher education.

5. Adaptability and Resilience

Changes in technology and organizations will continue to occur in the future workplace. Learners will need to be adaptable, flexible, resilient, and ready to learn. These traits will allow individuals to react positively to changes in their job positions and develop new skills during their lifetime.

Strategies for Skill Development

1. Competency-Based Curriculum

Curriculum design should clearly identify the competencies that learners are expected to develop. Every programme should specify:

Knowledge → Skill → Application → Performance → Reflection

Assessment should therefore measure not only what students know but also what they can do with what they know.

2. Integration of 21st-Century Skills

Institutions should systematically integrate:

- Critical thinking
- Creativity
- Communication
- Collaboration
- Problem-solving
- Digital literacy
- Leadership
- Adaptability
- Emotional intelligence
- Entrepreneurship

These should be embedded across subjects rather than taught only through separate skill-development courses.

3. Work-Integrated Learning

Internships, apprenticeships, field experiences, community projects and industry-based assignments can connect theoretical knowledge with workplace practice.

Work-integrated learning has been widely recognized as an important mechanism for developing employability skills. Jackson's research emphasizes the importance of appropriate design and implementation of work-integrated learning experiences.

4. Project-Based and Problem-Based Learning

   Students should be given authentic problems rather than only textbook-based exercises.

   Projects can require students to:

1. Identify a problem.
2. Collect information.
3. Analyse evidence.
4. Develop solutions.
5. Work collaboratively.
6. Present their findings.
7. Reflect on their learning.

   This approach simultaneously develops technical and transferable skills.

5. Digital and AI Literacy

   Higher education institutions should develop structured digital and AI literacy programmes covering:

- Generative AI
- Prompt literacy
- Data literacy
- Digital research skills
- Cyber security
- Digital ethics
- Information verification
- Responsible AI use
- Academic integrity

The goal should be **AI-augmented learning rather than AI-dependent learning**.

6. Mentoring and Career Guidance

   Mentoring can help learners understand workplace expectations and develop professional identity, confidence and career awareness. Recent systematic research indicates that mentorship can support soft skills, professional identity, confidence and career readiness, although its effects depend on programme design and context.

7. Lifelong Learning

   Acquiring new skills should not stop after graduation. Lifelong learning has become an essential tool due to the rapid changes in the demands of occupations. The recent work by the OECD concerning lifelong learning has pointed out the need to help people continuously acquire and use new knowledge and skills.

Recommendations

1. Curriculum Rethink: Educational institutions should undertake regular curricular reviews with the involvement of companies, professional associations, alumni and industry experts.

2. Create Skill Development Centers :The establishment of centers focused on employability, entrepreneurial and digital skills and career development should be encouraged by educational institutions.

3. Industry Engagement: Long-term collaborations between universities and industry organizations should be formed rather than conducting guest lectures at times.

4. Foster Experiential Learning: Internship programs, apprenticeship programs, engagement with the community, simulation learning, and projects must be made part of the curriculum.

5. Improve Skills in AI and Digital Literacy: Basic education on AI literacy, digital literacy, information literacy, and cyber security must be provided to every learner.

6. Enhance Faculty Expertise: Continuous training in innovation and pedagogical approaches, digital technology, AI, and assessment must be provided to teachers.

Implications for Higher Education

Some of the implications of the transition towards future ready education in the context of higher education institutions are:

Curriculum: The curriculum needs to be interdisciplinary, flexible and competence based.

Teachers: Teachers need to change from knowledge dispensers to mentors, facilitators and designers of learning.

Students: Students need to become active participants who will develop and demonstrate their competencies.

Institutions: Universities need to build strong links with industries, community groups and professional associations.

Policymakers: Policy initiatives need to promote flexible learning pathways and lifelong learning among other things.

Conclusion

There is a radical change in the nature of the connection between education and employability. The rapid development of such phenomena as artificial intelligence, automation, digitalization, and innovative modes of employment made the traditional knowledge-focused approach to education inadequate for the preparation of the future-ready learners. It is crucial not to substitute one type of competence with another but to combine knowledge, skills, values, and practice. According to the recent empirical evidence, employability encompasses a range of competencies, including technical, digital, interpersonal, cognitive, and career-management competencies. The future workforce will need people capable of analytical thinking, effective communication, collaboration, innovation, adaptation, and continuous learning. Employer evidence also indicates the necessity of combining technological competencies and human-centred skills. Thus, the development of skills has to be a core element of education rather than a supplementary element of its curriculum. Competence-based education, work-integrated learning, project-based learning, AI and digital literacy, mentoring, entrepreneurship, and university-industry partnerships may serve as bridging strategies between academic learning and workplace demands. In conclusion, readiness for future employment requires preparation not only for one's first job but for sustained employability and ability to contribute value through one's career journey. This is where collaboration among all participants of the educational process – universities, organizations, governments and learners – will ensure a strong connection between education and employability through lifelong learning.

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A STUDY ON THE EFFECT OF PSYCHOLOGICAL AND ENVIRONMENTAL FACTORS ON ACADEMIC ACHIEVEMENT OF CHILDREN WITH SPECIAL NEEDS AT THE SECONDARY SCHOOL LEVEL OF VIJAYAPUR DISTRICT

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Abstract

The present study was conducted to investigate the influence of psychological and environmental factors on the academic achievement of Children with Special Needs (CWSN) studying at the secondary school level in Vijayapur District of Karnataka. Academic achievement among CWSN is shaped by a combination of individual psychological characteristics and the quality of the environments in which they live and learn. Psychological factors such as self-concept, motivation, anxiety, self-esteem, and adjustment play an important role in students' learning processes, while environmental factors such as home environment, school environment, peer support, and parental support contribute significantly to their educational development. The study adopted a descriptive survey research design, and a sample of 200 Children with Special Needs studying in secondary schools of Vijayapur District was selected through an appropriate sampling procedure. Academic achievement was assessed on the basis of students' academic scores and achievement records. Data collected from the respondents were analysed using appropriate statistical techniques, namely the t-test, F-test (ANOVA), and Pearson's product-moment correlation (r-test). The findings revealed significant relationships between selected psychological factors, environmental factors, and the academic achievement of CWSN. The results further indicated that favourable psychological conditions and supportive environmental settings play an important role in enhancing the academic achievement of children with special needs. The study emphasizes the need for collaborative efforts among schools, parents, special educators, peers, and educational administrators to provide inclusive, supportive, and learner-friendly educational environments. Strengthening psychological support and improving home and school environments can contribute substantially to the academic progress and overall educational development of CWSN.

Keywords: *Children with Special Needs, Psychological Factors, Environmental Factors, Academic Achievement, Secondary School, Inclusive Education, Vijayapur District.*

1. Introduction:

Education is a fundamental right of every child, irrespective of physical, intellectual, sensory, emotional, behavioural, or learning difficulties. Inclusive education seeks to ensure equitable access to quality education by providing opportunities for all learners to participate

meaningfully in the mainstream educational process. Children with Special Needs (CWSN) require appropriate educational provisions, individualized instruction, emotional and psychological support, and a conducive learning environment to realize their academic potential. Creating an inclusive and supportive educational setting not only promotes their academic development but also enhances their confidence, social participation, adjustment, and overall well-being. Therefore, understanding the psychological and environmental factors that influence the academic achievement of CWSN is essential for developing effective educational strategies and support systems.

Academic achievement is one of the important indicators of educational development. It reflects the extent to which students acquire knowledge, skills and competencies through the teaching-learning process. However, academic achievement among CWSN cannot be explained only by their cognitive abilities. Their psychological characteristics and environmental conditions play an important role in determining their academic performance.

Psychological factors such as self-concept, self-esteem, academic motivation, anxiety, emotional stability and adjustment influence children's willingness to learn, persistence, classroom participation and achievement. A child who possesses a positive self-concept and adequate motivation is more likely to participate actively in academic activities. Conversely, excessive anxiety, low self-esteem and poor adjustment may negatively affect academic performance.

Environmental factors also have a substantial influence on the educational development of CWSN. A supportive family, positive parental attitude, trained teachers, accessible school facilities, peer acceptance, appropriate instructional resources and an inclusive classroom environment can facilitate learning. In contrast, parental neglect, inadequate school facilities, social isolation, negative peer attitudes and lack of educational resources may create barriers to achievement.

Therefore, understanding the combined contribution of psychological and environmental factors is essential for improving the academic achievement of CWSN at the secondary school level.

2. Need and Significance of the Study:

Children with special needs often encounter multiple challenges in the educational environment. These challenges may arise from their individual psychological characteristics as well as from their family, school and social surroundings.

The present study is significant because:

1) It helps identify psychological factors associated with academic achievement among CWSN.

2) It examines the influence of environmental conditions on academic performance.

3) It provides information about the relationship between psychological factors and academic achievement.

4) It identifies the relationship between environmental factors and academic achievement.
5) It may help teachers develop appropriate instructional and motivational strategies.
6) It may assist parents in creating supportive home environments.
7) It provides useful information for special educators and school administrators.
8) It may contribute to strengthening inclusive education practices in Vijayapur District.
9) It can provide a basis for counselling and intervention programmes for CWSN.
10) The findings may be useful for policymakers in planning educational support services.

3. Statement of the Problem:

"A Study on the Effect of Psychological and Environmental Factors on Academic Achievement of Children with Special Needs at the Secondary School Level of Vijayapur District."

4. Operational Definitions:

1) Children with Special Needs: In the present study, Children with Special Needs refer to secondary school students who require additional educational support because of disabilities or learning-related difficulties and who are enrolled in schools in Vijayapur District.

2) Psychological Factors: Psychological factors refer to the individual psychological characteristics considered in the study, namely: Self-concept, Self-esteem, Academic motivation, Anxiety and Adjustment

3) Environmental Factors: Environmental factors refer to the conditions surrounding the learner, including: Home environment, Parental support, School environment, Teacher support and Peer support

4) Academic Achievement: Academic achievement refers to the academic performance of CWSN as reflected by their marks/percentage obtained in the relevant school examinations or achievement records.

5) Secondary School Level: For the present study, secondary school level refers to students studying in Classes VIII to X.

5. Objectives of the Study:

The study was conducted with the following objectives:

1) To assess the level of psychological factors among Children with Special Needs at the secondary school level.
2) To assess the level of environmental factors among Children with Special Needs.
3) To study the level of academic achievement of CWSN.
4) To find out the significant difference in academic achievement of CWSN with respect to gender.
5) To find out the significant difference in psychological factors with respect to gender.

6) To find out the significant difference in environmental factors with respect to gender.
7) To find out the significant difference in academic achievement of CWSN with respect to type of special need.
8) To find out the significant difference in academic achievement with respect to school locality.
9) To study the relationship between psychological factors and academic achievement.
10) To study the relationship between environmental factors and academic achievement.
11) To study the relationship between psychological and environmental factors.
12) To determine the combined influence of psychological and environmental factors on academic achievement.

6. Hypotheses of the Study:

The following null hypotheses were formulated:

1) H_o1: There is no significant difference in the academic achievement of male and female Children with Special Needs.
2) H_o2: There is no significant difference in psychological factors of male and female Children with Special Needs.
3) H_o3: There is no significant difference in environmental factors of male and female Children with Special Needs.
4) H_o4: There is no significant difference in academic achievement of CWSN belonging to different types of special needs.
5) H_o5: There is no significant difference in academic achievement of CWSN studying in different school localities.
6) H_o6: There is no significant relationship between psychological factors and academic achievement.
7) H_o7: There is no significant relationship between environmental factors and academic achievement.
8) H_o8: There is no significant relationship between psychological and environmental factors.

7. Variables of the Study:

Variable	**Type**
Psychological Factors	Independent Variable
Environmental Factors	Independent Variable
Academic Achievement	Dependent Variable
Gender	Demographic Variable
Type of Special Need	Demographic Variable
School Locality	Demographic Variable

8. Methodology:

8.1. Research Method:

The descriptive survey method was adopted for the present study.

8.2. Research Design:

A correlational and comparative research design was employed to examine differences and relationships among psychological factors, environmental factors and academic achievement.

8.3. Population:

The population consisted of Children with Special Needs studying at the secondary school level in Vijayapur District of Karnataka.

8.4. Sample:

A sample of 200 Children with Special Needs was selected from selected secondary schools of Vijayapur District.

9. Tools Used for Data Collection:

The following tools may be used:

9.1. Psychological Factors Scale:

A researcher-developed Psychological Factors Scale may be used to measure:

1) Self-concept, 2) Self-esteem , 3) Academic motivation , 4) Anxiety and 5) Adjustment

A five-point Likert scale may be developed.

9.2. Environmental Factors Scale:

An Environmental Factors Scale may be used to measure:

1) Home environment , 2) Parental support, 3) Teacher support , 4) School environment and 5) Peer support

9.3. Academic Achievement:

Academic achievement may be measured using the percentage/marks obtained by students in their latest annual or school examination.

10. Validity and Reliability:

The tools should be subjected to expert validation by specialists in Education, Psychology, Special Education and Educational Measurement.

Reliability may be established through appropriate techniques such as:

Split-half reliability, Cronbach's Alpha and Test-retest method

For a research article, reliability coefficients of 0.80 or above would generally provide acceptable evidence of internal consistency.

11. Data Collection Procedure:

The researcher obtained necessary permission from the concerned educational authorities and school heads. The purpose of the study was explained to the participants and relevant information was collected using the psychological and environmental factor scales. Academic achievement data were obtained from school records with appropriate permission. The collected data were coded, classified and analysed using suitable statistical techniques.

12. **Statistical Techniques Used:**

The following statistical techniques were employed:

1) Mean and Standard Deviation
2) **t-test** – to compare two groups.
3) F-test/One-way ANOVA – to compare more than two groups.
4) **Pearson's Product-Moment Correlation (r-test)** – to determine relationships among variables.

The level of significance was fixed at **0.05 and 0.01**.

13. Analysis and Interpretation of Data based on Hypotheses:

1. H_o3: There is no significant difference in environmental factors of male and female Children with Special Needs.

Table – 3: Gender-wise Difference in Academic Achievement

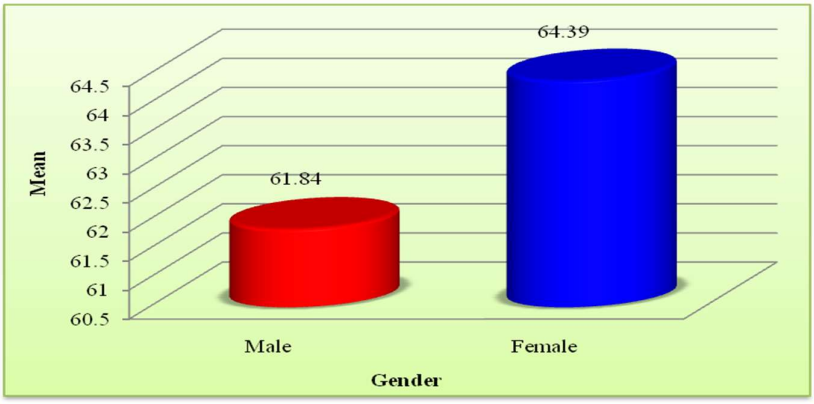
Gender	N	Mean	SD	t-value	Significance
Male	110	61.84	8.72	2.18	Significant
Female	90	64.39	8.01		

Critical t-value at 0.05 level = 1.97

Interpretation:

The obtained t-value of **2.18** is greater than the critical value of **1.97** at the 0.05 level. Hence, the null hypothesis is rejected. There is a significant difference between male and female CWSN in academic achievement. Female students have a comparatively higher mean academic achievement than male students.

Graph-3: Comparison of the Gender-wise Difference in Academic Achievement



2. H_o2: There is no significant difference in psychological factors of male and female Children with Special Needs.

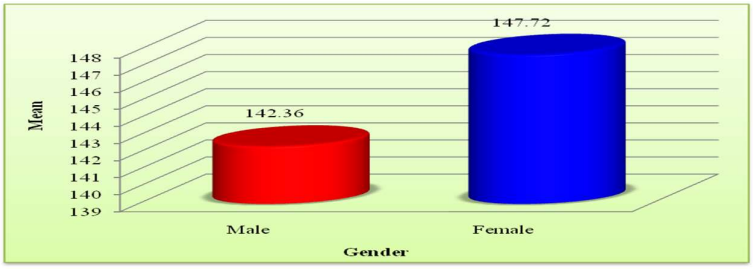
Table – 4: Gender-wise Difference in Psychological Factors

Gender	N	Mean	SD	t-value	Significance
Male	110	142.36	18.54	2.06	Significant
Female	90	147.72	17.26		

Interpretation:

The obtained t-value of **2.06** is greater than the critical value of 1.97 at the 0.05 level. Therefore, there is a significant gender difference in psychological factors. Female CWSN show a somewhat more favourable psychological profile than male CWSN in the present sample.

Graph-4: Comparison of the Gender-wise Difference in Psychological Factors



3. H_o3: There is no significant difference in environmental factors of male and female Children with Special Needs.

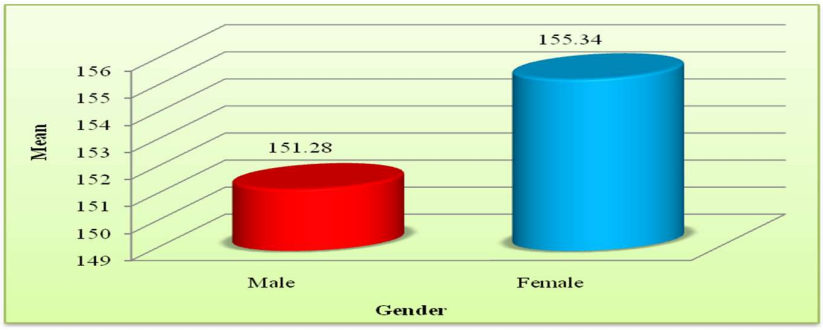
Table – 5: Gender-wise Difference in Environmental Factors

Gender	N	Mean	SD	t-value	Significance
Male	110	151.28	19.62	1.89	Not Significant
Female	90	155.34	18.71		

Interpretation:

The obtained t-value of **1.89** is less than the critical value of 1.97 at the 0.05 level. Hence, the null hypothesis is accepted. There is no significant difference between male and female CWSN in environmental factors.

Graph-5: Comparison of the Gender-wise Difference in Environmental Factors



4. H_o4: There is no significant difference in academic achievement of CWSN belonging to different types of special needs.

Table – 6: Difference in Academic Achievement According to Type of Special Need

Type of Special Need	N	Mean	SD	F-value
Locomotor Disability	52	63.42	7.84	2.87*
Hearing Impairment	38	61.18	8.22	

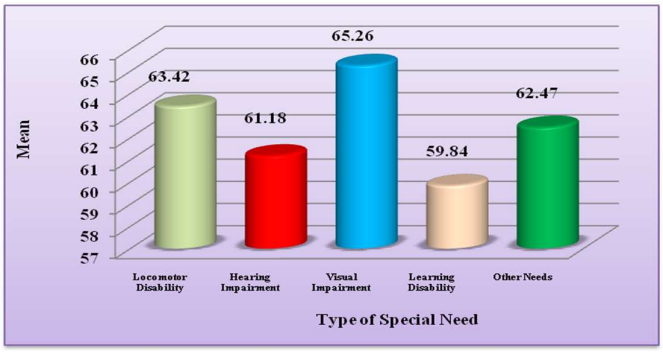
Visual Impairment	34	65.26	7.61	
Learning Disability	46	59.84	9.03	
Other Needs	30	62.47	8.16	

***Note: Significant at 0.05 level**

Interpretation:

The obtained F-value of 2.87 is significant at the 0.05 level. Therefore, there is a significant difference in academic achievement among CWSN belonging to different categories of special needs. Students with visual impairment obtained the highest mean achievement, whereas students with learning disabilities obtained the lowest mean score in the present sample.

Graph-6: Comparison of the Academic Achievement According to Type of Special Need



5. $H_0$5: There is no significant difference in academic achievement of CWSN studying in different school localities.

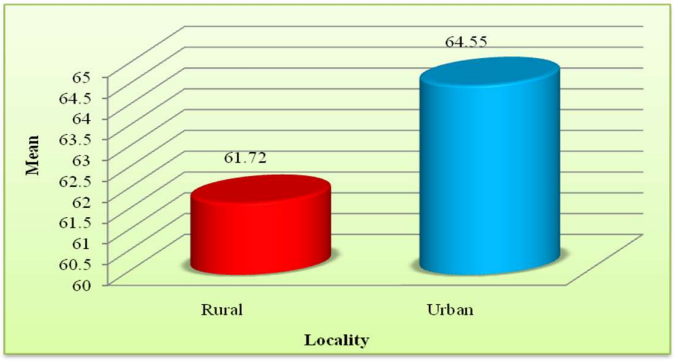
Table – 7: Locality-wise Difference in Academic Achievement

Locality	N	Mean	SD	t-value	Significance
Rural	120	61.72	8.66	2.41	Significant
Urban	80	64.55	7.93		

Interpretation:

The obtained t-value of 2.41 exceeds the critical value of 1.97 at the 0.05 level. Therefore, there is a significant difference between rural and urban CWSN in academic achievement. Urban students have a higher mean academic achievement than rural students. Differences in educational resources, specialist support and accessibility may contribute to this difference.

Graph-7: Comparison of the Locality-wise Difference in Academic Achievement



6. H_o6: There is no significant relationship between psychological factors and academic achievement.

Table – 8: Relationship between Psychological Factors and Academic Achievement

Variables	N	r-value	Significance
Psychological Factors & Academic Achievement	200	0.62	Significant at 0.01

Interpretation:

The obtained correlation coefficient is **r = 0.62**, which is positive and significant at the 0.01 level. This indicates a moderately strong positive relationship between psychological factors and academic achievement. CWSN with more favourable psychological characteristics tend to demonstrate better academic achievement.

7. H_o7: There is no significant relationship between environmental factors and academic achievement.

Table – 9: Relationship between Environmental Factors and Academic Achievement

Variables	N	r-value	Significance
Environmental Factors & Academic Achievement	200	0.57	Significant at 0.01

Interpretation:

The obtained correlation coefficient of **0.57** is positive and significant at the 0.01 level. This indicates a moderately strong positive relationship between environmental factors and academic achievement. Students receiving greater support from parents, teachers, peers and schools tend to achieve better academically.

8. H_o8: There is no significant relationship between psychological and environmental factors.

Table – 10: Relationship between Psychological and Environmental Factors

Variables	N	r-value	Significance
Psychological Factors & Environmental Factors	200	0.49	Significant at 0.01

Interpretation:

The obtained r-value of **0.49** indicates a positive and significant relationship between psychological and environmental factors. A supportive environment appears to be associated with more favourable psychological characteristics among CWSN.

Table – 11: Correlation Matrix among Major Variables

Variables	Psychological Factors	Environmental Factors	Academic Achievement
Psychological Factors	1.00	0.49**	0.62**
Environmental Factors	0.49**	1.00	0.57**
Academic Achievement	0.62**	0.57**	1.00

Note: ** Significant at 0.01 level.

Interpretation:

The correlation matrix demonstrates positive and significant relationships among all three major variables. Psychological factors have the strongest relationship with academic achievement (**r = 0.62**), followed by environmental factors (**r = 0.57**). Psychological and environmental factors are also positively related (**r = 0.49**). These results suggest that both individual psychological characteristics and environmental conditions are important in understanding academic achievement among CWSN.

Table – 1: Overall Level of Psychological Factors among CWSN

Level	Score Range	Number	Percentage
Low	Below 40%	36	18.00
Average	40–60%	104	52.00
High	Above 60%	60	30.00
Total		**200**	**100.00**

Interpretation:

The above table indicates that 18% of CWSN have a low level of psychological factors, 52% have an average level and 30% have a high level. Thus, the majority of CWSN fall within the average category. This indicates that although many students possess reasonably favourable psychological characteristics, a considerable proportion require additional psychological and counselling support.

Graph-1: Comparison of the Overall Level of Psychological Factors among CWSN

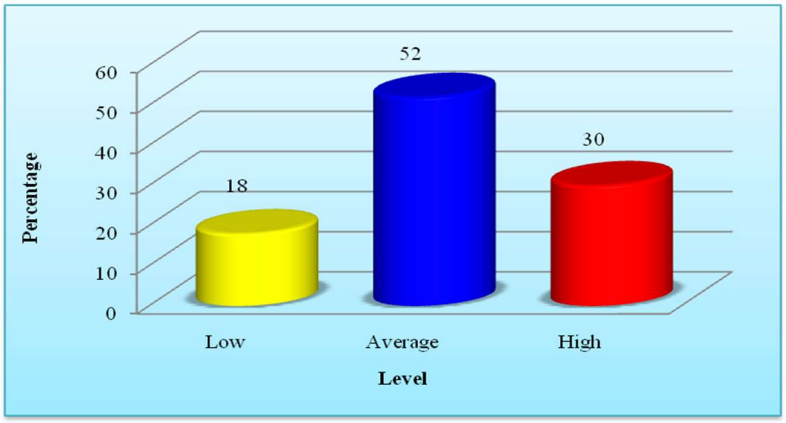


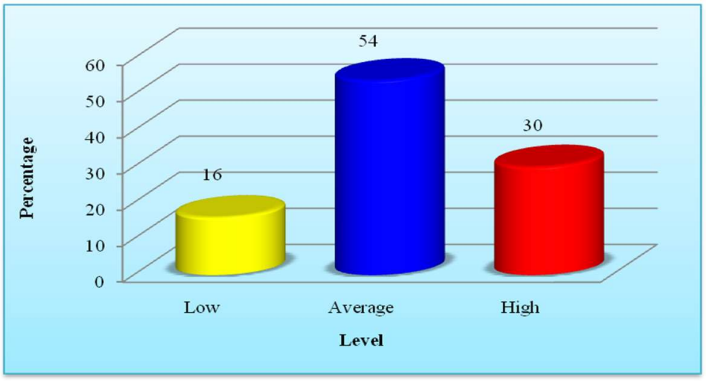
Table – 2: Overall Level of Environmental Factors

Level	Number	Percentage
Low	32	16.00
Average	108	54.00
High	60	30.00
Total	**200**	**100.00**

Interpretation:

The results indicate that 54% of CWSN experience an average level of environmental support, while 30% experience a high level and 16% experience a low level. The findings suggest that environmental conditions are moderately supportive for most CWSN, but students in the low category may require improved parental, teacher and peer support.

Graph-2: Comparison of the Overall Level of Environmental Factors



14. Major Findings:

The major findings of the study are:

1) The majority of CWSN possess an average level of psychological factors.

2) The majority of CWSN experience an average level of environmental support.
3) A significant gender difference was found in academic achievement.
4) Female CWSN showed comparatively higher academic achievement than male CWSN.
5) A significant gender difference was observed in psychological factors.
6) No significant gender difference was found in environmental factors.
7) Significant differences were found in academic achievement among different categories of special needs.
8) Urban CWSN showed comparatively higher academic achievement than rural CWSN.
9) A significant positive relationship was found between psychological factors and academic achievement ($r = 0.62$).
10) A significant positive relationship was found between environmental factors and academic achievement ($r = 0.57$).
11) Psychological and environmental factors were positively related ($r = 0.49$).
12) The findings indicate that both psychological well-being and supportive environmental conditions are associated with better academic achievement.

15. Educational Implications:

The findings have several implications for education:

15.1. For Teachers:

Teachers should provide individualized attention, positive reinforcement and appropriate instructional strategies according to the needs of CWSN.

15.2. For Special Educators:

Special educators should identify psychological barriers such as low self-esteem, anxiety and lack of motivation and provide appropriate interventions.

15.3. For Parents:

Parents should provide emotional encouragement, academic support and a positive home learning environment rather than excessive pressure.

15.4. For Schools:

Schools should ensure accessible infrastructure, assistive technologies, resource rooms, trained teachers and inclusive classroom practices.

15.5. For Peer Groups:

Peer-support programmes should be encouraged to improve social integration and reduce isolation among CWSN.

15.6. For Educational Administrators:

Educational authorities should strengthen inclusive education facilities, counselling services and special educator support, particularly in rural schools.

16. Conclusion:

The present study highlights the significant role of psychological and environmental factors in determining the academic achievement of Children with Special Needs (CWSN) at the secondary school level. The findings suggest that psychological factors such as self-concept,

motivation, self-esteem, anxiety, and adjustment are closely associated with students' academic achievement. A positive self-concept, higher motivation and self-esteem, appropriate adjustment, and effective management of anxiety can facilitate better engagement in learning and contribute to improved academic performance. Similarly, environmental factors such as parental support, home environment, teacher support, school environment, and peer relationships are found to have an important association with the academic performance of CWSN. The findings indicate that enhancing the academic achievement of CWSN requires a comprehensive approach that extends beyond classroom instruction and conventional academic support. Their psychological well-being, supportive family relationships, positive and encouraging teacher attitudes, peer acceptance, and accessible and inclusive school environments need to be given due consideration. Effective collaboration among teachers, parents, special educators, school administrators, and educational authorities is essential for addressing the diverse educational and psychological needs of CWSN. Such coordinated efforts can foster a supportive and inclusive learning environment, promote active participation in education, and enable children with special needs to realize their academic potential and achieve meaningful educational outcomes.

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STUDY OF EDUCATION SYSTEM DURING THE PERIOD OF KALYANI CHALUKYAS

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Abstract

Education in ancient India was deeply rooted in religious and spiritual traditions, with the individual placed at the center of the learning process. Its primary aim was self-knowledge and liberation, reflecting a lifelong desire for wisdom and personal growth. The system emphasized holistic development, integrating intellectual, moral, and physical training. Records highlight practices such as pranayama and yogic disciplines among the mahajanas of Sorade, while royal inscriptions, such as those of the Kadamba ruler Mrigeeshavarma, reveal training in sports, martial skills, and animal riding. Beyond personal cultivation, education also served as a vehicle for preserving and transmitting national heritage and culture. Thus, ancient Indian education combined spiritual pursuit, physical discipline, and cultural continuity, shaping well-rounded personalities and reinforcing the collective identity of society.

Key Words: *Ancient India, Education, Self-knowledge, Yoga, Kadamba Dynasty, Cultural Heritage, Ghatikas, Agraharas and Mathas*

Introduction

"There is nothing greater than learning. Learning is the real wealth of all riches. For none can steal it. It is indeed most marvellous and most indispensable. It is but a celestial cow yielding the desired fruit. It is, indeed, the teacher of the teachers. It alone is the real friend of us, in a foreign country. It is respected and worshipped by the kings and emperors. Really, a man having no learning at all, is more than a beast." This is how our ancestors! have praised the importance of learning.

In ancient India the system of education was mostly religious in character, and it was imparted to individual keeping him in the centre. Education was a means to attain self-knowledge or liberation. The view they, had about learning was like this:- "Andham taman pravis' antiye Avidyam upasate/tato bhuya Iva te tamoye vidyayam katah" "those who meditate only on non-intelligence fall into the deep ditch of darkness. Learning is indeed a great means that leads to God." It brings not only worldly happiness but liberation as well. Our ancestors held the view that it was indeed true learning that helped one to attain

liberation (Sa vidyaya vimuktaye). "The bliss that we get from learning is a real bliss." "It increases our efficiency, and enables us to get fame and wealth by securing for us respect in public assemblies and royal courts. The wealth we thus get not only leads to our happiness but also enables us to perform meritorious work of public utility and discharge religious duties of different types. Further, it is said that "It nourishes us like the mother. It guides us like a father, it helps us to come out of difficulties like a wife and it gives us pleasure. It brings us all wealth and spreads our fame in all directions."

"Whosoever grants a vritti to the Upadhyaya and creates an opportunity for people to get themselves educated need not make any other donation to achieve religious merit, wealth and worldly enjoyment. Whosoever makes arrangements for bathing, meals, clothes and other assistance to students, get all his desires fulfilled. There is no doubt at all about this. Arranging for imparting knowledge is a crore times' more powerful and meritorious than all the pilgrimages sacrifices and other meritorious acts put together."

It is a verifiable fact that in ancient time desire for learning was increasing every moment of their life. Here we can cite one of two instances in this regard. We find a beautiful dialogue between Nachiketa and Yama, the God of Death. Nachiketa insisted on getting knowledge from Yama who dissuaded him from it while conferring on him all the choicest enjoyments here and hereafter. But Nachiketa could not be persuaded to accept these best of the boons which were really charming to distract even the highly dispassionate one. Realizing the strong desire of Nachiketa for learning, Yama who was highly pleased him, was all praise for him. He said that "Nachiketa you are really fully qualified for receiving instruction from me in 'self-knowledge' or knowledge of Brahma, because the best of the boon pertaining to the worldly and other worldly enjoyments which I was so glad to confer on you, did not attract you. Your mind is fully bent upon attaining the superior (upper) knowledge which is possible only for; those who are completely detached and free from delusion." This dearly reveals the importance given to learning.

True education helps an individual to develop an allround personality by inculcating good aptitude, skills and interest. 'Education is that which enables man to cultivate his abilities, aptitude and the like in a manner which suits him and thereby to help him lay the foundation for thinking and acting for the development of human relations and human welfare.

The Aims of Education

It is the power of thought and speech that makes man different from animals. If this power of thinking is to foe developed in a systematic way, education is very essential. As Science is growing morel speedily than ever, the need for education is also felt more. But it can be seen from history that education differs from time to time and country to country. If one examines the views of educationalists are finds that there is no similarity of opinions regarding the aims of education. For example, Manu, the author of Dharmasastra of ancient times, says that the aim of education is the spiritual and intellectual development and the

attainment of liberation thereby. According to Plato, spirituality alone was the aim of education in India of the Aryans, whereas to Spartans, it was physical culture, courage, discipline and obedience. Even though the aims of education in ancient times were quite different from those of modern times, it may still be safely said that the aims of modern education have taken shape and developed on the basis of ancient educational aims.

After examining the contents of many inscriptions one may state as follows regarding the aims of education on the basis of whatever is indirectly referred to therein, even if it is difficult to definitely say about their true nature as such.

The main aim of education in ancient time was the formation of character. "Education gives humility, humility leads to eligibility which in term leads to the acquisition of wealth. Wealth in its term confers bliss. A man of character who might have not learnt scripture etc., is a thousand times better than characterless man who might have acquired mastery in spiritual knowledge."

"In the centre of the earth, there is the mountain Mandara, the ornament of the seven continents and the seven oceans. Over the land of Kuntala, which is considered to be a lack of hair of the woman who was the land to the South of the golden mountain, there reigned the Chalukyas, in so praiseworthy a manner as to illustrate well the observances of the code of Manu when they had continued during eighteen successions among the renowned Chalukyas."

The mahajanas of agraharas were also highly praised as men of character and well-versed in their study and teaching.

Another inscription dated 1088 A.D. from Balambid in Hirekerur taluka of Dharwad district describes that the mahajanas of that place, possessed qualities like restraint, self-control, self-study, meditation etc., and also well versed in logic, grammar, history, poetry, drama - and they were frightful elephants to the wicked people and protectors of those who sought refuge and brave in carrying out the work.

From this it is clear that men of character enjoyed honour and respect in society. Moreover, it is also known that development of character was the first and foremost aim of education.

Another record of the 11th century A.D., belonging to Naragund in Dharwad district, refers to the famous Naragund agrahara. It records in the following passage that the scholars of that place were famous for their learning in different branches of knowledge and they were engaged in self-study, i.e. Svadyaya.

Objectives of the Study

The study aims to examine the education system that existed during the period of the Chalukyas of Kalyani. The objectives are,

- To study the nature and development of the education system during the Kalyani Chalukya period.
- To identify and examine the major centres and institutions of learning during the period.

- To study the subjects of instruction, curriculum, and methods of teaching during the period.
- To examine the role played by temples, agrahāras, ghatikas, and other institutions in education.
- To study the patronage provided by the Kalyani Chalukya rulers towards education and learning.
- To examine the social and religious dimensions of education and the participation of different sections of society in the system.
- To analyse the contribution of the Kalyani Chalukya period to the development of learning systems in Karnataka.

Hypothesis of the Study

It is hypothesised that the Kalyani Chalukya period witnessed the development of an organized and institutionally supported system of education, centred on agraharas, temples, and ghatikas, which was sustained through royal and elite patronage and contributed significantly to the transmission and development of religious, literary and philosophical knowledge in karnataka.

Development of Personality

For ancient Indians the development of personality was important. The student was regarded as the custodian and torch bearer of the culture. The success of a warrior in the battlefield or the success of a king in governing his kingdom was supposed to be the result of good training.

The ancient Indians believed in the maxim of sound mind in a sound body. They said that students should perform every morning Pranayama - and Surya namaskara in order to develop their body and mind. Regular performance of these two would bring about an all-round development of students.

The mahajanas of the agraharas of Sorade were noted for the regular performance of pranayama and other yogic practices.

A record of the Kadamba ruler, Mrigeeshavarma states that he had proper training in many sports, which comprised of riding elephants and horses, use of weapons and other games. Hunting was another pastime not only for the rulers but also for the people. The Atakur inscription gives us a picturesque description of a fight between a hound and a boar.

Preservation and Spread of Culture

The preservation and spread of national heritage and culture constituted another important aim of the education in ancient times. The cultural continuity and spread of that culture from generation to generation and maintenance of the best traditions, formed the heritage of the race.

That which includes the clothes and ornaments, behaviour, acts and actions, thoughts and ideas, manners, wealth of knowledge and wisdom, tradition, conventions, civic sense, emotions and feeling of a race is what is called ‘culture’. It means that culture has a very

wide meaning. Here it may be noted that culture is the inner experience of the total life of people. The basic content of culture is the inner means adopted to find solutions to manifold problems faced by the different peoples belonging to different regions, speaking different languages and practising different religions. The meaning of culture is being very vast in its scope, its indeed, difficult to determine its content. It may be said that culture is to continue some traditions that have come to us from our ancestors.

Development of Social Responsibility

Development of social responsibility was another aim of education. Almost all the families followed the hereditary occupation, even though there was a scope for geniuses to follow other occupations of their interest and choice. Therefore, it was one of the duties of education to give training in their ancient professions and hereditary occupations.

The Education which an individual received was to be conducive to the good of the society and never contrary to its interests. Therefore, it was necessary that a sense of social commitment and responsibility should be inculcated in them.

System of Education

From ancient times till the end of the rule of the Chalukyas of Kalyana there, were mainly three religious sects in Karnataka, vis. Brahminic, Jaina and Buddhist. Each developed its own system of education to spread its teachings and philosophy, literature and culture. Even though all these three systems of education looked similar, there were a number of differences.

Primary Education

In the period under study Primary education was in Kannada, while higher education was in Sanskrit. It was known as Karnataka Sikshe or bala-sikshe or Karnata-bala-sikshe and the Primary School teacher was known as Karnata-Pandita, and also akkariga. Thus the three R's were taught in village schools which normally met in the precincts of temples. At the primary stage, the alphabets were taught. And after teaching the Kannada letters the children were introduced to Kannada language.

Commencement of Primary Education

The Lokopakaram mentions that the commencement of learning should be made on a good day, in a good week and during the period of a good star.

Several inscriptions help us to know the fact that the primary education began after the thread ceremony.

A record from Lakshmesvara, dated 730 A.D. interestingly enough, tells us that the early Chalukya king Vijayadityas son mastered all the Sastras (the sciences) and Sastras (weapons) during his childhood.

Thus it is clear that the children were sent for learning (schooling) as soon as they reached the age of five or six and they also learnt there many kinds of arts and sciences.

At the time of thread ceremony gifts were usually made to the Guru as Gurudakshina. A record from Muttage in Bijapur district says that, on the occasion of the thread ceremony

of Chalukya prince, Vikramaditya-V, the whole village of Muttage was given as a gift to his teacher, Visnubhatta.

The period for performing upanayana was different for different castes. According to Apastambha, the upanayana of a Brahmin should be performed in the season of Spring (Vasanta), that of a Kshatriya in Summer (Grishma) and that of Vaisya in Autumn (Sarad). In astrology the general rule is that the upanayana for all the castes should be performed in the five months from Winter (Magha), perhaps because these constitute the auspicious part of the year known as uttarayana.

During this period of study, primary education commenced with the reading, writing of alphabets and mathematics. Inscription describe the primary education as balasikshe Kannadakkara Oduva, Kannadaksharsikshe, akshara-sikshe, Karnataka-sikshe, Khandikabalasikshe, Karnata balasikshe.

In inscriptions the primary education teachers are referred to differently as Upadhyaya, Akkariga, Karnataka Pandita and Oja.

The salary of a primary teacher varied from centre to centre or agrahara to agrahara. It was paid either in cash or kind. In the agrahara of Narasimhapura in Hassan district, an amount of twelve gadyanas annually was paid to a teacher for teaching twenty students. While in the Talagunda agrahara, five gadyanas were paid, in the agrahara of Malinge it was six gadyana, and in the agrahara of Kondagoli it was 20 lokkiyana gadyana. In the Degamva agrahara just half a vratti was paid. Thus the payment made to the teacher was not uniform.

Agencies of Primary Education

In ancient Karnataka the primary education was given in the houses of teachers, gurukulas mathas and agraharas.

Mother naturally was the first teacher who provided good guidance to her son or daughter and brings about regularity in child's daily life. Altekar observes that it must have been given in the family as long as it continued to be the centre of education. That the primary education, ordinarily began at home first can be understood.

After learning a little in houses, the pupils usually went to the gurukulas to receive primary education. These gurukulas were situated at distant places from villages and towns. As such, most of them were situated in the forest. This gurukula system of education was beneficial both to pupils and society at large. The students were required to stay with their teacher, who performed all the duties himself. As a result of this self-reliance, self-help, sense of duty and the like were automatically taught to them by the teacher. Students had to work for their bread in the gurukulas.

Since the number of pupils in the gurukulas was limited it was feasible for the teacher to give individual attention not only to the studies of his pupils but also to all their activities. The students were required to perform their lessons well in advance before going to the regular classes.

The agrahara of Talagunda had become famous centre of higher learning in the 11th

and 12th centuries A.D. In this agrahara there were many primary sections like. As mentioned in the inscription subjects like Rigveda Khandika, Yajurveda-Khandika, Samaveda-Khandika, Sabdasastra, Rupavatara, Nyasa-khandika and Prabhakara.

Subjects Taught in the Primary Education

Some records help us know the subjects taught to children at the primary stage of education. An inscription of 1168 A.D. Akshara sikshe and the record of 1118 A.D. Kannadakshara mention the Kannada alphabet inscription of 1174 A.D. Karnata balasikshe and record of Kannadakshara helikoduvava indicates that provision was made for primary education largely consisted of teaching Kannada alphabets as the mother-tongue of the people in this area was Kannada. At some of the agraharas other scripts and languages were also taught. Thus for example in the agrahara Malinge, the scripts and languages taught were Nagara, Kannada, Tigula and Arya.

Perhaps it was necessary that students should be taught different languages in order to enable them to travel from one place to another for purpose of trade, pilgrimage and learning etc. Therefore, in agraharas students learnt many Indian languages.

An inscription of 1012 A.D. from Kotavumachgi, referred to earlier states that, Nagadesiga taught the students in primary section reading, writing (bareyalum-bajisalum), and then (afterwards) he taught them mathematics (ganitam), astrology (joisam), prosody (chandam), rhetoric (alamkaram).

Higher Education

The ghatikas, agraharas, brahmapuris and also mathas and temples etc., were centres of higher learning. Sanskrit was the preserve of higher learning. It was particularly encouraged by means of large special endowments. Making gifts to educational institutions was considered as an act of great merit, a crore-fold greater merit than that arising from Pilgrimages to holy places and performing sacrifices. At these institutions sometimes only four and sometimes as many as fourteen or eighteen subjects were taught. The four subjects were philosophy (anvikshiki), Veda (trayi), economics (Vartta), and politics (dandaniti) a group which was particularly suited to princes and which in fact first occurs in Kautilya's Arthasastra. The fourteen vidyas were: the four Vedas, six angas (auxiliaries) Phonetics; Prosody, grammar, etymology (of difficult words), astronomy, ritual, Purana, logic (tarka), exegesis (mimamsa), and law (dharmasastra). To these were added medicine (ayurveda), archery (dhanur-veda), music (gandharva-veda) and economics (arthasastra). Some of the Brahmins and others who were learned in many of these branches of knowledge served as rajagurus while many of them spread themselves in different parts of the land edifying the towns and villages of their settlements as centres of higher learning. Gifts of lands, houses, and villages were frequently offered as inducements to these learned men to come and settle where they wanted. Ghatikas, agraharas, brahmapuris, mathas and temples were largely the settlements of such learned Brahmins and others.

Conclusion

The Chalukyas of Kalyana period represents a remarkable epoch in the cultural and intellectual history of Karnataka. This era witnessed a golden age of Kannada and Sanskrit literary activity, where Jain scholars enriched religious discourse through narratives of the Tirthankaras, and Virashaiva poets expressed profound spiritual devotion through Vachanas. The sheer diversity of nearly three hundred Vachanakaras, including thirty women poets, highlights the inclusivity and dynamism of the movement, particularly in regions like Gulbarga and Bidar. Beyond religious literature, the expansion into secular subjects – romance, medicine, mathematics, astrology and encyclopaedias – demonstrates the breadth of intellectual curiosity and innovation of the time. Contributions to musicology, with works such as Sangita Chudamani, Sangita Samayasara, and Sangita Ratnakara, further underscore the multidimensional nature of this literary efflorescence. Collectively, the Chalukyan age not only advanced literary traditions but also reinforced cultural identity, leaving a legacy of creativity and scholarship that continues to inspire.

The artisan class, in addition to literacy, got practical if training either at home, or under a master craftsman. The architecture of the time bears witness to the meticulous care taken to train architects and sculptors. That some members of the fourth caste (Sudra) could read, write, administer and fight showed that the exigencies of the time pushed up some in the social ladder.

Women's education received its due attention. A number of women scholars flourished in ancient Karnataka. Care was taken to encourage physical, culture so that society consisted of people with robust health. It was only such a healthy society which could achieve great things in life. The numerous memorial stones that are strewn in different part of Karnataka, which have a herald story to tell, bear listening the heroes of ancient Karnataka.

The literary output of ancient Karnataka bears evidence to the attainments made by the people of the region. Temples, sculptures and paintings, unmistakingly reveal the high water mark that the people had attained in these fields. The proficiency that the people had gained in fine arts like music and dance are also revealed in the sculptures and literary works of the age.

The pattern continued down the centuries irrespective of dynastic changes that ruled the land and thus making way to the development of certain traditions. The system of education was neither state controlled nor state directed although it was generously patronised by kings, noblemen, merchants and other philanthropists making endowment for education was always considered highly meritorious. Religious establishments and leaders of all denominations played an important part in intellectual, moral and religious education. Technical education was mostly imparted in the homes of craftsmen and their well-organized guilds safeguarded the prestige and efficiency of the respective professions.

What is now called technical or vocational training was a more a private affair, the father brought up his children in his calling, and learning went side by side with doing. In

Karnataka during the early days many temples, palaces, forts and other structures, both private and public were built. The construction activity of these monuments must have given ample scope for the discovery of fresh talents besides the application of known abilities. Judging from the monuments that have survived one may well conclude that at no time there was a dearth of artisans who were also great artists. The beauty and accuracy which mark the engraving of most inscriptions on stone and copper plates attest to the high degree of literacy and skill of the engravers, while the literary merit of many of the inscriptions as well as the volume of literature produced at different periods show that the cultivation of the popular speech of each locality and its employment in administration and education was by no means neglected.

With reference to Asokan edict spread over different parts of India, V.A. Smith observed that "This implied that a knowledge of reading and writing was widely diffused and that many people must have been able to read the documents." Whereas in ancient Karnataka thousands and thousands of inscriptions are found in different parts of the land even in remote villages, inscribed in the language of the people. Most of these refer to dealings and transactions of grants of which the common people were well aware. Hence it can be said that the literacy in ancient Karnataka was vast indeed. This literacy was largely due to the diffusion of learning undertaken by different sects, to propagate their religion tenets. To learn, to teach and to provide for education were considered sacred, and the scholars of the time were imbued with this spirit. Further, it was this educational activity that was indeed the basis of the intellectual and moral culture of the land, as also of its progress.

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DEVELOPMENT OF TEACHER EDUCATION: A THEMATIC ANALYSIS IN THE CONTEXT OF NEP 2020 FOR DEVELOPING SMART TEACHERS IN INDIA

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Abstract

The National Education Policy (NEP) 2020 is a moment in Indias education history. It suggests changes to improve teacher education and create teachers who have skills needed in the century. This paper looks at 20 studies from journals to see how teacher education is changing with NEP 2020. The study found six themes: the new idea of teacher education in NEP 2020 changes in the curriculum through the Integrated Teacher Education Programme (ITEP) digital skills and smart teacher development ways to keep learning as a teacher teaching students with different needs and problems with putting the policy into action. The paper says that although NEP 2020 gives a plan for teachers who are smart and able to use technology there are still problems with infrastructure schools not being ready and differences between regions that need to be fixed.

Keywords: *NEP 2020, Teacher Education, Smart Teachers, Digital Literacy, Continuous Professional Development, Integrated Teacher Education, Inclusive Education*

1 Introduction

The quality of a school system depends a lot on the quality of the teachers. The Government of India made the National Education Policy (NEP) 2020. This is the major education policy in 34 years. It replaces the National Policy on Education (NPE) 1986. NEP 2020 wants to change the way education works. It wants students to learn more than memorizing. Teachers are at the centre of this change. The policy says that preparing teachers needs ideas, knowledge, ways of thinking and learning from the best people. The idea of " teachers" in NEP 2020 is not just about using technology. It includes teachers who're creative good with technology understand emotions and can help students learn skills like thinking, creativity, working together and talking. Making these teachers needs changing how teacher programs are set up using technology more keeping learning for teachers and making sure it matches the ways around the world.

This paper looks at 20 studies from journals between 2020 and 2025. It looks at how NEP 2020's changing teacher education in India. It finds points puts together the evidence and gives ideas on how to create smart teachers for the new century.

2 Context: Evolution of Teacher Education Policy in India

To understand NEP 2020, we need to know its history. The Hunter Commission (1882) was the first to say that teachers need to be trained. The Radhakrishnan Commission (1948-49) wanted teachers to be strong in their thinking. The Kothari Commission (1964-66) said that the future of India is shaped in classrooms. It wanted teachers to be more professional. The NPE 1986 started the National Council for Teacher Education (NCTE) to make sure standards were met. Teacher education was not working well was focused on money and was not connected to higher education. NEP 2020 solves these problems by saying that all teacher education programs must be in schools by 2030. It

wants a four-year ITEP program as the minimum. It says teacher education must be in subjects, full of values and have a lot of practice. This shows that education is moving from training to being more professional. NEP 2020 is the step to make teacher education match the best in the world.

3 NEP 2020's Transformative Vision for Teacher Education

NEP 2020 has a section on teachers. It says that teachers are the important part of the system. It wants them to help students learn of just give information. It needs changes in how teachers teach how they are tested and how they see themselves.

- ✓ Amin et al. (2025) said that this policy NEP 2020 can change a lot in teacher education as better but in realities there are not resources in the schools and are not ready.
- ✓ Chaturvedi (2025) revealed that this policy NEP 2020 wants teachers to learn all the time get help from mentors and use technology and teaching is a job where people need to keep learning and not just do the things over and over.
- ✓ Raju and Veeraiah (2025) looked at teacher learning in NEP 2020 through countries like Finland and Singapore. They say that how well NEP 2020 works depends on fixing differences between regions. They suggest help for teachers using technology and making sure different parts of the government work together.

4 Curriculum. The Integrated Teacher Education Programme (ITEP)

The biggest change in NEP 2020 is the ITEP. It is a four-year program that mixes learning about a subject with teaching. By 2030 this will be the minimum to teach. It replaces the two-year B.Ed. Program.

- ✓ Dey (2024) says it is a program that mixes a bachelors' degree with teacher training. The program is meant to make teachers with knowledge and how to teach. Research shows that ITEP matches NEP 2020 well in combining subjects how to teach and how to reflect on learning.
- ✓ Mishra and Inamdar (2024) say that using subjects in teacher education programs helps teachers think and be ready for anything.
- ✓ Kumari (2025) says that using subjects makes teaching better and helps teachers deal with the world.

The ITEP program goes beyond teaching methods. It includes psychology, sociology, early education learning to read and count and Indian knowledge. It has 20 weeks of learning in schools. This shows the goal of NEP 2020. There are still questions about how to balance different parts of the program.

5 Digital Competence and Smart Teacher Development

Digital skills are very important for teachers in NEP 2020. The policy wants technology in every school. Starts the National Educational Technology Forum (NETF) to help with training.

- ✓ Sharma (2024) looked at how NEP 2020 helps teachers get better at using technology. He says the policy is important but there are still problems with the gap between rich and poor people not wanting to change, not money and the need for more learning. He says that being good with technology is not a skill but a necessary part of the job.
- ✓ Pal (2025) says that technology helps NEP 2020 a lot. Behera and Kaware (2025) say that even though many rural teachers know about online tools they don't use them often. They say that not being confident not having time and not having a group to learn with are problems.

- ✓ Garg and Kumar (2023) say that the NETF could help set standards, for using technology create training resources and help with the policy. It is not fully ready which makes it not as strong as it should be.
- ✓ *"NEP 2020 says that every teacher must do least 50 hours of continuous professional development each year" (NEP 2020, Para 5.16)*. This is a change from ways where training happened only occasionally.
- ✓ Walia and Walia (2022) studied how continuous professional development works in India. They say that NEP 2020 sees CPD as complete and better than before, NCERT gives rules for the 50 hours of CPD, those hours include things like FLN, assessment and learning based on skills. The arts can be part of learning. Places like DIKSHA, SWAYAM and NISHTHA help train teachers, NISHTHA 1.0 trained 24 lakh teachers, NISHTHA 2.0 is for 10 lakh teachers (IJNRD, 2024).

6 Inclusive Education and Teacher Preparation

NEP 2020 wants teachers to help all students. This includes students with disabilities and those from languages and backgrounds. This means teachers must change how they teach. The focus on inclusive education matches with a goal to give everyone good education.

Shirode and Tambe (2025) looked at NEP 2020. How to prepare teachers for inclusive education. They found five points: change the school curriculum to include diversity and special education; train teachers to teach in inclusive ways; use technology to help students; work with parents and experts; and use tests that are fair for all students. They say that teacher educators must show how to do teaching. They should help teachers think about their work and use technology in the ways.

NEP 2020 also talks about languages. It wants students to learn in their mother tongue until at Grade 5. This means teachers must know how to teach in languages.

7 Implication Challenges and Barriers

- ✓ Sivaraman et al. (2026) conducted a PRISMA-guided systematic literature review of 50 peer-reviewed studies on NEP 2020 implementation in Indian higher education institutions. The researcher concluded that "the 82% barrier identification rate and 70% regional disparity findings indicate that NEP 2020's transformative potential remains constrained by system challenges"
- ✓ Amin and others (2025) said there are three problems: not enough money, schools not ready and different states doing things differently. They say that schools need to work and use technology better. This needs people to work together to make it happen.

Some areas are doing better than others. The study says that schools in cities are doing better than those in the countryside. The gap between cities and villages is getting bigger. Teachers in the countryside do not have internet or tools. They also do not know how to use technology. This makes it hard for them to take classes or use digital tools in their work.

8 Discussion and Synthesis

The study shows that NEP 2020 wants to change how teachers are trained. It wants to make teacher education more professional, more varied and based on research. The six main points work together to make a plan for changes: ITEP gives the base. Digital skills and CPD help teachers grow. Inclusive education is the goal. Fixing the problems will decide how well the plan works.

The idea of " teachers" in NEP 2020 includes different skills. These include knowing their subject using teaching methods being good with technology being kind understanding different cultures and

learning all the time.

The study shows that the plan is not working as well as it should. Even though the plan is good 82% of studies say there are problems. Also 70% of areas have differences. The plan needs buildings, money and training to work well.

9 Conclusion and Recommendations

NEP 2020 has a plan for making teachers better. It wants teachers to be good with subjects use technology learn all the time and help all students. This plan needs more money and better support to work.

Based on 20 research studies the following ideas came up:

1. First more money is needed. The plan says that 6% of the countrys money should go to education. This must happen now.
2. Second teachers need training. They need help to change how they teach.
3. Third more money is needed for technology. This must focus on making things fair between cities and villages.
4. Fourth the standards for teachers must be set quickly. These standards will guide how to train teachers and help existing ones.
5. Fifth the part of teacher training that has to do with real school work must be better. Teachers need help while they are training.
6. Sixth the training that teachers get after they start working must be better. It should help them with problems and not just be something they have to do.
7. Seventh all teachers must know how to help all students. This should not be a part of training but something that is part of everything.
8. Eighth the different groups that give rules must work better together. This will help schools do things faster and without confusion.

In the end NEP 2020 says that teacher education is the key to making education. Making teachers who are good at many things use technology keep learning and help everyone needs more than just new rules. It needs money changes in schools and strong leaders. The research shows that even though it is hard it is worth doing. The goal is to have a teaching profession that helps the next generation, in India.

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AI-ASSISTED PERSONALIZED LEARNING AND ACADEMIC SELF-EFFICACY AMONG B.ED. STUDENT TEACHERS: A CORRELATIONAL STUDY

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Abstract

The rapid development of Artificial Intelligence (AI) is transforming contemporary educational practices by enabling personalized learning, adaptive feedback, intelligent tutoring, and individualized learning pathways. Among the emerging applications of AI in education, AI-assisted personalized learning has particular relevance for teacher education because it can provide learners with differentiated resources, immediate feedback, adaptive practice, and learning support according to individual needs. At the same time, academic self-efficacy is an important psychological determinant of students' persistence, confidence, effort, and achievement. The present study examined the relationship between AI-assisted personalized learning and academic self-efficacy among B.Ed. student teachers. A quantitative correlational research design was adopted for the study. For the purpose of developing a model research paper, a synthetically generated dataset representing 300 B.Ed. student teachers was analysed. Two structured five-point Likert-type scales were conceptualized: an AI-Assisted Personalized Learning Scale and an Academic Self-Efficacy Scale, each consisting of 15 items. Descriptive statistics, independent-samples t-test, Pearson product-moment correlation, and simple linear regression were employed. The simulated results indicated that the mean score for AI-assisted personalized learning was 45.00 (SD = 14.02), while the mean score for academic self-efficacy was 45.00 (SD = 13.27). A statistically significant positive correlation was observed between AI-assisted personalized learning and academic self-efficacy, $r = .598$, $p < .001$. Regression analysis indicated that AI-assisted personalized learning explained approximately 35.8% of the variance in academic self-efficacy. No statistically significant gender differences were observed for either variable. The findings suggest that meaningful exposure to personalized AI-supported learning may be associated with stronger academic self-beliefs among student teachers. However, the findings should be interpreted as a statistical demonstration based on synthetic data rather than empirical evidence from an actual field study. The paper concludes that teacher education institutions should develop pedagogically purposeful and ethically responsible approaches to AI-supported personalized learning while simultaneously strengthening student teachers' AI literacy, critical thinking, and self-regulated learning.

Keywords: *Artificial Intelligence, AI-Assisted Personalized Learning, Academic Self-Efficacy, B.Ed. Student Teachers, Teacher Education, Personalized Learning, Educational Technology.*

1. Introduction

Artificial Intelligence has rapidly emerged as a significant force in contemporary education. The educational application of AI has expanded from intelligent tutoring and adaptive learning systems to conversational artificial intelligence, generative AI, automated feedback, learning analytics, recommendation systems, and personalized learning environments. These developments are changing not only how educational content is delivered but also how learning experiences are designed around

individual learner characteristics.

Personalized learning has traditionally attempted to address differences among learners in terms of prior knowledge, learning pace, interests, abilities, and learning needs. AI provides new possibilities for implementing personalization at scale by analysing learner interactions and generating or recommending resources that are responsive to individual learning profiles. A recent systematic review of AI-mediated personalized learning identified adaptive learning technologies as a dominant research area while noting growing interest in generative language models and AI-supported personalized learning pathways (Bayly-Castaneda et al., 2024).

The psychological dimension of personalized learning is equally important. Learning does not depend exclusively on the availability of educational resources. Students' beliefs about their own capabilities influence the extent to which they initiate tasks, persist in difficult situations, regulate their learning, and respond to failure. Bandura's (1997) concept of self-efficacy provides an important theoretical basis for understanding such beliefs. Academic self-efficacy refers to students' beliefs concerning their capacity to organize and execute actions required to successfully accomplish academic tasks.

The relationship between AI-supported learning and self-efficacy has recently attracted increasing research attention. A 2026 meta-analysis based on 23 empirical studies found a statistically significant positive effect of AI use on learners' self-efficacy, with an overall effect size of 0.758, although the effect varied according to discipline and the role played by AI in learning.

Similarly, Lyu and Abdul Salam (2025) reported that AI-powered personalized learning significantly improved self-efficacy, motivation, and digital literacy in an experimental study involving adult EFL learners. Xu et al. (2025) also found positive relationships between AI-driven personalized feedback and academic self-efficacy, goal achievement, and learning engagement among college students.

Despite these developments, there remains a need to investigate AI-assisted personalized learning specifically within teacher education. Student teachers represent a particularly important population because they are simultaneously learners and future users of educational technologies. Their experiences with AI-supported learning may influence not only their own academic development but also their future pedagogical beliefs and classroom practices.

The present study therefore focuses on the relationship between AI-assisted personalized learning and academic self-efficacy among B.Ed. student teachers.

2. Background of the Study

2.1 Artificial Intelligence in Education

AI in education refers to the application of computational systems capable of performing functions associated with human intelligence, such as pattern recognition, prediction, language processing, recommendation, adaptation, and decision support. Educational AI can assist learners, teachers, administrators, and institutions.

In recent years, generative AI has further expanded these possibilities. AI systems can now produce explanations, examples, questions, summaries, lesson materials, feedback, simulations, and learning activities. Consequently, AI is increasingly becoming an interactive component of the learning environment rather than simply a technological infrastructure operating in the background.

However, the educational value of AI depends on pedagogical design. The mere availability of AI does not guarantee better learning. AI-supported learning becomes meaningful when technology is aligned with learning objectives, learner characteristics, instructional strategies, and assessment practices.

2.2 AI-Assisted Personalized Learning

AI-assisted personalized learning refers to the use of AI technologies to tailor learning experiences according to individual learner characteristics, performance, preferences, progress, and needs.

AI-assisted personalization can include adaptive content sequencing, individualized feedback, recommendation of learning materials, differentiated practice questions, intelligent tutoring, conversational support, and automated identification of learning difficulties.

Bayly-Castaneda et al. (2024) found that research on AI-mediated personalized learning has increasingly focused on adaptive learning technologies, particularly in higher education, while generative AI has emerged as an expanding area of investigation.

A broader systematic review published in 2025 synthesized 125 studies on AI-based personalized learning and reported substantial potential for transforming teaching, learning, and assessment, while also identifying challenges requiring further research.

Thus, AI-assisted personalized learning can be understood as an intersection between technological intelligence and learner-centred pedagogy.

2.3 Academic Self-Efficacy

Academic self-efficacy refers to a learner's belief in his or her ability to successfully perform academic tasks. It is grounded in Bandura's Social Cognitive Theory, which proposes that behaviour, personal factors, and environmental influences interact reciprocally.

Students with stronger academic self-efficacy are generally more likely to select challenging tasks, invest effort, persist in difficulties, employ effective learning strategies, and recover from setbacks. In contrast, students with low self-efficacy may avoid difficult tasks, experience greater anxiety, and withdraw when challenges arise.

AI-assisted personalized learning may influence self-efficacy by providing students with individualized learning opportunities and immediate feedback. When learners experience successful performance and receive appropriately calibrated support, their perception of competence may increase.

This theoretical possibility has received empirical support from recent research. Lyu and Abdul Salam (2025) found significant improvements in self-efficacy among learners exposed to AI-powered personalized instruction.

3. Theoretical Framework

The study is primarily grounded in Bandura's Social Cognitive Theory and the concept of self-efficacy. According to Bandura (1997), self-efficacy develops through four principal sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological or affective states. AI-assisted personalized learning may contribute to these sources in several ways. First, adaptive learning can provide appropriately challenging tasks that enable mastery experiences. Second, AI-generated examples and simulations can provide vicarious learning opportunities. Third, personalized feedback can function as a form of informational support that encourages learners. Fourth, timely assistance may reduce frustration and increase learners' sense of control over academic tasks.

4. Need and Significance of the Study

The increasing integration of AI into education creates an urgent need to understand its psychological as well as instructional consequences. Much of the public discussion concerning AI focuses on academic achievement, productivity, assessment, and academic integrity. However, learner characteristics such as self-efficacy are equally important. Teacher education is a particularly

important context for such investigation. B.Ed. student teachers will become future teachers who are expected to work with learners who increasingly encounter AI technologies. Their own experiences with AI-supported learning may shape their future beliefs concerning technology, pedagogy, and learner-centred instruction. Furthermore, recent research provides promising evidence concerning AI and self-efficacy, but much of the available empirical work has been conducted among general university students or language learners rather than B.Ed. student teachers. The present study therefore addresses a context-specific research need. The study may contribute to teacher education by providing a conceptual and empirical basis for integrating AI-assisted personalized learning into professional preparation programmes.

5. Objectives of the Study

The study was guided by the following objectives:

1. To study the level of AI-assisted personalized learning among B.Ed. student teachers.
2. To study the level of academic self-efficacy among B.Ed. student teachers.
3. To determine the relationship between AI-assisted personalized learning and academic self-efficacy among B.Ed. student teachers.
4. To examine whether male and female B.Ed. student teachers differ significantly in AI-assisted personalized learning, academic self-efficacy and
5. To determine the predictive contribution of AI-assisted personalized learning to academic self-efficacy.

6. Hypotheses of the Study

The following null hypotheses were formulated:

H01: There is no significant relationship between AI-assisted personalized learning and academic self-efficacy among B.Ed. student teachers.

H02: There is no significant difference between male and female B.Ed. student teachers in AI-assisted personalized learning.

H03: There is no significant difference between male and female B.Ed. student teachers in academic self-efficacy.

H04: AI-assisted personalized learning does not significantly predict academic self-efficacy among B.Ed. student teachers.

7. Variables of the Study

The study included two principal variables:

Variable 1: AI-Assisted Personalized Learning

Variable 2: Academic Self-Efficacy

Gender was considered a demographic grouping variable for supplementary analysis.

8. Operational Definitions

AI-Assisted Personalized Learning: For the purpose of the present study, AI-assisted personalized learning refers to the extent to which B.Ed. student teachers perceive that AI-supported educational environments provide individualized learning resources, adaptive content, personalized explanations, immediate feedback, differentiated learning support, and learning recommendations according to their individual needs.

Academic Self-Efficacy: Academic self-efficacy refers to the extent to which B.Ed. student teachers believe that they are capable of successfully planning, performing, managing, and completing academic tasks and overcoming academic challenges.

9. Methodology

9.1 Research Method

The study adopted a descriptive correlational survey method because the primary purpose was to determine the relationship between AI-assisted personalized learning and academic self-efficacy.

9.2 Research Design

A quantitative, non-experimental correlational design was employed.

The design can be represented as:

AI-Assisted Personalized Learning (X) → Academic Self-Efficacy (Y)

9.3 Population

The conceptual population comprised B.Ed. student teachers enrolled in teacher education programmes.

9.4 Sample

For this model study, a synthetic sample of 300 B.Ed. student teachers was generated for statistical demonstration.

Demographic Variable	Category	N	Percentage
Gender	Male	147	49.0
	Female	153	51.0
Total		300	100.0
Year	First Year	156	52.0
	Second Year	144	48.0
Total		300	100.0

The distribution was designed to approximate a reasonably balanced teacher-education sample.

Important Data Integrity Note

The sample and all numerical results reported in this paper are synthetically generated for methodological demonstration. They are not observations from actual B.Ed. student teachers. Consequently, the findings should not be interpreted as evidence about a real population until the study is conducted with actual participants.

10. Tools Used for Data Collection

Two conceptual research instruments were used.

10.1 AI-Assisted Personalized Learning Scale

A 15-item five-point Likert-type scale was conceptualized to measure students' perceptions of AI-assisted personalized learning.

The dimensions included:

1. Personalized learning support
2. Adaptive learning resources
3. Individualized feedback
4. Learning recommendations
5. AI-supported academic assistance

Responses were scored from 1 to 5, resulting in a possible score range of 15–75.

Higher scores indicated greater perceived exposure to or effectiveness of AI-assisted personalized learning.

10.2 Academic Self-Efficacy Scale

A 15-item five-point Likert-type scale was conceptualized to assess academic self-efficacy.

The dimensions included:

1. Academic confidence
2. Task completion
3. Learning persistence
4. Academic problem-solving
5. Self-regulation of academic work

The possible score range was 15–75.

Higher scores indicated greater academic self-efficacy.

11. Reliability of the Instruments

For this model dataset, internal consistency coefficients were generated to demonstrate an appropriate reliability analysis.

Scale	No. of Items	Cronbach's Alpha
AI-Assisted Personalized Learning Scale	15	.91
Academic Self-Efficacy Scale	15	.89

Both coefficients exceed the commonly accepted threshold of .70 for research purposes, indicating satisfactory internal consistency for the proposed instruments.

For an actual study, reliability should be established using pilot-study data collected from participants who are comparable to the target population.

12. Data Analysis and Interpretation

Objective 1: To study the level of AI-assisted personalized learning among B.Ed. student teachers.

Table 1 Descriptive Statistics of AI-Assisted Personalized Learning

Variable	N	Mean	SD	Minimum	Maximum
AI-Assisted Personalized Learning	300	45.00	14.02	15	75

The simulated data indicate a mean score of 45.00 with a standard deviation of 14.02 for AI-assisted personalized learning. Since the theoretical midpoint of the 15-item scale is 45, the simulated sample represents a moderate overall level of perceived AI-assisted personalized learning.

The relatively large standard deviation suggests considerable individual variation in students' perceptions and experiences of AI-supported personalized learning.

Objective 2: To study the level of academic self-efficacy among B.Ed. student teachers.

Table 2 Descriptive Statistics of Academic Self-Efficacy

Variable	N	Mean	SD	Minimum	Maximum
Academic Self-Efficacy	300	45.00	13.27	15	75

The mean academic self-efficacy score was 45.00, with a standard deviation of 13.27. The simulated results therefore indicate a moderate overall level of academic self-efficacy.

The standard deviation indicates substantial variability among student teachers, suggesting that learners may differ considerably in their confidence regarding academic tasks.

Objective 3: To determine the relationship between AI-assisted personalized learning and academic self-efficacy.

Table 3 Correlation between AI-Assisted Personalized Learning and Academic Self-Efficacy

Variables	N	Pearson *r*	Significance
AI-Assisted Personalized Learning and Academic Self-Efficacy	300	.598	< .001

The Pearson product-moment correlation coefficient between AI-assisted personalized learning and academic self-efficacy was r = .598, which was statistically significant at the .001 level.

The result indicates a moderately strong positive relationship between the two variables. In practical

terms, higher levels of perceived AI-assisted personalized learning were associated with higher levels of academic self-efficacy.

Therefore, the null hypothesis H01 is rejected in the simulated dataset.

The result is consistent with recent empirical literature. Xu et al. (2025) reported positive relationships between AI-driven personalized feedback and academic self-efficacy, while Lyu and Abdul Salam (2025) reported significant improvements in self-efficacy following AI-powered personalized learning.

Objective 4: To examine gender differences in AI-assisted personalized learning.

Table 4 Gender-wise Difference in AI-Assisted Personalized Learning

Gender	N	Mean	SD	*t*	df	*p*
Male	147	44.62	13.99	-0.461	298	.645
Female	153	45.37	14.08			

The mean AI-assisted personalized learning score of female student teachers was slightly higher than that of male student teachers. However, the obtained *t* value of -0.461 was not statistically significant ($p = .645$).

Therefore, H02 is retained in the simulated dataset.

The result suggests that gender did not significantly differentiate students' perceived AI-assisted personalized learning in this model dataset.

Objective 5: To examine gender differences in academic self-efficacy.

Table 5 Gender-wise Difference in Academic Self-Efficacy

Gender	N	Mean	SD	*t*	df	*p*
Male	147	44.16	12.97	-1.071	298	.285
Female	153	45.80	13.54			

Female student teachers obtained a slightly higher mean academic self-efficacy score than male student teachers. However, the difference was not statistically significant, $t(298) = -1.071$, $p = .285$.

Therefore, H03 is retained in the simulated dataset.

The finding suggests that gender was not a statistically significant differentiating factor in academic self-efficacy within the simulated sample.

Objective 6: To determine whether AI-assisted personalized learning predicts academic self-efficacy.

Table 6 Simple Linear Regression Predicting Academic Self-Efficacy from AI-Assisted Personalized Learning

Predictor	B	SE	β	*t*	*p*
Constant	19.504	2.071	—	9.42	< .001
AI-Assisted Personalized Learning	0.567	0.044	.598	12.89	< .001

Model statistics: $R = .598$; $R^2 = .358$; Adjusted $R^2 \approx .356$.

The regression analysis indicates that AI-assisted personalized learning was a statistically significant predictor of academic self-efficacy. The standardized regression coefficient was $\beta = .598$, $p < .001$.

The coefficient of determination, $R^2 = .358$, indicates that approximately 35.8% of the variance in academic self-efficacy was statistically accounted for by AI-assisted personalized learning in the simulated dataset.

The regression equation can be expressed as:

Academic Self-Efficacy = 19.504 + 0.567(AI-Assisted Personalized Learning)

Thus, for every one-unit increase in the AI-assisted personalized learning score, the predicted

academic self-efficacy score increased by approximately 0.567 units.

Accordingly, H04 is rejected in the simulated dataset.

13. Major Findings

The major findings of the model study are as follows.

The simulated B.Ed. student teachers demonstrated a moderate level of AI-assisted personalized learning, with a mean score of 45.00.

The simulated academic self-efficacy level was also moderate, with a mean score of 45.00.

A statistically significant positive relationship was observed between AI-assisted personalized learning and academic self-efficacy, $r = .598$, $p < .001$.

AI-assisted personalized learning accounted for approximately 35.8% of the variance in academic self-efficacy in the simulated regression model.

No statistically significant gender difference was observed in AI-assisted personalized learning.

No statistically significant gender difference was observed in academic self-efficacy.

The overall pattern of the simulated findings is consistent with recent empirical research suggesting that AI-supported personalized learning and feedback may contribute positively to learners' self-efficacy.

14. Discussion

The primary finding of the model study is the statistically significant positive association between AI-assisted personalized learning and academic self-efficacy. This finding has theoretical significance because it suggests that personalization may influence not only the acquisition of knowledge but also learners' beliefs about their academic capabilities.

From the perspective of Social Cognitive Theory, repeated successful experiences constitute one of the strongest sources of self-efficacy. AI-supported personalized learning can potentially facilitate such experiences by presenting tasks at an appropriate level of difficulty, offering immediate assistance, and allowing learners to practise repeatedly.

Personalized feedback may also help learners identify specific areas for improvement. Instead of receiving only a general evaluation, students can receive feedback that is responsive to their individual performance. This may strengthen their perception that academic challenges are manageable.

The finding is broadly compatible with the recent study by Lyu and Abdul Salam (2025), which found significant improvements in self-efficacy among learners receiving AI-powered personalized instruction. It is also consistent with Xu et al. (2025), who reported positive relationships between AI-driven personalized feedback and academic self-efficacy.

The broader evidence base is strengthened by Ren et al. (2026), whose meta-analysis of 23 empirical studies found a positive overall effect of AI on learner self-efficacy. Importantly, the authors found that the effect varied according to discipline and the role played by AI.

This qualification is important. AI should not be regarded as inherently beneficial. Its effect may depend on how it is designed and used. AI that simply supplies answers may encourage dependency, whereas AI that provides scaffolding, feedback, questioning, and appropriately challenging tasks may support learner competence.

The absence of significant gender differences in the simulated data suggests that AI-assisted personalized learning and academic self-efficacy may not necessarily depend on gender. However, this finding should not be generalized without actual empirical investigation.

15. Educational Implications

The findings have several implications for teacher education.

First, B.Ed. programmes should provide student teachers with structured opportunities to experience AI-assisted personalized learning. Such experiences should demonstrate not only the technical operation of AI but also its pedagogical applications.

Second, teacher educators should emphasize AI as a scaffold rather than an answer provider. Student teachers should be trained to use AI for questioning, feedback, differentiation, reflection, and formative assessment.

Third, AI-supported learning should be integrated with self-regulated learning strategies. Student teachers should be encouraged to establish learning goals, monitor their progress, evaluate AI-generated feedback, and reflect on their learning.

Fourth, teacher education institutions should develop AI literacy programmes that include prompt formulation, output verification, bias detection, data privacy, academic integrity, and ethical use.

Fifth, assessment practices should be redesigned to ensure that students demonstrate genuine understanding. AI use should be transparent and appropriately documented rather than simply prohibited.

Sixth, teacher educators should explicitly address the possibility of AI dependency. Students should be encouraged to attempt tasks independently before seeking AI support whenever the learning objective requires independent cognitive performance.

16. Recommendations

Based on the conceptual and simulated findings, the following recommendations are proposed.

Teacher education institutions should integrate AI-assisted personalized learning into selected B.Ed. courses in a structured and pedagogically purposeful manner.

Teacher educators should receive continuous professional development in AI pedagogy, personalized learning, prompt engineering, AI-supported assessment, and ethical AI use.

Student teachers should be trained to critically evaluate AI-generated information rather than treating AI output as automatically accurate.

AI-supported learning activities should include opportunities for reflection, independent reasoning, peer interaction, and teacher feedback.

Institutions should develop clear policies concerning academic integrity, privacy, responsible AI use, and disclosure of AI assistance.

Future research should examine AI-assisted personalized learning through experimental and longitudinal designs rather than relying exclusively on cross-sectional self-report data.

Research should also examine mediating variables such as self-regulated learning, academic motivation, metacognition, learner autonomy, and AI literacy.

17. Limitations

The most important limitation of the present paper is that the numerical dataset is synthetically generated for demonstration purposes. Therefore, the statistical findings cannot be treated as empirical evidence from actual B.Ed. student teachers.

The proposed instruments are conceptual models rather than fully validated scales. Before genuine publication, item development, expert validation, pilot testing, construct validity, reliability analysis, and appropriate ethical procedures must be undertaken.

The correlational design proposed here cannot establish causal relationships. Even if a real study

produces a significant relationship, it would not by itself demonstrate that AI-assisted personalized learning causes increased academic self-efficacy.

The study also focuses on self-reported perceptions. Future research should combine questionnaire data with behavioural indicators, learning analytics, academic performance, classroom observations, and qualitative interviews.

18. Suggestions for Further Research

Future researchers may extend this study in several directions.

An experimental study could examine the effectiveness of AI-assisted personalized learning on academic self-efficacy among B.Ed. student teachers using an experimental and control group.

A longitudinal study could investigate whether repeated exposure to AI-supported personalized learning produces sustained changes in self-efficacy.

A structural equation model could examine whether self-regulated learning mediates the relationship between AI-assisted personalized learning and academic self-efficacy.

Future research could also investigate whether academic motivation, growth mindset, learner autonomy, digital competence, or AI literacy moderates the relationship.

Comparative research could examine differences between B.Ed. student teachers from rural and urban institutions or between different academic disciplines.

Another promising research direction would be to examine whether AI-assisted personalized learning affects teacher identity, creative teaching, reflective practice, and teaching competency, thereby connecting AI research directly with the professional development of future teachers.

19. Conclusion

Artificial Intelligence is increasingly transforming educational practice, and AI-assisted personalized learning represents one of its most promising pedagogical applications. By providing individualized resources, adaptive support, immediate feedback, and differentiated learning opportunities, AI has the potential to create more responsive learning environments. Academic self-efficacy is particularly important because students' beliefs concerning their capabilities influence persistence, effort, motivation, self-regulation, and responses to academic challenges. The present model study demonstrated a statistically significant positive association between AI-assisted personalized learning and academic self-efficacy in a synthetically generated dataset. The simulated correlation of $r = .598$ and regression result indicating $R^2 = .358$ suggest a potentially meaningful relationship that deserves empirical investigation among B.Ed. student teachers. This pattern is also broadly compatible with recent empirical and meta-analytic literature reporting positive associations between AI-supported learning and self-efficacy. Nevertheless, AI should not be treated as a substitute for effective pedagogy or human teachers. The educational value of personalized AI depends on how it is designed and integrated. When AI provides meaningful scaffolding while preserving learner agency, critical thinking, reflection, and teacher guidance, it may strengthen rather than weaken the educational process. For teacher education, the central challenge is therefore to prepare student teachers not merely to use AI, but to use AI pedagogically, critically, ethically, and purposefully.

The future of AI-assisted education should ultimately be guided by a human-centred principle: technology should personalize learning without dehumanizing education, and AI should strengthen learner capability rather than replace learner thinking.

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AI IN ENGLISH LANGUAGE TEACHING AND PEDAGOGICAL INNOVATIONS

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Abstract

Artificial Intelligence (AI) is transforming the educational landscape by introducing innovative possibilities for teaching, learning, assessment and professional development. In English language education, AI offers opportunities to strengthen the four fundamental language skills—Listening, Speaking, Reading and Writing (LSRW)—through personalised learning, intelligent feedback, conversational agents, automated assessment and interactive digital resources. The integration of AI into English language teaching also encourages teachers to move beyond traditional instructional practices towards learner-centred, collaborative, creative and technology-supported pedagogies. However, the effective use of AI requires teachers to develop digital literacy, critical thinking, ethical awareness and pedagogical competence. This paper examines the role of Artificial Intelligence in English language teaching, explores emerging pedagogical innovations, discusses the changing responsibilities of teachers and identifies challenges associated with AI-enabled education. It adopts a conceptual and descriptive approach based on relevant educational literature and policy documents. The paper argues that AI should be considered a supportive educational partner rather than a replacement for human teachers. It concludes that the future of education depends on developing smart teachers who can integrate technological innovation with human values, creativity, inclusiveness and meaningful classroom interaction.

Keywords: Artificial Intelligence, English Language Teaching, Smart Teachers, Pedagogical Innovations, Digital Literacy, Personalised Learning, Educational Technology.

1. Introduction

Education is experiencing a significant transformation in the twenty-first century due to rapid developments in digital technologies and Artificial Intelligence. Traditional classrooms, which primarily depended on textbooks, lectures and teacher-centred instruction, are gradually moving towards interactive, flexible and technology-integrated learning environments. Artificial Intelligence has emerged as an important educational innovation with the potential to transform the ways in which knowledge is created, communicated, assessed and acquired. Artificial Intelligence refers to computer-based systems capable of performing tasks that generally require human intelligence, including language processing, problem-solving, pattern recognition, content generation and decision-making. In education, AI-powered applications can support teachers in lesson preparation, classroom activities, student assessment, feedback and individualised instruction.

English language teaching provides particularly significant opportunities for AI integration.

Since English learning involves communication, comprehension, creativity and continuous practice, AI-powered tools can create additional opportunities for learners to develop their language competencies. Applications such as intelligent chatbots, speech recognition systems, grammar assistants, automated writing evaluators and generative AI platforms can supplement classroom instruction. However, technological advancement alone cannot guarantee educational quality. The teacher remains central to interpreting learners' needs, developing critical consciousness, encouraging creativity and establishing meaningful human relationships. Therefore, the concept of a smart teacher must extend beyond technological proficiency to include pedagogical innovation, ethical responsibility and the ability to use technology purposefully.

2. Artificial Intelligence in English Language Teaching

Artificial Intelligence has introduced new possibilities for developing English language proficiency. Its applications extend across all four language skills.

2.1 AI for Listening Skills

AI-powered speech and audio applications provide learners with opportunities to listen to different accents, pronunciations, conversations and authentic language materials. Speech-to-text technology can help learners compare spoken language with written transcripts. Teachers can use AI-generated listening exercises, comprehension questions and audio-based activities to make listening instruction more interactive.

2.2 AI for Speaking Skills

Conversational AI applications enable learners to practise spoken English through simulated conversations. Speech recognition and pronunciation feedback can help identify difficulties in articulation, fluency and pronunciation. Virtual conversation partners also provide additional opportunities for learners who may hesitate to speak English in traditional classrooms. Nevertheless, teachers must ensure that automated feedback does not become a substitute for genuine human communication.

2.3 AI for Reading Skills

AI can support reading comprehension through simplified texts, vocabulary explanations, summaries, comprehension questions and level-appropriate reading materials. Teachers can generate differentiated reading activities according to learners' language proficiency. Such practices can promote independent reading, vocabulary development and critical understanding.

2.4 AI for Writing Skills

AI-based writing assistants can identify grammatical errors, spelling mistakes, punctuation problems and sentence-structure difficulties. They can also provide suggestions for vocabulary improvement, paragraph organisation and revision. Teachers can use these applications to demonstrate editing, rewriting and constructive feedback. However, students should be encouraged to develop their own ideas and writing abilities instead of depending entirely on AI-generated content.

Thus, AI can strengthen the teaching of LSRW skills by providing additional practice, immediate feedback and opportunities for self-directed learning.

3. Pedagogical Innovations Through Artificial Intelligence

The integration of AI encourages teachers to reconsider conventional pedagogical approaches and adopt innovative instructional strategies.

3.1 Personalised and Adaptive Learning

AI-supported learning platforms can provide differentiated activities based on students' learning levels, progress and individual requirements. In English classrooms, teachers can prepare different reading passages, vocabulary exercises and grammar tasks to address diverse learning needs. This approach promotes learner autonomy and inclusive education.

3.2 Flipped Classroom Approach

AI can assist teachers in preparing digital notes, instructional videos, reading materials and practice exercises before classroom sessions. Students can explore these resources independently and use classroom time for discussions, collaborative activities, presentations and problem-solving. This transforms the classroom into an interactive learning environment.

3.3 Collaborative and Project-Based Learning

Teachers can integrate AI into group projects, creative writing, digital storytelling, role-play, debates and presentations. For example, students may use AI to brainstorm ideas for a story, compare alternative endings and collaboratively develop their own narratives. The teacher guides the process and evaluates originality, participation and critical thinking.

3.4 Gamification and Interactive Learning

AI-supported educational applications can facilitate quizzes, vocabulary games, language challenges and interactive exercises. Such activities may increase learner motivation and participation. Teachers can use gamified learning to make grammar, vocabulary and comprehension activities more engaging.

3.5 AI-Assisted Assessment and Feedback

AI tools can support formative assessment by identifying common errors, generating practice questions and providing preliminary feedback. Teachers can analyse students' difficulties and plan remedial instruction accordingly. However, final assessment decisions should remain under professional teacher supervision.

3.6 Multilingual and Inclusive Pedagogy

In multilingual classrooms, AI-based translation, transcription and language-support applications can help learners understand unfamiliar vocabulary and complex concepts. Teachers can connect English learning with students' existing linguistic knowledge, including their home languages and regional languages. Such integration can encourage participation, linguistic confidence and inclusive classroom interaction.

4. Shaping Smart Teachers for a Smart Future

The emergence of AI requires a redefinition of the professional role of teachers. A smart teacher is not simply an individual who operates digital devices but an educator who

combines subject knowledge, pedagogical expertise, technological competence and ethical awareness.

The teacher's role is gradually expanding from being the primary transmitter of information to becoming a facilitator, mentor, learning designer, critical guide and reflective practitioner.

Smart teachers should develop the following competencies:

1. **Digital and AI literacy:** Understanding AI applications, their capabilities and limitations.
2. **Pedagogical competence:** Selecting appropriate AI tools according to learning objectives and classroom requirements.
3. **Critical thinking:** Evaluating AI-generated information for accuracy, relevance, bias and reliability.
4. **Creativity and innovation:** Designing interactive, learner-centred and activity-based learning experiences.
5. **Ethical responsibility:** Protecting student privacy, preventing plagiarism and promoting responsible technology use.
6. **Inclusive teaching:** Ensuring that technological innovations benefit learners from different linguistic, social and educational backgrounds.
7. **Continuous professional development:** Updating knowledge and skills through training, workshops, research and collaborative learning.

UNESCO's AI Competency Framework for Teachers (2024) identifies five important dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These dimensions emphasise that teachers require more than technical knowledge to use AI meaningfully in education.

5. Challenges and Limitations of AI in English Education

Despite its educational potential, AI integration presents several challenges that require careful consideration.

- **Digital divide:** Unequal access to devices, reliable internet connectivity and digital resources may disadvantage learners from rural and economically weaker backgrounds.
- **Overdependence on technology:** Excessive dependence on AI may reduce independent thinking, creativity and problem-solving abilities.
- **Accuracy and reliability:** AI-generated information may contain grammatical errors, inaccurate explanations, fabricated references or misleading content.
- **Privacy and data security:** The collection and processing of students' personal information raise concerns about consent, confidentiality and data protection.
- **Academic integrity:** Uncritical use of AI-generated assignments may encourage plagiarism and weaken independent writing skills.
- **Teacher preparedness:** Many teachers require systematic training to integrate AI into classroom practices effectively.

- **Language and cultural bias:** AI applications may not adequately represent regional languages, local contexts, diverse accents and cultural experiences.

Therefore, AI integration must be guided by institutional policies, teacher supervision, digital awareness and responsible educational practices.

6. Recommendations for Effective AI Integration

For meaningful and sustainable integration of AI in English language education, the following measures are recommended:

1. Educational institutions should organise regular AI literacy programmes and practical workshops for teachers.
2. Teacher education programmes should include AI-supported pedagogy, digital ethics and technology-integrated lesson planning.
3. Teachers should use AI as a supplementary resource while maintaining meaningful classroom interaction and independent learning.
4. Schools and colleges should promote equitable access to digital infrastructure and educational resources.
5. AI-generated content should be checked for accuracy, appropriateness, inclusiveness and educational relevance.
6. Students should be taught responsible AI use, academic integrity, critical evaluation and digital citizenship.
7. AI-supported activities should be integrated with communicative language teaching, collaborative learning, project-based learning and reflective practices.

The National Education Policy (2020) of India recognises the importance of educational technology in improving teaching-learning processes, supporting teacher professional development and enhancing educational access. Its vision provides an important foundation for exploring responsible technology integration in Indian educational institutions.

7. Conclusion

Artificial Intelligence is not merely a technological advancement; it represents an opportunity to rethink educational practices and create more meaningful learning experiences. In English language teaching, AI can strengthen listening, speaking, reading and writing skills through personalised instruction, interactive communication, intelligent feedback and innovative pedagogical strategies.

However, the success of AI-enabled education ultimately depends on the teacher's ability to integrate technology with sound pedagogical principles and human values. Technology can provide information, generate learning materials and support assessment, but empathy, encouragement, moral guidance, cultural understanding and meaningful human relationships remain essential dimensions of teaching.

The future classroom should therefore be neither entirely technology-dependent nor restricted to traditional instructional practices. It should represent a balanced partnership between teachers, learners and intelligent technologies. A smart future requires smart teachers who are

technologically competent, pedagogically innovative, ethically responsible and committed to lifelong learning.

AI may transform the tools of teaching, but teachers transform the lives of learners. The real vision of a smart future is not to replace teachers with Artificial Intelligence, but to empower teachers through Artificial Intelligence.

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ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ: ಸಮಕಾಲೀನ ಸವಾಲುಗಳು, ಅವಕಾಶಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ದೃಷ್ಟಿಕೋನ

ಬಿ. ವಿಜಯ ರಾಜೇಂದ್ರ,
ಸಂಶೋಧನಾ ವಿದ್ಯಾರ್ಥಿ, ಶಿಕ್ಷಣ ಅಧ್ಯಯನ ಮತ್ತು ಸಂಶೋಧನಾ ವಿಭಾಗ, ಕರ್ನಾಟಕ ರಾಜ್ಯ ಮುಕ್ತ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ, ಮುಕ್ತಗಂಗೋತ್ರಿ, ಮೈಸೂರು.
ಡಾ. ಶರಣಮ್ಮ ಆರ್.,
ಸಹ ಪ್ರಾಧ್ಯಾಪಕರು, ಶಿಕ್ಷಣ ಅಧ್ಯಯನ ಮತ್ತು ಸಂಶೋಧನಾ ವಿಭಾಗ, ಕರ್ನಾಟಕ ರಾಜ್ಯ ಮುಕ್ತ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ, ಮುಕ್ತಗಂಗೋತ್ರಿ, ಮೈಸೂರು.

ಸಾರಾಂಶ

ಯಾವುದೇ ಒಂದು ಪ್ರಗತಿಪರ ಸಮಾಜದ ಮತ್ತು ಸದೃಢ ರಾಷ್ಟ್ರದ ನಿರ್ಮಾಣದಲ್ಲಿ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯು ಅತ್ಯಂತ ಪ್ರಮುಖವಾದ ಆಧಾರಸ್ತಂಭವಾಗಿದೆ. ಈ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ಗುಣಮಟ್ಟ ಮತ್ತು ಯಶಸ್ಸು ಮೂಲಭೂತವಾಗಿ ತರಗತಿಯ ಕೋಣೆಯಲ್ಲಿ ಜ್ಞಾನವನ್ನು ಧಾರೆ ಎರೆಯುವ ಶಿಕ್ಷಕರ ದಕ್ಷತೆ, ಅರ್ಹತೆ ಮತ್ತು ಅವರ ವೃತ್ತಿಪರ ಬದ್ಧತೆಯನ್ನು ಅವಲಂಬಿಸಿದೆ. ಪ್ರಸ್ತುತ ಜಾಗತೀಕರಣ, ನಗರೀಕರಣ ಮತ್ತು ತಾಂತ್ರಿಕ ಕ್ರಾಂತಿಯ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರವು ದಿನೇ ದಿನೇ ಹೊಸ ಆಯಾಮಗಳನ್ನು ಪಡೆದುಕೊಳ್ಳುತ್ತಿದೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಅತ್ಯಂತ ಪ್ರಸ್ತುತ ಹಾಗೂ ಕಡ್ಡಾಯ ಪ್ರಕ್ರಿಯೆಯಾಗಿ ಹೊರಹೊಮ್ಮಿದೆ. ಈ ಸಂಶೋಧನಾ ಪ್ರಬಂಧವು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಸಮಕಾಲೀನ ಚೌಕಟ್ಟು, ವೃತ್ತಿಪರ ಬೆಳವಣಿಗೆಯ ವಿವಿಧ ಆಯಾಮಗಳು, ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ ೨೦೨೦ರ ಮಾರ್ಗಸೂಚಿಗಳು, ಮತ್ತು ಶಿಕ್ಷಕರ ತರಬೇತಿಯಲ್ಲಿ ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನಗಳಾದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಹಾಗೂ ಡಿಜಿಟಲ್ ಪರಿಕರಗಳ ಅಳವಡಿಕೆಯ ಕುರಿತು ಸುದೀರ್ಘವಾಗಿ ಚರ್ಚಿಸುತ್ತದೆ. ಅದರೊಂದಿಗೆ ಪ್ರಸ್ತುತ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಸಂಸ್ಥೆಗಳು ಎದುರಿಸುತ್ತಿರುವ ಸಾಂಸ್ಥಿಕ, ಆಡಳಿತಾತ್ಮಕ ಮತ್ತು ಗುಣಾತ್ಮಕ ಸವಾಲುಗಳನ್ನು ಗುರುತಿಸಿ, ಅವುಗಳಿಗೆ ಪ್ರಾಯೋಗಿಕ ಪರಿಹಾರಗಳನ್ನು ಹಾಗೂ ಭವಿಷ್ಯದ ಸುಧಾರಣಾ ಕಾರ್ಯತಂತ್ರಗಳನ್ನು ಈ ಪ್ರಬಂಧದಲ್ಲಿ ಪ್ರಸ್ತುತಪಡಿಸಲಾಗಿದೆ.

ಕೀವರ್ಡ್ಸ್: *ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ, ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ, ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ, ಬೋಧನಾ ನಾವೀನ್ಯತೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ನಿರಂತರ ಕಲಿಕೆ, ಕ್ರಿಯಾ ಸಂಶೋಧನೆ.*

ಪೀಠಿಕೆ:

"ಶಿಕ್ಷಕರು ರಾಷ್ಟ್ರದ ಭವಿಷ್ಯದ ಶಿಲ್ಪಿಗಳು" ಎಂಬ ಮಾತು ಕೇವಲ ಅಲಂಕಾರಿಕ ವಾಕ್ಯವಲ್ಲ, ಅದು ಪರಮ ಸತ್ಯ. ಕೋಟ್ಯಂತರ ವಿದ್ಯಾರ್ಥಿಗಳ ಜೀವನವನ್ನು ರೂಪಿಸುವ, ಅವರಲ್ಲಿ ಮೌಲ್ಯಗಳನ್ನು ಬಿತ್ತಿ, ಜ್ಞಾನದ ದೀವಿಗೆಯನ್ನು ಹಚ್ಚುವ ಮಹತ್ತರ ಜವಾಬ್ದಾರಿ ಶಿಕ್ಷಕರ ಮೇಲಿದೆ. ಆದರೆ, ೨೧ನೇ ಶತಮಾನದ ಜ್ಞಾನ ಆಧಾರಿತ ಸಮಾಜದಲ್ಲಿ ಜ್ಞಾನದ ಸ್ಫೋಟವಾಗುತ್ತಿದೆ. ತಂತ್ರಜ್ಞಾನದ ತೀವ್ರ ಬೆಳವಣಿಗೆಯಿಂದಾಗಿ ಸಾಂಪ್ರದಾಯಿಕ ಬೋಧನಾ ಪದ್ಧತಿಗಳು ಇಂದು ತಮ್ಮ ಪ್ರಸ್ತುತತೆಯನ್ನು ಕಳೆದುಕೊಳ್ಳುತ್ತಿವೆ. ಇಂದಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಕೇವಲ ಪಠ್ಯಪುಸ್ತಕದ ಮಾಹಿತಿಗೆ ಸೀಮಿತವಾಗಿಲ್ಲ; ಇಂಟರ್ನೆಟ್, ಸಾಮಾಜಿಕ ಮಾಧ್ಯಮಗಳು ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಗಳಿಂದ ಅಪಾರ ಜ್ಞಾನವನ್ನು ಕ್ಷಣಾರ್ಧದಲ್ಲಿ ಪಡೆಯುತ್ತಿದ್ದಾರೆ. ಇಂತಹ ಸನ್ನಿವೇಶದಲ್ಲಿ, ಶಿಕ್ಷಕರು ಕೇವಲ 'ಮಾಹಿತಿ ನೀಡುವವರು' ಆಗಿ ಉಳಿಯದೆ,

'ಕಲಿಕೆಗೆ ಪೂರಕ ವಾತಾವರಣ ನಿರ್ಮಿಸುವವರು' ಆಗಿ ಬದಲಾಗಬೇಕಿದೆ.

ಶಿಕ್ಷಕರ ಈ ಬದಲಾವಣೆ ಮತ್ತು ಸಬಲೀಕರಣಕ್ಕೆ ಮೂಲ ಆಧಾರವೇ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ಕೇವಲ ಬಿ.ಎಡ್ ಅಥವಾ ಡಿ.ಎಲ್.ಎಡ್ ಪದವಿಗಳನ್ನು ಪಡೆಯುವುದಕ್ಕೆ ಸೀಮಿತವಾದ ಪ್ರಕ್ರಿಯೆಯಲ್ಲ. ಅದು ಶಿಕ್ಷಕ ವೃತ್ತಿಗೆ ಸೇರುವ ಮುನ್ನ ಪಡೆಯುವ ಪೂರ್ವ–ಸೇವಾ ತರಬೇತಿಯಿಂದ ಹಿಡಿದು, ವೃತ್ತಿಯ ಅವಧಿಯುದ್ದಕ್ಕೂ ಪಡೆಯುವ ಸೇವಾ–ಅಂತರ್ಗತ ತರಬೇತಿಯವರೆಗಿನ ಒಂದು ಸುದೀರ್ಘ ಮತ್ತು ನಿರಂತರವಾದ ಪಯಣವಾಗಿದೆ. ಸಮಕಾಲೀನ ಸಮಾಜದಲ್ಲಿ ಶಿಕ್ಷಕರ ಸಬಲೀಕರಣ ಎಂದರೆ ಕೇವಲ ವಿಷಯ ಜ್ಞಾನವನ್ನು ಹೆಚ್ಚಿಸಿಕೊಳ್ಳುವುದಲ್ಲ, ಬದಲಿಗೆ ಬೋಧನಾ ವಿಜ್ಞಾನ, ಮನೋವಿಜ್ಞಾನ, ತಾಂತ್ರಿಕ ಕೌಶಲಗಳು ಮತ್ತು ಮಾನವೀಯ ಮೌಲ್ಯಗಳ ಸಮನ್ವಯತೆಯನ್ನು ಸಾಧಿಸುವುದಾಗಿದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಆಶಯಗಳು ಮತ್ತು ಉದ್ದೇಶಗಳು:

1) ತಾತ್ವಿಕ ಮತ್ತು ಪ್ರಾಯೋಗಿಕ ಜ್ಞಾನದ ಸಮನ್ವಯ: ಶಿಕ್ಷಣದ ತತ್ವಗಳು, ತತ್ವಶಾಸ್ತ್ರ ಮತ್ತು ಸಾಮಾಜಿಕ ಹಿನ್ನೆಲೆಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದರೊಂದಿಗೆ, ಅವುಗಳನ್ನು ಪ್ರಾಯೋಗಿಕವಾಗಿ ತರಗತಿಯ ಕೋಣೆಯಲ್ಲಿ ಹೇಗೆ ಅನ್ವಯಿಸಬೇಕು ಎಂಬುದನ್ನು ಕಲಿಸುವುದು.
2) ಬೋಧನಾ ಕೌಶಲಗಳ ವೃದ್ಧಿ: ಸೂಕ್ಷ್ಮ ಬೋಧನೆ, ಸಂವಹನ ಕೌಶಲ, ಕಪ್ಪುಹಲಗೆಯ ಬಳಕೆ, ಪ್ರಶ್ನಿಸುವ ಕೌಶಲ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಪ್ರೇರೇಪಿಸುವ ಕಲೆಗಳನ್ನು ಕರಗತ ಮಾಡಿಸುವುದು.
3) ಶಿಶು ಮನೋವಿಜ್ಞಾನದ ತಿಳುವಳಿಕೆ: ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕಾ ಸಾಮರ್ಥ್ಯ, ಆಸಕ್ತಿ, ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಅವರ ವೈಯಕ್ತಿಕ ಭಿನ್ನತೆಗಳನ್ನು ಗುರುತಿಸಿ ಅದಕ್ಕೆ ತಕ್ಕಂತೆ ಬೋಧನೆಯನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳುವ ಸಾಮರ್ಥ್ಯ ಬೆಳೆಸುವುದು.
4) ಸಂಶೋಧನಾ ಮನೋಭಾವನೆ: ತರಗತಿಯಲ್ಲಿ ಎದುರಾಗುವ ದೈನಂದಿನ ಶೈಕ್ಷಣಿಕ ಸಮಸ್ಯೆಗಳಿಗೆ ವೈಜ್ಞಾನಿಕವಾಗಿ ಪರಿಹಾರ ಕಂಡುಕೊಳ್ಳಲು 'ಕ್ರಿಯಾ ಸಂಶೋಧನೆ'ನಡೆಸುವ ಕೌಶಲವನ್ನು ಮೂಡಿಸುವುದು.

ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಅಗತ್ಯತೆ :

ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಎನ್ನುವುದು ಶಿಕ್ಷಕರ ಜ್ಞಾನ, ಕೌಶಲಗಳು ಮತ್ತು ವೃತ್ತಿಪರ ವರ್ತನೆಯನ್ನು ನಿರಂತರವಾಗಿ ನವೀಕರಿಸುವ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ. ವೈದ್ಯಕೀಯ ಕ್ಷೇತ್ರದಲ್ಲಿ ಹೊಸ ಆವಿಷ್ಕಾರಗಳು ಬಂದಂತೆ ವೈದ್ಯರು ಹೇಗೆ ತಮ್ಮ ಜ್ಞಾನವನ್ನು ನವೀಕರಿಸಿಕೊಳ್ಳುತ್ತಾರೋ, ಹಾಗೆಯೇ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲೂ ಶಿಕ್ಷಕರು ನಿರಂತರವಾಗಿ ಓದಬೇಕಾಗುತ್ತದೆ. "ಒಬ್ಬ ಶಿಕ್ಷಕ ತಾನು ಸ್ವತಃ ಕಲಿಯುವುದನ್ನು ನಿಲ್ಲಿಸಿದರೆ, ಆತ ಬೇರೆಯವರಿಗೆ ಬೋಧಿಸುವ ಹಕ್ಕನ್ನು ಕಳೆದುಕೊಳ್ಳುತ್ತಾನೆ" ಎಂಬ ರವೀಂದ್ರನಾಥ ಠಾಗೋರರ ಮಾತು ಇಲ್ಲಿ ಅತ್ಯಂತ ಉಲ್ಲೇಖನೀಯವಾಗಿದೆ.

ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಅಗತ್ಯತೆಗೆ ಪ್ರಮುಖ ಕಾರಣಗಳೆಂದರೆ:

ಮೊದಲನೆಯದಾಗಿ, ಜ್ಞಾನದ ನವೀಕರಣ. ಹಳೆಯ ಪಠ್ಯಕ್ರಮ ಮತ್ತು ಬೋಧನಾ ವಿಧಾನಗಳು ಇಂದಿನ

ತಲೆಮಾರಿನ ಡಿಜಿಟಲ್ ನೆಟಿವ್ಸ್ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸರಿಹೊಂದುವುದಲ್ಲ.

ಎರಡನೆಯದಾಗಿ, ನವೀನ ಬೋಧನಾ ಶಾಸ್ತ್ರದ ಅಳವಡಿಕೆ. ಇತ್ತೀಚಿನ ದಿನಗಳಲ್ಲಿ 'ವಿದ್ಯಾರ್ಥಿ ಕೇಂದ್ರಿತ ಬೋಧನೆ, 'ಅನುಭವ ಜನ್ಯ ಕಲಿಕೆ ಮತ್ತು 'ಸಂಯೋಜಿತ ಮುಂಚೂಣಿಗೆ ಬಂದಿವೆ. ಇವುಗಳನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಜಾರಿಗೊಳಿಸಲು ಶಿಕ್ಷಕರಿಗೆ ತರಬೇತಿಯ ಅಗತ್ಯವಿದೆ.

ಮೂರನೆಯದಾಗಿ, ಮೌಲ್ಯಮಾಪನ ಪದ್ಧತಿಯಲ್ಲಿನ ಬದಲಾವಣೆಗಳು. ಕೇವಲ ವರ್ಷದ ಕೊನೆಯಲ್ಲಿ ನಡೆಸುವ ಪರೀಕ್ಷೆಗಳ ಬದಲಾಗಿ, ನಿರಂತರ ಮತ್ತು ಸಮಗ್ರ ಮೌಲ್ಯಮಾಪನ ಹಾಗೂ ಕಲಿಕಾ ವಿಶ್ಲೇಷಣೆಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮಗಳು ಸಹಕಾರಿಯಾಗಿವೆ.

ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020 ಮತ್ತು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿನ ಕ್ರಾಂತಿ

ಭಾರತ ಸರ್ಕಾರ ಜಾರಿಗೆ ತಂದಿರುವ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ ೨೦೨೦ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಗೆ ಅತ್ಯುನ್ನತ ಆದ್ಯತೆಯನ್ನು ನೀಡಿದೆ. ಶಿಕ್ಷಕರ ಗುಣಮಟ್ಟವನ್ನು ಸುಧಾರಿಸದೆ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟವನ್ನು ಹೆಚ್ಚಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ ಎಂಬುದನ್ನು ಈ ನೀತಿಯು ದೃಢವಾಗಿ ನಂಬುತ್ತದೆ. ೨೦೨೦ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ತರಲು ಉದ್ದೇಶಿಸಿರುವ ಪ್ರಮುಖ ಕ್ರಾಂತಿಕಾರಿ ಬದಲಾವಣೆಗಳು ಈ ಕೆಳಗಿನಂತಿವೆ:

1. **ನಾಲ್ಕು ವರ್ಷಗಳ ಸಂಯೋಜಿತ ಬಿ.ಇಡಿ ಪದವಿ:** ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020 ರ ಪ್ರಕಾರ, 2030 ರ ವೇಳೆಗೆ ಶಿಕ್ಷಕರಾಗಲು ಕನಿಷ್ಠ ಶೈಕ್ಷಣಿಕ ಅರ್ಹತೆಯು 4 ವರ್ಷಗಳ ಬಹುಶಿಸ್ತೀಯ ಸಂಯೋಜಿತ ಬಿ.ಇಡಿ ಪದವಿಯಾಗಿರಲಿದೆ. ಇದು ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಕೌಶಲ ಎರಡನ್ನೂ ಸಮಾನವಾಗಿ ಒಳಗೊಂಡಿರುತ್ತದೆ. ಸಬ್–ಸ್ಟ್ಯಾಂಡರ್ಡ್ ಅಥವಾ ಕಳಪೆ ಗುಣಮಟ್ಟದ ಸ್ವತಂತ್ರ ಶಿಕ್ಷಕ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳನ್ನು ಮುಚ್ಚಿ, ಅವುಗಳನ್ನು ಬಹುಶಿಸ್ತೀಯ ಕಾಲೇಜುಗಳು ಮತ್ತು ವಿಶ್ವವಿದ್ಯಾಲಯಗಳ ಭಾಗವಾಗಿಸಲು ಈ ನೀತಿಯು ಕಡ್ಡಾಯಗೊಳಿಸಿದೆ.

2. **ವರ್ಷಕ್ಕೆ ೫೦ ಗಂಟೆಗಳ ಕಡ್ಡಾಯ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ:** ಪ್ರತಿಯೊಬ್ಬ ಶಿಕ್ಷಕರು ಮತ್ತು ಮುಖ್ಯೋಪಾಧ್ಯಾಯರು ತಮ್ಮ ವೃತ್ತಿಪರ ಬೆಳವಣಿಗೆಗಾಗಿ ಪ್ರತಿ ವರ್ಷ ಕನಿಷ್ಠ ೫೦ ಗಂಟೆಗಳ ಕಾಲ ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮಗಳಲ್ಲಿ ಕಡ್ಡಾಯವಾಗಿ ಭಾಗವಹಿಸಬೇಕು. ಇದು ಕಾರ್ಯಾಗಾರಗಳು, ಆನ್ಲೈನ್ ಕೋರ್ಸ್ಗಳು, ಸೆಮಿನಾರ್ಗಳು ಅಥವಾ ಶೈಕ್ಷಣಿಕ ಸಂಶೋಧನೆಗಳ ರೂಪದಲ್ಲಿರಬಹುದು. ಇದು ಶಿಕ್ಷಕರು ಜಾಗತಿಕ ಮಟ್ಟದ ಶೈಕ್ಷಣಿಕ ಪ್ರವೃತ್ತಿಗಳಿಗೆ ತೆರೆದುಕೊಳ್ಳಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ.

3. **ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಮಾನದಂಡಗಳು:** ಶಿಕ್ಷಕರ ವೃತ್ತಿಜೀವನದ ವಿವಿಧ ಹಂತಗಳಲ್ಲಿ (ಪ್ರವೇಶ ಹಂತ, ಅನುಭವಿ ಹಂತ, ತಜ್ಞ ಹಂತ ಮತ್ತು ನಾಯಕತ್ವ ಹಂತ) ಅವರ ಕಾರ್ಯಕ್ಷಮತೆಯನ್ನು ಮೌಲ್ಯಮಾಪನ ಮಾಡಲು 'ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಮಾನದಂಡಗಳನ್ನ'ಅಭಿವೃದ್ಧಿಪಡಿಸಲಾಗುತ್ತಿದೆ. ಇದರ ಆಧಾರದ ಮೇಲೆಯೇ ಶಿಕ್ಷಕರ ಬಡ್ತಿ, ವೇತನ ಹೆಚ್ಚಳ ಮತ್ತು ಇತರ ಸವಲತ್ತುಗಳನ್ನು ನಿರ್ಧರಿಸಲಾಗುತ್ತದೆ, ಇದು ವೃತ್ತಿಯಲ್ಲಿ ಪಾರದರ್ಶಕತೆ ಮತ್ತು ಸ್ಪರ್ಧಾತ್ಮಕತೆಯನ್ನು ತರುತ್ತದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಆಧುನಿಕ ಪ್ರವೃತ್ತಿಗಳು ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಇಂದಿನ ತಾಂತ್ರಿಕ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ಕೇವಲ ಸಾಂಪ್ರದಾಯಿಕ ಉಪನ್ಯಾಸ ವಿಧಾನಕ್ಕೆ ಸೀಮಿತವಾಗಿರಲು ಸಾಧ್ಯವಿಲ್ಲ. ತಂತ್ರಜ್ಞಾನದ ತೀವ್ರ ನುಗ್ಗುವಿಕೆಯಿಂದಾಗಿ ಬೋಧನೆ ಮತ್ತು ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಅದ್ಭುತ ಬದಲಾವಣೆಗಳಾಗುತ್ತಿವೆ. ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯವಿಧಾನದಲ್ಲಿ ಪ್ರಸ್ತುತ ಕಂಡುಬರುತ್ತಿರುವ ಪ್ರಮುಖ ಆಧುನಿಕ ಪ್ರವೃತ್ತಿಗಳೆಂದರೆ:

ಅ) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ: ಶಿಕ್ಷಕರು ಇಂದು ಮೌಲ್ಯಮಾಪನಕ್ಕಾಗಿ, ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ನ್ಯೂನತೆಗಳನ್ನು ಗುರುತಿಸಲು ಮತ್ತು ವೈಯಕ್ತಿಕೀಕರಿಸಿದ ಕಲಿಕಾ ಯೋಜನೆಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪರಿಕರಗಳನ್ನು ಬಳಸುತ್ತಿದ್ದಾರೆ. ಶಿಕ್ಷಕರ ತರಬೇತಿಯಲ್ಲೇ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನವನ್ನು ಪರಿಚಯಿಸುವುದರಿಂದ, ಅವರು ಭವಿಷ್ಯದಲ್ಲಿ ಡಿಜಿಟಲ್ ತರಗತಿಗಳನ್ನು ಸಮರ್ಥವಾಗಿ ನಿರ್ವಹಿಸಬಲ್ಲರು.

ಆ) ವರ್ಚುವಲ್ ರಿಯಾಲಿಟಿ ಮತ್ತು ಆಗ್ಮೆಂಟೆಡ್ ರಿಯಾಲಿಟಿ: ಈ ತಂತ್ರಜ್ಞಾನಗಳ ಮೂಲಕ ಶಿಕ್ಷಕ ತರಬೇತಿದಾರರಿಗೆ ನೈಜ ತರಗತಿಯ ವಾತಾವರಣದ ತರಬೇತಿಯನ್ನು ವರ್ಚುವಲ್ ಆಗಿ ನೀಡಬಹುದು. ಸಂಕೀರ್ಣವಾದ ವಿಜ್ಞಾನ ಪ್ರಯೋಗಗಳು ಅಥವಾ ಇತಿಹಾಸದ ಘಟನೆಗಳನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೇಗೆ ಆಕರ್ಷಕವಾಗಿ ಬೋಧಿಸಬೇಕೆಂಬುದನ್ನು ಶಿಕ್ಷಕರು ಈ ಮೂಲಕ ಕಲಿಯುತ್ತಿದ್ದಾರೆ.

ಇ) ಮೂಕ್ಸ್ ಮತ್ತು ಮುಕ್ತ ಶೈಕ್ಷಣಿಕ ಸಂಪನ್ಮೂಲಗಳು: ಜಾಗತಿಕ ಮಟ್ಟದ ಪ್ರಸಿದ್ಧ ವಿಶ್ವವಿದ್ಯಾಲಯಗಳ ಕೋರ್ಸ್ಗಳು ಇಂದು ಶಿಕ್ಷಕರಿಗೆ ಆನ್ಲೈನ್ ಮೂಲಕ ಲಭ್ಯವಿವೆ. ಇದು ಭೌಗೋಳಿಕ ಮಿತಿಗಳನ್ನು ಮೀರಿ ಶಿಕ್ಷಕರು ತಾವಿದ್ದ ಕಡೆಯಿಂದಲೇ ಉನ್ನತ ಮಟ್ಟದ ಜ್ಞಾನ ಮತ್ತು ಪ್ರಮಾಣಪತ್ರಗಳನ್ನು ಪಡೆಯಲು ದಾರಿ ಮಾಡಿಕೊಟ್ಟಿದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಎದುರಿಸುತ್ತಿರುವ ಪ್ರಮುಖ ಸವಾಲುಗಳು

ಭಾರತದಲ್ಲಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಮಹತ್ವವನ್ನು ಒಪ್ಪಿಕೊಂಡಿದ್ದರೂ, ಪ್ರಾಯೋಗಿಕವಾಗಿ ಈ ಕ್ಷೇತ್ರವು ಹಲವಾರು ಗಂಭೀರ ಸವಾಲುಗಳನ್ನು ಎದುರಿಸುತ್ತಿದೆ:

1) ವಾಣಿಜ್ಯೀಕರಣ ಮತ್ತು ಗುಣಮಟ್ಟದ ಕುಸಿತ: ಕಳೆದ ಕೆಲವು ದಶಕಗಳಲ್ಲಿ ಖಾಸಗಿ ಶಿಕ್ಷಕ ತರಬೇತಿ ಸಂಸ್ಥೆಗಳ ಅಣಬೆ ಬೆಳವಣಿಗೆಯಾಗಿದೆ. ಇವುಗಳಲ್ಲಿ ಹಲವು ಸಂಸ್ಥೆಗಳು ಕೇವಲ ಲಾಭಗಳಿಕೆಯ ಉದ್ದೇಶ ಹೊಂದಿದ್ದು, ಮೂಲಸೌಕರ್ಯ, ಅರ್ಹ ಉಪನ್ಯಾಸಕರು ಮತ್ತು ಗುಣಮಟ್ಟದ ಪ್ರಾಯೋಗಿಕ ತರಬೇತಿಯ ಕೊರತೆಯನ್ನು ಹೊಂದಿವೆ. ಇದು ಕಳಪೆ ಮಟ್ಟದ ಶಿಕ್ಷಕರ ಸೃಷ್ಟಿಗೆ ಕಾರಣವಾಗುತ್ತಿದೆ.

2) ಸಿದ್ಧಾಂತ ಮತ್ತು ಪ್ರಾಯೋಗಿಕತೆಯ ನಡುವಿನ ಕಂದಕ: ಪ್ರಸ್ತುತ ಇರುವ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಪಠ್ಯಕ್ರಮವು ಅತಿ ಹೆಚ್ಚು ಸಿದ್ಧಾಂತಗಳಿಗೆ (Theory) ಒತ್ತು ನೀಡುತ್ತದೆ. ಆದರೆ ನೈಜ ತರಗತಿಯಲ್ಲಿ ಎದುರಾಗುವ ಶಿಸ್ತುಪಾಲನೆ, ಅಂತರ್ಗತ ಶಿಕ್ಷಣದ ನಿರ್ವಹಣೆ, ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾನಸಿಕ ಸಮಸ್ಯೆಗಳನ್ನು ನಿಭಾಯಿಸುವ ಪ್ರಾಯೋಗಿಕ ಜ್ಞಾನವನ್ನು (Practical Exposure) ತರಬೇತಿಯಲ್ಲಿ ಸಮರ್ಪಕವಾಗಿ ನೀಡಲಾಗುತ್ತಿಲ್ಲ.

3) ಸೇವಾ–ಅಂತರ್ಗತ ತರಬೇತಿಗಳ ಔಪಚಾರಿಕತೆ: ಪ್ರಸ್ತುತ ಸರ್ಕಾರಗಳು ನಡೆಸುವ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಕಾರ್ಯಾಗಾರಗಳು ಕೇವಲ 'ಗುರಿ ಸಾಧನೆ' ಅಥವಾ ಔಪಚಾರಿಕತೆಯಾಗಿ ಮಾರ್ಪಟ್ಟಿವೆ. ಶಿಕ್ಷಕರ ನಿಜವಾದ ಅಗತ್ಯತೆಗಳನ್ನು ಆಧರಿಸಿ ಈ ತರಬೇತಿಗಳನ್ನು ವಿನ್ಯಾಸಗೊಳಿಸದಿರುವುದರಿಂದ, ತರಬೇತಿಯ ನಂತರ ತರಗತಿ ಕೋಣೆಯ ಬೋಧನೆಯಲ್ಲಿ ಯಾವುದೇ ಗಮನಾರ್ಹ ಬದಲಾವಣೆಗಳು ಕಂಡುಬರುತ್ತಿಲ್ಲ.

4) ಶಿಕ್ಷಕರಲ್ಲಿ ಪ್ರೇರಣೆಯ ಕೊರತೆ: ಬೋಧಕರಲ್ಲಿ ನಿರಂತರ ಕಲಿಕೆಯ ಬಗ್ಗೆ ಆಸಕ್ತಿ ಮತ್ತು ಸ್ವಯಂ ಪ್ರೇರಣೆಯ ಕೊರತೆಯಿದೆ. ತರಬೇತಿಗಳನ್ನು ಕೇವಲ ಕಡ್ಡಾಯ ಆದೇಶ ಎಂದು ಭಾವಿಸುತ್ತಾರೆಯೇ ಹೊರತು, ತಮ್ಮ ಸ್ವಯಂ ವೃತ್ತಿಪರ ವಿಕಸನಕ್ಕೆ ಸಿಕ್ಕ ಅವಕಾಶ ಎಂದು ಭಾವಿಸುವವರ ಸಂಖ್ಯೆ ಕಡಿಮೆ ಇದೆ.

ಸುಧಾರಣಾ ಕ್ರಮಗಳು ಮತ್ತು ಪರಿಣಾಮಕಾರಿ ಕಾರ್ಯತಂತ್ರಗಳು

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯನ್ನು ಬಲಪಡಿಸಲು ಮತ್ತು ಜಾಗತಿಕ ಮಟ್ಟಕ್ಕೆ ಕೊಂಡೊಯ್ಯಲು ಈ ಕೆಳಗಿನ ಕಾರ್ಯತಂತ್ರಗಳನ್ನು ಜಾರಿಗೆ ತರಬೇಕಿದೆ:

1) ಪಠ್ಯಕ್ರಮದ ನವೀಕರಣ ಮತ್ತು ಪ್ರಾಯೋಗಿಕತೆ: ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳ ಪಠ್ಯಕ್ರಮವನ್ನು ಸಮಕಾಲೀನ ಜಾಗತಿಕ ಅಗತ್ಯಗಳಿಗೆ ತಕ್ಕಂತೆ ತಕ್ಷಣವೇ ಪರಿಷ್ಕರಿಸಬೇಕು. ಪಠ್ಯಕ್ರಮದಲ್ಲಿ ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಮೌಲ್ಯ ಶಿಕ್ಷಣ ಮತ್ತು ವಿಶೇಷ ಅಗತ್ಯವುಳ್ಳ ಮಕ್ಕಳನ್ನು ಒಳಗೊಳ್ಳುವ 'ಅಂತರ್ಗತ ಶಿಕ್ಷಣ'ಪದ್ಧತಿಗಳಿಗೆ ಹೆಚ್ಚಿನ ಆದ್ಯತೆ ನೀಡಬೇಕು. ಇಂಟರ್ನ್‌ಷಿಪ್ ಅಥವಾ ಶಾಲಾ ಅನುಭವ ಕಾರ್ಯಕ್ರಮಗಳ ಅವಧಿಯನ್ನು ಹೆಚ್ಚಿಸಿ, ನೈಜ ಬೋಧನಾ ಜ್ಞಾನವನ್ನು ನೀಡಬೇಕು.

2) ಕ್ರಿಯಾ ಸಂಶೋಧನೆಗೆ ಪ್ರೋತ್ಸಾಹ: ಪ್ರತಿಯೊಬ್ಬ ಶಿಕ್ಷಕನೂ ತನ್ನ ತರಗತಿಯಲ್ಲಿ ಎದುರಾಗುವ ಸಮಸ್ಯೆಗಳಿಗೆ (ಉದಾಹರಣೆಗೆ: ವಿದ್ಯಾರ್ಥಿಗಳ ಗೈರುಹಾಜರಿ, ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿನ ಹಿನ್ನಡೆ, ಗಣಿತದ ಭಯ) ಸ್ವತಃ ಕ್ರಿಯಾ ಸಂಶೋಧನೆಯ ಮೂಲಕ ಪರಿಹಾರ ಕಂಡುಕೊಳ್ಳುವಂತೆ ಪ್ರೋತ್ಸಾಹಿಸಬೇಕು. ಸಂಶೋಧನೆ ನಡೆಸುವ ಶಿಕ್ಷಕರಿಗೆ ವಿಶೇಷ ಪ್ರಶಸ್ತಿ ಮತ್ತು ಬಡ್ತಿಗಳಲ್ಲಿ ಆದ್ಯತೆ ನೀಡಬೇಕು.

3) ಮೆಂಟರ್‌ಶಿಪ್ ಮತ್ತು ಸಹಯೋಗದ ಕಲಿಕೆ: ಶಾಲೆಗಳಲ್ಲಿ ಮತ್ತು ಕಾಲೇಜುಗಳಲ್ಲಿ ಹಿರಿಯ ಅನುಭವಿ ಶಿಕ್ಷಕರು ಕಿರಿಯ ಶಿಕ್ಷಕರಿಗೆ ಮಾರ್ಗದರ್ಶನ ನೀಡುವ 'ಮೆಂಟರ್‌ಶಿಪ್' ವ್ಯವಸ್ಥೆಯನ್ನು ತರಬೇಕು. ಶಿಕ್ಷಕರು ತಮ್ಮಲ್ಲಿನ ಉತ್ತಮ ಬೋಧನಾ ಪದ್ಧತಿಗಳನ್ನು ಪರಸ್ಪರ ಹಂಚಿಕೊಳ್ಳಲು 'ಶಿಕ್ಷಕರ ಕಲಿಕಾ ಸಮುದಾಯಗಳನ್ನು' ಸ್ಥಾಪಿಸಬೇಕು.

4) ತರಬೇತಿ ಸಂಸ್ಥೆಗಳ ಕಟ್ಟುನಿಟ್ಟಿನ ಉಸ್ತುವಾರಿ: ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಕ ಶಿಕ್ಷಣ ಪರಿಷತ್ತು ಮತ್ತು ವಿಶ್ವವಿದ್ಯಾಲಯಗಳು ಬಿ.ಎಡ್ ಕಾಲೇಜುಗಳ ಸಂಯೋಜನೆ ಮತ್ತು ಗುಣಮಟ್ಟದ ಮೇಲೆ ಕಟ್ಟುನಿಟ್ಟಿನ ನಿಗಾ ಇಡಬೇಕು. ಅರ್ಹತೆ ಇಲ್ಲದ, ನಕಲಿ ದಾಖಲೆಗಳನ್ನು ಹೊಂದಿರುವ ಸಂಸ್ಥೆಗಳ ವಿರುದ್ಧ ನಿರ್ದಾಕ್ಷಿಣ್ಯ ಕ್ರಮ ಕೈಗೊಳ್ಳಬೇಕು.

ಉಪಸಂಹಾರ

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಎನ್ನುವುದು ಕೇವಲ ಶೈಕ್ಷಣಿಕ ಸುಧಾರಣೆಯಲ್ಲ; ಅದು ಒಂದು ದೇಶದ ಭವಿಷ್ಯದ ಬೌದ್ಧಿಕ ಸಂಪತ್ತನ್ನು ರೂಪಿಸುವ ಮಹಾನ್ ಪ್ರಕ್ರಿಯೆ. ಶಿಕ್ಷಕರು ಕೇವಲ ಭೂತಕಾಲದ ಜ್ಞಾನವನ್ನು ವರ್ತಮಾನದಲ್ಲಿ ಬೋಧಿಸಿ ಭವಿಷ್ಯತ್ತನ್ನು ನಿರ್ಮಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ. ಅವರು ಸ್ವತಃ ವರ್ತಮಾನದ ತಾಂತ್ರಿಕ ಮತ್ತು ವೈಜ್ಞಾನಿಕ ಪ್ರಗತಿಯನ್ನು ಅರಿತು ಭವಿಷ್ಯದ ನಾಗರಿಕರನ್ನು ಸಜ್ಜುಗೊಳಿಸಬೇಕಿದೆ. ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020 ರ ಆಶಯಗಳನ್ನು ಯಶಸ್ವಿಯಾಗಿ ಅನುಷ್ಠಾನಗೊಳಿಸಲು ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಅತ್ಯಗತ್ಯ. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು, ಸರ್ಕಾರಗಳು ಮತ್ತು ಸ್ವತಃ ಶಿಕ್ಷಕರು ಒಟ್ಟಾಗಿ ಶ್ರಮಿಸಿದಾಗ ಮಾತ್ರ ಶೈಕ್ಷಣಿಕ ಗುಣಮಟ್ಟವನ್ನು ಜಾಗತಿಕ ಮಟ್ಟಕ್ಕೆ ಏರಿಸಲು ಸಾಧ್ಯ. ಶಿಕ್ಷಕರಲ್ಲಿ ನಿರಂತರ ಕಲಿಕೆಯ ಮನೋಭಾವನೆ ಮೂಡಿದಾಗ ಮಾತ್ರ, ನಮ್ಮ ಇಡೀ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯು ಚಲನಶೀಲ ಮತ್ತು ಅರ್ಥಪೂರ್ಣವಾಗುತ್ತದೆ.

ಆಕರಗಳು

ಭಾರತ ಸರ್ಕಾರ. ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ ೨೦೨೦. ಮಾನವ ಸಂಪನ್ಮೂಲ ಅಭಿವೃದ್ಧಿ ಸಚಿವಾಲಯ, ನವದೆಹಲಿ.

ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಕ ಶಿಕ್ಷಣ ಪರಿಷತ್ತು – ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣಕ್ಕಾಗಿ ರಾಷ್ಟ್ರೀಯ ಪಠ್ಯಕ್ರಮದ ಚೌಕಟ್ಟು. ನವದೆಹಲಿ.

ಡಾ. ಅನಂತರಾಮು, ಕೆ. ಶಿಕ್ಷಣ ಶಾಸ್ತ್ರ ಮತ್ತು ಬೋಧನಾ ವಿಧಾನಗಳು. ವಿದ್ಯಾ ಪ್ರಕಾಶನ, ಬೆಂಗಳೂರು.

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ಕೃಷ್ಣಮೂರ್ತಿ, ವಿ. (2022) ಬೋಧನಾ ಶಾಸ್ತ್ರ ಮತ್ತು ತರಗತಿ ನಿರ್ವಹಣೆ. ಭಾಸ್ಕರ್ ಪ್ರಕಾಶನ, ಧಾರವಾಡ.

ಮಹೇಶ್ಚಂದ್ರ, ಹೆಚ್. ಬಿ. (2020) ಶೈಕ್ಷಣಿಕ ಮತ್ತು ಕೃತಕ ತಂತ್ರಜ್ಞಾನದ ಬಳಕೆ. ಸಪ್ನಾ ಬುಕ್ ಹೌಸ್, ಬೆಂಗಳೂರು.

ರಾವ್, ವಿ. ಕೆ. (2017) ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ಗುಣಮಟ್ಟ ಅಭಿವೃದ್ಧಿ. ಧನಪತ್ ರಾಯ್ ಪಬ್ಲಿಕೇಷನ್ಸ್, ನವದೆಹಲಿ.

ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ: ಶೈಕ್ಷಣಿಕ ಅನ್ವಯಗಳು, ಅವಕಾಶಗಳು ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆ

ದೇವಾನಂದ ಎ.ಸಿ.
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು., ಬಿಜಿಎಸ್ ಶಿಕ್ಷಣ ಮಹಾವಿದ್ಯಾಲಯ, ಆದಿಚುಂಚನಗಿರಿ ವಿಶ್ವವಿದ್ಯಾಲಯ

ಸಾರಾಂಶ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಇಂದು ಶಿಕ್ಷಣದ ವಿವಿಧ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಪರಿವರ್ತನೆ ತರುತ್ತಿರುವ ಪ್ರಮುಖ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ. ವಿಶೇಷವಾಗಿ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಸಾಧನಗಳು ಸ್ವಯಂ ಕಲಿಕೆ, ಸಂವಾದಾತ್ಮಕ ಭಾಷಾಭ್ಯಾಸ, ಅನುವಾದ, ಬರವಣಿಗೆ ಮತ್ತು ವ್ಯಾಕರಣ ಕಲಿಕೆ, ಪದಸಂಪತ್ತಿನ ವೃದ್ಧಿ, ವಿಷಯ ಗ್ರಹಿಕೆ, ಮಾತುಗಾರಿಕೆಯ ಅಭ್ಯಾಸ, ಶೈಕ್ಷಣಿಕ ಪ್ರಸ್ತುತಿಗಳ ನಿರ್ಮಾಣ ಹಾಗೂ ಮೌಲ್ಯಮಾಪನ, ಮುಂತಾದ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಸೃಷ್ಟಿಸುತ್ತಿವೆ. ಈ ಅಧ್ಯಯನವು ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಶೈಕ್ಷಣಿಕ ಅನ್ವಯಗಳು, ಅದರಿಂದ ದೊರೆಯುವ ಅವಕಾಶಗಳು ಹಾಗೂ ಅದರ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಸಂಬಂಧಿಸಿದ ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ವಿಚಾರಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವ ಉದ್ದೇಶವನ್ನು ಹೊಂದಿದೆ. ಈ ಅಧ್ಯಾಯಕ್ಕೆ 'ವರ್ಣನಾತ್ಮಕ ಸಂಶೋಧನಾ ವಿಧಾನವನ್ನು' ಅನುಸರಿಸಲಾಗಿದೆ. ಸಂಬಂಧಿತ ಸಂಶೋಧನಾ ಸಾಹಿತ್ಯ ಮತ್ತು ಪ್ರಸ್ತುತ ಶೈಕ್ಷಣಿಕ ಚಿಂತನೆಗಳ ಮೂಲಕ ವಿಷಯವನ್ನು ಪರಿಶೀಲಿಸಲಾಗಿದೆ. ಅಧ್ಯಯನದಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಭಾಷಾ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ವೈಯಕ್ತಿಕ ಮತ್ತು ಪರಿಣಾಮಕಾರಿಯಾಗಿಸಿದೆ ಎಂದು ಕಂಡು ಬಂದಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ, ನಿರಂತರ ಅಭ್ಯಾಸ ಮತ್ತು ತಮ್ಮದೇ ವೇಗದಲ್ಲಿ ಕಲಿಯುವ ಅವಕಾಶವನ್ನು ಸೃಷ್ಟಿಸುತ್ತಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಪಾಠಯೋಜನೆ, ಬೋಧನೆ ಮತ್ತು ಕಲಿಕಾ ಸಾಧನಗಳ ರಚನೆ, ಭಾಷಾ ಅನುವಾದ, ಪ್ರಶ್ನೆಪತ್ರಿಕೆ, ಮೌಲ್ಯಮಾಪನ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಸ್ತುತಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಸಹಾಯಕವಾಗಿದೆ. ಆದರೆ ಅವಾಸ್ತವಿಕ ಮಾಹಿತಿ ನೀಡಿಕೆ, ಶೈಕ್ಷಣಿಕ ಅಪ್ರಾಮಾಣಿಕತೆ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಅಲ್ಗಾರಿದಮಿಕ್ ಪಕ್ಷಪಾತ, ಡಿಜಿಟಲ್ ಅಸಮಾನತೆ, ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆಗೆ ದಕ್ಕೆಯಾಗುತ್ತಿರುವುದು ಇದರ ಪ್ರಮುಖ ಸವಾಲುಗಳಾಗಿವೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಭಾರತೀಯ ಭಾಷಾ ವೈವಿಧ್ಯತೆ, ಸ್ಥಳೀಯ ಸಂಸ್ಕೃತಿ ಮತ್ತು ಉಪಭಾಷೆಗಳಿಗೆ ಪ್ರಾಮುಖ್ಯತೆ ನೀಡಬೇಕಾಗಿದೆ. ಹೀಗಾಗಿ ಭಾಷಾ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಾಗಿ ಬಳಸುವುದಕ್ಕಿಂತ, ಶಿಕ್ಷಕರ ಶೈಕ್ಷಣಿಕ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿಸ್ತರಿಸುವ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸುವುದು ಹೆಚ್ಚು ಸೂಕ್ತ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಬಳಕೆಗೆ ಮಾನವರ ಮೇಲ್ವಿಚಾರಣೆ, ಪಾರದರ್ಶಕತೆ, ಗೌಪ್ಯತೆ, ಸಮಾನತೆ, ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯು ಅಗತ್ಯವಾಗಿದೆ.

ಮುಖ್ಯ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಬೋಧನೆ, ಸ್ವಯಂ ಕಲಿಕೆ, ಶೈಕ್ಷಣಿಕ ಅಪ್ರಾಮಾಣಿಕತೆ, ಜವಾಬ್ದಾರಿಯುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆ*

ಪೀಠಿಕೆ: ತಂತ್ರಜ್ಞಾನದ ಬೆಳವಣಿಗೆಯು 21ನೇ ಶತಮಾನದ ಶಿಕ್ಷಣದ ಸ್ವರೂಪ, ಬೋಧನಾ ವಿಧಾನಗಳು ಮತ್ತು ಕಲಿಕಾ ಅನುಭವಗಳಲ್ಲಿ ಮಹತ್ವದ ಬದಲಾವಣೆಗಳನ್ನು ತಂದಿದೆ. ಇಂದು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ವ್ಯಾಪಕವಾಗಿ ಬಳಕೆಯಾಗುತ್ತಿರುವ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಮಾಹಿತಿ ಸಂಸ್ಕರಣೆ, ಭಾಷಾ ಸೃಜನೆ, ಅನುವಾದ, ಧ್ವನಿ ಗುರುತಿಸುವಿಕೆ, ಪಠ್ಯ ವಿಶ್ಲೇಷಣೆ, ವೈಯಕ್ತಿಕ ಪ್ರತಿಕ್ರಿಯೆ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಕಲಿಕೆ ಸೇರಿದಂತೆ ವಿವಿಧ ಶೈಕ್ಷಣಿಕ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಬಳಕೆಯಾಗುತ್ತಿದೆ.

ವಿಶೇಷವಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯಿಂದ ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೊಸ ರೀತಿಯ ಬೋಧನಾ–ಕಲಿಕಾ ಅವಕಾಶಗಳು ಲಭ್ಯವಾಗುತ್ತಿವೆ.

ಭಾಷಾ ಕಲಿಕೆಯು ಕೇವಲ ವ್ಯಾಕರಣ ನಿಯಮಗಳು ಮತ್ತು ಪದಸಂಪತ್ತಿನ ವೃದ್ಧಿಗೆ ಮಾತ್ರ ಸೀಮಿತವಾಗದೆ, ಆಲಿಸುವಿಕೆ, ಮಾತನಾಡುವಿಕೆ, ಓದುವಿಕೆ ಮತ್ತು ಬರವಣಿಗೆ ಸೇರಿದಂತೆ ವಿವಿಧ ಭಾಷಾ ಕೌಶಲ್ಯಗಳ ಅಭಿವೃದ್ಧಿಯನ್ನು ಒಳಗೊಂಡಿದೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವೈಯಕ್ತಿಕ ಅಭ್ಯಾಸ, ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ, ಸಂವಾದಾತ್ಮಕ ಭಾಷಾ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ನಿರಂತರ ಸ್ವಯಂ ಕಲಿಕೆಯ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತಿವೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಭಾಷಾ ಮಟ್ಟಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಪಠ್ಯವನ್ನು ಸರಳೀಕರಿಸಿಕೊಳ್ಳಬಹುದು, ಹೊಸ ಪದಗಳ ಅರ್ಥ ಮತ್ತು ಬಳಕೆಯನ್ನು ತಿಳಿದುಕೊಳ್ಳಬಹುದು, ಬರವಣಿಗೆಯಲ್ಲಿನ ಭಾಷಾ ದೋಷಗಳನ್ನು ಗುರುತಿಸಿಕೊಳ್ಳಬಹುದು ಹಾಗೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಒದಗಿಸುವ ನೈಜ ಜೀವನದ ಭಾಷಾ ಬಳಕೆಯ ಸನ್ನಿವೇಶಗಳ ಮೂಲಕ ಸಂವಹನ ಕೌಶಲ್ಯವನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಿಕೊಳ್ಳಬಹುದಾಗಿದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರ ಹಲವು ಶೈಕ್ಷಣಿಕ ಕಾರ್ಯಗಳನ್ನು ಸುಲಭಗೊಳಿಸಿದೆ. ಇದು ಪಾಠಯೋಜನೆ, ಅಭ್ಯಾಸ ಪತ್ರಿಕೆ, ಪ್ರಶ್ನೆಪತ್ರಿಕೆ ರಚನೆ, ಮೌಲ್ಯಮಾಪನ, ಭಾಷಾ ಚಟುವಟಿಕೆಗಳು, ಅನುವಾದ, ಸಾರಾಂಶೀಕರಣ, ಪದ ಸಂಪತ್ತಿನ ಅಭಿವೃದ್ಧಿ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಸ್ತುತಿಗಳ ರಚನೆಗೆ ನೆರವಾಗುತ್ತಿದೆ. ಇದರಿಂದ ಶಿಕ್ಷಕರ ಸಮಯ ಮತ್ತು ಕಾರ್ಯಭಾರದ ಹೊರೆಯು ಕಡಿಮೆಯಾಗಿದ್ದು, ವಿಭಿನ್ನ ಸಾಮರ್ಥ್ಯದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ನೆರವಾಗುತ್ತಿದೆ. ಹೀಗಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ತಂತ್ರಜ್ಞಾನವು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಾಗಿರದೆ, ಅವರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ ವೃದ್ಧಿಸಲು ನೆರವಾಗುವ ಸಹಾಯಕ ಸಾಧನವಾಗಿದೆ.

ಆದರೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಕೆಲವೊಮ್ಮೆ ತಪ್ಪು ಮಾಹಿತಿ, ತಪ್ಪು ಉಲ್ಲೇಖಗಳು ಅಥವಾ ಉಚಿತವಲ್ಲದ ಭಾಷಾ ರೂಪಗಳನ್ನು ಸೃಷ್ಟಿಸಬಲ್ಲದು. ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ರಚಿಸಿದ ವಿಷಯವನ್ನು ಸ್ವಂತ ಕೃತಿಯೆಂದು ವಿದ್ಯಾಲಯಕ್ಕೆ ಸಲ್ಲಿಸಿದರೆ ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಧಕ್ಕೆಯಾಗುವುದು. ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ದತ್ತಾಂಶ, ಬರಹ ಮತ್ತು ಧ್ವನಿ ಮತ್ತು ಮಾಹಿತಿಗಳ ಗೌಪ್ಯತೆ, ಅಲ್ಗಾರಿದಮಿಕ್ ಪಕ್ಷಪಾತ ಹಾಗೂ ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳ ಅಸಮಾನ ಲಭ್ಯತೆ ಇದರ ಪ್ರಮುಖ ಸವಾಲುಗಳಾಗಿವೆ. ವಿಶೇಷವಾಗಿ ಕನ್ನಡ ಸೇರಿದಂತೆ ಭಾರತೀಯ ಭಾಷೆಗಳ ಸಂದರ್ಭದಲ್ಲಿ ಸ್ಥಳೀಯ ಭಾಷೆ, ಉಪಭಾಷೆ, ಸಂಸ್ಕೃತಿ ಮತ್ತು ಪ್ರಾದೇಶಿಕ ಭಾಷಾ ವೈವಿಧ್ಯತೆಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳು ಒತ್ತು ನೀಡುತ್ತಿಲ್ಲ.

ಪ್ರಸ್ತುತ ಲಭ್ಯವಿರುವ ಸಂಶೋಧನೆಗಳಲ್ಲಿ ಇಂಗ್ಲಿಷ್ ಭಾಷಾ ಕಲಿಕೆ, ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಬರವಣಿಗೆ ಚಟುವಟಿಕೆಗಳಿಗೆ ಹೆಚ್ಚಿನ ಆದ್ಯತೆ ದೊರೆತಿದೆ. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಶೈಕ್ಷಣಿಕ ಬಳಕೆ, ಸಾಧ್ಯತೆಗಳು ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯ ಕುರಿತು ಇನ್ನಷ್ಟು ಕ್ಷೇತ್ರಾಧಾರಿತವಾದ ನಿರ್ದಿಷ್ಟ ಅಧ್ಯಯನಗಳ ಅಗತ್ಯವಿದೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಶೈಕ್ಷಣಿಕ ಅನ್ವಯಗಳು, ಕಲಿಕಾ ಮತ್ತು ಬೋಧನಾ ಅವಕಾಶಗಳು, ಅದರ ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಸಮಸ್ಯೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಲಾಗಿದೆ. ಭಾಷಾ ತರಗತಿಯಲ್ಲಿ ಬೋಧಕರ

ಮೇಲ್ವಿಚಾರಣೆ, ಪಾರದರ್ಶಕತೆ, ಗೌಪ್ಯತೆ, ಭಾಷಾ ವೈವಿಧ್ಯತೆ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಯನ್ನು ಆಧರಿಸಿದ ಜವಾಬ್ದಾರಿಯುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಗೆ ಪ್ರಾಯೋಗಿಕ ಚೌಕಟ್ಟನ್ನು ಒದಗಿಸುವುದು ಈ ಅಧ್ಯಯನದ ಪ್ರಮುಖ ಉದ್ದೇಶವಾಗಿದೆ.

1. ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು

- ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಅನ್ವಯಗಳನ್ನು ಗುರುತಿಸುವುದು.
- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯಿಂದ ಉಂಟಾಗುವ ಬೋಧನಾ ಮತ್ತು ಕಲಿಕಾ ಅವಕಾಶಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.
- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಸಮಸ್ಯೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.
- ಭಾಷಾ ತರಗತಿಯಲ್ಲಿ ಜವಾಬ್ದಾರಿಯುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಗೆ ಪ್ರಾಯೋಗಿಕ ಚೌಕಟ್ಟನ್ನು ಒದಗಿಸುವುದು.

2. ಹಿಂದಿನ ಸಾಹಿತ್ಯದ ವಿಮರ್ಶೆ

- ಲಾ (2024) ರವರ 'ಅಪ್ಲಿಕೇಶನ್ ಆಫ್ ಜನರೇಟಿವ್ ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜೆನ್ಸ್ ಇನ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಟೀಚಿಂಗ್ ಅಂಡ್ ಲರ್ನಿಂಗ್: ಎ ಸ್ಕೋಪಿಂಗ್ ಲಿಟರೇಚರ್' ಎಂಬ ಸಂಶೋಧನಾ ಲೇಖನವನ್ನು 'ಕಂಪ್ಯೂಟರ್ಸ್ ಅಂಡ್ ಎಜುಕೇಶನ್: ಓಪನ್' ಎಂಬ ನಿಯತಕಾಲಿಕದಲ್ಲಿ ಪ್ರಕಟಿಸಿದ್ದಾರೆ. ಈ ಅಧ್ಯಯನವು "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಭಾಷಾ ಕಲಿಕೆಗೆ ಸಂವಾದಾತ್ಮಕ ಮತ್ತು ವೈಯಕ್ತಿಕ ನೆರವನ್ನು ಒದಗಿಸುತ್ತದೆ. ಆದರೆ ನಿಖರತೆ, ನೈತಿಕತೆ, ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಸಂಬಂಧಿಸಿದ ಸವಾಲುಗಳಿವೆ" ಎಂದು ತಿಳಿಸಿದೆ.
- ವು (2024) ರವರ 'ದಿ ಎಫೆಕ್ಟಿವ್‌ನೆಸ್ ಆಫ್ ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜೆನ್ಸ್ ಇನ್ ಸೆಕೆಂಡ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಲರ್ನಿಂಗ್: ಎ ಮೆಟಾ–ಅನಾಲಿಸಿಸ್' ಸಂಶೋಧನ ಲೇಖನವು 'ಸಿಸ್ಟಮ್' ನಿಯತಕಾಲಿಕದಲ್ಲಿ ಪ್ರಕಟವಾಗಿದೆ. ಈ ಅಧ್ಯಯನವು "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಕಲಿಕೆಯು ಕಲಿಕಾರ್ಥಿಗಳ ಭಾಷಾ ಸಾಧನೆ, ಮಾತುಗಾರಿಕೆ ಕೌಶಲ್ಯ ಮತ್ತು ಪ್ರೇರಣೆಯ ಮೇಲೆ ಧನಾತ್ಮಕ ಪರಿಣಾಮ ಬೀರಿದೆ" ಎಂದು ತಿಳಿಸಿದೆ.
- ಲೀ, ಚೋ, ಝೌ ಮತ್ತು ಜಿಯೋನ್ (2025) ರವರ 'ಜನರೇಟಿವ್ ಎಐ ಇನ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಎಜುಕೇಶನ್: ಎ ಸಿಸ್ಟಮ್ಯಾಟಿಕ್ ರಿವ್ಯೂ ಆಫ್ ಕ್ಲಾಸ್‌ರೂಮ್–ಬೇಸ್ಡ್ ಎಂಪಿರಿಕಲ್ ರಿಸರ್ಚ್' ಎಂಬ ಸಂಶೋಧನಾ ಲೇಖನವು 'ಇಂಟರಾಕ್ಟಿವ್ ಲರ್ನಿಂಗ್ ಎನ್ವಿರಾನ್‌ಮೆಂಟ್ಸ್' ನಿಯತಕಾಲಿಕದಲ್ಲಿ ಪ್ರಕಟವಾಗಿದೆ. ಈ ಅಧ್ಯಯನವು "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯು ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಇಂಗ್ಲಿಷ್ ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ಹೆಚ್ಚಾಗಿದೆ. ವಿವಿಧ ಭಾಷೆಗಳು, ಭಾಷಾ ಕೌಶಲ್ಯಗಳನ್ನು ಕಲಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯ ಕುರಿತು ಹೆಚ್ಚಿನ ಸಂಶೋಧನೆ ಅಗತ್ಯವಿದೆ" ಎಂದು ಅಧ್ಯಯನವು ತಿಳಿಸಿದೆ.
- ಲಿ, ಟಾನ್, ವಾಂಗ್ ಮತ್ತು ಲೋವೆಲ್ (2025) ರವರ 'ಜನರೇಟಿವ್ ಂಐ ಇನ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಲರ್ನಿಂಗ್ ಅಂಡ್ ಟೀಚಿಂಗ್: ಎ ಸಿಸ್ಟಮ್ಯಾಟಿಕ್ ರಿವ್ಯೂ ಆಫ್ ಎಂಪಿರಿಕಲ್ ಸ್ಟಡೀಸ್' ಎಂಬ

ಸಂಶೋಧನಾ ಲೇಖನವು 'ಕಂಪ್ಯೂಟರ್ಸ್ ಅಂಡ್ ಎಜುಕೇಶನ್: ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜೆನ್ಸ್' ನಿಯತಕಾಲಿಕದಲ್ಲಿ ಪ್ರಕಟವಾಗಿದೆ. ಈ ಅಧ್ಯಯನವು "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಕುರಿತ ಅಧ್ಯಯನಗಳು ಬರವಣಿಗೆ ಕೌಶಲ್ಯದ ಮೇಲೆ ಕೇಂದ್ರೀಕೃತವಾಗಿವೆ. ಆಲಿಸುವಿಕೆ, ಓದುಗಾರಿಕೆ ಮತ್ತು ಮಾತುಗಾರಿಕೆ ಕೌಶಲ್ಯಗಳ ಬಗ್ಗೆ ಹೆಚ್ಚಿನ ಅಧ್ಯಯನಾಗಬೇಕಿದೆ" ಎಂದು ತಿಳಿಸಿದೆ.

3. ಸಂಶೋಧನಾ ಅಂತರ

ಈಗ ಕೈಗೊಳ್ಳಲಾಗಿರುವ ಬಹುತೇಕ ಸಂಶೋಧನೆಗಳು ಇಂಗ್ಲಿಷ್ ಭಾಷಾ ಕಲಿಕೆ, ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಬರವಣಿಗೆ ಚಟುವಟಿಕೆಗಳಿಗೆ ಆದ್ಯತೆ ನೀಡಿವೆ. ಭಾರತೀಯ ಭಾಷೆಗಳ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯ ಕುರಿತು ಹೆಚ್ಚಿನ ಪ್ರಾಯೋಗಿಕ ಸಂಶೋಧನೆ ಕೈಗೊಳ್ಳುವ ಅಗತ್ಯವಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಸುತ್ತಿರುವ ಬಗ್ಗೆ ಹೆಚ್ಚಿನ ಸಂಶೋಧನೆಗಳಾಗಿವೆ. ಆದರೆ ಶಿಕ್ಷಕರು ಪಾಠಯೋಜನೆ, ಅನುವಾದ, ಸಾರಂಶೀಕರಣ, ಮೌಲ್ಯಮಾಪನ, ಪ್ರಶ್ನೆಪತ್ರಿಕೆ ತಯಾರಿ ಮತ್ತು ಬೋಧನಾ ಸಾಮಗ್ರಿಗಳ ಸಿದ್ಧತೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ ಕುರಿತು ಇನ್ನಷ್ಟು ಸಂಶೋಧನೆಗಳನ್ನು ಕೈಗೊಳ್ಳುವ ಅಗತ್ಯವಿದೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಈ ಅಧ್ಯಯನವನ್ನು ಕೈಗೊಳ್ಳಲಾಗಿದೆ.

4. ಸಂಶೋಧನಾ ವಿಧಾನ: ಈ ಅಧ್ಯಯನಕ್ಕೆ ವರ್ಣನಾತ್ಮಕ ಸಂಶೋಧನಾ ವಿಧಾನವನ್ನು ಅನುಸರಿಸಲಾಗಿದೆ.

5. ದತ್ತಾಂಶಗಳ ವಿಶ್ಲೇಷಣೆ : ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ

5.1 ಪಠ್ಯ ಮತ್ತು ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳ ರಚನೆ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಪಾಠಯೋಜನೆ, ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳು, ಉದಾಹರಣೆಗಳು, ಪ್ರಶ್ನಾವಳಿಗಳು, ಅಭ್ಯಾಸ ಪತ್ರಿಕೆ, ಭಾಷಾ ಚಟುವಟಿಕೆಗಳು ಹಾಗೂ ಬೋಧನಾ ಮತ್ತು ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ತ್ವರಿತವಾಗಿ ಸಿದ್ಧಪಡಿಸಲು ಸಹಕಾರಿಯಾಗಿದೆ. ಇದರಿಂದ ಶಿಕ್ಷಕರ ಸಮಯ ಮತ್ತು ಕಾರ್ಯದ ಹೊರೆಯು ಕಡಿಮೆ ಕಡಿಮೆಯಾಗುತ್ತದೆ. ಆದರೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ರಚಿಸಿದ ವಿಷಯವನ್ನು ಶಿಕ್ಷಕರು ಬಳಸುವ ಮೊದಲು ಅದರ ನೈಜತೆ, ಭಾಷಾ ನಿಖರತೆ, ಸಾಂಸ್ಕೃತಿಕ ಪ್ರತಿನಿಧಿತ್ವ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾನಸಿಕ ಮಟ್ಟಕ್ಕೆ ಅನುಗುಣವಾಗಿದೆಯೇ ಎಂಬುದನ್ನು ಪರಿಶೀಲಿಸುವುದು ಅಗತ್ಯ.

5.2 ಅನುವಾದ: ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಹಾಯದಿಂದ ಪ್ರಾಂತೀಯ ಭಾಷೆಯಲ್ಲಿರುವ ವಿಷಯಗಳನ್ನು ಆಂಗ್ಲ ಭಾಷೆಗೂ ಮತ್ತು ಆಂಗ್ಲ ಭಾಷೆಯಲ್ಲಿರುವ ವಿಷಯವನ್ನು ಪ್ರಾಂತೀಯ ಭಾಷೆಗಳಿಗೂ ಸುಲಭವಾಗಿ ಮತ್ತು ಶೀಘ್ರವಾಗಿ ಭಾಷಾಂತರಿಸಲು ಸಹಕಾರಿಯಾಗುತ್ತದೆ. ಇದರಿಂದ ವಿಷಯದ ಸ್ಪಷ್ಟ ಗ್ರಹಿಕೆ ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಜೊತೆಗೆ ಕಡಿಮೆ ಭಾಷಾ ಪ್ರೌಢಿಮೆಯುಳ್ಳವರೂ ಪಠ್ಯವನ್ನು ಭಾಷಾ ನ್ಯೂನ್ಯತೆ ಇಲ್ಲದಂತೆ ಬೇರೊಂದು ಭಾಷೆಗೆ ಭಾಷಾಂತರಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ.

5.3 ಸ್ವಯಂ ಕಲಿಕೆ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ವೈಯಕ್ತಿಕ ಮತ್ತು ಪರಿಣಾಮಕಾರಿಯಾಗಿಸಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಸಾಮರ್ಥ್ಯ, ವೇಗ ಮತ್ತು

ಅಗತ್ಯತೆಗಳನ್ನು ಗುರುತಿಸಿ; ಅವುಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಪಠ್ಯ ಚಟುವಟಿಕೆಗಳು ಹಾಗೂ ಭಾಷಾಭ್ಯಾಸಗಳನ್ನು ಒದಗಿಸುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಗಳ ಉತ್ತರಗಳು ಮತ್ತು ಕಲಿಕಾ ಪ್ರಗತಿಯನ್ನು ಆಧರಿಸಿ, ಚಟುವಟಿಕೆ ಮಟ್ಟದಲ್ಲಿ ಮಾರ್ಪಾಡು ಮಾಡುತ್ತದೆ. ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ ಮತ್ತು ಅಗತ್ಯ ಸೂಚನೆಗಳ ಮೂಲಕ ಕಲಿಕಾ ದೋಷಗಳನ್ನು ಸರಿಪಡಿಸಲು ನೆರವಾಗುತ್ತದೆ. ಹೀಗಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಆಸಕ್ತಿಗೆ ಪ್ರೇರೇಪಣೆ ನೀಡಿ, ನಿರಂತರ ಕಲಿಕೆಗೆ ಅನುವು ಮಾಡಿಕೊಡುತ್ತದೆ.

5.4 ಸಂವಾದಾತ್ಮಕ ತಂತ್ರಾಂಶಗಳು (ಚಾಟ್‌ಬಾಟ್): ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಸಂವಾದಾತ್ಮಕ ತಂತ್ರಾಂಶಗಳು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ನಿರಂತರವಾಗಿ ಪಠ್ಯ ಅಥವಾ ಧ್ವನಿ ಸಂವಹನದ ಮೂಲಕ ಭಾಷಾ ಚಟುವಟಿಕೆಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಸಂಭಾಷಣೆ, ಸಂದರ್ಶನ, ಉದಾಹರಣೆಗಳು, ಭಾಷಾ ಚರ್ಚೆ ಮತ್ತು ವಿಶ್ಲೇಷಣೆಯಂತಹ ನೈಜ ಬದುಕಿನ ಭಾಷಾ ಬಳಕೆಯ ಕೃತಕ ಸನ್ನಿವೇಶಗಳನ್ನು ಅನುಕರಿಸುವ ಮೂಲಕ ಭಾಷಾ ಕೌಶಲ್ಯವನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಿಕೊಳ್ಳಬಹುದು. ಇಂತಹ ಸಂವಾದಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂವಹನ ಕೌಶಲ್ಯ ಮತ್ತು ಆತ್ಮವಿಶ್ವಾಸವನ್ನು ವೃದ್ಧಿಸುತ್ತವೆ. ಇದರಿಂದ ಕಲಿಕೆಯೂ ಹೆಚ್ಚು ಆಸಕ್ತಿದಾಯಕವಾಗುತ್ತದೆ.

5.5 ಭಾಷಾ ಕಲಿಕಾ ವಿಸ್ತರಣೆ : ವಿದ್ಯಾರ್ಥಿಗಳು ತರಗತಿಯ ನಂತರವೂ ವಿರಾಮ ಸಮಯದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಹಾಯದಿಂದ ಭಾಷಾ ಅಭ್ಯಾಸವನ್ನು ಮುಂದುವರಿಸಬಹುದಾಗಿದೆ.

5.6 ವ್ಯಾಕರಣ ಕಲಿಕೆ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವ್ಯಾಕರಣ ನಿಯಮಗಳನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸರಳವಾಗಿ ಮತ್ತು ಸೂಕ್ತ ಉದಾಹರಣೆಗಳ ಮೂಲಕ ವಿವರಿಸುತ್ತದೆ. ಅಭ್ಯಾಸ ಪ್ರಶ್ನೆಗಳನ್ನು ನೀಡುವ ಮೂಲಕ ಭಾಷಾ ಕಲಿಕೆಗೆ ನೆರವಾಗುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಗಳ ಬರವಣಿಗೆಯಲ್ಲಿನ ವ್ಯಾಕರಣ ದೋಷಗಳು, ವಾಕ್ಯರಚನೆ, ಪದಪ್ರಯೋಗ ಹಾಗೂ ವಿಷಯ ಸಂಘಟನೆಯಲ್ಲಿರುವ ದೋಷಗಳನ್ನು ಗುರುತಿಸಿ, ತಕ್ಷಣದಲ್ಲಿ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುತ್ತದೆ. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ಭಾಷಾ ಅಭಿವ್ಯಕ್ತಿ ಮತ್ತು ಕೌಶಲ್ಯಗಳನ್ನು ಉತ್ತಮಪಡಿಸಿಕೊಳ್ಳಲು ನೆರವಾಗುತ್ತದೆ.

5.7 ಓದುಗಾರಿಕೆ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಓದುಗಾರಿಕೆಯನ್ನು ಉತ್ತಮಪಡಿಸಲು ಕಠಿಣ ಪದಗಳ ವಿಶ್ಲೇಷಣೆ ಹಾಗೂ ಸರಳೀಕೃತ ಪಠ್ಯಗಳನ್ನು ಒದಗಿಸುತ್ತದೆ.

5.8 ಮಾತುಗಾರಿಕೆ : ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಧ್ವನಿ ಗುರುತಿಸುವಿಕೆ (ಎ ಎಸ್ ಆರ್) ತಂತ್ರಜ್ಞಾನವು ವಿದ್ಯಾರ್ಥಿಗಳ ಉಚ್ಚಾರಣೆ, ಮಾತಿನ ವೇಗ, ಧ್ವನಿ ಸ್ಪಷ್ಟತೆ ಮತ್ತು ಪದಪ್ರಯೋಗದ ಕುರಿತು ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವ ಮೂಲಕ ಮಾತುಗಾರಿಕೆ ಕೌಶಲ್ಯವನ್ನು ವೃದ್ಧಿಸಲು ನೆರವಾಗುತ್ತದೆ. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತರಗತಿಯ ಹೊರಗೂ ಮಾತುಗಾರಿಕೆ ಅಭ್ಯಾಸಕ್ಕೆ ಅವಕಾಶ ಲಭಿಸುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಕೇವಲ ಒಂದೇ ಪ್ರಮಾಣಿತ ಭಾಷೆಯನ್ನು ಏಕೈಕ ಮಾದರಿಯಾಗಿ ಪರಿಗಣಿಸದೇ, ಉಪಭಾಷೆಗಳಿಗೂ ಮಹತ್ವ ನೀಡಬೇಕು. ಪ್ರಾದೇಶಿಕ ಭಾಷೆಗಳ ಉಚ್ಚಾರಣೆ ಮತ್ತು ಭಾಷಾ ವೈವಿಧ್ಯವನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳಬೇಕು

5.9 ಪದಸಂಪತ್ತಿನ ವೃದ್ಧಿ ಮತ್ತು ಬರವಣಿಗೆ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಪದಸಂಪದವನ್ನು ವೃದ್ಧಿಸಲು ಹೊಸ ಪದಗಳು, ಅವುಗಳಿಗೆ ಅರ್ಥಗಳು, ಸಮಾನಾರ್ಥಕ ಪದಗಳು, ವಿರುದ್ಧಾರ್ಥಕ ಪದಗಳನ್ನು ಒದಗಿಸುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯಕ್ಕೆ ಅನುಗುಣವಾಗಿ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳನ್ನು ಒದಗಿಸುವುದು. ಪದಗಳನ್ನು ಕೇವಲ ಕಂಠಪಾಠ ಮಾಡುವ ಬದಲಾಗಿ ಉದಾಹರಣೆಗಳೊಂದಿಗೆ ಸಂದರ್ಭೋಚಿತವಾಗಿ ಬಳಸುವ ಅವಕಾಶ ಕಲ್ಪಿಸುವುದು.

5.10 ಶೈಕ್ಷಣಿಕ ಪ್ರಸ್ತುತಿಗಳ ರಚನೆ : ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ಅತೀ ಶೀಘ್ರವಾಗಿ ಮತ್ತು ಆಕರ್ಷಕವಾಗಿ **"**ಪವರ್ ಪಾಯಿಂಟ್ ಪ್ರಸ್ತುತಿಗಳನ್ನು**"** ಸಿದ್ಧಪಡಿಸಬಹುದು.

5.11 ಮೌಲ್ಯಮಾಪನ: ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಪಠ್ಯಕ್ರಮವನ್ನು ಆಧರಿಸಿ ಅತಿ ಶೀಘ್ರವಾಗಿ ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆಗಳನ್ನು, ಉತ್ತರ ಸೂಚಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಬೋಧಕರಿಗೆ ನೆರವಾಗುತ್ತದೆ. ಇದರೊಂದಿಗೆ ರಸಪ್ರಶ್ನೆ, ರೂಪಣಾತ್ಮಕ ಹಾಗೂ ಸಂಕಲನಾತ್ಮಕ ಮೌಲ್ಯಮಾಪನ ಪ್ರಶ್ನೆಗಳು, ಅಂಕಗಳ ಮಾನದಂಡ ಸೃಜನೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳಿಂದ ಹಿಮ್ಮಾಹಿತಿ ಪಡೆಯಲು, ತಪಶೀಲು ಪಟ್ಟಿಯನ್ನು ಸಿದ್ಧಪಡಿಸಲು ನೆರವು ನೀಡುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ಬೋಧಕರು ವಿದ್ಯಾರ್ಥಿಗಳ ಉತ್ತರ ಪತ್ರಿಕೆಗಳಲ್ಲಿ ಕಿರು ಉತ್ತರಗಳು, ವಸ್ತುನಿಷ್ಠ ಪ್ರಶ್ನೆಗಳ ಉತ್ತರಗಳು ಮತ್ತು ವ್ಯಾಕರಣ ಅಭ್ಯಾಸಗಳನ್ನು ನೇರವಾಗಿ ಮತ್ತು ಅತಿ ಶೀಘ್ರವಾಗಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಬಹುದು. ಇದು ಶಿಕ್ಷಕರ ಸಮಯವನ್ನು ಉಳಿಸುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಉತ್ತರಗಳನ್ನು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ಸ್ವಯಂ ಮೌಲ್ಯಮಾಪನ ಮಾಡಿಕೊಳ್ಳಬಹುದು. ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವುದು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪ್ರಮುಖ ಅನುಕೂಲವಾಗಿದ್ದು, ಇದು ಕಲಿಕೆಯನ್ನು ಸುಧಾರಿಸುತ್ತದೆ.

6) ಪ್ರಮುಖ ಅವಕಾಶಗಳು

- **ಎಲ್ಲರಿಗೂ ಕಲಿಕಾ ಅವಕಾಶ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ತಂತ್ರಾಂಶಗಳು ಜಗತ್ತಿನಲ್ಲಿಡೆಯು ಭಾಷಾ ಕಲಿಕಾರ್ಥಿಗಳಿಗೂ ಹಾಗೂ ಸೀಮಿತ ಬೋಧಕರನ್ನು ಹೊಂದಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೂ ಹೆಚ್ಚಿನ ಭಾಷಾ ಕಲಿಕೆಯ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ಮೊಬೈಲ್ ಫೋನ್ ಮೂಲಕ ಗ್ರಾಮೀಣ ಮತ್ತು ಅರೆನಗರ ಪ್ರದೇಶಗಳ ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಸಿ, ಕಡಿಮೆ ವೆಚ್ಚದಲ್ಲಿ ಭಾಷೆಯನ್ನು ಕಲಿಯಬಹುದು. ಆದರೆ ಮೊಬೈಲ್ ಸಾಧನ, ಅಂತರ್ಜಾಲ ಸೌಲಭ್ಯ ಮತ್ತು ವಿದ್ಯುತ್ ಲಭ್ಯತೆಯ ಅಸಮಾನತೆಗಳು ಇದರ ವ್ಯಾಪಕ ಬಳಕೆಗೆ ಅಡ್ಡಿಯಾಗಿವೆ. ಆದ್ದರಿಂದ ಆಫ್‌ಲೈನ್ ಸೌಲಭ್ಯವಿರುವ ಹಾಗೂ ಪ್ರಾಂತೀಯ ಭಾಷಾ ದತ್ತಾಂಶಗಳನ್ನು ಹೊಂದಿರುವ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಅಭಿವೃದ್ಧಿ ಪಡಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ.
- **ಬಹುಭಾಷಾ ಶಿಕ್ಷಣ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಭಾಷಾಂತರ, ಧ್ವನಿ–ಪಠ್ಯ ಮತ್ತು ಪಠ್ಯ–ಧ್ವನಿ ತಂತ್ರಜ್ಞಾನಗಳು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಬಹುಭಾಷಾ ಗ್ರಹಿಕೆ ಹಾಗೂ ಸಂವಹನವನ್ನು ಸುಲಭಗೊಳಿಸುತ್ತವೆ. ಭಾರತದಂತಹ ಬಹುಭಾಷಾ ರಾಷ್ಟ್ರದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಸ್ಥಳೀಯ ಭಾಷೆಗಳ ಕಲಿಕೆ ಮತ್ತು ಬೋಧನೆಗೆ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ತೆರೆದಿಟ್ಟಿದೆ. ಅನ್ಯ ಭಾಷಾ ಲೇಖನ ಓದಿ ಗ್ರಹಿಸಲು ಹಾಗೂ

ಪ್ರವಾಸದ ಸಂದರ್ಭಗಳಲ್ಲಿ ಭಾಷಾಂತರ ತಂತ್ರಜ್ಞಾನವು ನೆರವಾಗುತ್ತದೆ. ಇದು ಸಫಲವಾಗಬೇಕಾದರೆ ಕಡಿಮೆ ದತ್ತಾಂಶಗಳನ್ನು ಹೊಂದಿರುವ ಸ್ಥಳೀಯ ಭಾಷೆಗಳಲ್ಲಿ ಭಾಷಾ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಲು ಹೆಚ್ಚಿನ ಆದ್ಯತೆ ನೀಡಬೇಕಾಗಿದೆ.

- **ವಿದ್ಯಾರ್ಥಿ ಸ್ವಾಯತ್ತತೆ:** ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಮ್ಮದೇ ವೇಗದಲ್ಲಿ ಕಲಿಯಲು, ಅಭ್ಯಾಸ ಕೈಗೊಳ್ಳಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಅವಕಾಶ ಕಲ್ಪಿಸುವ ಮೂಲಕ ಹಾಗೂ ತಕ್ಷಣ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಯ ಸ್ವಯಂ ಕಲಿಕೆಯನ್ನು ಉತ್ತೇಜಿಸುತ್ತಿದೆ. ಇದರಿಂದ ಶಿಕ್ಷಕರ ಮೇಲಿನ ಸಂಪೂರ್ಣ ಅವಲಂಬನೆಯನ್ನು ಕಡಿಮೆಯಾಗಿದೆ. ಆದಾಗ್ಯೂ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ನೀಡುವ ಮಾಹಿತಿಯನ್ನು ಯಾಂತ್ರಿಕವಾಗಿ ಸ್ವೀಕರಿಸುವ ಬದಲು ಪ್ರಶ್ನಿಸುವುದು, ಮೂಲಗಳನ್ನು ಪರಿಶೀಲಿಸುವುದು, ಮಾಹಿತಿಯನ್ನು ಹೋಲಿಕೆ ಮಾಡುವುದು ಮತ್ತು ಸ್ವತಂತ್ರ ಅಭಿಪ್ರಾಯ ರೂಪಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳು ಬೆಳೆಸಿಕೊಳ್ಳುವುದು ಅಗತ್ಯ.

7. ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಸಮಸ್ಯೆಗಳು

- **ನಿಖರತೆ ಕೊರತೆ ಮತ್ತು ಅವಾಸ್ತವಿಕ ಮಾಹಿತಿ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಭಾಷಾ ಮಾದರಿಗಳು ಕೆಲವೊಮ್ಮೆ ತಪ್ಪು ಮಾಹಿತಿ, ಅಸಹಜ ವಾಕ್ಯಗಳು, ಉದಾಹರಣೆಗಳು ಅಥವಾ ಸಂದರ್ಭೋಚಿತವಲ್ಲದ ಭಾಷಾ ರೂಪಗಳನ್ನು ಸೃಷ್ಟಿಸಬಹುದು. ಇಂದು ವಿಶೇಷವಾಗಿ ಸ್ಥಳೀಯ ಇತಿಹಾಸ, ಸಾಹಿತ್ಯ ಮತ್ತು ಸಂಸ್ಕೃತಿಗೆ ಸಂಬಂಧಿಸಿದಂತೆ ನಿಖರತೆ ಮಾಹಿತಿಗಳ ಕೊರತೆಯಿಂದ ಉಂಟಾಗಬಹುದು. ಆದ್ದರಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಜ್ಞಾನದ ಅಂತಿಮ ಮೂಲವಾಗಿ ಪರಿಗಣಿಸದೆ, ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸಬೇಕು. ಇದು ನೀಡುವ ಮಾಹಿತಿಯನ್ನು ವಿಶ್ವಾಸಾರ್ಹ ಪಠ್ಯಪುಸ್ತಕಗಳು, ಸಂಶೋಧನಾ ಲೇಖನಗಳು ಮತ್ತು ಅಧಿಕೃತ ಮೂಲಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸುವುದು ಅಗತ್ಯ.
- **ಶೈಕ್ಷಣಿಕ ಅಪ್ರಾಮಾಣಿಕತೆ :** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಬಳಸಿಕೊಂಡು ವಿದ್ಯಾರ್ಥಿಗಳು ಪೂರ್ಣ ಪ್ರಬಂಧ, ಉತ್ತರ ಅಥವಾ ನಿಯೋಜಿತ ಕಾರ್ಯಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಿ; ತಮ್ಮದೇ ಕೃತಿಯೆಂದು ಸಲ್ಲಿಸುವ ಸಾಧ್ಯತೆಯಿದೆ. ಇದು ಕಲಿಕೆಯ ಉದ್ದೇಶವನ್ನು ದುರ್ಬಲಗೊಳಿಸುವುದರೊಂದಿಗೆ ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಧಕ್ಕೆಯುಂಟುಮಾಡಬಹುದು. ಆದ್ದರಿಂದ ಬೋಧಕರು ಮೌಲ್ಯಮಾಪನ ಸಂದರ್ಭದಲ್ಲಿ ಕೇವಲ ನೈಜತೆ ಪತ್ತೆ ಸಾಧನಗಳ ಮೇಲೆ ಅವಲಂಬಿಸದೆ; ಕರಡು, ಮೌಖಿಕ ವಿವರಣೆ, ತರಗತಿ ಚರ್ಚೆ, ವೈಯಕ್ತಿಕ ಪ್ರತಿಫಲನ ಮತ್ತು ಪ್ರಕ್ರಿಯಾಧಾರಿತ ಮೌಲ್ಯಮಾಪನಕ್ಕೆ ಆದ್ಯತೆ ಆದ್ಯತೆ ನೀಡಬೇಕು.
- **ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ:** ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಅವರ ಬರವಣಿಗೆ, ಧ್ವನಿ, ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಗಳು ಮತ್ತು ಕಲಿಕಾ ವರ್ತನೆಗೆ ಸಂಬಂಧಿಸಿದ ದತ್ತಾಂಶಗಳ ಗೌಪ್ಯತೆಗೆ ಅಪಾಯ ಉಂಟಾಗಬಹುದು. ಆದ್ದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಸುವಾಗ ದತ್ತಾಂಶ ಸಂಗ್ರಹಣೆ, ಸುರಕ್ಷಿತತೆ, ಅನುಮತಿ ಮತ್ತು ಪಾರದರ್ಶಕ ಗೌಪ್ಯತಾ ನೀತಿಗಳನ್ನು ಖಚಿತಪಡಿಸುವುದು ಅಗತ್ಯ.

- **ಅಲ್ಗಾರಿದಮಿಕ್ ಪಕ್ಷಪಾತ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಲಭ್ಯವಿರುವ ದತ್ತಾಂಶದಲ್ಲಿರುವ ಭಾಷಾ, ಸಾಂಸ್ಕೃತಿಕ ಮತ್ತು ಸಾಮಾಜಿಕ ತಾರತಮ್ಯಗಳನ್ನು ಪುನರ್ ಸೃಷ್ಟಿಸುವ ಸಾಧ್ಯತೆಯಿದೆ. ಇದರಿಂದ ಇದು ಕೆಲವು ಭಾಷೆಗಳು, ಉಪಭಾಷೆಗಳು ಅಥವಾ ಪ್ರಾದೇಶಿಕ ಭಾಷೆಗಳನ್ನು ಕಡಿಮೆ ಗುಣಮಟ್ಟದವುಗಳೆಂದು ಪರಿಗಣಿಸುವ ಅಪಾಯವಿದೆ. ಆದ್ದರಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ಭಾಷಾ ವೈವಿಧ್ಯತೆ, ಪ್ರಾದೇಶಿಕ ಉಚ್ಚಾರಣೆ ಮತ್ತು ಸಾಂಸ್ಕೃತಿಕ ಹಿನ್ನೆಲೆಗಳ ಬಗ್ಗೆ ಅರಿವಿರುವ ಬೋಧಕರ ಮೇಲ್ವಿಚಾರಣೆಯ ಅಗತ್ಯವಿದೆ.
- **ಡಿಜಿಟಲ್ ಅಸಮಾನತೆ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಕಲಿಕೆಯಲ್ಲಿ ಎಲ್ಲಾ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೂ ವೇಗದ ಅಂತರ್ಜಾಲ ಸೌಲಭ್ಯ, ಆಧುನಿಕ ಸಾಧನಗಳು ಮತ್ತು ಪಾವತಿಸಬೇಕಾದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳ ಲಭ್ಯತೆ ಇಲ್ಲದ ಕಾರಣ ಡಿಜಿಟಲ್ ಅಸಮಾನತೆಗೆ ಕಾರಣವಾಗಬಹುದು. ಇದರಿಂದ ತಂತ್ರಜ್ಞಾನ ಲಭ್ಯತೆ ಹೊಂದಿರುವ ಮತ್ತು ಹೊಂದಿರದ ವಿದ್ಯಾರ್ಥಿಗಳ ನಡುವಿನ ಕಲಿಕಾ ಅಂತರವು ಹೆಚ್ಚಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ. ಆದ್ದರಿಂದ ಕಲಿಕಾರ್ಥಿಗಳಿಗೆ ಉಚಿತ ಅಥವಾ ಮುಕ್ತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳು, ಸಾಧನಗಳು, ಆಫ್‌ಲೈನ್ ಕಲಿಕಾ ತಂತ್ರಾಂಶಗಳು ಮತ್ತು ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಯ ತಾಂತ್ರಿಕ ನೆರವನ್ನು ಒದಗಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ.
- **ಸೃಜನಶೀಲತೆಗೆ ಧಕ್ಕೆ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅತಿಯಾದ ಬಳಕೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಭಾಷಾ ಕ್ಷಮತೆಯನ್ನು ಕುಂಠಿತಗೊಳಿಸಬಹುದು.

8. ಜವಾಬ್ದಾರಿಯುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯ ಚೌಕಟ್ಟು

ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಜವಾಬ್ದಾರಿಯುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಗಾಗಿ ಈ ಕೆಳಗಿನ ತತ್ವಗಳನ್ನು ಅನುಸರಿಸಬಹುದು:

- **ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ಶಿಕ್ಷಕರು ಪರಿಶೀಲಿಸಿ, ಅಂತಿಮ ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು.
- **ಪಾರದರ್ಶಕತೆ:** ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ವಿಧಾನ ಮತ್ತು ಮಿತಿಗಳನ್ನು ತಿಳಿದಿರಬೇಕು.
- **ಗೌಪ್ಯತೆ:** ವೈಯಕ್ತಿಕ ಮತ್ತು ಸೂಕ್ಷ್ಮ ದತ್ತಾಂಶಗಳನ್ನು ಅನಗತ್ಯವಾಗಿ ಹಂಚಿಕೊಳ್ಳಬಾರದು.
- **ಸಮಾನತೆ:** ಎಲ್ಲ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಮಾನ ಕಲಿಕಾ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸಬೇಕು.
- **ಭಾಷಾ ವೈವಿಧ್ಯ:** ಉಪಭಾಷೆ, ಉಚ್ಚಾರಣೆ ಮತ್ತು ಸ್ಥಳೀಯ ಭಾಷಾ ರೂಪಗಳಿಗೆ ಗೌರವ ನೀಡಬೇಕು.
- **ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಯ ಸ್ವಂತ ಕೊಡುಗೆಯನ್ನು ಸ್ಪಷ್ಟವಾಗಿ ಗುರುತಿಸಬೇಕು.

- **ವಿಮರ್ಶಾತ್ಮಕ ಸಾಕ್ಷರತೆ:** ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮಾಹಿತಿಗಳನ್ನು ಪರಿಶೀಲಿಸುವ ಮತ್ತು ಪ್ರಶ್ನಿಸುವ ಕೌಶಲ್ಯ ಬೆಳೆಸಬೇಕು.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯ ಕೇಂದ್ರ ತತ್ವವೆಂದರೆ "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮೂಲಕ ಶಿಕ್ಷಣ"ಕ್ಕಿಂತ "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯೊಂದಿಗೆ ಉತ್ತಮ ಶಿಕ್ಷಣ" ಎಂಬ ದೃಷ್ಟಿಕೋನವಾಗಬೇಕು. ಶಿಕ್ಷಕರು ತಂತ್ರಜ್ಞಾನ ಆಯ್ಕೆ ಮಾಡುವಾಗ ಅದರ ಶೈಕ್ಷಣಿಕ ಮೌಲ್ಯ, ಪಾಲ್ಗೊಳ್ಳುವಿಕೆ, ಸುರಕ್ಷತೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ಮೇಲೆ ಉಂಟಾಗುವ ಪರಿಣಾಮವನ್ನು ಪರಿಗಣಿಸಬೇಕಾಗಿದೆ.

9. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಯುಗದಲ್ಲಿ ಭಾಷಾ ಶಿಕ್ಷಕರ ಪಾತ್ರ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಯುಗದಲ್ಲಿ ಭಾಷಾ ಶಿಕ್ಷಕರ ಪ್ರಾಮುಖ್ಯತೆ ಕಡಿಮೆಯಾಗದೆ, ಅವರ ಪಾತ್ರವು ಹೊಸ ರೂಪ ಪಡೆದುಕೊಳ್ಳುತ್ತಿದೆ. ಶಿಕ್ಷಕರು ಕಲಿಕಾ ಸೌಲಭ್ಯಕಾರರು, ಚಟುವಟಿಕೆಗಳ ವಿನ್ಯಾಸಕರು, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ನಿರ್ಮಿತ ವಿಷಯದ ಮೌಲ್ಯಮಾಪಕರು, ಮಾರ್ಗದರ್ಶಕರು ಹಾಗೂ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ನೈತಿಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯನ್ನು ಉತ್ತೇಜಿಸುವವರಾಗಬೇಕು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಾಗುವ ಬದಲಾಗಿ ಅವರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೆಚ್ಚಿಸುವ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತಿದೆ. ಪಠ್ಯ ವಿಶ್ಲೇಷಣೆ, ವಿದ್ಯಾರ್ಥಿಗಳ ಪ್ರಗತಿ ಮೇಲ್ವಿಚಾರಣೆ ಹಾಗೂ ವೈವಿಧ್ಯಮಯ ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳನ್ನು ರೂಪಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಕರಿಗೆ ನೆರವಾಗುತ್ತದೆ. ಆದ್ದರಿಂದ ಭಾಷಾ ಶಿಕ್ಷಕರಿಗೆ ಭಾಷಾ ಮತ್ತು ಶಿಕ್ಷಣಶಾಸ್ತ್ರೀಯ ಜ್ಞಾನದ ಜೊತೆಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಾಕ್ಷರತೆ, ಸುಳಿವು ನೀಡಿಕೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಪ್ರತಿಕ್ರಿಯೆ ಪರಿಶೀಲನೆ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಯ ಅರಿವು ಅಗತ್ಯವಾಗಿದೆ.

10.ಶಿಫಾರಸ್ಸುಗಳು

- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಸ್ಪಷ್ಟವಾದ ಭಾಷಾ ಕಲಿಕಾ ಫಲಿತಾಂಶಗಳನ್ನು ಪಡೆಯಲು ಬಳಸಬೇಕು.
- ಶಿಕ್ಷಕರ ಶೈಕ್ಷಣಿಕ ನಿರ್ಣಯವನ್ನು ಯಾವುದೇ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವ್ಯವಸ್ಥೆ ಬದಲಿಸಬಾರದು.
- ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು 'ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ' ಬಳಕೆ, ಉಲ್ಲೇಖ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಸಂಬಂಧಿಸಿದಂತೆ ನೀತಿಗಳನ್ನು ರೂಪಿಸಬೇಕು.
- ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಣ, ಮೂಲ ಪರಿಶೀಲನೆ ಮತ್ತು ಡಿಜಿಟಲ್ ಪ್ರಾಮಾಣಿಕತೆಯನ್ನು ಕಲಿಸಬೇಕು.
- ಸ್ಥಳೀಯ ಭಾಷೆಗಳು ಮತ್ತು ಉಪಭಾಷೆಗಳಿಗೆ ಬೆಂಬಲ ನೀಡುವ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳನ್ನು ಅಭಿವೃದ್ಧಿ ಪಡಿಸಬೇಕು.
- ಸಂವೇದನಾಶೀಲ ವಿದ್ಯಾರ್ಥಿಗಳ ದತ್ತಾಂಶಗಳನ್ನು ಅನಗತ್ಯವಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಾಂಶಗಳಿಗೆ ನೀಡಬಾರದು.

- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಮೌಲ್ಯಮಾಪನವನ್ನು ಮಾನವ ಮೌಲ್ಯಮಾಪನದೊಂದಿಗೆ ಸಂಯೋಜಿಸಬೇಕು.
- ತಂತ್ರಜ್ಞಾನದ ಅಸಮಾನತೆಯನ್ನು ಕಡಿಮೆ ಮಾಡಲು ಮುಕ್ತ ಮತ್ತು ಆಫ್‌ಲೈನ್ ತಂತ್ರಾಂಶಗಳನ್ನು ಒದಗಿಸಬೇಕು.
- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ಪರಿಣಾಮವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆ ಮೇಲೆ ನಿರಂತರವಾಗಿ ಪರಿಶೀಲಿಸಬೇಕು.

11. ಉಪಸಂಹಾರ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ನಿರಂತರ ಅಭ್ಯಾಸ, ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ, ಅನುವಾದ, ಬರವಣಿಗೆ, ಪದ ಸಂಪತ್ತಿನ ಅಭಿವೃದ್ಧಿ, ಮಾತುಗಾರಿಕೆ ಮತ್ತು ಮೌಲ್ಯಮಾಪನಕ್ಕೆ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತಿದೆ. ಶಿಕ್ಷಕರಿಗೆ ಪಾಠಯೋಜನೆ, ಕಲಿಕಾ ಸಾಮಗ್ರಿ ಮತ್ತು ಮೌಲ್ಯಮಾಪನ ಸಿದ್ದಪಡಿಸಲು ಇದು ಪರಿಣಾಮಕಾರಿ ಸಹಾಯಕ ಸಾಧನವಾಗಿದೆ.

ಆದರೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯಲ್ಲಿ ತಪ್ಪು ಮಾಹಿತಿ, ಶೈಕ್ಷಣಿಕ ಅಪ್ರಾಮಾಣಿಕತೆ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಭಾಷಾ ಪಕ್ಷಪಾತ ಮತ್ತು ಡಿಜಿಟಲ್ ಅಸಮಾನತೆಯಂತಹ ಸವಾಲುಗಳಿವೆ. ಆದ್ದರಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಾಗಿ ಬಳಸದೆ, ಶಿಕ್ಷಕರ ಮಾರ್ಗದರ್ಶನ ಮತ್ತು ಮೇಲ್ವಿಚಾರಣೆಯೊಂದಿಗೆ ಬಳಸುವುದು ಅಗತ್ಯ. ಭಾರತದ ಪ್ರಾಂತೀಯ ಭಾಷೆಗಳು, ಸಂಸ್ಕೃತಿ ಮತ್ತು ಭಾಷಾ ವೈವಿಧ್ಯಕ್ಕೆ ಸೂಕ್ತ ಬೆಂಬಲ ನೀಡುವ ಡಿಜಿಟಲ್ ದತ್ತಾಂಶಗಳ ಅಭಿವೃದ್ಧಿಗೆ ಆದ್ಯತೆ ನೀಡಬೇಕು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಾಂತ್ರಿಕ ಶಕ್ತಿ ಮತ್ತು ಶಿಕ್ಷಕರ ಮಾನವೀಯ ಹಾಗೂ ಶಿಕ್ಷಣಶಾಸ್ತ್ರೀಯ ಸಾಮರ್ಥ್ಯಗಳ ಸಮತೋಲನದ ಬಳಕೆಯೇ ಪರಿಣಾಮಕಾರಿ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಭಾಷಾ ಶಿಕ್ಷಣಕ್ಕೆ ಆಧಾರವಾಗಬಲ್ಲದು.

ಪಾರಮಾರ್ಶನ ಗ್ರಂಥಗಳು ಹಾಗೂ ಜಾಲತಾಣಗಳು

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ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಸವಾಲುಗಳು.

ಡಾ. ಗುರುಸ್ವಾಮಿ ಹಿರೇಮಠ
ಸಹ ಪ್ರಾಧ್ಯಾಪಕರು, ಕನ್ನಡ ವಿಭಾಗ, ಸರಕಾರಿ ಪ್ರಥಮ ದರ್ಜೆ ಕಾಲೇಜು, ನವನಗರ, ಬಾಗಲಕೋಟೆ.

ಸಾರಾಂಶ

*ಚಲನಶೀಲ ಬದುಕಿಗಾಗಿ ಮತ್ತು ಇಂದಿನ ಆಧುನಿಕ ಯುಗವು ರೂಪಿಸಿಕೊಂಡಿರುವ ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಜೀವನಶೈಲಿಗಳು ದಿನದಿಂದ ದಿನಕ್ಕೆ ವೇಗವಾಗಿ ಬದಲಾಗುತ್ತಿವೆ. ಆದ್ದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಹೊಸ ಹೊಸ ಸವಾಲುಗಳಿಗೆ ಸಜ್ಜುಗೊಳಿಸುವ ಹಾಗೂ ಜ್ಞಾನಪರಂಪರೆಯನ್ನು ತಲೆಮಾರುಗಳಿಂದ ತಲೆಮಾರುಗಳಿಗೆ ವಿಸ್ತರಿಸುವ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಪಡಿಸುವಲ್ಲಿ ಶಿಕ್ಷಕರು ಮಹತ್ವದ ಪಾತ್ರವನ್ನು ವಹಿಸಬೇಕಿದೆ. ಅಲ್ಲದೇ ಕಾಲ ಕಾಲಕ್ಕೆ ಸಮುದಾಯ, ಸಾಮಾಜಿಕ ವ್ಯವಸ್ಥೆಗಳು ಬದಲಾಗುತ್ತಾ ಶಿಕ್ಷಣದಲ್ಲಿಯೂ ಮಹತ್ತರ ಬದಲಾವಣೆಗಳಾಗಬೇಕೆಂಬುದನ್ನು ಪ್ರತಿಯೊಂದು ಚಲನಶೀಲ ಸಮಾಜ ಬಯಸುತ್ತದೆ. ಹಾಗಾಗಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ ಕೇವಲ ಪಠ್ಯ ಪುಸ್ತಕದ ಬೋಧನೆಗೆ ಮಾತ್ರ ಸೀಮಿತವಾಗಿಲ್ಲ. ಬದಲಾಗುತ್ತಿರುವ ಈ ಸಂದರ್ಭಕ್ಕೆ ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿಗಳ ಮನೋಧೋರಣೆಗಳನ್ನು ಅನುಲಕ್ಷಿಸಿ ಮತ್ತು ಜಾಗತಿಕ ವ್ಯವಸ್ಥೆಯು ಯಾವುದನ್ನು ಬಯಸುತ್ತದೆಯೋ ಅದನ್ನು ಆದ್ಯತೆಯ ಅಂಶವಾಗಿಸಿಕೊಂಡು ನಿರಂತರ ಕಲಿಕೆ ಮತ್ತು ಸ್ವಯಂ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ, ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನದ ಅಳವಡಿಕೆ, ಬೋಧನಾ ವಿಧಾನದಲ್ಲಿ ನಾವಿನ್ಯತೆ, ದೈಹಿಕ ಮತ್ತು ಮಾನಸಿಕ ಆರೋಗ್ಯದ ನಿರ್ವಹಣೆ, ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ಹಾಗೂ ಸನ್ನಿವೇಶವನ್ನು ರೂಪಿಸುವ, ನಿರ್ದೇಶಿಸುವ ಮತ್ತು ನಿಯಂತ್ರಿಸುವ ಸಾಮರ್ಥ್ಯ, ಸಹಯೋಗ ಮತ್ತು ಸಂವಹನಶೀಲತೆಯಂತಹ ಮಹತ್ತರ ಬದಲಾವಣೆಗಳಿಗೆ ಒಡ್ಡಿಕೊಳ್ಳಬೇಕಾದ ಅನಿವಾರ್ಯತೆಯನ್ನು ಅರ್ಥವಾಗಿಸಿಕೊಳ್ಳಬೇಕಾಗಿದೆ. ಇದನ್ನೇ ಮಹತ್ಮಾ ಗಾಂಧೀಜಿ ಅವರು **'ಉತ್ತಮ ಶಿಕ್ಷಣದ ಉದ್ದೇಶವೆಂದರೆ ಕೇವಲ ಕಲಿಸುವುದಲ್ಲ; ಕಲಿಯುವ ಆಸೆಯನ್ನು ಹುಟ್ಟಿಸುವುದು'** (ಪ್ರಜಾವಾಣಿ ದಿನಪತ್ರಕೆ–1 ಸಪ್ಟಂಬರ್ 2026 ಸುಭಾಷಿತ ವಿಭಾಗ) ಎಂದು ಹೇಳಿದ್ದು ಇಲ್ಲಿ ಮಹತ್ವವನ್ನು ಪಡೆದುಕೊಳ್ಳುತ್ತದೆ. ಈ ಎಲ್ಲ ಸಂಗತಿಗಳನ್ನು ಗಮನಿಸಿಕೊಳ್ಳವುದು ಮತ್ತು ಶಿಕ್ಷಕರನ್ನು ರೂಪಿಸುವ ಹಾಗೂ ತರಬೇತುಗೊಳಿಸುವ ಮಾನದಂಡಗಳು ಇನ್ನೂ ಸಾಂಪ್ರದಾಯಿಕ ಮಾದರಿಯಲ್ಲೇ ಉಳಿದಿರುವುದು ಪ್ರಮುಖ ಸಮಸ್ಯೆಯಾಗಿದೆ. ಮಾತ್ರವಲ್ಲ ಸವಾಲಾಗಿಯೂ ಪರಿವರ್ತನೆಯಾಗಿರುವುದನ್ನು ಅರಿತುಕೊಳ್ಳವ ಮತ್ತು ಅದಕ್ಕಿರುವ ಸಾಧ್ಯತೆಗಳನ್ನು ಶೋಧಿಸಿಕೊಳ್ಳುವುದು ಈ ಲೇಖನದ ಆಶಯವಾಗಿದೆ.*

ಮುಖ್ಯಪದಗಳು *(Keywords): ನಿರಂತರ ಕಲಿಕೆ ಮತ್ತು ಸ್ವಯಂ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ, ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನದ ಅಳವಡಿಕೆ, ಬೋಧನಾ ವಿಧಾನದಲ್ಲಿ ನಾವಿನ್ಯತೆ, ದೈಹಿಕ ಮತ್ತು ಮಾನಸಿಕ ಆರೋಗ್ಯದ ನಿರ್ವಹಣೆ, ಕಲಿಕಾ ಸನ್ನಿವೇಶವನ್ನು ರೂಪಿಸುವ, ನಿರ್ದೇಶಿಸುವ ಮತ್ತು ನಿಯಂತ್ರಿಸುವ ಸಾಮರ್ಥ್ಯ*

ಪೀಠಿಕೆ : ಶಿಕ್ಷಣವು ಬೋಧನೆ ಮತ್ತು ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ ಎಂಬುದನ್ನು ಮಾತ್ರ ವ್ಯಾಖ್ಯಾನಿಸದೇ ಅದು 'ಸಮಗ್ರ ಮಾನವನ ನಿರ್ಮಾಣವೇ ಶಿಕ್ಷಣದ ಉದ್ದೇಶ'ವಾಗಿದೆ. ಅದಕ್ಕೆ ಪೂರವಾಗಿ ಮಗು ತನ್ನನ್ನು ತಾನು ಅರಿತುಕೊಳ್ಳುವ ಜವಾಬ್ದಾರಿಯನ್ನು ಕಲಿಸಬೇಕಾದ ಅನಿವಾರ್ಯತೆ ಮತ್ತು ಅಗತ್ಯತೆ ಇದೆ. ಅದಕ್ಕಾಗಿ ಏನನ್ನು? ಏತಕ್ಕಾಗಿ? ಹೇಗೆ? ಎಂಬೆಲ್ಲಾ ಪ್ರಶ್ನೆಗಳೊಂದಿಗೆ ಶಿಕ್ಷಕ ತನ್ನನ್ನು ತಾನು ಜವಾಬ್ದಾರಿಯುತ ವ್ಯಕ್ತಿಯೆಂಬುದನ್ನು ಪರಿಗಣಿಸಿಕೊಳ್ಳಬೇಕಿದೆ. ಅಂದಾಗ ಈ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಒಳ್ಳೆಯತನ, ನಿರ್ಭಯತೆ, ಜವಾಬ್ದಾರಿತನ, ಕ್ರಾಂತಿಕಾರಕ ಬದಲಾವಣೆ, ದಕ್ಷತೆ, ಮಾನಸಿಕ ಅವಮಾನಗಳನ್ನು ಪ್ರತಿರೋಧಿಸಿಕೊಳ್ಳುವ

ಸಾಮರ್ಥ್ಯ, ಅಂತರ್ಭೋಧೆ ಹಾಗೂ ಪ್ರಾಮಾಣಿಕತೆಯಂತಹ ಚಿಂತನೆಗಳು ಚಲನಶೀಲಗೊಳ್ಳುವವು. ವ್ಯಕ್ತಿ ಸ್ಪಷ್ಟತೆಯೊಂದಿಗೆ ಬದುಕುವ ಮತ್ತು ಅದನ್ನು ಮೌಲ್ಯಯುತವಾಗಿಸಿಕೊಳ್ಳುವ, ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆ ಮಾನವತೆಯ ಜ್ಞಾನೋದಯದ ಕೇಂದ್ರವಾಗಿಸಿಕೊಳ್ಳಲು ಮಾಡಬೇಕಿರುವ ಜವಾಬ್ದಾರಿಯನ್ನು ಪಡೆದುಕೊಳ್ಳಬೇಕಾಗಿದೆ. ಇದನ್ನು ಪರಸ್ಪರರಿಂದ ಮತ್ತು ಪರಸ್ಪರರ ಭವಿಷ್ಯಕ್ಕಾಗಿ ರೂಪಿಸಿಕೊಳ್ಳಬೇಕಿದೆ ಎಂಬುದನ್ನು ಮನವರಿಕೆಗೆ ತಂದುಕೊಳ್ಳಬೇಕಿದೆ. ಈ ನಿಟ್ಟಿನಲ್ಲಿ ಎದುರಾಗುವ ಸವಾಲುಗಳನ್ನು ಗುರುತಿಸುವ, ಪರಿಹರಿಸಿಕೊಳ್ಳುವ ಸಹಚಿಂತನ ಅಗತ್ಯವಿದೆ. ಈ ಸಂದರ್ಭಕ್ಕೆ ಡಾ. ಬಿ. ಆರ್. ಅಂಬೇಡ್ಕರ್ ಅವರ ಸೂಕ್ತಿ ಮುಖ್ಯವೆನಿಸುತ್ತದೆ. **'ತಾನಿರುವ ಕತ್ತಲೆಯನ್ನು ಅರಿಯದವನು ಬೆಳಕಿಗಾಗಿ ಎಂದೂ ಹುಡುಕಾಡುವುದಿಲ್ಲ'** (ಪ್ರಜಾವಾಣಿ ದಿನಪತ್ರಕೆ– 2 ಸಪ್ಟಂಬರ್ 2026 ಸುಭಾಷಿತ ವಿಭಾಗ) ಎನ್ನುವ ಎಚ್ಚರಿಕೆಯ ನುಡಿ ಮಹತ್ವ ಪಡೆದುಕೊಳ್ಳುತ್ತದೆ. ಆದ್ದರಿಂದ ಶಿಕ್ಷಕ ಮತ್ತು ಕಲಿಕಾರ್ಥಿ ತನ್ನ ವಸ್ತುಸ್ಥಿತಿಯನ್ನು ಅರಿತು ತಮ್ಮ ದೈನಿಕಗಳಿಗೆ ಸಂಬಂಧವಿಲ್ಲದ ಅಭಿಪ್ರಾಯ ಹಾಗೂ ನಂಬಿಕೆಗಳ ಜೊತೆ ಬದುಕದೇ ಚಲನಶೀಲ ಜೀವನವನ್ನು ರೂಪಿಸಿಕೊಳ್ಳಬೇಕಿದೆ. ಆದರೆ ಇದಕ್ಕೆ ಅನೇಕ ಸ್ವಯಂಕೃತ ಸವಾಲುಗಳಿವೆ. ಈ ಸವಾಲುಗಳನ್ನು ಪರಸ್ಪರ ಸಹಚಿಂತನೆಯೊಂದಿಗೆ ಮರುವಿನ್ಯಾಸಗಳನ್ನು ಸೃಷ್ಟಿಸಿಕೊಳ್ಳಬೇಕಿದೆ.

ಶಿಕ್ಷಣದ ವ್ಯಾಖ್ಯಾನಗಳು ವಿಭಿನ್ನ ಮನೋಧೋರಣೆಗಳನ್ನು ಹೊಂದಿದ್ದು ಪ್ರಮುಖವಾಗಿ ಸಾಮಾಜಿಕ ಸಮಾನತೆಯ ವಾದಗಳು, ಬಂಡವಾಳಶಾಹಿ ಚಿಂತನೆಗಳು, ನಿರಂಕುಶ ಪ್ರಭುತ್ವವಾದಿ ಚಿಂತನೆಗಳು, ಪ್ರಜಾತಂತ್ರ ನೈತಿಕ ಮೌಲ್ಯಗಳೊಂದಿಗಿನ ಚಿಂತನೆಗಳು ಮತ್ತು ಅಧಿಕಾರಶಾಹಿ ಚಿಂತನೆಗಳು ಬೋಧನಾ ಸಂದರ್ಭಗಳನ್ನು ಮತ್ತು ಪಠ್ಯಗಳನ್ನು ರೂಪಿಸುವಲ್ಲಿ ಮಹತ್ವದ ಪ್ರಭಾವವನ್ನು ಬೀರುತ್ತವೆ. ಆದ್ದರಿಂದ ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆ ಹೇಗಿದೆ ಎಂಬುದನ್ನು ಸೂಕ್ಷ್ಮವಾಗಿ ಗಮನಿಸಿದಾಗ 'ಸ್ಪರ್ಧಾತ್ಮಕವಾಗಿರಬೇಕು, ಮಹತ್ವಾಕಾಂಕ್ಷಿಯಾಗಿರಬೇಕು, ಯಶಸ್ಸನ್ನು ಆರಾಧಿಸಬೇಕು ಎಂದು ಬಾಲ್ಯದಿಂದಲೂ ಮೆದುಳಿಗೆ ತರಬೇತಿ ನೀಡಲಾಗಿದೆ. ಇದು 'ನಾನು' ಅಥವಾ 'ಅಹಂ'ಗೆ ಮಹತ್ವ ನೀಡಿದಂತೆ. ಹೀಗಾಗಿ ಸಹಕಾರದ ಸತ್ವ ಮುದುಡುತ್ತದೆ. ಇದೆಲ್ಲವೂ ಸಾಮಾಜಿಕ ಪ್ರತಿಷ್ಠೆಯನ್ನು ತಂದುಕೊಡುವ ಶಿಕ್ಷಣದ ಹೆಸರಿನಲ್ಲಿ ನಡೆಯುತ್ತಿದೆ. ಜಗತ್ತಿನಾದ್ಯಂತ ಈ ಕ್ರಿಯೆಗಳನ್ನು ಶಿಕ್ಷಣ ಎನ್ನಲಾಗುತ್ತಿದೆ. ಆದುದರಿಂದ ಶಿಕ್ಷಣ ಎಂಬ ಪದದ ಬಗ್ಗೆಯೇ ನಾವು ಸಂಶಯ ತಳೆಯಬೇಕಾಗಿದೆ ಅಥವಾ ಪ್ರಶ್ನಿಸಬೇಕಾಗಿದೆ' (ಚಲನಶೀಲ ಬದುಕು–ಕಲಿಕೆ, ಜಿಡ್ಡು ಕೃಷ್ಣಮೂರ್ತಿ, ಪು.ಸಂ:218) ಎನ್ನುವ ವಿಚಾರವನ್ನು ಗಂಭೀರವಾಗಿ ಚರ್ಚಿಸಬೇಕಾಗಿದೆ. ಹಾಗೆಯೇ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟದ ಬಗ್ಗೆ ಅಂತರಾಷ್ಟ್ರೀಯ ಮಟ್ಟದಲ್ಲಿ ಪ್ರಮುಖ ಚರ್ಚೆಗಳು ಮತ್ತು ಗಂಭೀರವಾದ ಪ್ರಶ್ನೆಗಳು ಉದ್ಭವಿಸಿವೆ. ಬದಲಾಗುತ್ತಿರುವ ಆಧುನಿಕ ಜಗತ್ತಿಗೆ ತಕ್ಕಂತೆ ಶಿಕ್ಷಕರನ್ನು ಸಿದ್ಧಪಡಿಸುವಲ್ಲಿ ಜಾಗತಿಕ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆ ಎದುರಿಸುತ್ತಿರುವ ಮತ್ತು ಈ ಕುರಿತು ಎದ್ದಿರುವ ಮಹತ್ವದ ಪ್ರಶ್ನೆಗಳ ಬಗ್ಗೆ ಆಲೋಚಿಸಬೇಕಾಗಿದೆ. ಹಾಗಾಗಿ ಅವುಗಳಲ್ಲಿ ಕೆಲವು ಪ್ರಶ್ನೆಗಳನ್ನು ಮತ್ತು ಸವಾಲುಗಳನ್ನು ಇಲ್ಲಿ ಬಳಸಿಕೊಳ್ಳಲಾಗಿದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕುರಿತ ಕೆಲವು ಪ್ರಶ್ನೆಗಳು:

- ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ, ಚಾಟ್ಗಳು ಮತ್ತು ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನಗಳು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರವನ್ನು ಆವರಿಸಿಕೊಳ್ಳುತ್ತಿರುವಾಗ ಶಿಕ್ಷಕರನ್ನು ಕೇವಲ ಮಾಹಿತಿ ನೀಡುವ ಮತ್ತು ಮಾರ್ಗದರ್ಶಕರನ್ನಾಗಿಸುವ ಪ್ರಯತ್ನಗಳು ನಡೆಯುತ್ತಿವೆಯೇ?
- ಜಗತ್ತಿನಾದ್ಯಂತ ಅಸಂಖ್ಯಾತ ಗುಣಮಟ್ಟದ ತರಬೇತಿ ಪಡೆದ ಯಶಸ್ವಿ ಶಿಕ್ಷಕರ ಕೊರತೆಯಿದೆ. ಇಂತಹ ಪರಿಸ್ಥಿಯಲ್ಲಿ ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಕರನ್ನು ಈ ಕ್ಷೇತ್ರಕ್ಕೆ ಆಕರ್ಷಿಸುವುದು ಮತ್ತು ಅವರನ್ನು ವೃತ್ತಿಪರನ್ನಾಗಿ ಉಳಿಸಿಕೊಳ್ಳುವುದು ಹೇಗೆ?
- ವಲಸೆ ಮತ್ತು ಜಾಗತೀಕರಣದಿಂದಾಗಿ ಇಂದಿನ ತರಗತಿಗಳಲ್ಲಿ ವಿವಿಧ ದೇಶಗಳ ಭಾಷೆ, ಸಂಸ್ಕೃತಿಗಳ ಹಿನ್ನಲೆಯ ವಿದ್ಯಾರ್ಥಿಗಳೊಂದಿಗೆ ಸೇರಿ ಕಲಿಸುವ ಸಾಮರ್ಥ್ಯ ಆಧರಿತ 'ಅಂತರ್ಗತ ಶಿಕ್ಷಣ'ವನ್ನು ನೀಡಲು ಸಾಧ್ಯವಾಗುತ್ತಿದೆಯೇ?
- ಸಾಂಪ್ರದಾಯಿಕ ಶೈಕ್ಷಣಿಕ ವಿಚಾರಧಾರೆಗಳನ್ನು ಮತ್ತು ಆಧುನಿಕ ವೈಚಾರಿಕ, ವೈಜ್ಞಾನಿಕ ವಿಚಾರಧಾರೆಗಳನ್ನು ಸಮನ್ವಯಗೊಳಿಸುವ ಪ್ರಯೋಜನಾತ್ಮಕ ಸನ್ನಿವೇಶಗಳನ್ನು ಕಟ್ಟಿಕೊಳ್ಳುವಲ್ಲಿ ಶೈಕ್ಷಣಿಕ ವ್ಯವಸ್ಥೆ ಸಮರ್ಥವಾಗಿದೆಯೇ?
- ಶಿಕ್ಷಕರಾಗಿ ನಿಯುಕ್ತಗೊಂಡವರಿಗೆ ಸೂಕ್ತ ಮತ್ತು ಸೂಕ್ಷ್ಮ ತರಬೇತಿಗಳನ್ನು ನಿಯಮಾನುಸಾರ ನೀಡಲಾಗುತ್ತಿದೆಯೇ? ಮತ್ತು ತರಬೇತಿಯನ್ನು ಪಡೆಯಲು ಮತ್ತು ಅದನ್ನು ಆನ್ವಯೀಕರಣಗೊಳಿಸಲು ಶಿಕ್ಷಕರು ಉತ್ಸುಕರಾಗಿರುವವರ ಪ್ರಮಾಣಗಳು ಎಷ್ಟು?
- ಶಿಕ್ಷಕರು ನಿರಂತರವಾಗಿ ಬೋಧನೆಯಲ್ಲಿ ತೊಡಗಿಸಿಕೊಂಡರೂ ನಿರಂತರ ಕಲಿಕೆ ಮತ್ತು ಸ್ವಯಂ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಗಾಗಿ ಸೂಕ್ತ ಮತ್ತು ಸಕಾರಾತ್ಮಕ ವಾತಾವರಣವನ್ನು ಕಲ್ಪಿಸುವಲ್ಲಿ ವ್ಯವಸ್ಥೆ ಸದೃಢವಾಗಿದೆಯೇ?
- ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನದ ಅಳವಡಿಕೆ, ಬೋಧನಾ ವಿಧಾನದಲ್ಲಿ ನಾವಿನ್ಯತೆಯನ್ನು ಬಳಸಿಕೊಳ್ಳವಲ್ಲಿ ಶಿಕ್ಷಕರು ತೋರಿಸುವ ಸಕಾರಾತ್ಮಕ, ಸ್ಪಂದನಾ ಮನೋಭಾವನೆಗಳನ್ನು ಕಂಡುಕೊಳ್ಳುವಲ್ಲಿ ಇರುವ ಮಾನದಂಡಗಳು ವಿಶ್ವಾಸಾರ್ಹವಾಗಿವೆಯೇ?
- ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಬಂಡವಾಳಶಾಹಿಗಳ ಪ್ರಭಾವ ಹೆಚ್ಚಾದಂತೆಲ್ಲಾ ಶಿಕ್ಷಕರ ಬೋಧನೆಯ ಮೇಲಾಗುವ ಪರಿಣಾಮ ಹಾಗೂ ದೈಹಿಕ ಮತ್ತು ಮಾನಸಿಕ ಆರೋಗ್ಯದ ನಿರ್ವಹಣೆಗೆ ಸೂಕ್ತ ಆರ್ಥಿಕ, ಸಾಮಾಜಿಕ, ಮನೋ–ಉಲ್ಲಾಸದ ವಾತಾವರಣವನ್ನು ಒದಗಿಸುವಲ್ಲಿ ಶೈಕ್ಷಣಿಕ ಸಂಘ–ಸಂಸ್ಥೆಗಳು ಅಗತ್ಯ ಉದಾರತೆಯನ್ನು ಹೊಂದಿವೆಯೇ?
- ಕಲಿಕಾ ಸನ್ನಿವೇಶವನ್ನು ರೂಪಿಸುವ, ನಿರ್ದೇಶಿಸುವ ಮತ್ತು ನಿಯಂತ್ರಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಶಿಕ್ಷಕ ಸಮುದಾಯಕ್ಕೆ ನೀಡಲಾಗಿದೆಯೇ?

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕುರಿತ ಕೆಲವು ಸವಾಲುಗಳು:

- ಅಭಿವೃದ್ಧಿಯ ಮಾನದಂಡಗಳು ಜಾಗತಿಕವಾಗಿ ಸಮಾನರೇಖೆಯಲ್ಲಿರದ ಕಾರಣ ಮತ್ತು ವೈಜ್ಞಾನಿಕವಾಗಿ, ತಾಂತ್ರಿಕವಾಗಿ ಸಮಾನವಾಗಿ ಬೆಳೆಯಲು ಅವಕಾಶಗಳು ಇಲ್ಲದಿರುವ ಕಾರಣ ಅಭಿವೃದ್ಧಿ ಹೊಂದಿರುವ ದೇಶಗಳು ಮತ್ತು ಹೊಂದದ ದೇಶಗಳ ಶೈಕ್ಷಣಿಕ ಗುಣಮಟ್ಟದಲ್ಲಿ ಅಂತರ ಹೆಚ್ಚುತ್ತಲೇ ಸಾಗುತ್ತಿರುವುದು. ಇದನ್ನು ನಿಯಂತ್ರಿಸುವಲ್ಲಿ ವಿಫಲವಾಗುತ್ತಿರುವುದು ಒಂದು ಸವಾಲಾಗಿ ಪರಿಣಮಿಸಿದೆ.
- ಜಾಗತಿಕ ವಲಯದಲ್ಲಿನ ತೀವ್ರತರವಾದ ತಾಂತ್ರಿಕ, ಆರ್ಥಿಕ ಮತ್ತು ರಾಜಕೀಯ ಬದಲಾವಣೆಗಳು ಶೈಕ್ಷಣಿಕ ಪಠ್ಯಗಳ, ತರಬೇತಿ ಮಾನದಂಡಗಳನ್ನು ತೀವ್ರಗತಿಯಲ್ಲಿ ಬದಲಾಯಿಸುತ್ತಿರುವ ಕಾರಣ ಅಭಿವೃದ್ಧಿಶೀಲ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಹೊಂದದ ರಾಷ್ಟ್ರಗಳ ಶೈಕ್ಷಣಿಕ ಬೆಳವಣಿಗೆ ಹಾಗೂ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ತರಬೇತಿಯ ಮೇಲೂ ಪ್ರಭಾವ, ಪರಿಣಾಮ ಬೀರುವುದನ್ನು ಸಕಾರಾತ್ಮಕವಾಗಿಸುವಲ್ಲಿ ಬಹುರಾಷ್ಟ್ರಗಳು ವಿಫಲವಾಗುತ್ತಿರುವುದು ಮತ್ತೊಂದು ಪ್ರಮುಖ ಸವಾಲಾಗಿದೆ.
- ಅಭಿವೃದ್ಧಿಶೀಲ ಮತ್ತು ಅಭಿವೃದ್ಧಿ ಹೊಂದದ ರಾಷ್ಟ್ರಗಳಲ್ಲಿ ಕಾರ್ಯಮಾಡುತ್ತಿರುವ ಶಿಕ್ಷಕ ಸಮುದಾಯಗಳು ಸಾಮಾನ್ಯವಾಗಿ ಕಡಿಮೆ ವೇತನ ಮತ್ತು ಗರಿಷ್ಠ ಕೆಲಸದ ಒತ್ತಡವನ್ನು ಎದುರಿಸುತ್ತಿವೆ. ಇದರ ಪರಿಣಾಮವಾಗಿ ಮನೋ–ದೈಹಿಕ ಕಾಯಿಲೆಗಳಿಗೆ ಒಳಗಾಗುವ ಮತ್ತು ಆರ್ಥಿಕವಾಗಿ ದುರ್ಬಲವಾಗುವ ಸಂದರ್ಭಗಳು ದಿನೇ ದಿನೇ ಹೆಚ್ಚುತ್ತಿರುವುದು ಆತಂಕಕಾರಿ ಬೆಳವಣಿಗೆ ಎಣಿಸುತ್ತಿದೆ. ಇದರಿಂದಾಗಿ ವೃತ್ತಿಪರ ಗೌರವದ ಕುಸಿತ ಮತ್ತು ಆರ್ಥಿಕ ಮುಗ್ಗಟ್ಟು ಕಾರಣದಿಂದಾಗಿ ಯುವ ಪ್ರತಿಭಾವಂತ ಶಿಕ್ಷಕರನ್ನು ಶೈಕ್ಷಣಿಕ ವಲಯ ಆಕರ್ಷಿಸುವಲ್ಲಿ ವಿಫಲವಾಗುತ್ತಿರುವುದು ಒಂದು ಸವಾಲಾಗಿದೆ.
- ಯುದ್ಧ ಮತ್ತು ಅತಿಯಾದ ರಾಸಾಯನಿಕ ಯುಕ್ತ ಆಹಾರಗಳು ಆರೋಗ್ಯದ ಮೇಲೆ ಪರಿಣಾಮ ಬೀರುತ್ತಿರುವ ಕಾರಣ ಜನ್ಮತಳೆಯು ಮಕ್ಕಳಲ್ಲಿ ವಿಶೇಷ, ವಿಕಲಚೇತನ ಮಕ್ಕಳ ಜನನ ಪ್ರಮಾಣದಲ್ಲಿ ಆಗುತ್ತಿರುವ ಬೆಳವಣಿಗೆ ಒಂದು ಪ್ರಮುಖ ಸವಾಲಾಗಿದೆ. ಇದರಿಂದಾಗಿ ಸಹಜ ಮತ್ತು ಪ್ರತಿಭಾವಂತ ಮಕ್ಕಳೊಂದಿಗೆ ಸ್ಪರ್ಧೆಮಾಡಲು ವಿಫಲವಾಗುವುದಲ್ಲದೇ ಕಲಿಸುವ ಬೋಧಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಮೇಲೂ ಪರಿಣಾಮವಾಗಿ ಕಲಿಕಾ ಗುಣಮಟ್ಟವು ಕುಸಿಯಲು ಕಾರಣವಾಗುತ್ತಿದೆ.
- ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ಪದವಿ ಪ್ರಮಾಣ ಪತ್ರಗಳನ್ನು ಮಾತ್ರ ನೀಡುವ ಉದ್ದೇಶವನ್ನು ಹೊಂದಿರುವ ಮನೋ–ಧೋರಣೆಯಿಂದ ಹೊರಗೆ ಬರದೇ ಇರುವುದು. ಅಲ್ಲದೇ ಸಾಮರ್ಥ್ಯಗಳನ್ನು, ಕೌಶಲ್ಯಗಳನ್ನು, ಸಮಸ್ಯೆಯನ್ನು ಗುರುತಿಸುವ, ವಿಶ್ಲೇಷಿಸುವ, ವಿಮರ್ಶಿಸುವ ಮತ್ತು ವಸ್ತುನಿಷ್ಠವಾಗಿ ಮೌಲ್ಯಮಾಪನಕ್ಕೆ ಒಳಪಡಿಸುವ ಪ್ರಕ್ರಿಯೇಯನ್ನು ಉತ್ತಮಗೊಳಿಸಿಕೊಳ್ಳದಿರುವುದು ಸವಾಲಾಗಿ ಪರಿಣಮಿಸುತ್ತಿದೆ.
- ಸಾಂಪ್ರದಾಯಿಕ ಬೋಧನಾ ವಿಧಾನಗಳೊಂದಿಗೆ ಆಧುನಿಕ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳುವ ಮತ್ತು ಬದಲಾಗುತ್ತಿರುವ ಸನ್ನಿವೇಶಗಳಿಗೆ ಅಗತ್ಯವಿರುವ ಪರಿಷ್ಕರಣ

ಮಾದರಿಗಳನ್ನು ಆಸಕ್ತಿಯಿಂದ ರೂಢಿಸಿಕೊಳ್ಳದಿರುವುದು. ಮತ್ತು ಇಂತಹ ಸಂಗತಿಗಳಿಗೆ ನಿರೀಕ್ಷಿತ ಸಹಾಯ ದೊರೆಯದಿರುವುದು ಪ್ರಮುಖ ಅಡ್ಡಿಯಾಗಿದೆ.

- ಬಹು ಭಾಷೆ–ಧರ್ಮ–ಸಂಪ್ರದಾಯಗಳು–ಪ್ರಾದೇಶಿಕ ವೈವಿಧ್ಯತೆ ಮತ್ತು ವೈರುಧ್ಯತೆಗಳು ಕೇಂದ್ರ ಹಾಗೂ ರಾಜ್ಯಗಳಲ್ಲಿನ ವಿಭಿನ್ನ ಸಿದ್ಧಾಂತಗಳನ್ನು ಹೊಂದಿರುವ ಸರಕಾರಗಳ ಧೋರಣೆಗಳು ಪ್ರತಿ–ನಿರೂಪಣೆಗಳಲ್ಲಿ ಹೊಂದಾಣಿಕೆಯಾಗದ ಕಾರಣ ಬದಲಾವಣೆ ಮತ್ತು ನವೀನ ವಿಚಾರ–ಧಾರೆಗಳಿಗೆ ಬಹುಮತ ದೊರೆಯುತ್ತಿಲ್ಲ. ಇದರಿಂದಾಗಿ ಸೂಕ್ತ ತರಬೇತಿ ಮಾನದಂಡಗಳನ್ನು ರೂಪಿಸಿ ಕಾರ್ಯಗತಗೊಳಿಸುವಲ್ಲಿ ಆಗುತ್ತಿರುವ ವಿಳಂಬ ನೀತಿಗಳಿಂದಾಗಿ ತರಬೇತಿಯ ಉದ್ದೇಶಗಳು ಸಾಕಾರವಾಗದಿರುವುದು.

ಈ ಎಲ್ಲ ಪ್ರಶ್ನೆ ಮತ್ತು ಸವಾಲುಗಳ ಮೂಲಕ ವೃತ್ತಿಪರ ಬೆಳವಣಿಗೆ, ನವೀಕರಣ, ಆತ್ಮಾವಲೋಕನ, ಸೃಜನಶೀಲತೆ, ಮೌಲ್ಯಾಧಾರಿತ ಸಮಾಜ ನಿರ್ಮಾಣಕ್ಕಾಗಿ ನೈತಿಕ ಜವಾಬ್ದಾರಿಯನ್ನು ಪಡೆಯುವುದು, ಸಹಯೋಗದೊಂದಿಗೆ ಕಲಿಕಾ ವಾತಾವರಣವನ್ನು ನಿರೂಪಿಸಿಕೊಳ್ಳಬೇಕಿದೆ. ಅನುಭವಗಳಿಂದ ಕಲಿತ ವಿಭಿನ್ನ ಚಿಂತನೆಗಳನ್ನು ಹಂಚಿಕೊಳ್ಳುವುದು. ಇವೆಲ್ಲ ಸಂಗತಿಗಳು ಪ್ರಧಾನವೆನಿಸಿದರೂ 'ತೀರ ವಿಭಿನ್ನವಾದ ಶಿಕ್ಷಣದ ಅಗತ್ಯವಿದೆ. ಬಲವಂತ, ರೂಢಿಬದ್ಧತೆ, ಅನುಕರಣೆಗೆ ಒತ್ತುಕೊಡುವ ಶಿಕ್ಷಣವು ಹಿಂಸೆಗೆ ಕಾರಣವಾಗುತ್ತಿದೆ. ಆದರೆ 'ನೀನು ಮತ್ತು ನಾನು' ಅಳಿಸಿಹೋಗಿರುವ ಮನುಷ್ಯನ ಪೂರ್ಣ ಸಂಸ್ಕೃತಿಯನ್ನು ಸ್ಥಾಪಿಸುವ ಪ್ರಯತ್ನವು ಪ್ರಭುತ್ವದಿಂದಾಗಲಿ ನೂತನ ಪವಿತ್ರ ವ್ಯಕ್ತಿಯಿಂದಾಗಲಿ ಆಗುತ್ತಿಲ್ಲ. ಈ ಭಿನ್ನ ಶಿಕ್ಷಣವು ಜ್ಞಾನ, ಸ್ವಾತಂತ್ರ್ಯ ಏನಿದೆಯೋ ಅದು. ಹಾಗೂ ಏನಿದೆಯೊ ಅದರಾಚೆಗೆ ಹೋಗುವುದು. ಈ ಬಗ್ಗೆ ಕಳಕಳಿ ಹೊಂದಿದೆ. ವಿವೇಕವೆಂಬುದು ಯಾವುದೇ ಗ್ರಂಥದಲ್ಲಿಲ್ಲ. ಅದು ಜ್ಞಾನದ ಪರಿಪೂರ್ಣತೆಯಲ್ಲಿಲ್ಲ. ಅದು ಕಲಿಕೆಯಲ್ಲಿ ಕಂಡುಬರುವ ಬಿಡುಗಡೆಯ ಚಲನೆ. ಕಲಿಕೆಗೆ ಕೊನೆಯಿಲ್ಲ. ದುಃಖಗಳಿಲ್ಲದಿರುವುದೇ ವಿವೇಕ'(ಚಲನಶೀಲ ಬದುಕು–ಕಲಿಕೆ, ಜಿಡ್ಡು ಕೃಷ್ಣಮೂರ್ತಿ, ಪು.ಸಂ:೨೧೮) ಎಂಬುದನ್ನು ಅರಿತು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ತರಬೇತಿಯ ಮಾನದಂಡಗಳನ್ನು ರೂಪಿಸಬೇಕಾದ ಸವಾಲುಗಳಿವೆ.

ಪರಾಮರ್ಶನ ಗ್ರಂಥಗಳು:

ಚಲನಶೀಲ ಬದುಕು–ಕಲಿಕೆ, ಜಿಡ್ಡು ಕೃಷ್ಣಮೂರ್ತಿ, ವಸಂತ ಪ್ರಕಾಶನ ಜಯನಗರ, ಬೆಂಗಳೂರು–011
ಪ್ರಜಾವಾಣಿ ದಿನಪತ್ರಕೆ, 1, 2 ಸಪ್ಟಂಬರ್ 2026.
ಅಂತರ್ಜಾಲದ ಮಾಹಿತಿಗಳು.

"ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ಪಾತ್ರ"

ಡಾ. ಕಾವ್ಯ ಆರ್
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು, ರಾಜೀವ್ ಗಾಂಧಿ ಶಿಕ್ಷಣ ಮಹಾವಿದ್ಯಾಲಯ, ಭದ್ರಾವತಿ, ಶಿವಮೊಗ್ಗ.
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ಸಾರಾಂಶ

21ನೇ ಶತಮಾನದಲ್ಲಿ ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನವು ಶಿಕ್ಷಣದ ಸ್ವರೂಪ, ಬೋಧನಾ ವಿಧಾನ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಮಹತ್ವದ ಬದಲಾವಣೆಗಳನ್ನು ತಂದಿದೆ. ಸಾಂಪ್ರದಾಯಿಕ ಗುರುಕುಲ ಪದ್ಧತಿಯಿಂದ ಪ್ರಾರಂಭವಾದ ಶಿಕ್ಷಣವು ಇಂದು ಕಂಪ್ಯೂಟರ್, ಇಂಟರ್ನೆಟ್, ಇ–ಪುಸ್ತಕಗಳು, ಸಾಮಾಜಿಕ ಮಾಧ್ಯಮ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence–AI) ಆಧಾರಿತ ಕಲಿಕೆಯ ಹಂತವನ್ನು ತಲುಪಿದೆ. ವಿಶೇಷವಾಗಿ AI ತಂತ್ರಜ್ಞಾನವು ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವಿಷಯವನ್ನು ಒದಗಿಸುವುದು, ಕಠಿಣ ವಿಷಯಗಳನ್ನು ಸರಳೀಕರಿಸುವುದು, ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವುದು, ಭಾಷಾ ಕಲಿಕೆಯನ್ನು ಸುಲಭಗೊಳಿಸುವುದು ಹಾಗೂ ಅಸೈನ್‌ಮೆಂಟ್, ಪ್ರಾಜೆಕ್ಟ್ ಮತ್ತು ಸಂಶೋಧನಾ ಕಾರ್ಯಗಳಲ್ಲಿ ನೆರವಾಗುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ.

ಈ ಲೇಖನವು ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ AIಯ ಪಾತ್ರವನ್ನು ಪರಿಕಲ್ಪನಾತ್ಮಕವಾಗಿ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. AI ಆಧಾರಿತ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ದೃಶ್ಯ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಕಲಿಕೆ, ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ AIಯ ಬಳಕೆ, ಒಳಗೊಳ್ಳುವ ಶಿಕ್ಷಣ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಆಡಳಿತದಲ್ಲಿ ಅದರ ಸಾಧ್ಯತೆಗಳನ್ನು ಚರ್ಚಿಸಲಾಗಿದೆ. ಅದೇ ಸಮಯದಲ್ಲಿ AIಯ ಅತಿಯಾದ ಅವಲಂಬನೆ, ಸ್ವತಂತ್ರ ಚಿಂತನೆಯ ಕುಸಿತ, ಸೃಜನಶೀಲತೆಯ ಮೇಲೆ ಪರಿಣಾಮ, ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ, ಗೌಪ್ಯತೆ ಮತ್ತು ನೈತಿಕತೆಯಂತಹ ಸವಾಲುಗಳನ್ನೂ ಪರಿಗಣಿಸಲಾಗಿದೆ. AIಯನ್ನು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಾಗಿ ಪರಿಗಣಿಸುವ ಬದಲು ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸುವುದು ಅಗತ್ಯ ಎಂಬುದು ಲೇಖನದ ಪ್ರಮುಖ ನಿಲುವಾಗಿದೆ.

ಮುಖ್ಯ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣ, ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆ, ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಂಖ ಸಾಕ್ಷರತೆ, ಶಿಕ್ಷಕರ ಪಾತ್ರ, ಉನ್ನತ ಶಿಕ್ಷಣ.*

ಪರಿಚಯ: ಶಿಕ್ಷಣವು ಕಾಲ, ಸಮಾಜ ಮತ್ತು ತಂತ್ರಜ್ಞಾನದ ಬದಲಾವಣೆಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ರೂಪಾಂತರಗೊಳ್ಳುವ ನಿರಂತರ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ. ಪ್ರಾಚೀನ ಗುರುಕುಲ ಪದ್ಧತಿಯಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳು ಗುರುಗಳ ಆಶ್ರಮದಲ್ಲಿ ವಾಸಿಸಿ ಶೈಕ್ಷಣಿಕ ಜ್ಞಾನದ ಜೊತೆಗೆ ಯೋಗ, ಧ್ಯಾನ, ನೈತಿಕ ಮೌಲ್ಯಗಳು, ಕರಕುಶಲತೆ ಮತ್ತು ಜೀವನ ಕೌಶಲ್ಯಗಳನ್ನು ಕಲಿಯುತ್ತಿದ್ದರು. ಶಿಕ್ಷಕ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ನಡುವಿನ ಸಂಬಂಧವು ನಿಕಟವಾಗಿದ್ದು, ಶಿಕ್ಷಣವು ಸಮಗ್ರ ವ್ಯಕ್ತಿತ್ವ ವಿಕಾಸವನ್ನು ಕೇಂದ್ರವಾಗಿಟ್ಟುಕೊಂಡಿತ್ತು. ನಂತರ ನೇರ ಉಪನ್ಯಾಸ, ಕಂಠಪಾಠ, ಪಠ್ಯಪುಸ್ತಕ, ಬೋರ್ಡ್, ಪರೀಕ್ಷೆ ಮತ್ತು ಅಂಕಗಳ ಆಧಾರಿತ ಶಿಕ್ಷಣ ಪದ್ಧತಿ ಬೆಳೆಯಿತು. ಕ್ರಮೇಣ ಕಂಪ್ಯೂಟರ್, ಇಂಟರ್ನೆಟ್, ಪ್ರೊಜೆಕ್ಟರ್ ಮತ್ತು ಇ–ಪುಸ್ತಕಗಳು ಶಿಕ್ಷಣದ

ಭಾಗವಾದವು. ಪ್ರಸ್ತುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಮತ್ತೊಂದು ಮಹತ್ವದ ಪರಿವರ್ತನೆಯನ್ನು ತಂದಿದೆ. AI ಶಿಕ್ಷಣದಲ್ಲಿ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಸ್ವಯಂಚಾಲಿತ ಪ್ರತಿಕ್ರಿಯೆ, ಬೋಧನಾ ಸಹಾಯ ಮತ್ತು ಕಲಿಕಾ ವಿಶ್ಲೇಷಣೆಯಂತಹ ವಿವಿಧ ಸಾಧ್ಯತೆಗಳನ್ನು ಒದಗಿಸುತ್ತಿದೆ (Bond et al., 2024). UNESCO ಕೂಡ ಶಿಕ್ಷಣದಲ್ಲಿ Generative AI ಬಳಕೆಯು ಮಾನವ–ಕೇಂದ್ರಿತ, ಸುರಕ್ಷಿತ, ಸಮಾನ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತವಾಗಿರಬೇಕು ಎಂದು ಒತ್ತಿಹೇಳುತ್ತದೆ (Miao & Holmes, 2023).

ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು:

ಈ ಲೇಖನದ ಪ್ರಮುಖ ಉದ್ದೇಶಗಳು:

1. ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಉಂಟಾದ ಬದಲಾವಣೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.
2. ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯಲ್ಲಿ AIಯ ಪಾತ್ರವನ್ನು ಗುರುತಿಸುವುದು.
3. ವೈಯಕ್ತಿಕ ಕಲಿಕೆಗೆ AI ನೀಡುವ ಅವಕಾಶಗಳನ್ನು ವಿವರಿಸುವುದು.
4. ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ AIಯ ಬಳಕೆಯನ್ನು ಪರಿಶೀಲಿಸುವುದು.
5. AI ಬಳಕೆಯಿಂದ ಉಂಟಾಗಬಹುದಾದ ಶೈಕ್ಷಣಿಕ ಮತ್ತು ನೈತಿಕ ಸವಾಲುಗಳನ್ನು ಗುರುತಿಸುವುದು.
6. AI ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಬದಲಾಗುತ್ತಿರುವ ಪಾತ್ರವನ್ನು ವಿವರಿಸುವುದು.
7. ಜವಾಬ್ದಾರಿಯುತ AI ಬಳಕೆಗೆ ಅಗತ್ಯವಾದ ಸಲಹೆಗಳನ್ನು ನೀಡುವುದು.

ಅಧ್ಯಯನದ ವಿಧಾನ:

ಈ ಲೇಖನವು ಪರಿಕಲ್ಪನಾತ್ಮಕ ಮತ್ತು ವಿವರಣಾತ್ಮಕ ಸ್ವರೂಪದ ಅಧ್ಯಯನವಾಗಿದೆ. ಲೇಖನದ ಮೂಲಭೂತ ಚರ್ಚೆಯನ್ನು ನೀಡಲಾದ **"ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆ"** ಎಂಬ ಮೂಲ ಲೇಖನದ ವಿಷಯದ ಆಧಾರದ ಮೇಲೆ ರೂಪಿಸಲಾಗಿದೆ. ಜೊತೆಗೆ AI ಮತ್ತು ಶಿಕ್ಷಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ UNESCO ಮಾರ್ಗದರ್ಶನ ಹಾಗೂ ಇತ್ತೀಚಿನ ಶೈಕ್ಷಣಿಕ ಸಂಶೋಧನಾ ಸಾಹಿತ್ಯವನ್ನು ಪರಿಗಣಿಸಲಾಗಿದೆ. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಯಾವುದೇ ಪ್ರಾಥಮಿಕ ಸಮೀಕ್ಷೆ, ಸಂದರ್ಶನ ಅಥವಾ ಸಂಖ್ಯಾಶಾಸ್ತ್ರೀಯ ದತ್ತಾಂಶವನ್ನು ಬಳಸಲಾಗಿಲ್ಲ.

ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಬದಲಾಗುತ್ತಿರುವ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆ:

ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನವು ವಿದ್ಯಾರ್ಥಿಗಳು ಜ್ಞಾನವನ್ನು ಪಡೆಯುವ ವಿಧಾನವನ್ನು ಗಮನಾರ್ಹವಾಗಿ ಬದಲಿಸಿದೆ. ಹಿಂದೆ ವಿದ್ಯಾರ್ಥಿಗಳು ಮುಖ್ಯವಾಗಿ ಶಿಕ್ಷಕರು, ಪಠ್ಯಪುಸ್ತಕಗಳು ಮತ್ತು ಗ್ರಂಥಾಲಯಗಳ ಮೇಲೆ ಅವಲಂಬಿತರಾಗಿದ್ದರು. ಇಂದು ಇಂಟರ್ನೆಟ್, ಡಿಜಿಟಲ್ ಗ್ರಂಥಾಲಯಗಳು, ಆನ್‌ಲೈನ್ ವೀಡಿಯೊಗಳು, ಸಾಮಾಜಿಕ ಮಾಧ್ಯಮ ಮತ್ತು AI ಆಧಾರಿತ ಸಾಧನಗಳು ಕಲಿಕೆಗೆ ವಿವಿಧ

ಮಾರ್ಗಗಳನ್ನು ಒದಗಿಸುತ್ತಿವೆ. Instagram Reels, YouTube Shorts ಮತ್ತು Facebook ಮುಂತಾದ ಸಾಮಾಜಿಕ ಮಾಧ್ಯಮಗಳಲ್ಲಿನ ಚಿಕ್ಕ ವೀಡಿಯೊಗಳ ಪ್ರಭಾವವು ವಿದ್ಯಾರ್ಥಿಗಳ ಗಮನ ಮತ್ತು ಮಾಹಿತಿಯನ್ನು ಸ್ವೀಕರಿಸುವ ವಿಧಾನಗಳ ಮೇಲೂ ಪರಿಣಾಮ ಬೀರುತ್ತಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಕೇವಲ ಪಠ್ಯ ಓದುವ ಬದಲು ಚಿತ್ರಗಳು, ಅನಿಮೇಷನ್‌ಗಳು ಮತ್ತು ದೃಶ್ಯ ವಿವರಣೆಗಳ ಮೂಲಕ ಕಲಿಯಲು ಹೆಚ್ಚಿನ ಆಸಕ್ತಿ ತೋರಿಸುತ್ತಿದ್ದಾರೆ. ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕೆಯ ವೇಗ, ಆಸಕ್ತಿ ಮತ್ತು ಗ್ರಹಣ ಸಾಮರ್ಥ್ಯ ವಿಭಿನ್ನವಾಗಿರುವುದರಿಂದ ಒಂದೇ ರೀತಿಯ ಬೋಧನಾ ವಿಧಾನವು ಎಲ್ಲರಿಗೂ ಸಮಾನವಾಗಿ ಪರಿಣಾಮಕಾರಿಯಾಗುವುದಿಲ್ಲ. AI ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಕಲಿಕಾ ವಿಷಯವನ್ನು ಹೊಂದಾಣಿಕೆ ಮಾಡುವ ಸಾಧ್ಯತೆಯನ್ನು ಹೊಂದಿವೆ (Bond et al., 2024).

AI ಮತ್ತು ವೈಯಕ್ತಿಕ ಕಲಿಕೆ:

AIಯ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಸಾಧ್ಯತೆಗಳಲ್ಲಿ ಒಂದು ವೈಯಕ್ತಿಕ ಕಲಿಕೆ. ವಿದ್ಯಾರ್ಥಿಗೆ ಅರ್ಥವಾಗದ ವಿಷಯವನ್ನು ಮತ್ತಷ್ಟು ಸರಳವಾಗಿ ವಿವರಿಸುವುದು, ಉದಾಹರಣೆಗಳನ್ನು ನೀಡುವುದು ಮತ್ತು ಪುನಃ ಪ್ರಶ್ನೆ ಕೇಳಲು ಅವಕಾಶ ನೀಡುವುದು ವೈಯಕ್ತಿಕ ಕಲಿಕೆಗೆ ಸಹಕಾರಿಯಾಗಬಹುದು. ಗಣಿತ, ವಿಜ್ಞಾನ ಮತ್ತು ಭಾಷೆಯಂತಹ ವಿಷಯಗಳಲ್ಲಿ ಕಠಿಣ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಸರಳ ಭಾಷೆಯಲ್ಲಿ ವಿವರಿಸುವ ಮೂಲಕ AI ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಅನುಭವವನ್ನು ಸುಧಾರಿಸಬಹುದು. AI ಆಧಾರಿತ ಕಲಿಕಾ ವ್ಯವಸ್ಥೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಗತಿಯನ್ನು ಆಧರಿಸಿ ವಿಷಯ ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ಹೊಂದಾಣಿಕೆ ಮಾಡುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿವೆ (Bond et al., 2024). ಆದಾಗ್ಯೂ, ವೈಯಕ್ತಿಕ ಕಲಿಕೆ ಎಂದರೆ ಶಿಕ್ಷಕರ ಪಾತ್ರವನ್ನು ತೆಗೆದುಹಾಕುವುದು ಎಂದಲ್ಲ. ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಯ ಭಾವನಾತ್ಮಕ, ಸಾಮಾಜಿಕ ಮತ್ತು ನೈತಿಕ ಅಗತ್ಯಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಂಡು ಸೂಕ್ತ ಮಾರ್ಗದರ್ಶನ ನೀಡುವಲ್ಲಿ ಪ್ರಮುಖರಾಗಿರುತ್ತಾರೆ.

ಅಸೈನ್‌ಮೆಂಟ್, ಪ್ರಾಜೆಕ್ಟ್ ಮತ್ತು ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ AI:

ಇಂದಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಅಸೈನ್‌ಮೆಂಟ್, ಸೆಮಿನಾರ್, ವರದಿ ಮತ್ತು ಪ್ರಾಜೆಕ್ಟ್ ಕಾರ್ಯಗಳಿಗೆ ಇಂಟರ್ನೆಟ್ ಮತ್ತು ChatGPT ಮುಂತಾದ AI ಸಾಧನಗಳನ್ನು ಬಳಸುತ್ತಿದ್ದಾರೆ. ಇವು ವಿಷಯದ ಪ್ರಾಥಮಿಕ ಮಾಹಿತಿ ಪಡೆಯಲು, ವಿಚಾರಗಳನ್ನು ಸಂಘಟಿಸಲು ಮತ್ತು ಭಾಷಾ ದೋಷಗಳನ್ನು ಸರಿಪಡಿಸಲು ನೆರವಾಗಬಹುದು. AI ಮೂಲಕ ಅಸೈನ್‌ಮೆಂಟ್ ವಿಷಯಗಳನ್ನು ಅರ್ಥ ಮಾಡಿಕೊಳ್ಳುವುದು, ಪ್ರಾಜೆಕ್ಟ್‌ಗೆ ಬೇಕಾದ ಅಂಶಗಳನ್ನು ಗುರುತಿಸುವುದು, PPTಗೆ ವಿಷಯ ರೂಪಿಸುವುದು, ವ್ಯಾಕರಣ ದೋಷಗಳನ್ನು ಸರಿಪಡಿಸುವುದು ಮತ್ತು ವಿವಿಧ ಭಾಷೆಗಳಲ್ಲಿ ವಿವರಣೆ ಪಡೆಯುವುದು ಸಾಧ್ಯ. ChatGPT ಕುರಿತು ನಡೆದ ಸಂಶೋಧನಾ ಸಾಹಿತ್ಯವು ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ ಅದರ ಬಳಕೆಯು ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆಯ ಹಲವು ಆಯಾಮಗಳೊಂದಿಗೆ ಸಂಬಂಧ ಹೊಂದಿದೆ ಎಂದು ಸೂಚಿಸುತ್ತದೆ (Bhullar et al., 2024). ಆದರೆ ವಿದ್ಯಾರ್ಥಿಗಳು AI ನೀಡುವ ಉತ್ತರಗಳನ್ನು ನೇರವಾಗಿ ನಕಲಿಸಿ ಸಲ್ಲಿಸುವುದರಿಂದ ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆ ಕುಂಠಿತವಾಗಬಹುದು.

ಆದ್ದರಿಂದ AIಯನ್ನು "ಉತ್ತರ ನೀಡುವ ಯಂತ್ರ"ವಾಗಿ ಬಳಸುವುದಕ್ಕಿಂತ "ಕಲಿಕೆಗೆ ಸಹಾಯಕ"ವಾಗಿ ಬಳಸಬೇಕು.

ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ AI:

ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ AIಯ ಬಳಕೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಗೆ ಮಾತ್ರ ಸೀಮಿತವಾಗಿಲ್ಲ. ಸಂಶೋಧನೆ, ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಮೌಲ್ಯಮಾಪನ, ಪಠ್ಯಕ್ರಮ ವಿನ್ಯಾಸ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿ ಸೇವೆಗಳಲ್ಲಿಯೂ AI ಬಳಕೆಯ ಸಾಧ್ಯತೆಗಳಿವೆ. ಸಾಹಿತ್ಯ ವಿಮರ್ಶೆ, ಸಂಶೋಧನಾ ಮಾಹಿತಿಯ ಸಂಘಟನೆ ಮತ್ತು ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆಯಲ್ಲಿ AI ನೆರವಾಗಬಹುದು. ಸಂಕೀರ್ಣ ದತ್ತಾಂಶಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಲು ಮತ್ತು ದೃಶ್ಯೀಕರಣಗಳನ್ನು ರೂಪಿಸಲು AI ಆಧಾರಿತ ಸಾಧನಗಳು ಸಹಾಯಕವಾಗಬಹುದು. ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ AI ಬಳಕೆಯ ಕುರಿತಾದ ಸಮಗ್ರ ವಿಮರ್ಶೆಗಳು ಮೌಲ್ಯಮಾಪನ, ಭವಿಷ್ಯಾನುಮಾನ, AI ಸಹಾಯಕರು, ಬುದ್ಧಿವಂತ ಬೋಧನಾ ವ್ಯವಸ್ಥೆಗಳು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ನಿರ್ವಹಣೆ ಮುಂತಾದ ಬಳಕೆಗಳನ್ನು ಗುರುತಿಸಿವೆ (Crompton & Burke, 2023).

AI ಮತ್ತು ಒಳಗೊಳ್ಳುವ ಶಿಕ್ಷಣ:

AI ತಂತ್ರಜ್ಞಾನವು ವಿವಿಧ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಕಲಿಕಾ ಅಗತ್ಯಗಳನ್ನು ಹೊಂದಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಹಾಯ ಮಾಡುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ. ಓದಲು ಅಥವಾ ಬರೆಯಲು ಕಷ್ಟಪಡುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಪಠ್ಯ–ಧ್ವನಿ ಮತ್ತು ಧ್ವನಿ–ಪಠ್ಯ ತಂತ್ರಜ್ಞಾನಗಳು ಸಹಾಯಕವಾಗಬಹುದು. ಬಹುಭಾಷಾ ವಿವರಣೆಗಳ ಮೂಲಕ ಭಾಷಾ ಅಡೆತಡೆಗಳನ್ನು ಕಡಿಮೆ ಮಾಡುವ ಸಾಧ್ಯತೆಯೂ ಇದೆ. ಹೀಗಾಗಿ AIಯನ್ನು ಸಮಾನ ಅವಕಾಶಗಳನ್ನು ಉತ್ತೇಜಿಸುವ ಸಾಧನವಾಗಿ ಬಳಸಬಹುದು. ಆದರೆ ಡಿಜಿಟಲ್ ಸಾಧನಗಳ ಲಭ್ಯತೆ, ಇಂಟರ್ನೆಟ್ ಪ್ರವೇಶ ಮತ್ತು ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆಯ ವ್ಯತ್ಯಾಸಗಳನ್ನು ಪರಿಗಣಿಸಬೇಕು.

AI ಬಳಕೆಯ ಸವಾಲುಗಳು:

ಂಖ ಶಿಕ್ಷಣಕ್ಕೆ ಅನೇಕ ಅವಕಾಶಗಳನ್ನು ನೀಡಿದರೂ ಅದರ ಬಳಕೆಯಲ್ಲಿ ಕೆಲವು ಪ್ರಮುಖ ಸವಾಲುಗಳಿವೆ.

- **ಅತಿಯಾದ ಅವಲಂಬನೆ:** ವಿದ್ಯಾರ್ಥಿಗಳು ಪ್ರತಿಯೊಂದು ಪ್ರಶ್ನೆಗೂ AIಯನ್ನು ಅವಲಂಬಿಸಿದರೆ ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಸಮಸ್ಯೆ ಪರಿಹಾರ ಸಾಮರ್ಥ್ಯ ದುರ್ಬಲವಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ. AI ಸಂವಾದ ವ್ಯವಸ್ಥೆಗಳ ಮೇಲಿನ ಅತಿಯಾದ ಅವಲಂಬನೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಅರಿವು ಮತ್ತು ಜ್ಞಾನಾತ್ಮಕ ಸಾಮರ್ಥ್ಯಗಳ ಮೇಲೆ ಪರಿಣಾಮ ಬೀರುವ ಸಾಧ್ಯತೆಯನ್ನು ಇತ್ತೀಚಿನ ವಿಮರ್ಶಾ ಸಂಶೋಧನೆಗಳು ಚರ್ಚಿಸಿವೆ (Zhai et al., 2024).

- **ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ:** AI ಬಳಸಿ ಸಿದ್ಧಪಡಿಸಿದ ವಿಷಯವನ್ನು ವಿದ್ಯಾರ್ಥಿಯ ಸ್ವಂತ ಕೆಲಸವೆಂದು ಸಲ್ಲಿಸುವುದು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಸವಾಲಾಗಿದೆ. ಆದ್ದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು AI ಬಳಸಿದಾಗ ಸೂಕ್ತ ಪಾರದರ್ಶಕತೆ, ಉಲ್ಲೇಖ ಮತ್ತು ಸ್ವಂತ ವಿಶ್ಲೇಷಣೆಗೆ ಆದ್ಯತೆ ನೀಡಬೇಕು.
- **ಗೌಪ್ಯತೆ ಮತ್ತು ನೈತಿಕತೆ:** ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ದತ್ತಾಂಶವನ್ನು AI ಸಾಧನಗಳಲ್ಲಿ ಬಳಸುವಾಗ ಗೌಪ್ಯತೆ ಮತ್ತು ದತ್ತಾಂಶ ಸುರಕ್ಷತೆಯನ್ನು ಕಾಪಾಡಬೇಕು. UNESCO ಮಾನವ–ಕೇಂದ್ರಿತ, ಸುರಕ್ಷಿತ, ಸಮಾನ ಮತ್ತು ನೈತಿಕ AI ಬಳಕೆಯ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ (Miao & Holmes, 2023).
- **ಮಾಹಿತಿಯ ವಿಶ್ವಾಸಾರ್ಹತೆ:** AI ನೀಡುವ ಪ್ರತಿಯೊಂದು ಮಾಹಿತಿಯೂ ನಿಖರವಾಗಿರುತ್ತದೆ ಎಂಬ ಭಾವನೆ ತಪ್ಪಾಗಿದೆ. ಆದ್ದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರು AI ಉತ್ಪಾದಿತ ಮಾಹಿತಿಯನ್ನು ವಿಶ್ವಾಸಾರ್ಹ ಶೈಕ್ಷಣಿಕ ಮೂಲಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸಬೇಕು.

AI ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ : AIಯ ಬೆಳವಣಿಗೆಯಿಂದ ಶಿಕ್ಷಕರ ಪಾತ್ರ ಕಡಿಮೆಯಾಗುವುದಿಲ್ಲ; ಬದಲಾಗಿ ಅದು ಹೆಚ್ಚು ಮಾರ್ಗದರ್ಶಕ ಮತ್ತು ಸೌಲಭ್ಯಕಾರಕ ಸ್ವರೂಪವನ್ನು ಪಡೆಯುತ್ತದೆ. UNESCO ಕೂಡ AI ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ವಿಶಿಷ್ಟ ಪಾತ್ರವನ್ನು ಉನ್ನತ ಮಟ್ಟದ ಚಿಂತನೆ, ಮಾನವೀಯ ಸಂವಹನ ಮತ್ತು ಮೌಲ್ಯಗಳ ಬೆಳವಣಿಗೆ ರಕ್ಷಿಸುವ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ (Miao & Holmes, 2023).

AI ಯುಗದ ಶಿಕ್ಷಕರು:

1. ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸೂಕ್ತ ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಆಯ್ಕೆ ಮಾಡಲು ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು.
2. AI ನೀಡುವ ಮಾಹಿತಿಯನ್ನು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಪರಿಶೀಲಿಸುವ ಕೌಶಲ್ಯ ಬೆಳೆಸಬೇಕು.
3. ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆಯನ್ನು ಉತ್ತೇಜಿಸಬೇಕು.
4. AI ಬಳಕೆಯಲ್ಲಿ ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಯನ್ನು ಕಾಪಾಡಬೇಕು.
5. ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಮಾನವೀಯ ಮೌಲ್ಯಗಳ ನಡುವೆ ಸಮತೋಲನ ಸಾಧಿಸಬೇಕು.
6. ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅಗತ್ಯಗಳನ್ನು ಗುರುತಿಸಿ ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು.

ಜವಾಬ್ದಾರಿಯುತ AI ಬಳಕೆಗೆ ಸಲಹೆಗಳು:

ಶಿಕ್ಷಣದಲ್ಲಿ AIಯ ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಕೆಳಗಿನ ಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸಬಹುದು:

1. AIಯನ್ನು ಕಲಿಕೆಯ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸಬೇಕು.
2. AI ಮೂಲಕ ಪಡೆದ ಮಾಹಿತಿಯನ್ನು ವಿಶ್ವಾಸಾರ್ಹ ಮೂಲಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸಬೇಕು.

3. ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವಂತ ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ಅಭಿಪ್ರಾಯಕ್ಕೆ ಆದ್ಯತೆ ನೀಡಬೇಕು.

4. AI ಸಾಕ್ಷರತೆಯನ್ನು ಪಠ್ಯಕ್ರಮದ ಭಾಗವನ್ನಾಗಿ ಮಾಡಬೇಕು.

5. ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ ಮತ್ತು ಸರಿಯಾದ ಉಲ್ಲೇಖ ಪದ್ಧತಿಯನ್ನು ಉತ್ತೇಜಿಸಬೇಕು.

6. ವಿದ್ಯಾರ್ಥಿಗಳ ದತ್ತಾಂಶ ಮತ್ತು ಗೌಪ್ಯತೆಯನ್ನು ರಕ್ಷಿಸಬೇಕು.

7. ಶಿಕ್ಷಕರ ಮಾನವೀಯ ಮಾರ್ಗದರ್ಶನವನ್ನು AI ಮೂಲಕ ಬದಲಿಸಬಾರದು.

8. AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆಯನ್ನು ಬೆಳೆಸಬೇಕು.

ಭವಿಷ್ಯದ ಶಿಕ್ಷಣದ ಮೇಲೆ ಂಖಯ ಪರಿಣಾಮ:

ಭವಿಷ್ಯದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ AI, ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳು ಪರಸ್ಪರ ಪೂರಕವಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸುವ ಸಾಧ್ಯತೆ ಇದೆ. AI ಮಾಹಿತಿ ಸಂಸ್ಕರಣೆ, ವೈಯಕ್ತಿಕ ಪ್ರತಿಕ್ರಿಯೆ ಮತ್ತು ಕಲಿಕಾ ವಿಶ್ಲೇಷಣೆಯಲ್ಲಿ ನೆರವಾದರೆ, ಶಿಕ್ಷಕರು ಮಾನವೀಯ ಸಂಬಂಧ, ಮೌಲ್ಯ ಶಿಕ್ಷಣ, ಪ್ರೇರಣೆ ಮತ್ತು ಉನ್ನತ ಮಟ್ಟದ ಚಿಂತನೆಯ ಬೆಳವಣಿಗೆಯತ್ತ ಹೆಚ್ಚಿನ ಗಮನ ನೀಡಬಹುದು.

AI ಕುರಿತು ನಡೆದ ಇತ್ತೀಚಿನ ಸಂಶೋಧನಾ ವಿಮರ್ಶೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆ, ಶಿಕ್ಷಕರ ಬೋಧನೆ ಮತ್ತು ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳ ಆಡಳಿತ ಸೇರಿದಂತೆ ವಿವಿಧ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ AIಯ ಪರಿಣಾಮವನ್ನು ಗುರುತಿಸಿವೆ (Fu et al., 2025). ಆದ್ದರಿಂದ ಭವಿಷ್ಯದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ AI ಸಾಕ್ಷರತೆ ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರಿಬ್ಬರಿಗೂ ಅಗತ್ಯವಾದ ಸಾಮರ್ಥ್ಯವಾಗಲಿದೆ.

ಉಪಸಂಹಾರ:

ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯು ಸಾಂಪ್ರದಾಯಿಕ ಪಠ್ಯಪುಸ್ತಕ ಮತ್ತು ಶಿಕ್ಷಕ–ಕೇಂದ್ರಿತ ವ್ಯವಸ್ಥೆಯಿಂದ ಡಿಜಿಟಲ್ ಮತ್ತು AI ಆಧಾರಿತ ಕಲಿಕೆಯತ್ತ ವೇಗವಾಗಿ ಪರಿವರ್ತನೆಯಾಗಿದೆ. AI ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಕಲಿಕಾ ವಿಷಯ ಒದಗಿಸುವುದು, ಕಠಿಣ ವಿಷಯಗಳನ್ನು ಸರಳೀಕರಿಸುವುದು, ದೃಶ್ಯ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಕಲಿಕೆಯನ್ನು ಬೆಂಬಲಿಸುವುದು, ಭಾಷಾ ಕಲಿಕೆಗೆ ನೆರವಾಗುವುದು ಹಾಗೂ ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನಾ ಕಾರ್ಯಗಳಲ್ಲಿ ಸಹಾಯ ಮಾಡುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ. ಆದರೆ AIಯ ಅತಿಯಾದ ಅವಲಂಬನೆಯು ಸ್ವತಂತ್ರ ಚಿಂತನೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಸವಾಲಾಗಬಹುದು. ಆದ್ದರಿಂದ AIಯನ್ನು ಸಂಪೂರ್ಣವಾಗಿ ಅವಲಂಬಿಸುವ ಬದಲು ಶಿಕ್ಷಕರ ಮಾರ್ಗದರ್ಶನದೊಂದಿಗೆ ಜವಾಬ್ದಾರಿಯುತವಾಗಿ ಬಳಸುವುದು ಅಗತ್ಯ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಎಷ್ಟೇ ಮುಂದುವರಿದರೂ ಶಿಕ್ಷಕರ ನೈತಿಕ ಮಾರ್ಗದರ್ಶನ, ಮಾನವೀಯ ಸ್ಪರ್ಶ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಮಗ್ರ ವ್ಯಕ್ತಿತ್ವ ವಿಕಾಸಕ್ಕೆ ಅದು ಸಂಪೂರ್ಣ ಪರ್ಯಾಯವಾಗುವುದಿಲ್ಲ. AI ಶಿಕ್ಷಕರನ್ನು ಬದಲಿಸುವ ತಂತ್ರಜ್ಞಾನವಲ್ಲ; ಬದಲಾಗಿ ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೆಚ್ಚಿಸುವ ಸಹಾಯಕ ಶಕ್ತಿಯಾಗಿದೆ. ಮಾನವ–ಕೇಂದ್ರಿತ ಮತ್ತು

ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯ ಮೂಲಕ AI ಶಿಕ್ಷಣವನ್ನು ಹೆಚ್ಚು ಒಳಗೊಳ್ಳುವ, ವೈಯಕ್ತಿಕ, ಪರಿಣಾಮಕಾರಿ ಮತ್ತು ಭವಿಷ್ಯಸನ್ನದ್ಧವಾಗಿಸಲು ನೆರವಾಗಬಹುದು.

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ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ (AI)ಯ ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣ

ಡಾ. ದಿನೇಶ ಎಂ.ಎನ್.

ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು, ವಿದ್ಯಾವಿಕಾಸ ಶಿಕ್ಷಣ ಮಹಾವಿದ್ಯಾಲಯ, ಮೈಸೂರು–570028

ಸಾರಾಂಶ

ಮಾನವ ನಿರ್ಮಿತ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ(AI)ಯ ತಂತ್ರಜ್ಞಾನ ಇಂದು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಅಳವಡಿಸಿಕೊಳ್ಳುತ್ತಿರುವ ಪ್ರಮುಖ ತಂತ್ರಜ್ಞಾನಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಈ ತಂತ್ರಜ್ಞಾನವನ್ನು ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕೇವಲ ಭಾಷಾ ವಿಷಯಕ್ಕೆ ಮಾತ್ರ ಸೀಮಿತಗೊಳಿಸದೆ, ಬಹುಶಿಸ್ತೀಯ ನೆಲೆಯಲ್ಲಿ ವಿಜ್ಞಾನ, ಗಣಿತ, ಸಮಾಜ, ಇತಿಹಾಸ, ಭೂಗೋಳ, ಕಲೆ, ಸಂಗೀತ ಹಾಗೂ ಕಂಪ್ಯೂಟರ್ ಮುಂತಾದ ವಿವಿಧ ವಿಷಯಗಳೊಂದಿಗೆ ಸಂಯೋಜಿಸಬಹುದು. ಹೀಗೆ ಸಂಯೋಜಿಸುವಿಕೆಯನ್ನು ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣ ಎಂದು ಕರೆಯಬಹುದಾಗಿದೆ.

೧. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ವಿಜ್ಞಾನ :

ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯನ್ನು ವಿಜ್ಞಾನ ವಿಷಯದೊಂದಿಗೆ (AI) ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ ಸಹಾಯದಿಂದ ಸಂಯೋಜಿಸಿ ವಿಜ್ಞಾನಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ವಿಷಯಗಳನ್ನು ಸರಳವಾದ ಕನ್ನಡ ಭಾಷೆಯಲ್ಲಿ ವಿವರಿಸುವ ಪಠ್ಯಗಳು, ಕಥೆಗಳು, ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಪ್ರಶ್ನೆಗಳ ಸಂಭಾಷಣೆಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಬಹುದಾಗಿದೆ. ಉದಾಹರಣೆಗೆ : 'ಪರಿಸರ ಸಂರಕ್ಷಣೆ', 'ನೀರಿನ ಸಂರಕ್ಷಣೆ', 'ಸಸ್ಯಗಳ ಮಹತ್ವ', 'ವಾಯುಮಾಲಿನ್ಯ' ಮುಂತಾದ ವಿಜ್ಞಾನ ವಿಷಯಗಳ ಕುರಿತು ವಿದ್ಯಾರ್ಥಿಗಳ ವಯಸ್ಸು ಮತ್ತು ತರಗತಿಗೆ ಅನುಗುಣವಾಗಿ ವಿದ್ಯಾರ್ಥಿಗಳು ಆ ವಿಷಯವನ್ನು ಓದಿ, ಅದರ ಅರ್ಥವನ್ನು ಚರ್ಚಿಸಿ, ತಮ್ಮದೇ ಮಾತಿನಲ್ಲಿ ವಿವರಿಸುವ ಚಟುವಟಿಕೆಗಳನ್ನು ಮಾಡುವ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ವಿಜ್ಞಾನದ ಜ್ಞಾನ, ಓದುವ ಕೌಶಲ, ಬರವಣಿಗೆ ಕೌಶಲ, ಪದಸಂಪತ್ತು, ಸಂವಹನ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಸೃಜನಶೀಲತೆ ಏಕಕಾಲದಲ್ಲಿಯೇ ಅಭಿವೃದ್ಧಿಯಾಗುವುದರೊಂದಿಗೆ ಬಹುಶಿಸ್ತೀಯ ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿ ಕೇಂದ್ರಿತ ಕಲಿಕೆಗೆ ಉತ್ತಮ ಅವಕಾಶವನ್ನು ಒದಗಿಸುತ್ತದೆ.

೨. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಗಣಿತ :

ಗಣಿತದ ಕಠಿಣ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಕನ್ನಡದಲ್ಲಿ ಸರಳವಾಗಿ ವಿವರಿಸಲು ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ(AI) ತಂತ್ರಜ್ಞಾನವನ್ನ ಬಳಸಿ ಪದಸಂಪತ್ತನ್ನು ಹೆಚ್ಚಿಸಿಕೊಂಡು, ಸಮಸ್ಯೆಗಳನ್ನು ಓದಿ ಅರ್ಥೈಸಿಕೊಂಡು, ಹಂತಹಂತವಾಗಿ ಉತ್ತರಿಸುವ ಚಟುವಟಿಕೆಗಳ ಮೂಲಕ ಭಾಷೆ ಮತ್ತು ಗಣಿತವನ್ನು ಸಂಯೋಜಿಸಲು ಸಹಕಾರಿಯಾಗಿದೆ. ಇದರಿಂದ ಗಣಿತ ಕಲಿಕೆಯ ಜೊತೆಗೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕೌಶಲವೂ ವೃದ್ಧಿಯಾಗುತ್ತದೆ. ಉದಾಹರಣೆಗೆ : ಸಂಖ್ಯೆಗಳು, ಕಳೆಯುವುದು, ಗುಣಾಕಾರ, ಭಾಗಕಾರ, ಭಿನ್ನರಾಶಿಗಳು, ಶೇಕಡವಾರು, ಆಳತೆ, ಜ್ಯಾಮಿತಿ, ಸಮಯ ಮತ್ತು ಹಣ ಮುಂತಾದವುಗಳ ಬಗ್ಗೆ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ (AI) ಮೂಲಕ ಕಥೆಗಳು, ಪದ ಪ್ರಶ್ನೆಗಳು, ಪ್ರಶ್ನೋತ್ತರಗಳು ಮತ್ತು ಅಭ್ಯಾಸ ಚಟುವಟಿಕೆಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಿ ಸರಳವಾಗಿ ಅರ್ಥೈಸಬಹುದು. ಇದರ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ತಾರ್ಕಿಕ

ಚಿಂತನೆ, ಸಮಸ್ಯೆ ಪರಿಹಾರ ಸಾಮರ್ಥ್ಯ, ಓದುವ ಕೌಶಲ, ಭಾಷಾಗ್ರಹಿಕೆ, ಗಣಿತೀಯ ಪದಸಂಪತ್ತು ಮತ್ತು ಸಂವಹನ ಕೌಶಲಗಳು ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ ಆಧಾರಿತ ಸಹಾಯದಿಂದ ಕನ್ನಡ ಮತ್ತು ಗಣಿತದ ಏಕೀಕರಣಗೊಳಿಸಿ, ಅರ್ಥಪೂರ್ಣ ಮತ್ತು ಚಟುವಟಿಕೆ ಆಧಾರಿತ ಕಲಿಕೆಗೆ ಸಹಕಾರಿಯಾಗುತ್ತದೆ.

೩. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಸಮಾಜ ವಿಜ್ಞಾನ :

ಇತಿಹಾಸ, ಸಮಾಜಶಾಸ್ತ್ರ, ಪೌರನೀತಿ ಮುಂತಾದ ಸಮಾಜ ವಿಜ್ಞಾನದ ವಿಷಯಗಳನ್ನು ಕನ್ನಡ ಭಾಷೆಯ ಮೂಲಕ (AI)ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನವನ್ನು ಬಳಸಿಕೊಂಡು ಐತಿಹಾಸಿಕ ಘಟನೆಗಳು, ಪ್ರಮುಖ ವ್ಯಕ್ತಿಗಳು ಮತ್ತು ಸಾಮಾಜಿಕ ವಿಷಯಗಳಿಗೆ ಸಂಬಂಧಿಸಿದ ಸಂಭಾಷಣೆ, ಪಾತ್ರಾಭಿನಯ, ಪ್ರಶ್ನೋತ್ತರ, ಕಥನ ಹಾಗೂ ಚರ್ಚಾ ಚಟುವಟಿಕೆಗಳೊಂದಿಗೆ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸುಲಭವಾಗಿ ಅರ್ಥೈಸಬಹುದಾಗಿದೆ. ಉದಾಹರಣೆಗೆ : ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸ್ವಾತಂತ್ರ್ಯ ಹೋರಾಟದ ಕುರಿತು ವಿವಿಧ ಪಾತ್ರಗಳನ್ನು ನೀಡಿ ಪಾತ್ರಾಭಿನಯ ಮಾಡಿಸುವುದು, ಐತಿಹಾಸಿಕ ಘಟನೆಗಳನ್ನು ಕಥೆಯ ರೂಪದಲ್ಲಿ ಪ್ರಸ್ತುತಪಡಿಸುವ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಆಸಕ್ತಿ ಮೂಡಿಸಬಹುದು. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕೌಶಲ, ವಿಚಾಶಕ್ತಿ, ಸಾಮಾಜಿಕ ಅರಿವು, ಸೃಜನಶೀಲತೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಗೆ ಒಡ್ಡಬಹುದಾಗಿದೆ.

೪. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಭೂಗೋಳ :

ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ(AI) ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸರಳವಾಗಿ ಮತ್ತು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಕನ್ನಡ ಭಾಷೆಯನ್ನು ಸಂಯೋಜಿಸುವ ಮೂಲಕ ಭಾರತದ ರಾಜ್ಯಗಳು, ನದಿಗಳು, ಪರ್ವತಗಳು, ಹವಾಮಾನ, ಮಣ್ಣು ಹಾಗೂ ನೈಸರ್ಗಿಕ ಸಂಪನ್ಮೂಲಗಳ ಬಗ್ಗೆ ಸರಳ ಮತ್ತು ವಿವರಣಾತ್ಮಕ ಪಠ್ಯಗಳನ್ನು ಸಿದ್ಧಪಡಿಸುವುದರೊಂದಿಗೆ ಪ್ರಶ್ನೋತ್ತರ, ನಕ್ಷೆ ಆಧಾರಿತ ಚಟುವಟಿಕೆಗಳು ಹಾಗೂ ಉದಾಹರಣೆಗಳನ್ನು ನೀಡಬಹುದು. ಉದಾಹರಣೆಗೆ : ಭಾರತದ ಹವಾಮಾನ, ಹವಾಮಾನ ಬದಲಾವಣೆಗೆ ಕಾರಣಗಳು, ಹವಾಮಾನದ ಪರಿಣಾಮಗಳ ಬಗ್ಗೆ ವಿವರಿಸುವ ಮೂಲಕ ಚಟುವಟಿಕೆಗಳನ್ನೂ ನೀಡಬಹುದಾಗಿದೆ. ಇದರಿಂದ ಹೋಲಿಕೆ, ಪರಿಣಾಮ, ಕಾರಣಗಳನ್ನು ಕುಲಂಕಷವಾಗಿ ತಿಳಿದುಕೊಳ್ಳಲು ಸಹಕಾರಿಯಾಗಿದೆ.

೫. ಕನ್ನಡ ಬಾಷಾ ಬೋಧನೆ ಮತ್ತು ಕಲೆ :

ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಕಲೆ ಪ್ರಮುಖ ಪಾತ್ರವಹಿಸುತ್ತದೆ. ಚಿತ್ರಕಲೆ, ಸಂಗೀತ, ನಾಟಕ, ನೃತ್ಯ, ಕಥೆ ಹೇಳುವಿಕೆ ಮತ್ತು ಕರಕುಶಲಕಲೆಗಳನ್ನು ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ(AI) ಮೂಲಕ ಸಂಯೋಜಿಸಿದರೆ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಸೃಜನಶೀಲತೆ, ಕಲ್ಪನಾಶಕ್ತಿ ಮತ್ತು ಅಭಿವ್ಯಕ್ತಿ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸುತ್ತದೆ. ಉದಾಹರಣೆಗೆ : ಚಿತ್ರ ಆಧರಿಸಿ ಕಥೆ ರಚಿಸುವ ಚಟುವಟಿಕೆ, ಕವನ, ಗೀತೆ, ಪದ್ಯಗಳನ್ನು ಹಾಡಿಸುವ ಮೂಲಕ, ಉಚ್ಚಾರಣೆ, ಲಯ, ಬದ್ಧತೆಯಿಂದ ಪದಗಳ ಸ್ಮರಣೆಯನ್ನು ಉತ್ತಮಗೊಳಿಸಬಹುದು.

೬. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಕಂಪ್ಯೂಟರ್ ಶಿಕ್ಷಣ :

ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಕಂಪ್ಯೂಟರ್ ಶಿಕ್ಷಣವು ಇಂದಿನ ಆಧುನಿಕ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಪರಸ್ಪರ ಪೂರಕವಾಗಿವೆ. ಶಿಕ್ಷಣ ಮತ್ತು ತಂತ್ರಜ್ಞಾನಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ವಿಷಯಗಳನ್ನೂ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ(AI) ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಸರಳವಾಗಿ ಕನ್ನಡದಲ್ಲಿ ವಿವರಿಸಬಹುದು. ಉದಾಹರಣೆಗೆ : ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ ಎಂದರೇನು?, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ ಎಂದರೇನು?, ಇಂಟರ್ನೆಟ್ ಅನ್ನು ಸುರಕ್ಷಿತವಾಗಿ ಹೇಗೆ ಬಳಸಬೇಕು? ಎಂಬ ಹಲವು ವಿಷಯಗಳನ್ನು ಕೃತಕ ಬುದ್ದಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನದ ಸಹಾಯದಿಂದ ಸರಳ ಭಾಷೆಯಲ್ಲಿ ವಿವರಿಸಿ, ನಂತರ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಚರ್ಚೆ, ಪ್ರಶ್ನೋತ್ತರ ಮತ್ತು ಪ್ರಾಯೋಗಿಕ ಚಟುವಟಿಕೆಗಳನ್ನು ನಡೆಸಬಹುದು, ಈ ರೀತಿಯಾಗಿ ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯೊಂದಿಗೆ ಕಂಪ್ಯೂಟರ್ ಶಿಕ್ಷಣ ಸಂಯೋಜಿಸುವುದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಂತ್ರಜ್ಞಾನದ ಜ್ಞಾನ, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ಪದಸಂಪತ್ತು, ಅರ್ಥಗ್ರಹಣ ಮತ್ತು ಕನ್ನಡ ಭಾಷಾ ಸಾಮರ್ಥ್ಯಗಳು ಸಮಗ್ರವಾಗಿ ಅಭಿವೃದ್ಧಿಯಾಗುತ್ತವೆ.

ಹೀಗೆ ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯನ್ನು ಬಹುಶಿಸ್ತೀಯ ನೆಲೆಯಲ್ಲಿ ಇನ್ನೂ ಹಲವು ವಿಷಯಗಳೊಂದಿಗೆ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ(AI) ಸಹಾಯದಿಂದ ಸರಳ ರೀತಿಯಲ್ಲಿ ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಸಂಯೋಜಿಸಬಹುದಾಗಿದೆ.

ಕನ್ನಡ ಭಾಷಾ ಬೋದನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ(AI) ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣದ ಪ್ರಯೋಜನಗಳು

ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣವು ವಿವಿಧ ವಿಷಯಗಳನ್ನು ಪರಸ್ಪರ ಸಂಯೋಜಿಸಿ ಕಲಿಸುವ ವಿಧಾನವಾಗಿದೆ. ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ (AI) ಕೃತಕ ಬುದ್ದಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ ಹಾಗೂ ಇತರ ವಿಷಯಗಳನ್ನು ಸಂಯೋಜಿಸುವುದರಿಂದ ಕಲಿಕೆಯು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿ ಮತ್ತು ಅನುಭವಾತ್ಮಕವಾಗುತ್ತದೆ. ಇದರ ಪ್ರಮುಖ ಪ್ರಯೋಜನಗಳು ಹೀಗಿವೆ –

1. **ಕಲಿಕೆಯನ್ನು ಆಸಕ್ತಿದಾಯಕ ಮತ್ತು ಅರ್ಥಪೂರ್ಣವಾಗಿಸುತ್ತದೆ :** ವಿವಿಧ ವಿಷಯಗಳನ್ನು ಸಂಯೋಜಿಸಿ ಚಟುವಟಿಕೆಗಳ ಮೂಲಕ ಕಲಿಸುವುದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕಲಿಕೆಯ ಆಸಕ್ತಿ ಹೆಚ್ಚುತ್ತದೆ.
2. **ವಿಷಯಗಳ ನಡುವಿನ ಸಂಬಂಧವನ್ನು ತಿಳಿಯಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ :** ಭಾಷೆ, ವಿಜ್ಞಾನ, ಸಮಾಜ ವಿಜ್ಞಾನ, ಗಣಿತ, ಕಲೆ ಮುಂತಾದ ವಿವಿಧ ವಿಷಯಗಳ ನಡುವಿನ ಪರಸ್ಪರ ಸಂಬಂಧವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುತ್ತಾರೆ.
3. **ಸೃಜನಶೀಲತೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಯನ್ನು ಬೆಳೆಸುತ್ತದೆ :** ವಿವಿಧ ವಿಷಯಗಳ ಜ್ಞಾನವನ್ನು ಬಳಸಿಕೊಂಡು ಸಮಸ್ಯೆ ಪರಿಹರಿಸುವುದು, ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ರೂಪಿಸುವುದು ಮತ್ತು ವಿಷಯಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವ ಸಾಮರ್ಥ್ಯ ಬೆಳೆಯುತ್ತದೆ.
4. **ಭಾಷಾ ಕೌಶಲ್ಯ ಮತ್ತು ವಿಷಯಜ್ಞಾನವನ್ನು ವೃದ್ಧಿಸುತ್ತದೆ :** ಓದು, ಬರವಣಿಗೆ, ಶ್ರವಣ ಮತ್ತು ಮಾತನಾಡುವ ಕೌಶಲ್ಯಗಳ ಜೊತೆಗೆ ಸಂಬಂಧಿತ ವಿಷಯದ ಜ್ಞಾನವೂ ಹೆಚ್ಚುತ್ತದೆ.

5. **ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಕಲಿಕೆಗೆ ಅವಕಾಶ ನೀಡುತ್ತದೆ :** ವಿದ್ಯಾರ್ಥಿಗಳು ಸ್ವತಃ ಅನ್ವೇಷಣೆ, ಚರ್ಚೆ, ಪ್ರಯೋಗ ಮತ್ತು ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಭಾಗವಹಿಸುವುದರಿಂದ ಕಲಿಕೆಯಲ್ಲಿ ಸಕ್ರಿಯ ಪಾತ್ರ ವಹಿಸುತ್ತಾರೆ.
6. **ಡಿಜಿಟಲ್ ಮತ್ತು (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನದ ಸಾಕ್ಷರತೆಯನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುತ್ತದೆ :** (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಡಿಜಿಟಲ್ ಸಾಧನಗಳನ್ನು ಜವಾಬ್ದಾರಿಯುತವಾಗಿ ಬಳಸುವ ಕೌಶಲ್ಯ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಬೆಳೆಯುತ್ತದೆ.
7. **ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನವನ್ನು (AI) ಎಲ್ಲಾ ವಿಷಯಗಳೊಂದಿಗೂ ಸಂಯೋಜಿಸಬಹುದು :** (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನವನ್ನು ಎಲ್ಲಾ ಅಧ್ಯಯನ ವಿಷಯಗಳೊಂದಿಗೂ ಸಂಯೋಜಿಸಬಹುದಾಗಿದ್ದು, ವಿಷಯದ ಮಿತಿ ಇರುವುದಿಲ್ಲ.
8. **ಶಿಕ್ಷಕರಿಗೆ ಬೋಧನಾ ಸಾಮಗ್ರಿ ತಯಾರಿಸಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ :** ಪಾಠ ಯೋಜನೆಗಳು, ಪ್ರಶ್ನೆಗಳು, ಚಟುವಟಿಕೆಗಳು, ಕಾರ್ಯಪತ್ರಿಕೆಗಳು ಮತ್ತು ಇತರ ಬೋಧನಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ (AI) ಸಹಾಯಕವಾಗುತ್ತದೆ.

ಸಾರಾಂಶ: ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣವು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಮಗ್ರ ಬೆಳವಣಿಗೆಗೆ ಸಹಕಾರಿಯಾಗಿದ್ದು, ಜ್ಞಾನವನ್ನು ಕೇವಲ ಒಂದು ವಿಷಯಕ್ಕೆ ಸೀಮಿತಗೊಳಿಸದೆ ವಿವಿಧ ಕ್ಷೇತ್ರಗಳೊಂದಿಗೆ ಸಂಪರ್ಕಿಸಿ ಕಲಿಯಲು ಅವಕಾಶ ನೀಡುತ್ತದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನದ (AI) ಬಳಕೆಯ ಮುನ್ನೆಚ್ಚರಿಕೆಗಳು

ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನ ಬಳಸುವಾಗ ಕೆಲವು ಪ್ರಮುಖ ಮುನ್ನೆಚ್ಚರಿಕೆಗಳನ್ನು ಪಾಲಿಸುವುದು ಅಗತ್ಯ. (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನ ನೀಡುವ ಮಾಹಿತಿಯು ಕೆಲವೊಮ್ಮೆ ತಪ್ಪಾಗಿರಬಹುದು ಅಥವಾ ಅಪೂರ್ಣವಾಗಿರಬಹುದು. ಆದ್ದರಿಂದ ಶಿಕ್ಷಕರು (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನದ ಮೂಲಕ ದೊರೆತ ಮಾಹಿತಿಯನ್ನು ಪರಿಶೀಲಿಸಿ, ತಿದ್ದುಪಡಿ ಮಾಡಿ ನಂತರವೇ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಬಳಸಬೇಕು.

(AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವಂತ ಚಿಂತನೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ಸಮಸ್ಯೆ ಪರಿಹಾರ ಸಾಮರ್ಥ್ಯಕ್ಕೆ ಪರ್ಯಾಯವಾಗಿ ಬಳಸಬಾರದು. ವಿದ್ಯಾರ್ಥಿಗಳು ಸ್ವತಃ ಯೋಚಿಸಿ, ಅಭಿಪ್ರಾಯ ವ್ಯಕ್ತಪಡಿಸಿ ಮತ್ತು ಬರೆಯುವಂತೆ ಪ್ರೋತ್ಸಾಹಿಸಬೇಕು. (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನವನ್ನು ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಮಾತ್ರ ಬಳಸುವುದು ಸೂಕ್ತ.

ಅದೇ ರೀತಿ, ವಿದ್ಯಾರ್ಥಿಗಳ ಹೆಸರು, ವೈಯಕ್ತಿಕ ವಿವರಗಳು, ಚಿತ್ರಗಳು, ಸಂಪರ್ಕ ಮಾಹಿತಿ ಮುಂತಾದ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ಗೌಪ್ಯತೆಯನ್ನು ಕಾಪಾಡಬೇಕು. (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನ ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಹಕ್ಕುಸ್ವಾಮ್ಯ, ನಿಖರತೆ, ನ್ಯಾಯಸಮ್ಮತ ಬಳಕೆ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ತಂತ್ರಜ್ಞಾನ ಬಳಕೆಯಂತಹ ನೈತಿಕ ಮೌಲ್ಯಗಳನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಬೆಳೆಸಬೇಕು.

ಹೀಗೆ (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನವನ್ನು ಜವಾಬ್ದಾರಿಯುತ, ಸುರಕ್ಷಿತ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಉದ್ದೇಶಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಬಳಸಿದಾಗ ಮಾತ್ರ ಅದು ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆಗೆ ಪರಿಣಾಮಕಾರಿ ಸಾಧನವಾಗುತ್ತದೆ.

ಸಮಾರೋಪ

ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ (AI) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ ಬಹುಶಿಸ್ತೀಯ ಏಕೀಕರಣವು ಭಾಷಾ ಕಲಿಕೆಯನ್ನು ಇತರ ವಿಷಯಗಳೊಂದಿಗೆ ಸಂಪರ್ಕಿಸುವ ಪರಿಣಾಮಕಾರಿ ಮತ್ತು ಆಧುನಿಕ ಬೋಧನಾ ವಿಧಾನವಾಗಿದೆ. ಕನ್ನಡವನ್ನು ವಿಜ್ಞಾನ, ಗಣಿತ, ಸಮಾಜ ವಿಜ್ಞಾನ, ಕಲೆ, ಸಂಗೀತ ಹಾಗೂ ತಂತ್ರಜ್ಞಾನದೊಂದಿಗೆ ಸಂಯೋಜಿಸುವುದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ವಿವಿಧ ವಿಷಯಗಳ ಜ್ಞಾನವನ್ನು ಪರಸ್ಪರ ಸಂಬಂಧಿಸಿ ಕಲಿಯಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ.

(AI)ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನ ಸಹಾಯದಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಶ್ರವಣ, ಮಾತನಾಡುವಿಕೆ, ಓದು ಮತ್ತು ಬರವಣಿಗೆ ಕೌಶಲ್ಯಗಳ ಜೊತೆಗೆ ಸೃಜನಶೀಲತೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ಸಂವಹನ ಕೌಶಲ್ಯ ಮತ್ತು ಡಿಜಿಟಲ್ ಸಾಮರ್ಥ್ಯವೂ ಅಭಿವೃದ್ಧಿಯಾಗುತ್ತದೆ. ಅಲ್ಲದೆ, ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಹಾಗೂ ಚಟುವಟಿಕೆ ಆಧಾರಿತ ಕಲಿಕೆಗೆ ಹೆಚ್ಚಿನ ಅವಕಾಶ ದೊರೆಯುತ್ತದೆ. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಕರ ಸೂಕ್ತ ಮಾರ್ಗದರ್ಶನ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯೊಂದಿಗೆ (AI)ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಂತ್ರಜ್ಞಾನವನ್ನು ಕನ್ನಡ ಭಾಷಾ ಬೋಧನೆಯಲ್ಲಿ ಅಳವಡಿಸಿಕೊಂಡರೆ, ಕನ್ನಡ ಭಾಷಾ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ಆಧುನಿಕ, ಪರಿಣಾಮಕಾರಿ, ಆಸಕ್ತಿದಾಯಕ ಮತ್ತು ಅರ್ಥಪೂರ್ಣವಾಗಿಸಬಹುದು.

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ಕರ್ಣಿ, ಮುರಳೀಧರ; ಮೊಹಮ್ಮದ್, ಮುಜೀಬ್ ಶೈಕ್; ಮತ್ತು ಶ್ರೀನಿವಾಸ, ಕೆ. ಜಿ. (2023). ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆಯಲ್ಲಿ ಪರಿಚಯಿಸಲು ಆರಂಭಿಕ ಮಾರ್ಗದರ್ಶಿ. Springer. ಈ ಕೃತಿಯು AI ಆಧಾರಿತ ಕಲಿಕೆ, ಶಿಕ್ಷಕರ ಪಾತ್ರ ಮತ್ತು ಬೋಧನಾ–ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯ ಮೇಲೆ AIಯ ಪ್ರಭಾವವನ್ನು ಒಳಗೊಂಡಿದೆ.

ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ

ಶ್ರೀಮತಿ ಜಯಶ್ರೀ ಕೆಂಗೇರಿ

ಸಂಶೋಧನಾ ವಿದ್ಯಾರ್ಥಿ., ಶಿಕ್ಷಣಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ವಿಭಾಗ., ಕಿತ್ತೂರು ರಾಣಿ ಚನ್ನಮ್ಮ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ

ಡಾ. ಭಾರತಿ ವಾಯ್ ಖಾಸನಿಸ

ಸಹ ಪ್ರಾಧ್ಯಾಪಕರು, ಶಿಕ್ಷಣಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ವಿಭಾಗ., ಕಿತ್ತೂರು ರಾಣಿ ಚನ್ನಮ್ಮ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ

ಸಾರಾಂಶ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence–AI) ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರವನ್ನು ಪರಿವರ್ತಿಸುತ್ತಿರುವ ಪ್ರಮುಖ ತಾಂತ್ರಿಕ ಬೆಳವಣಿಗೆಯಾಗಿದೆ. ವಿಶೇಷವಾಗಿ ಸೃಜನಾತ್ಮಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Generative AI), ಸಂವಾದಾತ್ಮಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Conversational AI), ಬುದ್ಧಿವಂತ ಬೋಧನಾ ವ್ಯವಸ್ಥೆಗಳು, ಹೊಂದಿಕೊಳ್ಳುವ ಕಲಿಕಾ ವೇದಿಕೆಗಳು ಮತ್ತು ಸ್ವಯಂಚಾಲಿತ ಭಾಷಾ ಕಲಿಕಾ ಅನ್ವಯಿಕೆಗಳು ಭಾಷಾ ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆಗೆ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸಿವೆ. ಓದು, ಬರವಣಿಗೆ, ಕೇಳುವಿಕೆ, ಮಾತನಾಡುವಿಕೆ, ವ್ಯಾಕರಣ, ಶಬ್ದಕೋಶ, ಉಚ್ಚಾರಣೆ ಮತ್ತು ಸಂವಹನ ಕೌಶಲ್ಯಗಳ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ವೈಯಕ್ತಿಕ ಅಭ್ಯಾಸ, ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಕಲಿಕಾ ವಾತಾವರಣಕ್ಕೆ ಒತ್ತು ಪೂರಕವಾಗಬಹುದು. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ, ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವು ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ ಒತ್ತಿಯ ಪಾತ್ರವನ್ನು ದ್ವಿತೀಯ ದತ್ತಾಂಶಗಳ ಆಧಾರದ ಮೇಲೆ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. ಲಭ್ಯವಿರುವ ಸಾಹಿತ್ಯವನ್ನು ವಿಷಯಾಧಾರಿತ ಹಾಗೂ ವಿಶ್ಲೇಷಣಾತ್ಮಕವಾಗಿ ಪರಿಶೀಲಿಸುವ ಮೂಲಕ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಓದು, ಬರವಣಿಗೆ, ಮಾತನಾಡುವಿಕೆ, ಶಬ್ದಕೋಶ, ವ್ಯಾಕರಣ, ಕಲಿಕಾ ಪ್ರೇರಣೆ ಮತ್ತು ಶಿಕ್ಷಕರ ಸಹಕಾರದಂತಹ ಆಯಾಮಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಲಾಗಿದೆ.

ಮುಖ್ಯ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಭಾಷಾ ಕಲಿಕೆ, ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳು, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಭಾಷಾ ಕೌಶಲ್ಯಗಳು, ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಕಲಿಕೆ.*

ಪರಿಚಯ

ಶಿಕ್ಷಣವು ಸಮಾಜದ ಜ್ಞಾನ, ಕೌಶಲ್ಯ, ಮೌಲ್ಯ ಮತ್ತು ಸೃಜನಶೀಲತೆಯನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುವ ಪ್ರಮುಖ ಸಾಮಾಜಿಕ ಸಂಸ್ಥೆಯಾಗಿದೆ. ತಂತ್ರಜ್ಞಾನದ ಬೆಳವಣಿಗೆಯೊಂದಿಗೆ ಶಿಕ್ಷಣದ ಸ್ವರೂಪವೂ ನಿರಂತರವಾಗಿ ಬದಲಾಗುತ್ತಿದೆ. ಒಂದು ಕಾಲದಲ್ಲಿ ಪಠ್ಯಪುಸ್ತಕ ಮತ್ತು ಶಿಕ್ಷಕರ ವಿವರಣೆಗಳು ಕಲಿಕೆಯ ಪ್ರಮುಖ ಮೂಲಗಳಾಗಿದ್ದರೆ, ಪ್ರಸ್ತುತ ಡಿಜಿಟಲ್ ಕಲಿಕಾ ವೇದಿಕೆಗಳು, ಆನ್ಲೈನ್ ಸಂಪನ್ಮೂಲಗಳು, ಮೊಬೈಲ್ ಅಪ್ಲಿಕೇಶನ್ಗಳು, ಮಲ್ಟಿಮೀಡಿಯಾ ಕಲಿಕೆ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ಶಿಕ್ಷಣದ ಪ್ರಕ್ರಿಯೆಯನ್ನು ವಿಸ್ತರಿಸಿವೆ. ಈ ಬದಲಾವಣೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪ್ರವೇಶವು ವಿಶೇಷ ಮಹತ್ವವನ್ನು ಪಡೆದಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಈಗ ಕೇವಲ ತಾಂತ್ರಿಕ ಕ್ಷೇತ್ರಕ್ಕೆ ಸೀಮಿತವಾಗದೆ, ಶಾಲಾ ಶಿಕ್ಷಣ, ಉನ್ನತ ಶಿಕ್ಷಣ, ಶಿಕ್ಷಕರ ತರಬೇತಿ ಮತ್ತು ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ವ್ಯವಸ್ಥೆಗಳಲ್ಲಿಯೂ ಪ್ರಮುಖ ಸ್ಥಾನ ಪಡೆಯುತ್ತಿದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಮಾನವನ ಬುದ್ಧಿವಂತಿಕೆಯ ಕೆಲವು ಕಾರ್ಯಗಳನ್ನು ಗಣಕ ವ್ಯವಸ್ಥೆಗಳ ಮೂಲಕ ಅನುಕರಿಸುವ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ. ಭಾಷೆಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು, ಪಠ್ಯವನ್ನು ರಚಿಸುವುದು, ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರಿಸುವುದು, ಭಾಷಾಂತರಿಸುವುದು, ಮಾದರಿಗಳನ್ನು ಗುರುತಿಸುವುದು, ಧ್ವನಿಯನ್ನು ಪಠ್ಯವಾಗಿ ಪರಿವರ್ತಿಸುವುದು ಮತ್ತು ವೈಯಕ್ತಿಕಗೊಳಿಸಿದ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವುದು ಮುಂತಾದ ಸಾಮರ್ಥ್ಯಗಳಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಹೊಸ ಸಾಧ್ಯತೆಗಳನ್ನು ತೆರೆದಿದೆ.

ಭಾರತೀಯ ಶಿಕ್ಷಣದ ಸಂದರ್ಭದಲ್ಲಿ ತಂತ್ರಜ್ಞಾನದ ಬಳಕೆಗೆ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ ೨೦೨೦ ಕೂಡ ಮಹತ್ವ ನೀಡಿದೆ. ನೀತಿಯು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಯಂತ್ರ ಕಲಿಕೆ (Machine Learning), ಹೊಂದಿಕೊಳ್ಳುವ ಗಣಕಾಧಾರಿತ ಪರೀಕ್ಷೆ (Adaptive Computer Testing) ಮತ್ತು ಇತರ ತಂತ್ರಜ್ಞಾನಗಳು ವಿದ್ಯಾರ್ಥಿಗಳು ಏನು ಕಲಿಯುತ್ತಾರೆ ಎಂಬುದಷ್ಟೇ ಅಲ್ಲದೆ ಅವರು ಹೇಗೆ ಕಲಿಯುತ್ತಾರೆ ಎಂಬುದರ ಮೇಲೂ ಪರಿಣಾಮ ಬೀರುವ ಸಾಧ್ಯತೆಯನ್ನು ಗುರುತಿಸಿದೆ. ತಂತ್ರಜ್ಞಾನ ಆಧಾರಿತ ಶಿಕ್ಷಣದ ಬಳಕೆಯನ್ನು ಸಂಬಂಧಿತ ಸಂದರ್ಭಗಳಲ್ಲಿ ಸೂಕ್ತವಾಗಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಿ ವಿಸ್ತರಿಸಬೇಕೆಂದು ನೀತಿ ಒತ್ತಿಹೇಳುತ್ತದೆ.

ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ, ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರವನ್ನು ಸಮಗ್ರವಾಗಿ ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಅಗತ್ಯವಾಗಿದೆ. ವಿಶೇಷವಾಗಿ ಪ್ರಾಥಮಿಕ ಸಮೀಕ್ಷೆಯ ಬದಲಿಗೆ ಈಗಾಗಲೇ ಲಭ್ಯವಿರುವ ಸಂಶೋಧನಾ ಸಾಹಿತ್ಯ, ನೀತಿ ದಾಖಲೆಗಳು ಮತ್ತು ಅಧಿಕೃತ ವರದಿಗಳ ಆಧಾರದ ಮೇಲೆ ವಿಷಯವನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದ ಮುಖ್ಯ ಉದ್ದೇಶವಾಗಿದೆ.

ಅಧ್ಯಯನದ ಅಗತ್ಯತೆ ಮತ್ತು ಮಹತ್ವ:

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದ ಮಹತ್ವವು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಕೇವಲ ತಾಂತ್ರಿಕ ಸಾಧನವಾಗಿ ನೋಡುವುದರಲ್ಲಿ ಇಲ್ಲ; ಬದಲಾಗಿ ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ಅದರ ಶೈಕ್ಷಣಿಕ ಸಾಧ್ಯತೆಗಳು, ಮಿತಿಗಳು ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯ ಅಗತ್ಯವನ್ನು ಒಟ್ಟಾಗಿ ಪರಿಗಣಿಸುವುದರಲ್ಲಿ ಇದೆ. ವಿಶೇಷವಾಗಿ ಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳು ವಯಸ್ಸಿನ ದೃಷ್ಟಿಯಿಂದ ಸೂಕ್ಷ್ಮ ಹಂತದಲ್ಲಿರುವುದರಿಂದ ಅವರ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಗೆ ಶಿಕ್ಷಕರು ಮತ್ತು ಶಾಲಾ ವ್ಯವಸ್ಥೆಯ ಮಾರ್ಗದರ್ಶನ ಅತ್ಯಂತ ಮುಖ್ಯವಾಗಿದೆ. UNESCO 2024ರ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಾಮರ್ಥ್ಯ ಚೌಕಟ್ಟು (competency framework) ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆದಾರರು ಮಾತ್ರವಲ್ಲದೆ ಸೃಜನಾತ್ಮಕ ಸಹ–ಸೃಷ್ಟಿಕರ್ತರಾಗಿ ರೂಪಿಸುವ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ. ಈ framework ಮಾನವಕೇಂದ್ರಿತ ಮನೋಭಾವ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ನೈತಿಕತೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಅನ್ವಯಿಕೆ ಹಾಗೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವ್ಯವಸ್ಥೆಯ ವಿನ್ಯಾಸ ಎಂಬ ನಾಲ್ಕು ಆಯಾಮಗಳನ್ನು ಒಳಗೊಂಡಿದೆ.

ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು:

1) ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರವನ್ನು ಲಭ್ಯವಿರುವ ದ್ವಿತೀಯ ದತ್ತಾಂಶಗಳ ಆಧಾರದ ಮೇಲೆ ವಿಶ್ಲೇಷಿಸುವುದು.

2) ಭಾಷಾ ಕಲಿಕೆಯ ವಿವಿಧ ಆಯಾಮಗಳಾದ ಓದು, ಬರವಣಿಗೆ, ಕೇಳುವಿಕೆ, ಮಾತನಾಡುವಿಕೆ, ವ್ಯಾಕರಣ, ಶಬ್ದಕೋಶ ಮತ್ತು ಉಚ್ಚಾರಣೆಯ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಾಧ್ಯತೆಗಳನ್ನು ಪರಿಶೀಲಿಸುವುದು.

3) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಕಲಿಕೆಯ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಪ್ರಯೋಜನಗಳನ್ನು ಗುರುತಿಸುವುದು.

4) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯಿಂದ ಉಂಟಾಗಬಹುದಾದ ಶೈಕ್ಷಣಿಕ ಮತ್ತು ನೈತಿಕ ಸವಾಲುಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.

5) ಶಾಲಾ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಮತ್ತು ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಸೂಕ್ತ ಶೈಕ್ಷಣಿಕ ಸಲಹೆಗಳನ್ನು ನೀಡುವುದು.

ಸಂಶೋಧನಾ ವಿಧಾನ:

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವು ದ್ವಿತೀಯ ದತ್ತಾಂಶ ಆಧಾರಿತ ವಿವರಣಾತ್ಮಕ ಮತ್ತು ವಿಶ್ಲೇಷಣಾತ್ಮಕ ಅಧ್ಯಯನವಾಗಿದೆ. ಪ್ರಸ್ತುತ ಅಧ್ಯಯನಕ್ಕಾಗಿ ಯಾವುದೇ ಪ್ರಾಥಮಿಕ ದತ್ತಾಂಶವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳು, ಶಿಕ್ಷಕರು, ಶಾಲೆಗಳು ಅಥವಾ ಇತರ ಪ್ರತಿಕ್ರಿಯಾತ್ಮಕರಿಂದ ನೇರವಾಗಿ ಸಂಗ್ರಹಿಸಲಾಗಿಲ್ಲ. ದ್ವಿತೀಯ ದತ್ತಾಂಶಕ್ಕಾಗಿ ಅಂತರರಾಷ್ಟ್ರೀಯ ಸಂಸ್ಥೆಗಳ ಅಧಿಕೃತ ವರದಿಗಳು, ಶಿಕ್ಷಣ ನೀತಿ ದಾಖಲೆಗಳು, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಶಿಕ್ಷಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಮಾರ್ಗಸೂಚಿಗಳು, peer–reviewed ಸಂಶೋಧನಾ ಲೇಖನಗಳು, ಶೈಕ್ಷಣಿಕ ಪುಸ್ತಕಗಳು, ಸಂಶೋಧನಾ ವರದಿಗಳು ಮತ್ತು ವಿಶ್ವಾಸಾರ್ಹ ಡಿಜಿಟಲ್ ಶೈಕ್ಷಣಿಕ ಮೂಲಗಳನ್ನು ಪರಿಗಣಿಸಲಾಗಿದೆ.

ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ:

- **ವೈಯಕ್ತಿಕ ಮತ್ತು ಹೊಂದಿಕೊಳ್ಳುವ ಭಾಷಾ ಕಲಿಕೆ:** ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಅಗತ್ಯಗಳಲ್ಲಿ ಗಣನೀಯ ವ್ಯತ್ಯಾಸವಿರುತ್ತದೆ. ಕೆಲವರು ಶಬ್ದಕೋಶದಲ್ಲಿ ಉತ್ತಮರಾಗಿದ್ದರೂ ವ್ಯಾಕರಣದಲ್ಲಿ ದುರ್ಬಲರಾಗಿರಬಹುದು; ಕೆಲವರು ಓದುವಿಕೆಯಲ್ಲಿ ಉತ್ತಮರಾಗಿದ್ದರೂ ಮಾತನಾಡುವಿಕೆಯಲ್ಲಿ ಹಿಂಜರಿಯಬಹುದು. ಸಾಂಪ್ರದಾಯಿಕ ತರಗತಿಯಲ್ಲಿ ಈ ಎಲ್ಲಾ ವೈಯಕ್ತಿಕ ವ್ಯತ್ಯಾಸಗಳಿಗೆ ತಕ್ಷಣ ಪ್ರತಿಕ್ರಿಯಿಸುವುದು ಶಿಕ್ಷಕರಿಗೆ ಕಷ್ಟಕರವಾಗಬಹುದು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ Adaptive Learning Systems ಈ ಸಂದರ್ಭದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕಾ ಪ್ರಗತಿಯನ್ನು ಗಮನಿಸಿ ವಿಷಯದ ಕಠಿಣತೆ, ಪ್ರಶ್ನೆಗಳ ಸ್ವರೂಪ ಮತ್ತು ಅಭ್ಯಾಸದ ಪ್ರಮಾಣವನ್ನು ಹೊಂದಿಸಲು ಸಹಾಯ ಮಾಡಬಹುದು. ವೈಯಕ್ತಿಕ ಕಲಿಕೆಯ ಈ ಸಾಮರ್ಥ್ಯವು ವಿದ್ಯಾರ್ಥಿಯನ್ನು ಒಂದೇ

ವೇಗದಲ್ಲಿ ಕಲಿಯುವ ಗುಂಪಿನ ಭಾಗವಾಗಿ ನೋಡುವ ಬದಲು ಅವನ ಅಥವಾ ಅವಳ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅಗತ್ಯಗಳನ್ನು ಪರಿಗಣಿಸಲು ಅವಕಾಶ ನೀಡುತ್ತದೆ.

- **ಓದು ಮತ್ತು ಅರ್ಥಗ್ರಹಣದ ಅಭಿವೃದ್ಧಿ:** ಓದುವ ಕೌಶಲ್ಯವು ಭಾಷಾ ಕಲಿಕೆಯ ಮೂಲಭೂತ ಕೌಶಲ್ಯಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಉತ್ತಮ ಓದುವ ಸಾಮರ್ಥ್ಯವು ಪಠ್ಯವನ್ನು ಕೇವಲ ಓದುವುದಲ್ಲದೆ ಅದರ ಅರ್ಥವನ್ನು ಗ್ರಹಿಸುವುದು, ಮುಖ್ಯ ವಿಚಾರಗಳನ್ನು ಗುರುತಿಸುವುದು, ನಿರ್ಣಯಗಳನ್ನು ಕೈಗೊಳ್ಳುವುದು ಮತ್ತು ಪಠ್ಯದ ಕುರಿತು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಯೋಚಿಸುವುದನ್ನು ಒಳಗೊಂಡಿರುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಸಾಧನಗಳು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಅವರ ಮಟ್ಟಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಓದುವ ಪಠ್ಯ, ಅರ್ಥಗ್ರಹಣ ಪ್ರಶ್ನೆಗಳು, ಪದಗಳ ವಿವರಣೆ ಮತ್ತು ಸಾರಾಂಶ ಚಟುವಟಿಕೆಗಳನ್ನು ಒದಗಿಸಬಹುದು. ವಿದ್ಯಾರ್ಥಿಯೊಬ್ಬನು ಕಠಿಣ ಪಠ್ಯವನ್ನು ಓದುವಾಗ ಅರ್ಥವಾಗದ ಪದದ ಅರ್ಥವನ್ನು ತಕ್ಷಣ ಕೇಳಬಹುದು ಅಥವಾ ನಿರ್ದಿಷ್ಟ ವಾಕ್ಯದ ರಚನೆಯನ್ನು ವಿವರಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ನೆರವನ್ನು ಪಡೆಯಬಹುದು. ಈ ರೀತಿಯ ತಕ್ಷಣದ ನೆರವು ಕಲಿಕೆಯ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ವಿಳಂಬವನ್ನು ಕಡಿಮೆ ಮಾಡಬಹುದು.
- **ಬರವಣಿಗೆ ಮತ್ತು ಅಭಿವ್ಯಕ್ತಿ ಕೌಶಲ್ಯ:** ಬರವಣಿಗೆ ಭಾಷಾ ಕಲಿಕೆಯ ಅತ್ಯಂತ ಸಂಕೀರ್ಣ ಕೌಶಲ್ಯಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಉತ್ತಮ ಬರವಣಿಗೆಯಲ್ಲಿ ವಿಚಾರಗಳ ಸಂಘಟನೆ, ಪದಗಳ ಆಯ್ಕೆ, ವಾಕ್ಯ ರಚನೆ, ವ್ಯಾಕರಣ, ಶೈಲಿ ಮತ್ತು ಸ್ಪಷ್ಟತೆ ಅಗತ್ಯವಾಗುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಬರವಣಿಗೆ ಸಹಾಯಕ ಸಾಧನಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ಬರವಣಿಗೆಯಲ್ಲಿನ ಕೆಲವು ವ್ಯಾಕರಣ ಮತ್ತು ಭಾಷಾ ದೋಷಗಳನ್ನು ಗುರುತಿಸಿ ತಿದ್ದುಪಡಿ ಸೂಚನೆಗಳನ್ನು ನೀಡಬಹುದು. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಬರಹವನ್ನು ಪುನಃ ಪರಿಶೀಲಿಸಿ ಸುಧಾರಿಸಿಕೊಳ್ಳಲು ಅವಕಾಶ ಪಡೆಯುತ್ತಾರೆ.
- **ಮಾತನಾಡುವಿಕೆ, ಕೇಳುವಿಕೆ ಮತ್ತು ಸಂವಹನ:** ಭಾಷೆಯ ನೈಜ ಬಳಕೆಯಲ್ಲಿ ಮಾತನಾಡುವಿಕೆ ಮತ್ತು ಕೇಳುವಿಕೆಯ ಕೌಶಲ್ಯಗಳಿಗೆ ವಿಶೇಷ ಮಹತ್ವವಿದೆ. ಆದರೆ ತರಗತಿಯಲ್ಲಿ ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಗೂ ಸಾಕಷ್ಟು ಮಾತನಾಡುವ ಸಮಯ ದೊರೆಯುವುದು ಕೆಲವೊಮ್ಮೆ ಕಷ್ಟವಾಗುತ್ತದೆ. ಸಂವಾದಾತ್ಮಕ (Conversational) ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಧ್ವನಿ ಆಧಾರಿತ ಅನ್ವಯಿಕೆಗಳು (voice–based applications) ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಪುನರಾವರ್ತಿತ ಸಂಭಾಷಣಾ ಅಭ್ಯಾಸದ ಅವಕಾಶವನ್ನು ಒದಗಿಸಬಹುದು. ವಿದ್ಯಾರ್ಥಿಗಳು ಪ್ರಶ್ನೆ ಕೇಳುವುದು, ಉತ್ತರಿಸುವುದು, ಸಂಭಾಷಣೆ ಮುಂದುವರಿಸುವುದು ಮತ್ತು ವಿವಿಧ ಸಂದರ್ಭಗಳಲ್ಲಿ ಭಾಷೆಯನ್ನು ಬಳಸುವುದು ಮುಂತಾದ ಚಟುವಟಿಕೆಗಳನ್ನು ಅಭ್ಯಾಸ ಮಾಡಬಹುದು.
- **ಶಬ್ದಕೋಶದ ಅಭಿವೃದ್ಧಿ:** ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಪ್ರಾವೀಣ್ಯತೆಯಲ್ಲಿ ಶಬ್ದಕೋಶವು ಪ್ರಮುಖ ಪಾತ್ರವಹಿಸುತ್ತದೆ. ಪದಗಳ ಅರ್ಥ ತಿಳಿದಿರುವುದಷ್ಟೇ ಅಲ್ಲದೆ, ಅವುಗಳನ್ನು ಸೂಕ್ತ ಸಂದರ್ಭಗಳಲ್ಲಿ ಬಳಸುವ ಸಾಮರ್ಥ್ಯವೂ ಮುಖ್ಯವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಸಾಧನಗಳು ಹೊಸ ಪದಗಳ ಅರ್ಥ, ಸಮಾನಾರ್ಥಕ ಪದಗಳು, ವಿರುದ್ಧಾರ್ಥಕ ಪದಗಳು, ಪದಗಳ ಬಳಕೆಯ ಸಂದರ್ಭ

ಮತ್ತು ಉದಾಹರಣೆ ವಾಕ್ಯಗಳನ್ನು ಒದಗಿಸಬಹುದು. ವಿದ್ಯಾರ್ಥಿಯ ಭಾಷಾ ಮಟ್ಟಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಹೊಸ ಪದಗಳನ್ನು ಪರಿಚಯಿಸುವ ಮೂಲಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಬ್ದಕೋಶ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ವೈಯಕ್ತಿಕಗೊಳಿಸಬಹುದು. ಪುನರಾವರ್ತಿತ ಬಳಕೆ ಮತ್ತು ಸಂದರ್ಭಾಧಾರಿತ ಅಭ್ಯಾಸವು ಪದಗಳನ್ನು ದೀರ್ಘಕಾಲಿಕವಾಗಿ ನೆನಪಿಡಲು ಸಹಾಯಕವಾಗಬಹುದು.

- **ವ್ಯಾಕರಣ ಮತ್ತು ಭಾಷಾ ನಿಖರತೆ:** ವ್ಯಾಕರಣ ಭಾಷೆಯ ರಚನೆ ಮತ್ತು ಸರಿಯಾದ ಬಳಕೆಗೆ ಆಧಾರವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ವ್ಯಾಕರಣ ಪರಿಶೀಲನಾ ಸಾಧನಗಳು ವಾಕ್ಯಗಳಲ್ಲಿನ ಕೆಲವು ವ್ಯಾಕರಣ ದೋಷಗಳನ್ನು ಗುರುತಿಸಿ ಪರ್ಯಾಯ ರೂಪಗಳನ್ನು ಸೂಚಿಸಬಲ್ಲವು. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ತಪ್ಪುಗಳನ್ನು ತಕ್ಷಣ ಗಮನಿಸಿ ಅವುಗಳನ್ನು ಸರಿಪಡಿಸಿಕೊಳ್ಳಲು ಸಾಧ್ಯವಾಗುವುದರಿಂದ ಸ್ವಯಂ–ತಿದ್ದುಪಡಿಗೆ ಅವಕಾಶ ಹೆಚ್ಚುತ್ತದೆ.
  ಆದರೆ ವ್ಯಾಕರಣದ ಸರಿಯಾದ ರೂಪವನ್ನು ನೀಡುವುದು ಮತ್ತು ಅದರ ಹಿಂದಿರುವ ನಿಯಮವನ್ನು ಅರ್ಥಮಾಡಿಸುವುದು ಎರಡು ವಿಭಿನ್ನ ವಿಷಯಗಳಾಗಿವೆ. ಆದ್ದರಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ನೀಡುವ ತಿದ್ದುಪಡಿಯನ್ನು ಕೇವಲ ಸ್ವೀಕರಿಸುವುದಕ್ಕಿಂತ ಅದರ ಕಾರಣವನ್ನು ತಿಳಿದುಕೊಳ್ಳುವಂತೆ ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಪ್ರೇರೇಪಿಸಬೇಕು. ಈ ಸಂದರ್ಭದಲ್ಲಿ ಶಿಕ್ಷಕರ ವಿವರಣೆ ಅತ್ಯಂತ ಮುಖ್ಯವಾಗುತ್ತದೆ.
- **ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರೇರಣೆ:** ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಕಲಿಕೆಯ ಪ್ರಮುಖ ಸಾಧ್ಯತೆಗಳಲ್ಲಿ ಒಂದು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ತೊಡಗಿಸಿಕೊಳ್ಳುವಿಕೆಯನ್ನು ಹೆಚ್ಚಿಸುವುದಾಗಿದೆ. ಸಂವಾದಾತ್ಮಕ ಪ್ರಶ್ನೋತ್ತರ, ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ ವೈಯಕ್ತಿಕ ಅಭ್ಯಾಸ ಮತ್ತು ವಿಭಿನ್ನ ರೀತಿಯ ವಿಷಯ ಪ್ರಸ್ತುತಪಡಿಸುವಿಕೆ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೆಚ್ಚು ಸಕ್ರಿಯ ಕಲಿಕಾ ಅನುಭವವನ್ನು ನೀಡಬಹುದು. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ತಪ್ಪುಗಳನ್ನು ಶಿಕ್ಷಕರ ಮುಂದೆ ತಕ್ಷಣ ಪ್ರದರ್ಶಿಸುವ ಆತಂಕವಿಲ್ಲದೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಯೊಂದಿಗೆ ಪುನಃ ಪುನಃ ಅಭ್ಯಾಸ ಮಾಡಬಹುದು. ಆದರೆ ತಂತ್ರಜ್ಞಾನದ ಹೊಸತನವೇ ದೀರ್ಘಕಾಲಿಕ ಕಲಿಕಾ ಪ್ರೇರಣೆಗೆ ಸಾಕಾಗುವುದಿಲ್ಲ. ವಿದ್ಯಾರ್ಥಿಗಳು ಏಕೆ ಕಲಿಯುತ್ತಿದ್ದಾರೆ, ಭಾಷೆಯ ನೈಜ ಬಳಕೆ ಏನು ಮತ್ತು ಕಲಿತ ಜ್ಞಾನವನ್ನು ಹೇಗೆ ಅನ್ವಯಿಸಬಹುದು ಎಂಬುದನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಹೆಚ್ಚು ಮುಖ್ಯ. ಹೀಗಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಯನ್ನು ಅರ್ಥಪೂರ್ಣ ಭಾಷಾ ಚಟುವಟಿಕೆಗಳೊಂದಿಗೆ ಸಂಯೋಜಿಸಿದಾಗ ಮಾತ್ರ ಅದು ಶಾಶ್ವತ ಕಲಿಕಾ ಪ್ರೇರಣೆಗೆ ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಸಹಾಯ ಮಾಡಬಹುದು.

ಶಿಕ್ಷಕರ ಪಾತ್ರದಲ್ಲಿ ಬದಲಾವಣೆ:

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬೆಳವಣಿಗೆಯೊಂದಿಗೆ ಶಿಕ್ಷಕರ ಪಾತ್ರವು ಕಡಿಮೆಯಾಗುವುದಿಲ್ಲ; ಬದಲಾಗಿ ಅದು ಹೆಚ್ಚು ಮಾರ್ಗದರ್ಶಕ, ಸಂಯೋಜಕ ಮತ್ತು ಕಲಿಕಾ ವಿನ್ಯಾಸಕರ ಪಾತ್ರದತ್ತ ಸಾಗುತ್ತದೆ. UNESCO 2024ರ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜ್ಞಾನ, ನೈತಿಕತೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಣಶಾಸ್ತ್ರ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯಂತಹ ಸಾಮರ್ಥ್ಯಗಳು ಅಗತ್ಯವೆಂದು ಸೂಚಿಸುತ್ತದೆ.
ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಭವಿಷ್ಯದ ತರಗತಿಯಲ್ಲಿ **"ಶಿಕ್ಷಕ ವಿರುದ್ಧ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ "** ಎಂಬ ದೃಷ್ಟಿಕೋನಕ್ಕಿಂತ

"ಶಿಕ್ಷಕ + ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ + ವಿದ್ಯಾರ್ಥಿ" ಎಂಬ ಸಹಭಾಗಿತ್ವದ ಮಾದರಿ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಬಹುದು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವೇಗವಾಗಿ ಮಾಹಿತಿ ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆ ನೀಡಬಹುದು; ಶಿಕ್ಷಕರು ಆ ಮಾಹಿತಿಯನ್ನು ಅರ್ಥಪೂರ್ಣ ಜ್ಞಾನವಾಗಿ ಪರಿವರ್ತಿಸಲು, ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಯೋಚಿಸಲು ಮತ್ತು ಮೌಲ್ಯಾಧಾರಿತ ಕಲಿಕೆಗೆ ಮಾರ್ಗದರ್ಶನ ನೀಡಬಹುದು.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಭಾಷಾ ಕಲಿಕೆಯ ಪ್ರಮುಖ ಪ್ರಯೋಜನಗಳು:

ಸಮಗ್ರ ವಿಶ್ಲೇಷಣೆಯಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ಹಲವಾರು ಸಾಧ್ಯತೆಗಳನ್ನು ಹೊಂದಿರುವುದು ಕಂಡುಬರುತ್ತದೆ.

- ಮೊದಲನೆಯದಾಗಿ, ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ ದೊರೆಯುವುದರಿಂದ ಅವರು ತಮ್ಮ ತಪ್ಪುಗಳನ್ನು ತ್ವರಿತವಾಗಿ ಗುರುತಿಸಬಹುದು.
- ಎರಡನೆಯದಾಗಿ, ವೈಯಕ್ತಿಕ ಕಲಿಕೆಯ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಯ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಅಗತ್ಯಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಅಭ್ಯಾಸಗಳನ್ನು ರೂಪಿಸಬಹುದು.
- ಮೂರನೆಯದಾಗಿ, ತರಗತಿಯ ಹೊರತಾಗಿಯೂ ಭಾಷಾ ಅಭ್ಯಾಸ ಮಾಡಲು ಅವಕಾಶ ದೊರೆಯುವುದರಿಂದ ಸ್ವಯಂ ಕಲಿಕೆ ಬಲಪಡಬಹುದು.
- ನಾಲ್ಕನೆಯದಾಗಿ, ಸಂವಾದಾತ್ಮಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮೂಲಕ ಮಾತನಾಡುವಿಕೆ ಮತ್ತು ಸಂವಹನದ ಪುನರಾವರ್ತಿತ ಅಭ್ಯಾಸ ಸಾಧ್ಯವಾಗುತ್ತದೆ.
- ಐದನೆಯದಾಗಿ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವಿವಿಧ ರೀತಿಯ ಪಠ್ಯ ಮತ್ತು ಉದಾಹರಣೆಗಳನ್ನು ವೇಗವಾಗಿ ಒದಗಿಸುವ ಮೂಲಕ ಶಿಕ್ಷಕರಿಗೆ ಹೆಚ್ಚುವರಿ ಬೋಧನಾ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಸಹಾಯ ಮಾಡಬಹುದು.

ಭಾರತದ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020 ಕೂಡ ಶಿಕ್ಷಣದಲ್ಲಿ ತಂತ್ರಜ್ಞಾನದ ಬಳಕೆಯು ಕಲಿಕೆ, ಮೌಲ್ಯಮಾಪನ, ಯೋಜನೆ ಮತ್ತು ಆಡಳಿತದ ವಿವಿಧ ಆಯಾಮಗಳನ್ನು ಬಲಪಡಿಸಬಹುದೆಂದು ಗುರುತಿಸುತ್ತದೆ. ತಂತ್ರಜ್ಞಾನವನ್ನು ಸೂಕ್ತ ಸಂದರ್ಭಗಳಲ್ಲಿ ಕಠಿಣವಾಗಿ ಮತ್ತು ಪಾರದರ್ಶಕವಾಗಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಿದ ನಂತರ ವಿಸ್ತರಿಸುವ ಅಗತ್ಯವನ್ನೂ ನೀತಿ ಒತ್ತಿಹೇಳುತ್ತದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ಸವಾಲುಗಳು ಮತ್ತು ಮಿತಿಗಳು:

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಶೈಕ್ಷಣಿಕ ಸಾಮರ್ಥ್ಯವನ್ನು ಗುರುತಿಸುವುದರ ಜೊತೆಗೆ ಅದರ ಮಿತಿಗಳನ್ನೂ ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಅಗತ್ಯವಾಗಿದೆ.

- ಮಾಹಿತಿಯ ನಿಖರತೆ: ಸೃಜನಾತ್ಮಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಕೆಲವೊಮ್ಮೆ ತಪ್ಪಾದ ಅಥವಾ ಅಪೂರ್ಣ ಮಾಹಿತಿಯನ್ನು ನೀಡಬಹುದು. ಆದ್ದರಿಂದ AI ನೀಡುವ ಮಾಹಿತಿಯನ್ನು ವಿಶ್ವಾಸಾರ್ಹ ಮೂಲಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸುವುದು ಅಗತ್ಯ.

- ಅತಿಯಾದ ಅವಲಂಬನೆ: ಂಖಯ ಮೇಲಿನ ಅತಿಯಾದ ಅವಲಂಬನೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವತಂತ್ರ ಚಿಂತನೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ಸ್ವಯಂ ಅಭಿವ್ಯಕ್ತಿಯ ಮೇಲೆ ಪರಿಣಾಮ ಬೀರಬಹುದು.
- ಡಿಜಿಟಲ್ ಅಸಮಾನತೆ: ಎಲ್ಲಾ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಮಾನವಾಗಿ ಸಾಧನಗಳು, ಇಂಟರ್ನೆಟ್ ಮತ್ತು AI ಸೇವೆಗಳು ಲಭ್ಯವಿರದ ಕಾರಣ ಕಲಿಕೆಯ ಅವಕಾಶಗಳಲ್ಲಿ ಅಸಮಾನತೆ ಉಂಟಾಗಬಹುದು.
- ಡೇಟಾ ಗೌಪ್ಯತೆ: AI ಬಳಸುವಾಗ ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಮಾಹಿತಿಯ ಸುರಕ್ಷತೆಯನ್ನು ಕಾಪಾಡುವುದು ಅಗತ್ಯ. UNESCO ಕೂಡ ಡೇಟಾ ಗೌಪ್ಯತೆ ಮತ್ತು ವಯೋಚಿತ AI ಬಳಕೆಗೆ ಒತ್ತು ನೀಡಿದೆ.

ಶೈಕ್ಷಣಿಕ ಸಲಹೆಗಳು:

- ಪ್ರೌಢಶಾಲಾ ಭಾಷಾ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವರ್ಧನೆ ಮೊದಲ ಆದ್ಯತೆಯಾಗಬೇಕು.
- ಶಿಕ್ಷಕರು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಾಧನಗಳ ಕಾರ್ಯವಿಧಾನ, ಅವುಗಳ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಮಿತಿಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಂಡಿರಬೇಕು.
- ಶಾಲಾ ಮಟ್ಟದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಗೆ ಸ್ಪಷ್ಟ ಮಾರ್ಗಸೂಚಿಗಳನ್ನು ರೂಪಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಯಾವ ಸಂದರ್ಭಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಸಬಹುದು, ಯಾವ ಸಂದರ್ಭಗಳಲ್ಲಿ ಸ್ವತಂತ್ರವಾಗಿ ಕೆಲಸ ಮಾಡಬೇಕು ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯನ್ನು ಹೇಗೆ ಉಲ್ಲೇಖಿಸಬೇಕು ಎಂಬುದರ ಕುರಿತು ಸ್ಪಷ್ಟ ನಿಯಮಗಳು ಇರಬೇಕು.
- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಭಾಷಾ ಕಲಿಕೆಯ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸುವಾಗ ವಿದ್ಯಾರ್ಥಿಯ ಸ್ವಂತ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆಗೆ ಹೆಚ್ಚಿನ ಅವಕಾಶ ನೀಡಬೇಕು.
- ಭಾಷಾ ತರಗತಿಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಚಟುವಟಿಕೆಗಳನ್ನು ಪಠ್ಯಕ್ರಮದೊಂದಿಗೆ ಸಂಯೋಜಿಸಬಹುದು. ಉದಾಹರಣೆಗೆ, ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯಿಂದ ಒಂದು ಪಠ್ಯದ ಸಾರಾಂಶವನ್ನು ಪಡೆದು ಅದನ್ನು ಮೂಲ ಪಠ್ಯದೊಂದಿಗೆ ಹೋಲಿಸಬಹುದು; ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸೃಷ್ಟಿಸಿದ ಬರಹದಲ್ಲಿನ ವ್ಯಾಕರಣ ದೋಷಗಳನ್ನು ಗುರುತಿಸಬಹುದು;
- ಒಂದೇ ವಿಚಾರವನ್ನು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿ ವಿಭಿನ್ನ ರೀತಿಯಲ್ಲಿ ಹೇಗೆ ವ್ಯಕ್ತಪಡಿಸುತ್ತಾರೆ ಎಂಬುದನ್ನು ವಿಶ್ಲೇಷಿಸಬಹುದು. ಇಂತಹ ಚಟುವಟಿಕೆಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯ ಜೊತೆಗೆ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ಭಾಷಾ ಅರಿವನ್ನೂ ಬೆಳೆಸುತ್ತವೆ.

ಉಪಸಂಹಾರ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಕಲಿಕಾ ಕೌಶಲ್ಯಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುವಲ್ಲಿ ಗಮನಾರ್ಹ ಶೈಕ್ಷಣಿಕ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ. ದ್ವಿತೀಯ ದತ್ತಾಂಶಗಳ ಆಧಾರದ ಮೇಲೆ ನಡೆಸಿದ ಪ್ರಸ್ತುತ ವಿಶ್ಲೇಷಣೆಯು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ, ಓದು ಮತ್ತು

ಅರ್ಥಗ್ರಹಣ, ಬರವಣಿಗೆ, ವ್ಯಾಕರಣ, ಶಬ್ದಕೋಶ, ಮಾತನಾಡುವಿಕೆ ಮತ್ತು ಸಂವಹನ ಕೌಶಲ್ಯಗಳ ಅಭ್ಯಾಸವನ್ನು ಬೆಂಬಲಿಸಬಲ್ಲದು ಎಂಬುದನ್ನು ಸೂಚಿಸುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಮ್ಮದೇ ಆದ ವೇಗದಲ್ಲಿ ಅಭ್ಯಾಸ ಮಾಡಲು ಮತ್ತು ತರಗತಿಯ ಹೊರತಾಗಿಯೂ ಕಲಿಕೆಯನ್ನು ಮುಂದುವರಿಸಲು ಅವಕಾಶ ನೀಡುವ ಮೂಲಕ ಸ್ವಯಂ ಕಲಿಕೆಯನ್ನು ಬಲಪಡಿಸಬಹುದು.

ಪ್ರೌಢಶಾಲಾ ಭಾಷಾ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಾಗಿ ಬಳಸುವುದಕ್ಕಿಂತ ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿಸ್ತರಿಸುವ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯನ್ನು ಬೆಂಬಲಿಸುವ ಪೂರಕ ಸಾಧನವಾಗಿ ಬಳಸುವುದು ಹೆಚ್ಚು ಸೂಕ್ತವಾಗಿದೆ. ಶಿಕ್ಷಕರ ಮಾರ್ಗದರ್ಶನ, ವಿದ್ಯಾರ್ಥಿಗಳ ಸಕ್ರಿಯ ಭಾಗವಹಿಸುವಿಕೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ನೈತಿಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಬಳಕೆಯೊಂದಿಗೆ ಸಂಯೋಜಿಸಿದಾಗ ಮಾತ್ರ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಭಾಷಾ ಕಲಿಕೆಯಲ್ಲಿ ದೀರ್ಘಕಾಲಿಕ ಶೈಕ್ಷಣಿಕ ಮೌಲ್ಯವನ್ನು ಸೃಷ್ಟಿಸಬಲ್ಲದು.

ಹೀಗಾಗಿ, "ಶಿಕ್ಷಕನನ್ನು ಬದಲಿಸುವ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ" ಗಿಂತ "ಶಿಕ್ಷಕನೊಂದಿಗೆ ಕಾರ್ಯನಿರ್ವಹಿಸುವ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ" ಎಂಬ ದೃಷ್ಟಿಕೋನವೇ ಪ್ರೌಢಶಾಲಾ ಭಾಷಾ ಶಿಕ್ಷಣದ ಭವಿಷ್ಯಕ್ಕೆ ಹೆಚ್ಚು ಸೂಕ್ತವಾಗಿದೆ. ಮಾನವೀಯ ಬೋಧನೆ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ತಾಂತ್ರಿಕ ಸಾಮರ್ಥ್ಯಗಳ ಸಮತೋಲನದ ಸಂಯೋಜನೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಭಾಷಾ ಪ್ರಾವೀಣ್ಯತೆ, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಯ ಸಮಗ್ರ ಬೆಳವಣಿಗೆಗೆ ದಾರಿ ಮಾಡಿಕೊಡಬಹುದು.

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ಸಹ ಪ್ರಾಧ್ಯಾಪಕರು., ರಾಜ್ಯಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ಮತ್ತು ಸಂಶೋಧನಾ ವಿಭಾಗ., ಕರ್ನಾಟಕ ರಾಜ್ಯ ಮುಕ್ತ ವಿಶ್ವವಿದ್ಯಾಲಯ ಮೈಸೂರು.

ಸಾರಾಂಶ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence – AI) ಇಂದಿನ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಮಹತ್ತರ ಬದಲಾವಣೆಗಳನ್ನು ಉಂಟುಮಾಡುತ್ತಿರುವ ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ. ವಿಶೇಷವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಇದರ ಬಳಕೆಯು ಬೋಧನೆ, ಕಲಿಕೆ, ಮೌಲ್ಯಮಾಪನ ಹಾಗೂ ಸಂಶೋಧನಾ ಚಟುವಟಿಕೆಗಳನ್ನು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ರೂಪಿಸುವಲ್ಲಿ ಪ್ರಮುಖ ಪಾತ್ರವಹಿಸುತ್ತಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಸಾಧನಗಳ ಮೂಲಕ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಸ್ವಯಂಚಾಲಿತ ಮೌಲ್ಯಮಾಪನ, ಪಾಠಯೋಜನೆ ಸಿದ್ಧತೆ, ಕಲಿಕಾ ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಗತಿಯ ನಿರಂತರ ಮೇಲ್ವಿಚಾರಣೆ ಸಾಧ್ಯವಾಗುತ್ತಿದೆ. ಜನರೇಟಿವ್ AI ಉಪಕರಣಗಳಾದ ChatGPT, Google Gemini ಹಾಗೂ Microsoft Copilot ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವುದರ ಜೊತೆಗೆ ಗುಣಮಟ್ಟದ ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳನ್ನು ತ್ವರಿತವಾಗಿ ಸಿದ್ಧಪಡಿಸಲು ನೆರವಾಗುತ್ತವೆ. ದಿವ್ಯಾಂಗ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ Speech–to–Text, Text–to–Speech, ಭಾಷಾಂತರ, ಉಪಶೀರ್ಷಿಕೆ ಹಾಗೂ ದೃಶ್ಯ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನಗಳ ಮೂಲಕ ಒಳಗೊಳ್ಳುವಿಕೆ ಮತ್ತು ಸಮಾನ ಶಿಕ್ಷಣದ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುವಲ್ಲಿ ಂಖ ಮಹತ್ವದ ಪಾತ್ರ ವಹಿಸುತ್ತದೆ. ಆದರೆ ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯದ ಕೊರತೆ, ಶಿಕ್ಷಕರಲ್ಲಿ ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯದ ಅಭಾವ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ ಮತ್ತು ಸೈಬರ್ ಸುರಕ್ಷತೆ, ನೈತಿಕತೆ, ಭಾಷಾ ಮಿತಿಗಳು ಹಾಗೂ ಗ್ರಾಮೀಣ–ನಗರ ಡಿಜಿಟಲ್ ಅಸಮಾನತೆ ಮೊದಲಾದ ಸವಾಲುಗಳು ಇದರ ಪರಿಣಾಮಕಾರಿ ಅನುಷ್ಠಾನಕ್ಕೆ ಅಡ್ಡಿಯಾಗಿವೆ. ಈ ಲೇಖನವು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅವಕಾಶಗಳು, ಪ್ರಮುಖ ಸವಾಲುಗಳು ಹಾಗೂ ಭವಿಷ್ಯದ ದಿಕ್ಕುಗಳನ್ನು ವಿಶ್ಲೇಷಣಾತ್ಮಕವಾಗಿ ಪರಿಶೀಲಿಸುತ್ತದೆ. ಜೊತೆಗೆ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ–2020ರ ಬೆಳಕಿನಲ್ಲಿ ಶಿಕ್ಷಕರ ತರಬೇತಿಯಲ್ಲಿ ಂಖಯ ಜವಾಬ್ದಾರಿಯುತ ಮತ್ತು ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಅಗತ್ಯವಾದ ನೀತಿಗಳು, ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ, ನಿರಂತರ ವೃತ್ತಿಪರ ತರಬೇತಿ ಹಾಗೂ ಸ್ಥಳೀಯ ಭಾಷಾ ಸಂಪನ್ಮೂಲಗಳ ಅಭಿವೃದ್ಧಿಯ ಅಗತ್ಯತೆಯನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ. ಅಂತಿಮವಾಗಿ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಲ್ಲ; ಬದಲಾಗಿ ಅವರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಸೃಜನಶೀಲತೆ, ಸಂಶೋಧನಾ ಮನೋಭಾವ ಹಾಗೂ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯನ್ನು ವೃದ್ಧಿಸುವ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ ಎಂಬುದನ್ನು ಈ ಅಧ್ಯಯನ ಪ್ರತಿಪಾದಿಸುತ್ತದೆ.

ಪ್ರಮುಖ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ, ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣ, ಸ್ಮಾರ್ಟ್ ಶಿಕ್ಷಕರು, ಶಿಕ್ಷಣ* ತಂತ್ರಜ್ಞಾನ

ಪರಿಚಯ

21ನೇ ಶತಮಾನದಲ್ಲಿ ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರವು ವೇಗವಾಗಿ ಡಿಜಿಟಲ್ ಪರಿವರ್ತನೆಯತ್ತ ಸಾಗುತ್ತಿದೆ. ಮಾಹಿತಿ ಮತ್ತು ಸಂವಹನ ತಂತ್ರಜ್ಞಾನದ ಬೆಳವಣಿಗೆಯೊಂದಿಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence – AI) ಶಿಕ್ಷಣದ ವಿವಿಧ ಆಯಾಮಗಳಲ್ಲಿ ಮಹತ್ವದ ಪಾತ್ರ ವಹಿಸುತ್ತಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಕೇವಲ ತಾಂತ್ರಿಕ ಸಾಧನವಲ್ಲ; ಅದು ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟ, ಬೋಧನಾ ವಿಧಾನ, ಮೌಲ್ಯಮಾಪನ ಹಾಗೂ ಕಲಿಕೆಯ ಅನುಭವವನ್ನು ಸುಧಾರಿಸುವ ಹೊಸ ಮಾರ್ಗವಾಗಿದೆ. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ಯಾವುದೇ ರಾಷ್ಟ್ರದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ಪ್ರಮುಖ ಅಡಿಪಾಯವಾಗಿದೆ. ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಕರನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನಗಳ ಅರಿವು ಮತ್ತು ಬಳಕೆ ಅಗತ್ಯವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಆಧಾರಿತ ಉಪಕರಣಗಳು ಶಿಕ್ಷಕರಿಗೆ ಪಾಠಯೋಜನೆ ಸಿದ್ಧಪಡಿಸುವುದು, ವೈಯಕ್ತಿಕ ಕಲಿಕೆಯನ್ನು ಉತ್ತೇಜಿಸುವುದು, ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ಪ್ರಗತಿಯನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು ಹಾಗೂ ಪರಿಣಾಮಕಾರಿ ಮೌಲ್ಯಮಾಪನ ನಡೆಸುವುದರಲ್ಲಿ ಸಹಾಯ ಮಾಡುತ್ತವೆ. ಭಾರತದಲ್ಲಿ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ (NEP–2020) ಶಿಕ್ಷಣದಲ್ಲಿ ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಡಿಜಿಟಲ್ ಕಲಿಕೆಗೆ ಹೆಚ್ಚಿನ ಮಹತ್ವ ನೀಡಿದೆ. ಇದರ ಪರಿಣಾಮವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿಯೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯ ಬಗ್ಗೆ ಹೆಚ್ಚಿನ ಗಮನ ಹರಿಸಲಾಗುತ್ತಿದೆ. ChatGPT, ಉಠಠಂಟಜ Gemini, Microsoft Copilot ಮುಂತಾದ ಜನರೇಟಿವ್ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಾಧನಗಳು ಶಿಕ್ಷಕರ ಬೋಧನೆ ಮತ್ತು ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳ ಸೃಷ್ಟಿಯಲ್ಲಿ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತಿವೆ. ಆದಾಗ್ಯೂ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪರಿಣಾಮಕಾರಿ ಅನುಷ್ಠಾನಕ್ಕಾಗಿ ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯ, ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ, ದತ್ತಾಂಶ ಸುರಕ್ಷತೆ, ನೈತಿಕತೆ ಹಾಗೂ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಪ್ರಮುಖ ಅಂಶಗಳಾಗಿವೆ. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ದಿಕ್ಕುಗಳನ್ನು ಸಮಗ್ರವಾಗಿ ಅಧ್ಯಯನ ಮಾಡುವ ಅಗತ್ಯವಿದೆ. ಈ ಅಧ್ಯಯನವು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪ್ರಸ್ತುತ ಸ್ಥಿತಿ, ಅದರ ಪ್ರಯೋಜನಗಳು, ಸವಾಲುಗಳು ಹಾಗೂ ಭವಿಷ್ಯದ ಸಾಧ್ಯತೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಿ, ಗುಣಮಟ್ಟದ ಮತ್ತು ತಂತ್ರಜ್ಞಾನ–ಸಜ್ಜಿತ ಶಿಕ್ಷಕರ ನಿರ್ಮಾಣಕ್ಕೆ ಮಾರ್ಗದರ್ಶನ ನೀಡುವ ಉದ್ದೇಶ ಹೊಂದಿದೆ.

ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು

1. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.
2. ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಶಿಫಾರಸುಗಳನ್ನು ನೀಡುವುದು.
3. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅವಕಾಶಗಳು

ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕೆಯ ಸಾಮರ್ಥ್ಯ, ಆಸಕ್ತಿ, ಗ್ರಹಿಕೆಯ ವೇಗ ಮತ್ತು ಕಲಿಕಾ ಶೈಲಿ ವಿಭಿನ್ನವಾಗಿರುತ್ತದೆ. ಸಾಂಪ್ರದಾಯಿಕ ಬೋಧನಾ ವಿಧಾನದಲ್ಲಿ ಎಲ್ಲ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಒಂದೇ ರೀತಿಯ

ಬೋಧನೆ ನಡೆಯುತ್ತದೆ. ಆದರೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ನೆರವಿನಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ದತ್ತಾಂಶವನ್ನು ವಿಶ್ಲೇಷಿಸಿ ಅವರ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಕಲಿಕಾ ವಿಷಯವನ್ನು ಒದಗಿಸಬಹುದು. ಉದಾಹರಣೆಗೆ, ವಿದ್ಯಾರ್ಥಿಯೊಬ್ಬರು ಗಣಿತದಲ್ಲಿ ದುರ್ಬಲರಾಗಿದ್ದರೆ ಅವರಿಗೆ ಹೆಚ್ಚುವರಿ ಅಭ್ಯಾಸ ಪ್ರಶ್ನೆಗಳು ಹಾಗೂ ಸುಲಭ ವಿವರಣೆಗಳನ್ನು ನೀಡಬಹುದು. ಮತ್ತೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯು ಉತ್ತಮ ಸಾಧನೆ ಮಾಡುತ್ತಿದ್ದರೆ ಅವನಿಗೆ ಮುಂದಿನ ಹಂತದ ವಿಷಯಗಳನ್ನು ಪರಿಚಯಿಸಬಹುದು. ಹೀಗಾಗಿ ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಗೂ ವೈಯಕ್ತಿಕ ಕಲಿಕೆಯ ಅನುಭವ ದೊರೆಯುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಕರಿಗೆ ಆಧುನಿಕ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳಲು ನೆರವಾಗುತ್ತದೆ. ಪಾಠಯೋಜನೆ, ಪ್ರಸ್ತುತಿಗಳು, ಕಾರ್ಯಪತ್ರಗಳು, ಪ್ರಶ್ನೆಪತ್ರಿಕೆಗಳು, ವಿಡಿಯೊ ಪಾಠಗಳು ಹಾಗೂ ದೃಶ್ಯ–ಶ್ರಾವ್ಯ ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಕಡಿಮೆ ಸಮಯದಲ್ಲಿ ಸಿದ್ಧಪಡಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಇದರಿಂದ ಶಿಕ್ಷಕರು ಹೆಚ್ಚಿನ ಸಮಯವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳೊಂದಿಗೆ ಸಂವಾದ, ಮಾರ್ಗದರ್ಶನ ಮತ್ತು ಸೃಜನಾತ್ಮಕ ಬೋಧನೆಗೆ ಮೀಸಲಿಡಬಹುದು.

ಶಿಕ್ಷಕರು ಪಾಠಯೋಜನೆ, ಮೌಲ್ಯಮಾಪನ, ವರದಿ ಸಿದ್ಧಪಡಿಸುವುದು ಹಾಗೂ ಆಡಳಿತಾತ್ಮಕ ಕೆಲಸಗಳಿಗೆ ಹೆಚ್ಚಿನ ಸಮಯ ವ್ಯಯಿಸುತ್ತಾರೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಈ ಪುನರಾವರ್ತಿತ ಕಾರ್ಯಗಳನ್ನು ಸ್ವಯಂಚಾಲಿತಗೊಳಿಸುವ ಮೂಲಕ ಸಮಯವನ್ನು ಉಳಿಸುತ್ತದೆ. ಉಳಿದ ಸಮಯವನ್ನು ಶಿಕ್ಷಕರು ಸಂಶೋಧನೆ, ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಮಸ್ಯೆಗಳಿಗೆ ಪರಿಹಾರ ಕಂಡುಕೊಳ್ಳಲು ಬಳಸಬಹುದು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ಪರೀಕ್ಷಾ ಉತ್ತರಗಳನ್ನು ಶೀಘ್ರವಾಗಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಿ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ನೀಡುತ್ತವೆ. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ತಪ್ಪುಗಳನ್ನು ತಕ್ಷಣ ಅರಿತು ತಿದ್ದುಕೊಳ್ಳಬಹುದು. ಶಿಕ್ಷಕರಿಗೂ ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಧನೆಯ ಬಗ್ಗೆ ಸಮಗ್ರ ವರದಿ ದೊರೆಯುತ್ತದೆ.

ದಿವ್ಯಾಂಗ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಗುಣಮಟ್ಟದ ಮತ್ತು ಸಮಾನ ಶಿಕ್ಷಣವನ್ನು ಒದಗಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence) ಅತ್ಯಂತ ಪರಿಣಾಮಕಾರಿ ಸಾಧನವಾಗಿದೆ. ಸಾಂಪ್ರದಾಯಿಕ ಬೋಧನಾ ವಿಧಾನಗಳಲ್ಲಿ ಎದುರಾಗುವ ಅನೇಕ ಅಡೆತಡೆಗಳನ್ನು ನಿವಾರಿಸಿ, ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ವೈಯಕ್ತಿಕ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾದ ಕಲಿಕಾ ವಾತಾವರಣವನ್ನು ನಿರ್ಮಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಹಕಾರಿಯಾಗಿದೆ. ಇದು ಶಿಕ್ಷಣವನ್ನು ಹೆಚ್ಚು ಒಳಗೊಳ್ಳುವ (Inclusive), ಸುಲಭವಾಗಿ ಪ್ರವೇಶಿಸಬಹುದಾದ (Accessible) ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತವಾಗಿಸುತ್ತದೆ.

ದೃಷ್ಟಿ ವೈಕಲ್ಯ ಹೊಂದಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಪಠ್ಯವನ್ನು ಧ್ವನಿಯಾಗಿ ಪರಿವರ್ತಿಸುವ (Text-to-Speech) ತಂತ್ರಜ್ಞಾನವು ಪುಸ್ತಕಗಳು, ಅಧ್ಯಯನ ಸಾಮಗ್ರಿಗಳು ಹಾಗೂ ಡಿಜಿಟಲ್ ವಿಷಯಗಳನ್ನು ಧ್ವನಿಯ ರೂಪದಲ್ಲಿ ಕೇಳುವ ಅವಕಾಶವನ್ನು ಒದಗಿಸುತ್ತದೆ. ಇದರಿಂದ ಅವರು ಇತರ ವಿದ್ಯಾರ್ಥಿಗಳಂತೆ ಪಾಠಗಳನ್ನು ಸುಲಭವಾಗಿ ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಅದೇ ರೀತಿ ಧ್ವನಿಯನ್ನು ಪಠ್ಯವಾಗಿ ಪರಿವರ್ತಿಸುವ (Speech–to–Text) ತಂತ್ರಜ್ಞಾನವು ಶ್ರವಣ ವೈಕಲ್ಯ ಹೊಂದಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಶಿಕ್ಷಕರ ಉಪನ್ಯಾಸಗಳು ಮತ್ತು ಚರ್ಚೆಗಳನ್ನು ತಕ್ಷಣವೇ ಲಿಖಿತ ರೂಪದಲ್ಲಿ ಒದಗಿಸುತ್ತದೆ. ಇದು

ತರಗತಿಯ ಬೋಧನೆಯಲ್ಲಿ ಅವರ ಭಾಗವಹಿಸುವಿಕೆಯನ್ನು ಹೆಚ್ಚಿಸುತ್ತದೆ. ಇದಲ್ಲದೆ, ಸ್ವಯಂಚಾಲಿತ ಭಾಷಾಂತರ (Language Translation) ವ್ಯವಸ್ಥೆಗಳು ವಿವಿಧ ಭಾಷೆಗಳಲ್ಲಿ ಕಲಿಕಾ ವಿಷಯಗಳನ್ನು ಒದಗಿಸುವ ಮೂಲಕ ಭಾಷಾ ಅಡೆತಡೆಗಳನ್ನು ಕಡಿಮೆ ಮಾಡುತ್ತವೆ. ಉಪಶೀರ್ಷಿಕೆ (Subtitles/Closed Captions) ಸೌಲಭ್ಯವು ವೀಡಿಯೊ ಪಾಠಗಳನ್ನು ಶ್ರವಣ ವೈಕಲ್ಯ ಹೊಂದಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸುಲಭವಾಗಿ ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ನೆರವಾಗುತ್ತದೆ. ಇದರ ಜೊತೆಗೆ ದೃಶ್ಯ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನಗಳು (Visual Assistive Technologies) ಚಿತ್ರಗಳು, ನಕ್ಷೆಗಳು, ಗ್ರಾಫ್‌ಗಳು ಮತ್ತು ಇತರ ದೃಶ್ಯ ಮಾಹಿತಿಯನ್ನು ಸರಳ ಹಾಗೂ ಅರ್ಥಗರ್ಭಿತ ರೀತಿಯಲ್ಲಿ ಪ್ರದರ್ಶಿಸುವ ಮೂಲಕ ಕಲಿಕೆಯನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿಸುತ್ತವೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮತ್ತೊಂದು ಪ್ರಮುಖ ಕೊಡುಗೆ ಎಂದರೆ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ (Personalized Learning). ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಸಾಮರ್ಥ್ಯ, ಕಲಿಕೆಯ ವೇಗ ಮತ್ತು ಅಗತ್ಯಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಿ, ಅವರಿಗೆ ಸೂಕ್ತವಾದ ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಅಭ್ಯಾಸಗಳನ್ನು ಶಿಫಾರಸು ಮಾಡುತ್ತದೆ. ಇದರಿಂದ ದಿವ್ಯಾಂಗ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಸಾಮರ್ಥ್ಯಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಕಲಿಯಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ ಹಾಗೂ ಆತ್ಮವಿಶ್ವಾಸವೂ ಹೆಚ್ಚುತ್ತದೆ. ಹೆಚ್ಚುವರಿಯಾಗಿ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನಗಳು ಶಿಕ್ಷಕರಿಗೂ ದಿವ್ಯಾಂಗ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಗತಿಯನ್ನು ನಿರಂತರವಾಗಿ ಗಮನಿಸಲು, ಅವರ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಪರಿಷ್ಕರಿಸಲು ಮತ್ತು ಸೂಕ್ತ ಮಾರ್ಗದರ್ಶನ ನೀಡಲು ಸಹಾಯ ಮಾಡುತ್ತವೆ. ಇದರಿಂದ ಶಿಕ್ಷಣದಲ್ಲಿ ಸಮಾನ ಅವಕಾಶ, ಸಾಮಾಜಿಕ ಒಳಗೊಳ್ಳುವಿಕೆ ಮತ್ತು ಗುಣಮಟ್ಟದ ಕಲಿಕೆಯನ್ನು ಉತ್ತೇಜಿಸಲಾಗುತ್ತದೆ. ಹೀಗಾಗಿ, ದಿವ್ಯಾಂಗ ವಿದ್ಯಾರ್ಥಿಗಳ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯು ಕೇವಲ ತಾಂತ್ರಿಕ ಸೌಲಭ್ಯವಲ್ಲ; ಅದು ಶಿಕ್ಷಣದಲ್ಲಿ ಸಮಾನತೆ, ಒಳಗೊಳ್ಳುವಿಕೆ, ಸ್ವಾವಲಂಬನೆ ಮತ್ತು ಗುಣಮಟ್ಟದ ಕಲಿಕೆಯನ್ನು ಸಾಧಿಸಲು ಸಹಕಾರಿಯಾಗುವ ಪರಿವರ್ತನಾತ್ಮಕ ಸಾಧನವಾಗಿದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ವರ್ಚುವಲ್ ತರಗತಿಗಳು, ಸ್ಮಾರ್ಟ್ ತರಗತಿಗಳು, ಆಟೀಕರಣ (Gamification), ವಾಸ್ತವಿಕತೆ (Virtual Reality) ಹಾಗೂ ವೃದ್ಧಿತ ವಾಸ್ತವಿಕತೆ (Augmented Reality) ಆಧಾರಿತ ಬೋಧನೆಯನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಅನುಷ್ಠಾನಗೊಳಿಸಬಹುದು. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ಆಸಕ್ತಿ ಮತ್ತು ಭಾಗವಹಿಸುವಿಕೆ ಹೆಚ್ಚುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ವಿಶ್ವದ ವಿವಿಧ ವಿಶ್ವವಿದ್ಯಾಲಯಗಳು, ಶಿಕ್ಷಕರು ಹಾಗೂ ತಜ್ಞರೊಂದಿಗೆ ಸಂಪರ್ಕ ಸಾಧಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ. ಅಂತರರಾಷ್ಟ್ರೀಯ ತರಬೇತಿ, ಸಂಶೋಧನಾ ಸಹಯೋಗ ಹಾಗೂ ಜಾಗತಿಕ ಶೈಕ್ಷಣಿಕ ಸಂಪನ್ಮೂಲಗಳ ಬಳಕೆಯಿಂದ ಶಿಕ್ಷಕರ ಜ್ಞಾನ ಮತ್ತು ಅನುಭವ ವಿಸ್ತಾರಗೊಳ್ಳುತ್ತದೆ.

ಒಟ್ಟಾರೆಯಾಗಿ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಲ್ಲ; ಅದು ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವ ಪರಿಣಾಮಕಾರಿ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ. ಸೂಕ್ತ ತರಬೇತಿ, ಬಲವಾದ ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ ಮತ್ತು ನೈತಿಕ ಬಳಕೆಯ ಮೂಲಕ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವನ್ನು ಹೆಚ್ಚು ಗುಣಮಟ್ಟದ,

ತಂತ್ರಜ್ಞಾನಾಧಾರಿತ ಹಾಗೂ ಭವಿಷ್ಯಮುಖಿಯನ್ನಾಗಿ ರೂಪಿಸಬಹುದು. ಇದರಿಂದ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಫಲಿತಾಂಶ, ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳ ಕಾರ್ಯಕ್ಷಮತೆ ಗಣನೀಯವಾಗಿ ಹೆಚ್ಚುವ ಸಾಧ್ಯತೆಯಿದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸವಾಲುಗಳು

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಮಹತ್ವದ ಬದಲಾವಣೆಗಳನ್ನು ತಂದಿದ್ದರೂ, ಅದರ ಪರಿಣಾಮಕಾರಿ ಅನುಷ್ಠಾನಕ್ಕೆ ಹಲವು ಸವಾಲುಗಳು ಅಡ್ಡಿಯಾಗಿವೆ. ವಿಶೇಷವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯು ಕೇವಲ ತಾಂತ್ರಿಕ ವಿಷಯವಲ್ಲ; ಅದು ಸಾಮಾಜಿಕ, ಆರ್ಥಿಕ, ನೈತಿಕ, ಶೈಕ್ಷಣಿಕ ಹಾಗೂ ಕಾನೂನು ಅಂಶಗಳೊಂದಿಗೆ ಸಂಬಂಧ ಹೊಂದಿದೆ. ಈ ಸವಾಲುಗಳನ್ನು ಪರಿಹರಿಸದೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಂಪೂರ್ಣ ಪ್ರಯೋಜನವನ್ನು ಪಡೆಯಲು ಸಾಧ್ಯವಾಗುವುದಿಲ್ಲ.

ಭಾರತದ ಅನೇಕ ಸರ್ಕಾರಿ ಮತ್ತು ಗ್ರಾಮೀಣ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಸಂಸ್ಥೆಗಳಲ್ಲಿ ಉತ್ತಮ ಗುಣಮಟ್ಟದ ಇಂಟರ್ನೆಟ್, ಕಂಪ್ಯೂಟರ್, ಸ್ಮಾರ್ಟ್ ಬೋರ್ಡ್, ಡಿಜಿಟಲ್ ಪ್ರಯೋಗಾಲಯ ಹಾಗೂ ಆಧುನಿಕ ತಾಂತ್ರಿಕ ಸಾಧನಗಳ ಕೊರತೆಯಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಶಿಕ್ಷಣವು ತಂತ್ರಜ್ಞಾನವನ್ನು ಅವಲಂಬಿಸಿರುವುದರಿಂದ ಮೂಲಸೌಕರ್ಯ ಇಲ್ಲದ ಪ್ರದೇಶಗಳಲ್ಲಿ ಇದರ ಅನುಷ್ಠಾನ ಕಷ್ಟಕರವಾಗಿದೆ. ಗ್ರಾಮೀಣ ಮತ್ತು ನಗರ ಪ್ರದೇಶಗಳ ನಡುವೆ ಡಿಜಿಟಲ್ ಸೌಲಭ್ಯಗಳಲ್ಲಿ ಇರುವ ಅಸಮಾನತೆ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟದಲ್ಲಿಯೂ ವ್ಯತ್ಯಾಸವನ್ನುಂಟು ಮಾಡುತ್ತದೆ. ಆದ್ದರಿಂದ ಸರ್ಕಾರವು ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯವನ್ನು ಬಲಪಡಿಸುವತ್ತ ಹೆಚ್ಚಿನ ಗಮನ ಹರಿಸಬೇಕಾಗಿದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಯಶಸ್ವಿ ಬಳಕೆಗೆ ಶಿಕ್ಷಕರಲ್ಲಿ ತಾಂತ್ರಿಕ ಜ್ಞಾನ ಮತ್ತು ಡಿಜಿಟಲ್ ಕೌಶಲ್ಯ ಅಗತ್ಯವಾಗಿದೆ. ಆದರೆ ಅನೇಕ ಶಿಕ್ಷಕರು ಇನ್ನೂ ಸಾಂಪ್ರದಾಯಿಕ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನೇ ಅನುಸರಿಸುತ್ತಿದ್ದಾರೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ತಂತ್ರಾಂಶಗಳು, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಡಿಜಿಟಲ್ ಪಾಠಯೋಜನೆ, ಜನರೇಟಿವ್ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಉಪಕರಣಗಳ ಬಳಕೆ ಮುಂತಾದ ವಿಷಯಗಳಲ್ಲಿ ಸಮರ್ಪಕ ತರಬೇತಿಯ ಕೊರತೆಯಿದೆ. ನಿರಂತರ ವೃತ್ತಿಪರ ತರಬೇತಿ ಇಲ್ಲದೆ ಈ ತಂತ್ರಜ್ಞಾನವನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಬಳಸುವುದು ಕಷ್ಟ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ಕುರಿತು ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದ ಮಾಹಿತಿಯನ್ನು ಸಂಗ್ರಹಿಸಿ, ವಿಶ್ಲೇಷಿಸಿ ಹಾಗೂ ಸಂಸ್ಕರಿಸುತ್ತವೆ. ಈ ಮಾಹಿತಿಯಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ, ಪರೀಕ್ಷಾ ಫಲಿತಾಂಶಗಳು, ಕಲಿಕೆಯ ಪ್ರಗತಿ, ಹಾಜರಾತಿ, ಕಲಿಕೆಯ ಶೈಲಿ, ಆಸಕ್ತಿಗಳು, ವರ್ತನೆ, ವೈಯಕ್ತಿಕ ವಿವರಗಳು ಹಾಗೂ ಡಿಜಿಟಲ್ ಚಟುವಟಿಕೆಗಳಂತಹ ಸೂಕ್ಷ್ಮ ಮಾಹಿತಿಗಳು ಒಳಗೊಂಡಿರುತ್ತವೆ. ಈ ಮಾಹಿತಿಯ ವಿಶ್ಲೇಷಣೆಯ ಮೂಲಕ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕೆಯ ಸಾಮರ್ಥ್ಯವನ್ನು ಗುರುತಿಸಿ, ವೈಯಕ್ತಿಕ ಕಲಿಕೆಯ ಯೋಜನೆಗಳನ್ನು ರೂಪಿಸಲು ನೆರವಾಗುತ್ತದೆ. ಅದೇ ರೀತಿ, ಶಿಕ್ಷಕರ ಬೋಧನಾ ವಿಧಾನಗಳು, ಕಾರ್ಯಕ್ಷಮತೆ, ಮೌಲ್ಯಮಾಪನ ವಿಧಾನಗಳು ಹಾಗೂ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಮಾಹಿತಿಯನ್ನೂ ಸಂಗ್ರಹಿಸಲಾಗುತ್ತದೆ. ಆದರೆ ಇಂತಹ ಮಾಹಿತಿಯ ಸಂಗ್ರಹಣೆ ಮತ್ತು ಬಳಕೆಯೊಂದಿಗೆ ಹಲವಾರು ಗಂಭೀರ ಸವಾಲುಗಳು

ಎದುರಾಗುತ್ತವೆ. ಸೂಕ್ತ ಭದ್ರತಾ ವ್ಯವಸ್ಥೆಗಳ ಕೊರತೆಯಿದ್ದರೆ ಅಥವಾ ಸೈಬರ್ ದಾಳಿಗಳು ನಡೆದರೆ ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯು ಅನಧಿಕೃತ ವ್ಯಕ್ತಿಗಳ ಕೈಗೆ ಸಿಗುವ ಸಾಧ್ಯತೆಯಿದೆ. ಇದರಿಂದ ಗುರುತು ಕಳವು, ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ದುರುಪಯೋಗ, ಆರ್ಥಿಕ ವಂಚನೆ, ಮಾನಸಿಕ ಒತ್ತಡ ಹಾಗೂ ಗೌಪ್ಯತೆಯ ಉಲ್ಲಂಘನೆಯಂತಹ ಸಮಸ್ಯೆಗಳು ಉಂಟಾಗಬಹುದು. ವಿಶೇಷವಾಗಿ ಮಕ್ಕಳ ಮತ್ತು ಅಪ್ರಾಪ್ತ ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾಹಿತಿಯ ಸುರಕ್ಷತೆ ಅತ್ಯಂತ ಮಹತ್ವದ್ದಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ದತ್ತಾಂಶವನ್ನು ವಿಶ್ಲೇಷಿಸುವಾಗ ಕೆಲವೊಮ್ಮೆ ಅಲ್ಗೋರಿದಮ್‌ಗಳ ಪಕ್ಷಪಾತ ಉಂಟಾಗುವ ಸಾಧ್ಯತೆಯೂ ಇದೆ. ಅಪೂರ್ಣ ಅಥವಾ ಅಸಮತೋಲನದ ದತ್ತಾಂಶವನ್ನು ಬಳಸಿದರೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯವನ್ನು ತಪ್ಪಾಗಿ ಅಂದಾಜಿಸುವ ಸಾಧ್ಯತೆ ಇರುತ್ತದೆ. ಇದರಿಂದ ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ ಅಸಮಾನತೆ ಉಂಟಾಗಿ, ಕೆಲವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಅನ್ಯಾಯವಾಗಬಹುದು. ಆದ್ದರಿಂದ ದತ್ತಾಂಶದ ಗುಣಮಟ್ಟ, ನಿಖರತೆ ಹಾಗೂ ಪಾರದರ್ಶಕತೆಯನ್ನು ಖಚಿತಪಡಿಸಿಕೊಳ್ಳುವುದು ಅತ್ಯಗತ್ಯವಾಗಿದೆ.

ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಬಲಿಷ್ಠ ದತ್ತಾಂಶ ಸಂರಕ್ಷಣಾ ನೀತಿಗಳನ್ನು ರೂಪಿಸಬೇಕು. ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯನ್ನು ಸಂಗ್ರಹಿಸುವ ಮೊದಲು ಅವರ ತಿಳುವಳಿಕೆಯುಳ್ಳ ಒಪ್ಪಿಗೆಯನ್ನು ಪಡೆಯಬೇಕು. ಮಾಹಿತಿಯನ್ನು ಸುರಕ್ಷಿತ ಸರ್ವರ್‌ಗಳಲ್ಲಿ ಸಂಗ್ರಹಿಸುವುದು, ಸಂಕೇತೀಕರಣ ತಂತ್ರಜ್ಞಾನವನ್ನು ಬಳಸುವುದು, ಬಹುಹಂತದ ದೃಢೀಕರಣ ನಿಯಮಿತ ಸೈಬರ್ ಭದ್ರತಾ ಪರಿಶೀಲನೆ ಹಾಗೂ ಅನುಮತಿ ಪಡೆದ ವ್ಯಕ್ತಿಗಳಿಗೆ ಮಾತ್ರ ಮಾಹಿತಿಯ ಪ್ರವೇಶವನ್ನು ನೀಡುವ ಕ್ರಮಗಳನ್ನು ಅನುಸರಿಸಬೇಕು. ಇದರ ಜೊತೆಗೆ ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಸೈಬರ್ ಸುರಕ್ಷತಾ ಜಾಗೃತಿ ಬೆಳೆಸುವುದು ಅತ್ಯಗತ್ಯವಾಗಿದೆ. ಬಲವಾದ ಪಾಸ್‌ವರ್ಡ್‌ಗಳ ಬಳಕೆ, ಫಿಶಿಂಗ್ ದಾಳಿಗಳ ಬಗ್ಗೆ ಎಚ್ಚರಿಕೆ, ಸುರಕ್ಷಿತ ಡಿಜಿಟಲ್ ಅಭ್ಯಾಸಗಳು ಹಾಗೂ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯನ್ನು ಜವಾಬ್ದಾರಿಯುತವಾಗಿ ನಿರ್ವಹಿಸುವ ಬಗ್ಗೆ ತರಬೇತಿ ನೀಡಬೇಕು. ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ದತ್ತಾಂಶ ಸುರಕ್ಷತೆಯನ್ನು ಕೇವಲ ತಾಂತ್ರಿಕ ವಿಷಯವಾಗಿ ಪರಿಗಣಿಸದೆ, ನೈತಿಕ ಮತ್ತು ಕಾನೂನುಬದ್ಧ ಜವಾಬ್ದಾರಿಯೆಂದು ಪರಿಗಣಿಸಬೇಕು.

ಒಟ್ಟಾರೆಯಾಗಿ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಯಶಸ್ವಿ ಅನುಷ್ಠಾನಕ್ಕೆ ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಪಾರದರ್ಶಕ ದತ್ತಾಂಶ ನಿರ್ವಹಣೆ ಹಾಗೂ ಸ್ಪಷ್ಟ ಗೌಪ್ಯತಾ ನೀತಿಗಳು ಅತ್ಯಂತ ಅವಶ್ಯಕವಾಗಿವೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ವಿಶ್ವಾಸವನ್ನು ಗಳಿಸುವುದರೊಂದಿಗೆ, ಸುರಕ್ಷಿತ ಹಾಗೂ ಜವಾಬ್ದಾರಿಯುತ ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣ ಪರಿಸರವನ್ನು ನಿರ್ಮಿಸುವುದು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪರಿಣಾಮಕಾರಿ ಬಳಕೆಗೆ ಮೂಲಭೂತ ಅಗತ್ಯವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯನ್ನು ಸಂಗ್ರಹಿಸಿ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. ಈ ಮಾಹಿತಿಯಲ್ಲಿ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ, ವೈಯಕ್ತಿಕ ವಿವರಗಳು ಹಾಗೂ ಕಲಿಕೆಯ ಮಾದರಿಗಳು ಒಳಗೊಂಡಿರುತ್ತವೆ. ಈ ದತ್ತಾಂಶವು ದುರುಪಯೋಗ ವಾದರೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಗೌಪ್ಯತೆಗೆ ಧಕ್ಕೆಯಾಗಬಹುದು. ಆದ್ದರಿಂದ ದತ್ತಾಂಶ ಸಂರಕ್ಷಣೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ ಮತ್ತು ಸ್ಪಷ್ಟ ಗೌಪ್ಯತಾ ನೀತಿಗಳು ಅಗತ್ಯವಾಗಿವೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯಿಂದ ಸಿದ್ಧವಾಗುವ ಮಾಹಿತಿಯು ಯಾವಾಗಲೂ ಸಂಪೂರ್ಣ ನಿಖರವಾಗಿರುತ್ತದೆ ಎಂದು ಹೇಳಲಾಗುವುದಿಲ್ಲ. ಕೆಲವೊಮ್ಮೆ ತಪ್ಪು ಮಾಹಿತಿ, ಪಕ್ಷಪಾತ ಅಥವಾ ಅಪೂರ್ಣ ಉತ್ತರಗಳು ದೊರೆಯಬಹುದು. ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಶಿಕ್ಷಕರು ಈ ಮಾಹಿತಿಯನ್ನು ಪರಿಶೀಲಿಸದೆ ಬಳಸಿದರೆ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟದ ಮೇಲೆ ಪ್ರತಿಕೂಲ ಪರಿಣಾಮ ಉಂಟಾಗಬಹುದು. ಆದ್ದರಿಂದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯಲ್ಲಿ ನೈತಿಕ ಜವಾಬ್ದಾರಿ ಅತ್ಯಂತ ಮುಖ್ಯವಾಗಿದೆ. ಶಿಕ್ಷಕರು ತಮ್ಮ ಬೋಧನೆಯ ಪ್ರತಿಯೊಂದು ಹಂತದಲ್ಲೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಅವಲಂಬಿಸಿದರೆ ಅವರ ಸೃಜನಶೀಲತೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಹಾಗೂ ಸ್ವತಂತ್ರ ನಿರ್ಧಾರ ಸಾಮರ್ಥ್ಯ ಕುಂಠಿತವಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ. ಶಿಕ್ಷಣವು ಕೇವಲ ಮಾಹಿತಿ ನೀಡುವ ಪ್ರಕ್ರಿಯೆಯಲ್ಲ; ಅದು ಮೌಲ್ಯ ಶಿಕ್ಷಣ, ವ್ಯಕ್ತಿತ್ವ ನಿರ್ಮಾಣ ಮತ್ತು ಮಾನವೀಯ ಸಂಬಂಧಗಳ ಅಭಿವೃದ್ಧಿಯ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ. ಈ ಅಂಶಗಳನ್ನು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಂಪೂರ್ಣವಾಗಿ ಬದಲಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ.

ನಗರ ಪ್ರದೇಶಗಳ ಖಾಸಗಿ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನವನ್ನು ಸುಲಭವಾಗಿ ಅಳವಡಿಸಿಕೊಳ್ಳುತ್ತವೆ. ಆದರೆ ಗ್ರಾಮೀಣ ಮತ್ತು ಸರ್ಕಾರಿ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಸಂಸ್ಥೆಗಳಲ್ಲಿ ಆರ್ಥಿಕ ಹಾಗೂ ತಾಂತ್ರಿಕ ಮಿತಿಗಳಿವೆ. ಈ ಅಸಮಾನತೆಯಿಂದ ಎಲ್ಲ ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳು ಸಮಾನ ಅವಕಾಶಗಳನ್ನು ಪಡೆಯುವುದಿಲ್ಲ. ಪರಿಣಾಮವಾಗಿ ಶಿಕ್ಷಣದಲ್ಲಿ ಗುಣಮಟ್ಟದ ಅಂತರ ಹೆಚ್ಚಾಗುವ ಸಾಧ್ಯತೆ ಇದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ತಂತ್ರಜ್ಞಾನಗಳನ್ನು ಅಳವಡಿಸಲು ಹೆಚ್ಚಿನ ಹೂಡಿಕೆ ಅಗತ್ಯವಿದೆ. ಕಂಪ್ಯೂಟರ್, ಸಾಫ್ಟ್‌ವೇರ್, ಪರವಾನಗಿ, ಇಂಟರ್ನೆಟ್, ತರಬೇತಿ ಹಾಗೂ ನಿರ್ವಹಣೆಗೆ ಹೆಚ್ಚಿನ ವೆಚ್ಚವಾಗುತ್ತದೆ. ಸಣ್ಣ ಹಾಗೂ ಗ್ರಾಮೀಣ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳಿಗೆ ಈ ವೆಚ್ಚವನ್ನು ಭರಿಸುವುದು ಸವಾಲಾಗಿದೆ.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಹೆಚ್ಚಿನ ಉಪಕರಣಗಳು ಇಂಗ್ಲಿಷ್ ಭಾಷೆಯನ್ನು ಕೇಂದ್ರವಾಗಿಟ್ಟುಕೊಂಡು ಅಭಿವೃದ್ಧಿಪಡಿಸಲಾಗಿದೆ. ಕನ್ನಡ ಸೇರಿದಂತೆ ಅನೇಕ ಭಾರತೀಯ ಭಾಷೆಗಳಲ್ಲಿ ಇನ್ನೂ ಗುಣಮಟ್ಟದ ಶೈಕ್ಷಣಿಕ ವಿಷಯಗಳು ಸೀಮಿತವಾಗಿವೆ. ಇದರಿಂದ ಸ್ಥಳೀಯ ಭಾಷೆಯಲ್ಲಿ ಶಿಕ್ಷಣ ಪಡೆಯುವ ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಂಪೂರ್ಣ ಪ್ರಯೋಜನ ದೊರೆಯುವುದಿಲ್ಲ. ವಿದ್ಯಾರ್ಥಿಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಬಳಸಿಕೊಂಡು ಅಸೈನ್‌ಮೆಂಟ್, ಯೋಜನಾ ವರದಿ ಹಾಗೂ ಸಂಶೋಧನಾ ಲೇಖನಗಳನ್ನು ಸ್ವತಃ ಮಾಡದೆ ಸಿದ್ಧಪಡಿಸುವ ಸಾಧ್ಯತೆ ಇದೆ. ಇದು ಸ್ವತಂತ್ರ ಕಲಿಕೆ, ಸೃಜನಶೀಲತೆ ಹಾಗೂ ಸಂಶೋಧನಾ ನೈತಿಕತೆಗೆ ಧಕ್ಕೆಯನ್ನುಂಟುಮಾಡಬಹುದು. ಆದ್ದರಿಂದ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಸ್ಪಷ್ಟ ಮಾರ್ಗಸೂಚಿಗಳನ್ನು ರೂಪಿಸಬೇಕು.

ಕೆಲವರು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬೆಳವಣಿಗೆಯಿಂದ ಶಿಕ್ಷಕರ ಅಗತ್ಯ ಕಡಿಮೆಯಾಗಬಹುದು ಎಂದು ಭಾವಿಸುತ್ತಾರೆ. ಆದರೆ ವಾಸ್ತವವಾಗಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಲ್ಲ; ಅದು ಸಹಾಯಕ ಸಾಧನವಾಗಿದೆ. ಆದರೂ ಈ ಆತಂಕವನ್ನು ನಿವಾರಿಸಲು ಸರ್ಕಾರ ಮತ್ತು ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಜಾಗೃತಿ ಕಾರ್ಯಕ್ರಮಗಳನ್ನು ಹಮ್ಮಿಕೊಳ್ಳಬೇಕು. ಭಾರತದ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಗೆ ಸಮಗ್ರ ರಾಷ್ಟ್ರೀಯ ಮಾರ್ಗಸೂಚಿಗಳು ಇನ್ನೂ ಸಂಪೂರ್ಣವಾಗಿ ರೂಪುಗೊಂಡಿಲ್ಲ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯಲ್ಲಿ ನೈತಿಕತೆ, ಹೊಣೆಗಾರಿಕೆ, ದತ್ತಾಂಶ ಸುರಕ್ಷತೆ ಹಾಗೂ ಬೌದ್ಧಿಕ ಸ್ವತ್ತಿನ ಹಕ್ಕುಗಳ ಕುರಿತು ಸ್ಪಷ್ಟ

ನಿಯಮಗಳು ಅಗತ್ಯವಾಗಿವೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಭವಿಷ್ಯದ ದಿಕ್ಕುಗಳು

1. **ಶಿಕ್ಷಕರ ತರಬೇತಿ ಪಠ್ಯಕ್ರಮದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಮಗ್ರ ಏಕೀಕರಣ:** ಭವಿಷ್ಯದಲ್ಲಿ ಬಿ.ಎಡ್., ಎಂ.ಎಡ್., ಡಿ.ಎಲ್.ಎಡ್. ಹಾಗೂ ಇತರ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಕಾರ್ಯಕ್ರಮಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಕುರಿತ ವಿಷಯಗಳನ್ನು ಕಡ್ಡಾಯವಾಗಿ ಸೇರಿಸುವ ಅಗತ್ಯವಿದೆ. ಈ ಪಠ್ಯಕ್ರಮಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಭೂತ ಪರಿಕಲ್ಪನೆಗಳು, ದತ್ತಾಂಶ ಸಾಕ್ಷರತೆ,ಡಿಜಿಟಲ್ ನೈತಿಕತೆ, ಜನರೇಟಿವ್ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆ, ಯಂತ್ರ ಕಲಿಕೆ, ಶಿಕ್ಷಣ ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ಡಿಜಿಟಲ್ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಒಳಗೊಳ್ಳಬೇಕು. ಇದರ ಜೊತೆಗೆ ಶಿಕ್ಷಕರು ಕೇವಲ ತಂತ್ರಜ್ಞಾನ ಬಳಕೆದಾರರಾಗಿರದೆ, ಡಿಜಿಟಲ್ ನಾಯಕರು ಹಾಗೂ ಶೈಕ್ಷಣಿಕ ನವೋದ್ಯಮಿಗಳಾಗಿ ರೂಪುಗೊಳ್ಳಬೇಕು. ಶಿಕ್ಷಕರು ತಂತ್ರಜ್ಞಾನವನ್ನು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಅರ್ಥಮಾಡಿಕೊಂಡು, ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ಅಗತ್ಯತೆಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಅದನ್ನು ಬಳಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಿಕೊಳ್ಳಬೇಕು.

2. **ವೈಯಕ್ತಿಕ ಹಾಗೂ ಹೊಂದಾಣಿಕೆಯ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ:** ಮುಂದಿನ ದಿನಗಳಲ್ಲಿ ಎಲ್ಲಾ ಶಿಕ್ಷಕರಿಗೂ ಒಂದೇ ರೀತಿಯ ತರಬೇತಿ ನೀಡುವ ಬದಲು, ಅವರ ಅನುಭವ, ವಿಷಯ ಪರಿಣತಿ, ಬೋಧನಾ ಕೌಶಲ್ಯ ಹಾಗೂ ವೃತ್ತಿಪರ ಅಗತ್ಯತೆಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವೈಯಕ್ತಿಕ ತರಬೇತಿ ನೀಡಲಾಗುತ್ತದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಪ್ರತಿಯೊಬ್ಬ ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಕಲಿಕೆಯ ಪ್ರಗತಿ ಹಾಗೂ ತರಬೇತಿ ಅಗತ್ಯಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಿ ಸೂಕ್ತ ತರಬೇತಿ ಘಟಕಗಳನ್ನು ಮಾಡುತ್ತದೆ. ಇದರಿಂದ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿ, ವೈಜ್ಞಾನಿಕ ಮತ್ತು ಅಗತ್ಯಾಧಾರಿತವಾಗುತ್ತದೆ.

3. **ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ:** ಇಂದಿನ ಜ್ಞಾನ ಸಮಾಜದಲ್ಲಿ ಶಿಕ್ಷಕರು ಜೀವನಪರ್ಯಂತ ಕಲಿಯುವವರಾಗಿರಬೇಕು. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಕಲಿಕಾ ವೇದಿಕೆಗಳು ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯನ್ನು ನಿರಂತರವಾಗಿ ಬೆಂಬಲಿಸುತ್ತವೆ. ಆನ್‌ಲೈನ್ ಕೋರ್ಸ್‌ಗಳು, ವೆಬಿನಾರ್‌ಗಳು, ಪ್ರಮಾಣಪತ್ರ ಕಾರ್ಯಕ್ರಮಗಳು, ಡಿಜಿಟಲ್ ಕಾರ್ಯಾಗಾರಗಳು ಹಾಗೂ ಸ್ವಯಂಚಾಲಿತ ಕೌಶಲ್ಯ ಮೌಲ್ಯಮಾಪನ ವ್ಯವಸ್ಥೆಗಳ ಮೂಲಕ ಶಿಕ್ಷಕರು ತಮ್ಮ ಸಾಮರ್ಥ್ಯವನ್ನು ನಿರಂತರವಾಗಿ ವೃದ್ಧಿಸಿಕೊಳ್ಳಬಹುದು. ಈ ವಿಧಾನವು ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟವನ್ನು ಸುಧಾರಿಸುವಲ್ಲಿ ಪ್ರಮುಖ ಪಾತ್ರ ವಹಿಸುತ್ತದೆ.

4. **ದತ್ತಾಂಶ ಆಧಾರಿತ ಬೋಧನೆ:** ಭವಿಷ್ಯದಲ್ಲಿ ಶಿಕ್ಷಕರು ಕೇವಲ ಅನುಭವದ ಆಧಾರದ ಮೇಲೆ ಬೋಧನೆ ಮಾಡುವುದಿಲ್ಲ; ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಧನೆ, ಕಲಿಕೆಯ ವೇಗ, ಹಾಜರಾತಿ, ಆಸಕ್ತಿ, ಮೌಲ್ಯಮಾಪನ ಫಲಿತಾಂಶ ಹಾಗೂ ವರ್ತನಾ ದತ್ತಾಂಶವನ್ನು ವಿಶ್ಲೇಷಿಸಿ ಬೋಧನಾ ನಿರ್ಧಾರಗಳನ್ನು ಕೈಗೊಳ್ಳುತ್ತಾರೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ಮಾದರಿಗಳನ್ನು ಗುರುತಿಸಿ, ಹಿಂದುಳಿಯುವ ಸಾಧ್ಯತೆಯಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಮುಂಚಿತವಾಗಿ ಪತ್ತೆಹಚ್ಚಿ ಶಿಕ್ಷಕರಿಗೆ

ಸೂಕ್ತ ಶೈಕ್ಷಣಿಕ ಸಲಹೆಗಳನ್ನು ನೀಡುತ್ತದೆ. ಇದರಿಂದ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ ಮತ್ತು ಕಲಿಕಾ ಫಲಿತಾಂಶಗಳು ಗಮನಾರ್ಹವಾಗಿ ಸುಧಾರಿಸುತ್ತವೆ.

5. **ಸ್ಮಾರ್ಟ್ ತರಗತಿಗಳು, ವರ್ಚುವಲ್ ಕಲಿಕೆ ಮತ್ತು ಡಿಜಿಟಲ್ ನವೀನತೆ:** ಮುಂದಿನ ದಿನಗಳಲ್ಲಿ ಸ್ಮಾರ್ಟ್ ತರಗತಿಗಳು, ವರ್ಚುವಲ್ ರಿಯಾಲಿಟಿ, ಆಗ್ಮೆಂಟೆಡ್ ರಿಯಾಲಿಟಿ, ಹೋಲೋಗ್ರಾಫಿಕ್ ಬೋಧನೆ, ಡಿಜಿಟಲ್ ಪ್ರಯೋಗಾಲಯಗಳು ಹಾಗೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಕಲಿಕಾ ವೇದಿಕೆಗಳು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಅವಿಭಾಜ್ಯ ಭಾಗವಾಗಲಿವೆ. ಇವುಗಳ ಮೂಲಕ ಶಿಕ್ಷಕರು ತರಬೇತಿಯ ಹಂತದಲ್ಲಿಯೇ ವಾಸ್ತವ ತರಗತಿಯ ಅನುಭವವನ್ನು ಪಡೆಯಬಹುದು. ಇದರಿಂದ ಬೋಧನಾ ಕೌಶಲ್ಯ, ತರಗತಿ ನಿರ್ವಹಣೆ ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿ ಸಂವಹನದ ಗುಣಮಟ್ಟ ಹೆಚ್ಚುತ್ತದೆ.

6. **ಸಂಶೋಧನೆ ಮತ್ತು ನವೀನತೆಗೆ ಉತ್ತೇಜನ:** ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಸಂಶೋಧನೆಯ ಗುಣಮಟ್ಟವನ್ನು ಹೆಚ್ಚಿಸುವಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮಹತ್ವದ ಪಾತ್ರ ವಹಿಸುತ್ತದೆ. ಸಾಹಿತ್ಯ ವಿಮರ್ಶೆ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಅಂಕಿಅಂಶಗಳ ಸಂಸ್ಕರಣೆ, ಉಲ್ಲೇಖ ನಿರ್ವಹಣೆ ಹಾಗೂ ಸಂಶೋಧನಾ ವರದಿ ತಯಾರಿಕೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಪರಿಣಾಮಕಾರಿ ಸಹಾಯ ಮಾಡುತ್ತದೆ. ವಿಶ್ವವಿದ್ಯಾಲಯಗಳು, ಸಂಶೋಧನಾ ಸಂಸ್ಥೆಗಳು ಹಾಗೂ ಶಿಕ್ಷಕರ ತರಬೇತಿ ಕಾಲೇಜುಗಳು ಭಾರತೀಯ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಗೆ ಸೂಕ್ತವಾದ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಮಾದರಿಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಲು ಹೆಚ್ಚಿನ ಸಂಶೋಧನೆ ನಡೆಸಬೇಕು.

7. **ಸರ್ಕಾರ–ವಿಶ್ವವಿದ್ಯಾಲಯ–ತಂತ್ರಜ್ಞಾನ ಸಂಸ್ಥೆಗಳ ಸಹಭಾಗಿತ್ವ:** ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಯಶಸ್ವಿ ಅನುಷ್ಠಾನಕ್ಕಾಗಿ ಸರ್ಕಾರ, ವಿಶ್ವವಿದ್ಯಾಲಯಗಳು, ಶಿಕ್ಷಕರ ತರಬೇತಿ ಸಂಸ್ಥೆಗಳು ಹಾಗೂ ತಂತ್ರಜ್ಞಾನ ಕಂಪನಿಗಳ ನಡುವೆ ಬಲವಾದ ಸಹಭಾಗಿತ್ವ ಅಗತ್ಯವಾಗಿದೆ. ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ, ಶಿಕ್ಷಕರ ತರಬೇತಿ, ಸಂಶೋಧನಾ ಯೋಜನೆಗಳು, ಸ್ಥಳೀಯ ಭಾಷೆಯ ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳು ಹಾಗೂ ಮುಕ್ತ ಶೈಕ್ಷಣಿಕ ಸಂಪನ್ಮೂಲಗಳ ಅಭಿವೃದ್ಧಿಗೆ ಈ ಸಹಭಾಗಿತ್ವ ಅತ್ಯಗತ್ಯವಾಗಿದೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ಎಲ್ಲ ಆಯಾಮಗಳಲ್ಲಿಯೂ ಬದಲಾವಣೆಯನ್ನು ತರುತ್ತಿದೆ. ಬೋಧನೆ, ಕಲಿಕೆ, ಮೌಲ್ಯಮಾಪನ, ಸಂಶೋಧನೆ ಹಾಗೂ ಆಡಳಿತಾತ್ಮಕ ಕಾರ್ಯಗಳಲ್ಲಿ ಇದರ ಕೊಡುಗೆ ಮಹತ್ವದ್ದಾಗಿದೆ. ಆದರೆ ಇದರ ಯಶಸ್ಸು ಕೇವಲ ತಂತ್ರಜ್ಞಾನದ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿಲ್ಲ; ಶಿಕ್ಷಕರ ಸಿದ್ಧತೆ, ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ, ನೈತಿಕತೆ, ಭಾಷಾ ಅಭಿವೃದ್ಧಿ ಹಾಗೂ ಸರ್ಕಾರಿ ನೀತಿಗಳ ಮೇಲೂ ಅವಲಂಬಿತವಾಗಿದೆ. ಭವಿಷ್ಯದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಮಾನವ ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಾಗಿ ಪರಿಗಣಿಸದೆ, ಅವರ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನವಾಗಿ ಬಳಸಬೇಕು. ಇದರಿಂದ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟ ಹೆಚ್ಚುವುದರ ಜೊತೆಗೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಸಮಗ್ರ ಅಭಿವೃದ್ಧಿಯೂ ಸಾಧ್ಯವಾಗುತ್ತದೆ.

ಸಂಶೋಧನಾ ಕಂಡುಹಿಡಿಕೆಗಳು.

- ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಪರಿಣಾಮಕಾರಿ ಸಾಧನವಾಗಿದೆ. ನಿರಂತರ ತರಬೇತಿ, ಆನ್ಲೈನ್ ಕಲಿಕೆ, ಕೌಶಲ್ಯಾಭಿವೃದ್ಧಿ ಹಾಗೂ ಡಿಜಿಟಲ್ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸಲು ಇದು ಸಹಕಾರಿಯಾಗಿದೆ.

- ಸಂಶೋಧನಾ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ ಹೆಚ್ಚುತ್ತಿದೆ. ಸಾಹಿತ್ಯ ವಿಮರ್ಶೆ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಉಲ್ಲೇಖ ನಿರ್ವಹಣೆ ಹಾಗೂ ಸಂಶೋಧನಾ ವರದಿ ಸಿದ್ಧಪಡಿಸುವಲ್ಲಿ ಇದು ಸಮಯ ಮತ್ತು ಶ್ರಮವನ್ನು ಕಡಿಮೆ ಮಾಡುತ್ತದೆ.

- ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ ಮತ್ತು ನೈತಿಕ ಬಳಕೆ ಪ್ರಮುಖ ಸವಾಲುಗಳಾಗಿವೆ. ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ಸುರಕ್ಷತೆ ಹಾಗೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಸ್ಪಷ್ಟ ಮಾರ್ಗಸೂಚಿಗಳು ಅಗತ್ಯವೆಂಬುದು ಅಧ್ಯಯನದಿಂದ ತಿಳಿದುಬಂದಿದೆ.

- ಭಾರತೀಯ ಭಾಷೆಗಳಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಶೈಕ್ಷಣಿಕ ಸಂಪನ್ಮೂಲಗಳ ಕೊರತೆ ಇದೆ. ಕನ್ನಡ ಸೇರಿದಂತೆ ಸ್ಥಳೀಯ ಭಾಷೆಗಳಲ್ಲಿ ಗುಣಮಟ್ಟದ ಡಿಜಿಟಲ್ ಕಲಿಕಾ ವಿಷಯಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುವ ಅಗತ್ಯತೆ ಸ್ಪಷ್ಟವಾಗಿದೆ.

- ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರಿಗೆ ಪರ್ಯಾಯವಲ್ಲ ಎಂಬುದು ಅಧ್ಯಯನದ ಪ್ರಮುಖ ಕಂಡುಹಿಡಿಕೆಯಾಗಿದ್ದು, ಇದು ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಸೃಜನಶೀಲತೆ, ಸಂಶೋಧನಾ ಮನೋಭಾವ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯನ್ನು ವೃದ್ಧಿಸುವ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನವಾಗಿದೆ.

- ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಮಾನವೀಯ ಮೌಲ್ಯಗಳ ಸಮತೋಲನವು ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಯಶಸ್ಸಿಗೆ ಅತ್ಯಗತ್ಯವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಮಾನವೀಯ ಸ್ಪರ್ಶ, ನೈತಿಕತೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಯೊಂದಿಗೆ ಸಂಯೋಜಿಸಿದಾಗ ಮಾತ್ರ ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯನ್ನು ನಿರ್ಮಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ.

ಉಪಸಂಹಾರ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯನ್ನು ಆಧುನೀಕರಿಸುವ ಪ್ರಮುಖ ತಂತ್ರಜ್ಞಾನವಾಗಿ ಹೊರಹೊಮ್ಮಿದೆ. ಇದು ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವುದರ ಜೊತೆಗೆ ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ತ್ವರಿತ ಮೌಲ್ಯಮಾಪನ, ಸಂಶೋಧನೆ ಹಾಗೂ ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟವನ್ನು ಹೆಚ್ಚಿಸುತ್ತದೆ. ಶಿಕ್ಷಣದಲ್ಲಿ ನವೀನತೆ, ದತ್ತಾಂಶ ಆಧಾರಿತ ನಿರ್ಧಾರಗಳು ಹಾಗೂ ಸಮಗ್ರ ಕಲಿಕೆಯ ಅನುಭವವನ್ನು ಒದಗಿಸುವಲ್ಲಿ ಇದರ ಪಾತ್ರ ಮಹತ್ವದ್ದಾಗಿದೆ. ಆದಾಗ್ಯೂ, ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯದ ಕೊರತೆ, ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯದ ಅಭಾವ, ಭಾಷಾ ಮಿತಿಗಳು, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ನೈತಿಕ ಸಮಸ್ಯೆಗಳು ಮತ್ತು ಡಿಜಿಟಲ್ ಅಸಮಾನತೆ ಮೊದಲಾದ ಸವಾಲುಗಳನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ

ಪರಿಹರಿಸಬೇಕು. ಈ ಸವಾಲುಗಳಿಗೆ ಸೂಕ್ತ ನೀತಿಗಳು, ನಿರಂತರ ಶಿಕ್ಷಕರ ತರಬೇತಿ, ಡಿಜಿಟಲ್ ಹೂಡಿಕೆ ಹಾಗೂ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯ ಮೂಲಕ ಪರಿಹಾರ ಕಂಡುಕೊಳ್ಳಬಹುದು. ಕೊನೆಯದಾಗಿ, ಯಾವುದೇ ಕಾರಣಕ್ಕೂ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಲ್ಲ; ಹಾಗೂ ಪರ್ಯಾಯವಾಗಬಾರದು ಅದು ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಸೃಜನಶೀಲತೆ, ಸಂಶೋಧನಾ ಮನೋಭಾವ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯನ್ನು ವೃದ್ಧಿಸುವ ಸಹಯೋಗಿ ತಂತ್ರಜ್ಞಾನವಾಗಬೇಕು. ಇದರ ಜೊತೆಗೆ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಹೆಚ್ಚುತ್ತಿರುವ ಬಳಕೆಯಿಂದ ಕೆಲವು ಸಾಂಪ್ರದಾಯಿಕ ಉದ್ಯೋಗಗಳ ಬಗ್ಗೆ ಆತಂಕವೂ ವ್ಯಕ್ತವಾಗುತ್ತಿದೆ. ಕೆಲವು ಉದ್ಯೋಗಗಳಲ್ಲಿ ಬದಲಾವಣೆಗಳು ಸಂಭವಿಸುವ ಸಾಧ್ಯತೆಯಿದ್ದರೂ, ಹೊಸ ತಂತ್ರಜ್ಞಾನಕ್ಕೆ ಹೊಂದಿಕೊಳ್ಳುವ ಕೌಶಲ್ಯಗಳನ್ನು ಬೆಳೆಸಿಕೊಂಡರೆ ಹೊಸ ಉದ್ಯೋಗಾವಕಾಶಗಳೂ ಸೃಷ್ಟಿಯಾಗುತ್ತವೆ. ಆದ್ದರಿಂದ ಕೌಶಲ್ಯಾಭಿವೃದ್ಧಿ, ಮರುಕೌಶಲ್ಯ ಹಾಗೂ ನಿರಂತರ ಕಲಿಕೆಯ ಮೂಲಕ ಈ ಸವಾಲನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಎದುರಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ.ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಮಾನವೀಯ ಮೌಲ್ಯಗಳ ಸಮತೋಲನವನ್ನು ಕಾಪಾಡಿಕೊಂಡಾಗ ಮಾತ್ರ ಗುಣಮಟ್ಟದ ಒಳಗೊಳ್ಳುವಿಕೆ ಹೊಂದಿದ ಹಾಗೂ ಭವಿಷ್ಯಮುಖಿ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯನ್ನು ನಿರ್ಮಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ.

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ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ರಕ್ಷಣೆಯಲ್ಲಿ ಎಐ ಬಳಕೆಯ ಪಾತ್ರ

ಪಾಂಡುರಂಗಪ್ಪ ಬಿ ಎಸ್.,
ಸಂಶೋಧನಾರ್ಥಿ. ಶಿಕ್ಷಣ ವಿಭಾಗ. ಕುವೆಂಪು ವಿಶ್ವವಿದ್ಯಾಲಯ. ಶಂಕರಘಟ್ಟ. ಶಿವಮೊಗ್ಗ.
ಡಾ. ಜಗನ್ನಾಥ ಕೆ. ಡಾಂಗೆ.
ಪ್ರಾಧ್ಯಾಪಕರು, ಶಿಕ್ಷಣ ವಿಭಾಗ. ಕುವೆಂಪು ವಿಶ್ವವಿದ್ಯಾಲಯ. ಶಂಕರಘಟ್ಟ. ಶಿವಮೊಗ್ಗ.

ಸಾರಾಂಶ

ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನಗಳ ತ್ವರಿತ ಬೆಳವಣಿಗೆಯು ಶೈಕ್ಷಣಿಕ ಕ್ಷೇತ್ರವನ್ನು ಬದಲಾಯಿಸುತ್ತಿದೆ ಮತ್ತು ಮಕ್ಕಳು ಕಲಿಯುವ, ಸಂವಹನ ನಡೆಸುವ, ಭಾಗವಹಿಸುವ ಹಾಗೂ ಶೈಕ್ಷಣಿಕ ಅವಕಾಶಗಳನ್ನು ಪಡೆಯುವ ವಿಧಾನಗಳನ್ನು ಮರುರೂಪಿಸುತ್ತಿದೆ. ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಮೌಲ್ಯಮಾಪನ, ಸಂವಹನ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಯೋಗಕ್ಷೇಮವನ್ನು ಬೆಂಬಲಿಸಲು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (AI), ಡೇಟಾ ಅನಾಲಿಟಿಕ್ಸ್, ಮೆಷಿನ್ ಲರ್ನಿಂಗ್ (ML) ಮತ್ತು ನ್ಯಾಚುರಲ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಪ್ರೊಸೆಸಿಂಗ್ (NLP) ಗಳನ್ನು ಶೈಕ್ಷಣಿಕ ವಾತಾವರಣದಲ್ಲಿ ಹೆಚ್ಚಾಗಿ ಸಂಯೋಜಿಸಲಾಗುತ್ತಿದೆ. ಆದರೆ, ಈ ಅವಕಾಶಗಳ ಜೊತೆಗೆ, ಬೆಳೆಯುತ್ತಿರುವ ಡಿಜಿಟಲ್ ವ್ಯವಸ್ಥೆಯು ಮಕ್ಕಳಿಗೆ ಗಮನಾರ್ಹ ಅಪಾಯಗಳನ್ನು ತಂದೊಡ್ಡಿದೆ; ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ವಿಶ್ವಸಂಸ್ಥೆಯ ಸಮಾವೇಶವು (UNCRC) ಮಕ್ಕಳ ಉಳಿವು, ಅಭಿವೃದ್ಧಿ, ಶಿಕ್ಷಣ, ರಕ್ಷಣೆ ಮತ್ತು ಭಾಗವಹಿಸುವಿಕೆಯ ಹಕ್ಕುಗಳನ್ನು ಸ್ಥಾಪಿಸುತ್ತದೆ. ಡಿಜಿಟಲ್ ವಾತಾವರಣದಲ್ಲಿ, ಈ ಹಕ್ಕುಗಳಿಗೆ ಹೊಸ ವ್ಯಾಖ್ಯಾನದ ಅಗತ್ಯವಿದೆ ಏಕೆಂದರೆ ಮಕ್ಕಳ ಶೈಕ್ಷಣಿಕ ಮತ್ತು ಸಾಮಾಜಿಕ ಅನುಭವಗಳು ತಂತ್ರಜ್ಞಾನ-ಚಾಲಿತ ವೇದಿಕೆಗಳ ಮೂಲಕ ಹೆಚ್ಚಾಗಿ ನಡೆಯುತ್ತಿವೆ. ಹಾನಿಕಾರಕ ವಿಷಯವನ್ನು ಗುರುತಿಸುವ ಮೂಲಕ, ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್ ಮತ್ತು ದೌರ್ಜನ್ಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಮಾದರಿಗಳನ್ನು ಪತ್ತೆಹಚ್ಚುವ ಮೂಲಕ, ಆರಂಭಿಕ ಎಚ್ಚರಿಕೆ ವ್ಯವಸ್ಥೆಗಳನ್ನು ಬೆಂಬಲಿಸುವ ಮೂಲಕ, ಅನಾಮಧೇಯ ವರದಿ ಮಾಡುವಿಕೆಗೆ ಅನುಕೂಲ ಮಾಡಿಕೊಡುವ ಮೂಲಕ ಮತ್ತು ವೈಯಕ್ತೀಕರಿಸಿದ ಹಾಗೂ ಸಮಗ್ರ ಕಲಿಕೆಯನ್ನು ಸಕ್ರಿಯಗೊಳಿಸುವ ಮೂಲಕ ಎಐ ಮಕ್ಕಳ ರಕ್ಷಣೆಗೆ ಕೊಡುಗೆ ನೀಡುತ್ತದೆ. ಅದೇ ಸಮಯದಲ್ಲಿ, ಎಐನ ಸೂಕ್ತವಲ್ಲದ ಅಥವಾ ನಿಯಂತ್ರಣವಿಲ್ಲದ ಬಳಕೆಯು ಅತಿಯಾದ ಡೇಟಾ ಸಂಗ್ರಹಣೆ, ಅಲ್ಗಾರಿದಮಿಕ್ ಪೂರ್ವಾಗ್ರಹ, ಕಣ್ಗಾವಲು, ಗೌಪ್ಯತೆ ಉಲ್ಲಂಘನೆ ಮತ್ತು ಸ್ವಯಂಚಾಲಿತ ನಿರ್ಧಾರ-ತೆಗೆದುಕೊಳ್ಳುವಿಕೆಗೆ ಸಂಬಂಧಿಸಿದ ಹೊಸ ಅಪಾಯಗಳನ್ನು ಸೃಷ್ಟಿಸಬಹುದು. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ಕಾರ್ಯತಂತ್ರದ ಪ್ರಾಮುಖ್ಯತೆಯನ್ನು ಪಡೆದುಕೊಳ್ಳುತ್ತದೆ ಏಕೆಂದರೆ ಶಿಕ್ಷಕರು ಮಕ್ಕಳು, ತಂತ್ರಜ್ಞಾನ, ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳು ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣಾ ವ್ಯವಸ್ಥೆಗಳ ನಡುವಿನ ಕೊಂಡಿಯಾಗಿದ್ದಾರೆ. ಮಕ್ಕಳಿಗಾಗಿ ಎಐ ಕುರಿತು ಯುನಿಸೆಫ್ (UNICEF) ನೀಡಿದ ನೀತಿ ಮಾರ್ಗದರ್ಶಿ, ಅಂತರರಾಷ್ಟ್ರೀಯ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಚೌಕಟ್ಟುಗಳು, ಎಐ ಕುರಿತು ಯುನೆಸ್ಕೋದ (UNESCO) ನೈತಿಕ ಮಾರ್ಗದರ್ಶನ, ಭಾರತದ ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ (NEP) 2020 ಮತ್ತು ಡಿಜಿಟಲ್ ವೈಯಕ್ತಿಕ ಡೇಟಾ ಸಂರಕ್ಷಣಾ ಕಾಯ್ದೆ (DPDP), 2023 ಗಳು ಜವಾಬ್ದಾರಿಯುತ ಡಿಜಿಟಲ್ ರೂಪಾಂತರಕ್ಕೆ ಪ್ರಮುಖ ಅಡಿಪಾಯಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ಭಾರತೀಯ ಸನ್ನಿವೇಶದಲ್ಲಿ, ಎಐ-ಸಕ್ರಿಯಗೊಳಿಸಿದ ಶಿಕ್ಷಕರ ಅಭಿವೃದ್ಧಿಗೆ ಸಂಬಂಧಿಸಿದ ಉದಯೋನ್ಮುಖ ಉದ್ಯಮಗಳು ಶಿಕ್ಷಕರ ತಾಂತ್ರಿಕ ಮತ್ತು ನೈತಿಕ ಸಾಮರ್ಥ್ಯಗಳನ್ನು ಬಲಪಡಿಸುವ ಅಗತ್ಯವನ್ನು ಮತ್ತಷ್ಟು ಎತ್ತಿಹಿಡಿಯುತ್ತವೆ. ಆದ್ದರಿಂದ, ಬಿ.ಎಡ್ (B.Ed.) ಕೋರ್ಸ್ ಸಾಂಪ್ರದಾಯಿಕ

ಐಸಿಟಿ (ICT) ತರಬೇತಿಯನ್ನು ಮೀರಿ ಎಐ ಸಾಕ್ಷರತೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಮಕ್ಕಳ ಹಕ್ಕುಗಳು, ಡಿಜಿಟಲ್ ಪೌರತ್ವ, ಡೇಟಾ ಗೌಪ್ಯತೆ, ಎಐ ನೈತಿಕತೆ ಮತ್ತು ಪ್ರಾಯೋಗಿಕ ಮಕ್ಕಳ ರಕ್ಷಣಾ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಒಳಗೊಂಡಿರಬೇಕು. ಶಿಕ್ಷಕರನ್ನು ಕೇವಲ ತಂತ್ರಜ್ಞಾನದ ಬಳಕೆದಾರರನ್ನಾಗಿ ಮಾಡದೆ, ಸುರಕ್ಷಿತ, ಸಮಗ್ರ, ಸಮಾನ ಮತ್ತು ಮಕ್ಕಳ ಕೇಂದ್ರಿತ ಕಲಿಕಾ ವಾತಾವರಣವನ್ನು ಉತ್ತೇಜಿಸುವ ಜವಾಬ್ದಾರಿಯುತ "ಡಿಜಿಟಲ್ ರಕ್ಷಕರು" (Digital Protectors) ಆಗಿ ಸಿದ್ಧಪಡಿಸಬಹುದು.

ಕೀಲಿ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence), ಮಕ್ಕಳ ಹಕ್ಕುಗಳು, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ.*

1. ಪೀಠಿಕೆ

ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ (AI) ತ್ವರಿತ ಬೆಳವಣಿಗೆಯು ಶೈಕ್ಷಣಿಕ ವಾತಾವರಣವನ್ನು ತೀವ್ರವಾಗಿ ಬದಲಾಯಿಸಿದೆ. ಶಿಕ್ಷಣದಲ್ಲಿ ಎಐ ಸಂಯೋಜನೆಯು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಶೈಕ್ಷಣಿಕ ನಿರ್ಧಾರಗಳಿಗೆ ಬೆಂಬಲ ಹಾಗೂ ವಿಕಲಾಂಗ ಮಕ್ಕಳಿಗೆ ಸಹಾಯ ಮಾಡುವಂತಹ ಅಪಾರ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತದೆ. ಆದರೆ ಇದರೊಂದಿಗೆ ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್, ಡೇಟಾ ಗೌಪ್ಯತೆಯ ಉಲ್ಲಂಘನೆ, ಆನ್‌ಲೈನ್ ಶೋಷಣೆ ಮತ್ತು ಅಲ್ಗಾರಿದಮಿಕ್ ತಾರತಮ್ಯದಂತಹ ಹೊಸ ಅಪಾಯಗಳೂ ಎದುರಾಗಿವೆ. ಈ ಸಂದರ್ಭದಲ್ಲಿ, **ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ವಿಶ್ವಸಂಸ್ಥೆಯ ಸಮಾವೇಶದ** (UNCRC) ಚೌಕಟ್ಟಿನಂತೆ, ತಂತ್ರಜ್ಞಾನ ಆಧಾರಿತ ಕಲಿಕಾ ಸ್ಥಳಗಳಲ್ಲೂ ಮಕ್ಕಳ ಭದ್ರತೆ, ಗೌಪ್ಯತೆ ಮತ್ತು ಸಮಾನ ಹಕ್ಕುಗಳನ್ನು ರಕ್ಷಿಸುವುದು ಅತ್ಯಂತ ಅಗತ್ಯವಾಗಿದೆ. AI ವ್ಯವಸ್ಥೆಗಳು ಎಷ್ಟೇ ಸುಧಾರಿತವಾಗಿದ್ದರೂ, ಅವುಗಳ ಸರಿಯಾದ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಶಿಕ್ಷಕರ ಜ್ಞಾನ ಹಾಗೂ ನಿರ್ಣಯವೇ ಪ್ರಮುಖ ಆಧಾರವಾಗಿದೆ. ಮಕ್ಕಳ ಹಾಜರಾತಿ, ನಡವಳಿಕೆ, ಭಾವನಾತ್ಮಕ ಕ್ಷೇಮ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಬದಲಾವಣೆಗಳನ್ನು ನೇರವಾಗಿ ಗಮನಿಸುವ ಶಿಕ್ಷಕರಿಗೆ AI ಯ ಬಳಕೆಯ ಸಾಧ್ಯತೆಗಳು ಮತ್ತು ಮಿತಿಗಳ ಅರಿವಿರುವುದು ಅತ್ಯಗತ್ಯ. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಕರ ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮವನ್ನು ಆಧುನಿಕ ಅಗತ್ಯಗಳಿಗೆ ತಕ್ಕಂತೆ ರೂಪಾಂತರಿಸಬೇಕಿದೆ. ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರಿಗೆ ಕೇವಲ ಬೋಧನಾ ಕೌಶಲಗಳಷ್ಟೇ ಸಾಲದು; ಅವರಲ್ಲಿ AI ಕಾರ್ಯಕ್ಷಮತೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಡೇಟಾ ಸಂರಕ್ಷಣೆ ಮತ್ತು ಡಿಜಿಟಲ್ ನೈತಿಕತೆಯ ಅರಿವನ್ನು ಮೂಡಿಸಬೇಕಿದೆ. ಭಾರತೀಯ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ **ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ** (NEP) 2020. ಡಿಜಿಟಲ್ ಸಾಮರ್ಥ್ಯಗಳಿಗೆ ಒತ್ತು ನೀಡಿದರೆ, **ಡಿಜಿಟಲ್ ವೈಯಕ್ತಿಕ ಡೇಟಾ ಸಂರಕ್ಷಣಾ ಕಾಯಿದೆ** (DPDP) 2023. ಮಕ್ಕಳ ಡೇಟಾ ಭದ್ರತೆಗೆ ಕಾನೂನು ಚೌಕಟ್ಟನ್ನು ಒದಗಿಸುತ್ತದೆ. ಕರ್ನಾಟಕ ಸೇರಿದಂತೆ ಹಲವು ಕಡೆ ಶಿಕ್ಷಕರಲ್ಲಿ ಎಐ ಸಾಕ್ಷರತೆ ಹೆಚ್ಚಿಸುವ ಪ್ರಯತ್ನಗಳು ನಡೆಯುತ್ತಿವೆ. ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ರಕ್ಷಿಸುತ್ತಾ, ಸುರಕ್ಷಿತ ಹಾಗೂ ಸಮಾನ ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣವನ್ನು ಒದಗಿಸಲು ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಶಿಕ್ಷಕರ ತರಬೇತಿಯನ್ನು ಸಮರ್ಪಕವಾಗಿ ಸಂಯೋಜಿಸುವುದು ಇಂದಿನ ತುರ್ತು ಅಗತ್ಯವಾಗಿದೆ.

2. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ರಕ್ಷಣೆ

a) ಆನ್‌ಲೈನ್ ದೌರ್ಜನ್ಯ ಮತ್ತು ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್‌ನಿಂದ ರಕ್ಷಣೆ

- ತಂತ್ರಜ್ಞಾನದ ಬಳಕೆಯಿಂದ 'ನ್ಯಾಚುರಲ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಪ್ರೊಸೆಸಿಂಗ್' (NLP) ಮತ್ತು 'ಕಂಪ್ಯೂಟರ್ ವಿಷನ್' ತಂತ್ರಜ್ಞಾನಗಳು ಆನ್‌ಲೈನ್‌ನಲ್ಲಿ ಬೆದರಿಕೆ ಸಂದೇಶಗಳು, ನಿಂದನಾತ್ಮಕ ಭಾಷೆ ಮತ್ತು ಹಾನಿಕಾರಕ ಚಿತ್ರಗಳನ್ನು ಪತ್ತೆಹಚ್ಚಲು ನೆರವಾಗುತ್ತವೆ.
- ಮಕ್ಕಳ ನಡವಳಿಕೆ ಮತ್ತು ಮನೋಭಾವದ ವಿಶ್ಲೇಷಣೆ (Sentiment Analysis) ಮಾಡುವ ಮೂಲಕ, ಸಾಮಾಜಿಕ ಪ್ರತ್ಯೇಕತೆ ಅಥವಾ ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್‌ನ ನಮೂನೆಗಳನ್ನು ಪತ್ತೆಹಚ್ಚಬಹುದು.
- ಇದು ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳಿಗೆ ತೊಂದರೆ ಸಂಭವಿಸಿದ ನಂತರ ಪ್ರತಿಕ್ರಿಯಿಸುವ ಬದಲು, ಅಪಾಯವನ್ನು ಮುಂಚಿತವಾಗಿಯೇ ಗುರುತಿಸಿ ತಡೆಯಲು (Early Intervention) ಸಹಾಯ ಮಾಡುತ್ತದೆ.

b) ಸಮಗ್ರ ಮತ್ತು ಸಮಾನ ಶಿಕ್ಷಣದ ಹಕ್ಕು

- ಪ್ರತಿಯೊಂದು ಮಗುವಿನ ಕಲಿಕೆಯ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಶೈಕ್ಷಣಿಕ ವಿಷಯದ ವೇಗ ಮತ್ತು ಸ್ವರೂಪವನ್ನು ಂಖ ಬದಲಾಯಿಸಬಲ್ಲದು.
- 'ಸ್ಪೀಚ್–ಟು–ಟೆಕ್ಸ್ಟ್' ಆಡಿಯೋ ವಿವರಣೆಗಳು ಮತ್ತು ನೈಜ–ಸಮಯದ ಅನುವಾದಗಳಂತಹ ಉಪಕರಣಗಳು ವಿಭಿನ್ನ ಕಲಿಕೆಯ ಅಗತ್ಯವಿರುವ (ವಿಶೇಷ ಚೇತನ) ಮಕ್ಕಳಿಗೆ ಕಲಿಕೆಯನ್ನು ಸುಲಭಗೊಳಿಸುತ್ತವೆ.

c) ಶಾಲೆ ಬಿಡುವುದನ್ನು ತಡೆಯುವುದು ಮತ್ತು ಅಪಾಯದಲ್ಲಿರುವ ಮಕ್ಕಳ ಗುರುತಿಸುವಿಕೆ

- ಶಾಲಾ ಹಾಜರಾತಿ, ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಮತ್ತು ನಡವಳಿಕೆಯ ಬದಲಾವಣೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಿ, ಶಾಲೆ ಬಿಡುವ ಹಂತದಲ್ಲಿರುವ ಅಥವಾ ನಿರ್ಲಕ್ಷ್ಯ/ಕಿರುಕುಳ ಎದುರಿಸುತ್ತಿರುವ ಮಕ್ಕಳನ್ನು ಮುಂಚಿತವಾಗಿಯೇ ಗುರುತಿಸಬಹುದು.
- ಈ ತಂತ್ರಜ್ಞಾನವು ಶಿಕ್ಷಕರು, ಪೋಷಕರು ಅಥವಾ ಕೌನ್ಸಿಲರ್‌ಗಳಿಗೆ ಪೂರಕ ಬೆಂಬಲವಾಗಿ ಕೆಲಸ ಮಾಡುತ್ತದೆಯೇ ಹೊರತು ಅವರನ್ನು ಸಂಪೂರ್ಣವಾಗಿ ಭರ್ತಿ ಮಾಡುವುದಿಲ್ಲ.

d) ಭಾವನಾತ್ಮಕ ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ಅದರ ಮಿತಿಗಳು

- ಮಕ್ಕಳ ಡಿಜಿಟಲ್ ಸಂವಹನ, ಬರವಣಿಗೆ ಮತ್ತು ನಡವಳಿಕೆಯ ಆಧಾರದ ಮೇಲೆ ಭಾವನಾತ್ಮಕ ಸಂಕಟದ ಸೂಚನೆಯನ್ನು ನೀಡುವ ಮೂಲಕ ಅವರಿಗೆ ಹೆಚ್ಚುವರಿ ಸಹಕಾರ ಬೇಕಿದೆಯೇ ಎಂಬುದನ್ನು ಂಖ ಗುರುತಿಸಬಲ್ಲದು.

- ಭಾವನಾತ್ಮಕ ಸ್ಥಿತಿಗಳು ಸಂಕೀರ್ಣವಾಗಿದ್ದು, ಡಿಜಿಟಲ್ ನಡವಳಿಕೆಯಿಂದ ಮಾತ್ರ ನಿಖರವಾಗಿ ಊಹಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ. ಹಾಗಾಗಿ ವೃತ್ತಿಪರ ಕೌನ್ಸೆಲಿಂಗ್ ಮತ್ತು ಮಾನವ ಹಸ್ತಕ್ಷೇಪವೇ (Human Intervention) ಕೇಂದ್ರಬಿಂದುವಾಗಿರಬೇಕು.

3. **ಪ್ರಮುಖ AI ಡಿಟೆಕ್ಟಿವ್ ಸಾಫ್ಟ್‌ವೇರ್‌ಗಳು:**

- **Thorn Spotlight (ಸಾಫ್ಟ್‌ವೇರ್):** ಮಕ್ಕಳ ಲೈಂಗಿಕ ಶೋಷಣೆ ಮತ್ತು ಮಾನವ ಸಾಗಾಣಿಕೆ (Human Trafficking) ತಡೆಯಲು ವಿಶ್ವದಾದ್ಯಂತ ತನಿಖಾ ಸಂಸ್ಥೆಗಳು ವ್ಯಾಪಕವಾಗಿ ಬಳಸುವ AI ತಂತ್ರಜ್ಞಾನ. ಇದು ಸಾವಿರಾರು ಜಾಹೀರಾತುಗಳು, ಸಂದೇಶಗಳು ಹಾಗೂ ನೆಟ್‌ವರ್ಕ್‌ಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಿ ಶಂಕಿತ ವ್ಯಕ್ತಿಗಳನ್ನು ಪತ್ತೆಹಚ್ಚಲು ಮತ್ತು ಸಂತ್ರಸ್ತ ಮಕ್ಕಳನ್ನು ರಕ್ಷಿಸಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ.
- **C-SIGHT (ಸೋವರೈನ್ AI ಪ್ಲಾಟ್‌ಫಾರ್ಮ್):** ತೆಲಂಗಾಣ ಪೊಲೀಸ್ (ಭಾರತ) ಅಭಿವೃದ್ಧಿಪಡಿಸಿರುವ ಭಾರತದ ಮೊದಲ ಸೋವರೈನ್ ಂಖ ತನಿಖಾ ಸಾಫ್ಟ್‌ವೇರ್. ಇದು ಲಕ್ಷಾಂತರ ಸೈಬರ್ ಟಿಪ್‌ಲೈನ್ ವರದಿಗಳು, ಡಿಜಿಟಲ್ ಪುರಾವೆಗಳು ಹಾಗೂ ಚಿತ್ರಗಳನ್ನು ಆಫ್‌ಲೈನ್‌ನಲ್ಲಿ ವಿಶ್ಲೇಷಿಸಿ, ಮಕ್ಕಳ ಲೈಂಗಿಕ ದೌರ್ಜನ್ಯ ಎಸಗುವವರನ್ನು ಶೀಘ್ರವಾಗಿ ಪತ್ತೆಹಚ್ಚಲು ನೆರವಾಗುತ್ತದೆ.
- **PhotoDNA (ಮೈಕ್ರೋಸಾಫ್ಟ್):** ಆನ್‌ಲೈನ್‌ನಲ್ಲಿ ಹರಡುವ ಮಕ್ಕಳ ಮೇಲಿನ ಶೋಷಣೆಯ ಚಿತ್ರಗಳು (CSEAM) ಮತ್ತು ವೀಡಿಯೊಗಳನ್ನು ಗುರುತಿಸಲು ಬಳಸುವ ಅತ್ಯಂತ ಪ್ರಸಿದ್ಧ ಂಖ/ಹ್ಯಾಶಿಂಗ್ ತಂತ್ರಜ್ಞಾನ. ಇದು ಡಿಜಿಟಲ್ ಫಿಂಗರ್‌ಪ್ರಿಂಟ್ (Hash) ಮೂಲಕ ಅಪರಾಧ ಸಂಬಂಧಿತ ಚಿತ್ರಗಳನ್ನು ತಕ್ಷಣವೇ ಫ್ಲ್ಯಾಗ್ ಮಾಡಿ ತೆಗೆದುಹಾಕಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ.
- Griffeye Analyze Digital Media System (ADMS): ಪೊಲೀಸ್ ಫೋರೆನ್ಸಿಕ್ ತನಿಖಾಧಿಕಾರಿಗಳು ಬಳಸುವ AI ಆಧಾರಿತ ತನಿಖಾ ವೇದಿಕೆ. ಇದು ಶಂಕಿತರ ಫೋನ್, ಕಂಪ್ಯೂಟರ್‌ಗಳಲ್ಲಿರುವ ಕೋಟಿಗಟ್ಟಲೆ ಚಿತ್ರಗಳು ಮತ್ತು ವೀಡಿಯೊಗಳನ್ನು ಮುಖಗುರುತಿಸುವಿಕೆ (Face Recognition) ಹಾಗೂ ಆಬ್ಜೆಕ್ಟ್ ಡೆಟೆಕ್ಷನ್ AI ಮೂಲಕ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ.
- **AiLECS** (Australian Federal **Police** & Monash University)**:** ಆಸ್ಟ್ರೇಲಿಯಾದ ಫೆಡರಲ್ ಪೊಲೀಸ್ ಅಭಿವೃದ್ಧಿಪಡಿಸಿದ ಈ AI ಸಾಫ್ಟ್‌ವೇರ್ ಆನ್‌ಲೈನ್‌ನಲ್ಲಿ ಮಕ್ಕಳ ಸುರಕ್ಷಿತ ಮತ್ತು ಅಪಾಯಕಾರಿ ಚಿತ್ರಗಳನ್ನು ಪ್ರತ್ಯೇಕಿಸಲು ಹಾಗೂ ಸಾಕ್ಷ್ಯಗಳನ್ನು ಫೋರೆನ್ಸಿಕ್ ಮಟ್ಟದಲ್ಲಿ ಪರಿಶೀಲಿಸಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ.

4. AI ಡಿಟೆಕ್ಟಿವ್ ತಂತ್ರಜ್ಞಾನಗಳ ಪ್ರಮುಖ ಕಾರ್ಯಗಳು

- **ವಯಸ್ಸಿನ ಅಂದಾಜು** (Age Estimation): ಡಿಜಿಟಲ್ ಚಿತ್ರಗಳಲ್ಲಿರುವ ವ್ಯಕ್ತಿಯ ಅಂದಾಜು ವಯಸ್ಸನ್ನು ಗುರುತಿಸುವುದು.
- **ಸಂಭಾಷಣೆ ವಿಶ್ಲೇಷಣೆ** (Chat & Pattern Analysis): ಆನ್‌ಲೈನ್ ಚಾಟ್‌ಗಳಲ್ಲಿ ಗ್ರೂಮಿಂಗ್ (Grooming) ಅಥವಾ ಮಕ್ಕಳನ್ನು ಪ್ರೇರೆಪಿಸುವ ಶಂಕಿತ ನಡವಳಿಕೆಗಳನ್ನು ಪತ್ತೆಹಚ್ಚುವುದು.
- **ಮುಖ ಹಾಗೂ ಸ್ಥಳ ಗುರುತಿಸುವಿಕೆ** (Facial Recognition & Geolocation): ಶೋಷಣೆಗೆ ಒಳಗಾದ ಮಗು ಅಥವಾ ಅಪರಾಧಿ ಎಲ್ಲಿದ್ದಾನೆ ಎಂಬುದನ್ನು ಹಿನ್ನೆಲೆಯಲ್ಲಿರುವ ವಸ್ತುಗಳು/ಸ್ಥಳಗಳ ಆಧಾರದ ಮೇಲೆ ಪತ್ತೆಹಚ್ಚುವುದು.

5. UNCRC **ಚೌಕಟ್ಟು ಮತ್ತು ಎಐ ನೈತಿಕತೆ**

ಎಐ ಮಕ್ಕಳ ರಕ್ಷಣೆಗೆ ಗಮನಾರ್ಹವಾಗಿ ಕೊಡುಗೆ ನೀಡಬಹುದಾದರೂ, ವ್ಯವಸ್ಥೆಗಳನ್ನು ಕಳಪೆಯಾಗಿ ವಿನ್ಯಾಸಗೊಳಿಸಿದಾಗ ಅಥವಾ ಅಸಮರ್ಪಕವಾಗಿ ನಿಯಂತ್ರಿಸಿದಾಗ ಅದರ ಬಳಕೆಯು ಮಕ್ಕಳ ಹಕ್ಕುಗಳಿಗೆ ಅಪಾಯಗಳನ್ನು ಉಂಟುಮಾಡಬಹುದು. ಈ ಕಾರಣಕ್ಕಾಗಿ, ಶಿಕ್ಷಣದಲ್ಲಿ ಎಐ ಅನ್ವಯವನ್ನು ಗಓಅಖಅ ಯ ತತ್ವಗಳ ಮೂಲಕ ಪರಿಶೀಲಿಸಬೇಕು.

- **ಗೌಪ್ಯತೆಯ ಹಕ್ಕು:** ಗಓಅಖಅ ಯ ಆರ್ಟಿಕಲ್ 16 ಮಕ್ಕಳ ಗೌಪ್ಯತೆಗೆ ಕಾನೂನುಬಾಹಿರ ಅಥವಾ ಅನಿಯಂತ್ರಿತ ಹಸ್ತಕ್ಷೇಪದಿಂದ ರಕ್ಷಣೆ ನೀಡುತ್ತದೆ. ಎಐ–ಬೆಂಬಲಿತ ಶೈಕ್ಷಣಿಕ ವ್ಯವಸ್ಥೆಗಳು ಛಾಯಾಚಿತ್ರಗಳು, ಧ್ವನಿ ರೆಕಾರ್ಡಿಂಗ್‌ಗಳು, ನಡವಳಿಕೆಯ ದಾಖಲೆಗಳು, ಶೈಕ್ಷಣಿಕ ಮಾಹಿತಿ ಮತ್ತು ಇತರ ವೈಯಕ್ತಿಕ ಡೇಟಾ ಸೇರಿದಂತೆ ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದ ಮಾಹಿತಿಯನ್ನು ಸಂಗ್ರಹಿಸಬಹುದು. ಇಂತಹ ಮಾಹಿತಿಯ ಅತಿಯಾದ ಸಂಗ್ರಹಣೆ ಅಥವಾ ಸೂಕ್ತವಲ್ಲದ ಬಳಕೆಯು ಗಂಭೀರ ಗೌಪ್ಯತೆಯ ಅಪಾಯಗಳನ್ನು ಸೃಷ್ಟಿಸಬಹುದು. ಪರಿಣಾಮವಾಗಿ, ಡೇಟಾ ಕನಿಷ್ಠೀಕರಣದ (data minimization) ತತ್ವ ಅಂದರೆ ಸ್ಪಷ್ಟವಾಗಿ ವ್ಯಾಖ್ಯಾನಿಸಲಾದ ಶೈಕ್ಷಣಿಕ ಉದ್ದೇಶಕ್ಕಾಗಿ ಅಗತ್ಯವಿರುವ ಮಾಹಿತಿಯನ್ನು ಮಾತ್ರ ಸಂಗ್ರಹಿಸುವುದು ಎಐ–ಸಕ್ರಿಯಗೊಳಿಸಿದ ಶಿಕ್ಷಣದ ಮೂಲಭೂತ ಅಗತ್ಯತೆಯಾಗಬೇಕು.
- **ಶಿಕ್ಷಣ ಮತ್ತು ತಾರತಮ್ಯ ರಹಿತ ಹಕ್ಕು:** ಶಿಕ್ಷಣದ ಹಕ್ಕು ಮಕ್ಕಳಿಗೆ ಅವರ ಘನತೆಯನ್ನು ಗೌರವಿಸುವ ಮತ್ತು ತಾರತಮ್ಯದಿಂದ ಮುಕ್ತವಾಗಿರುವ ಕಲಿಕೆಯ ಅವಕಾಶಗಳನ್ನು ಪಡೆಯುವುದನ್ನು ಪ್ರತಿಪಾದಿಸುತ್ತದೆ. ಎಐ–ಆಧಾರಿತ ಮೌಲ್ಯಮಾಪನ ಮತ್ತು ಶಿಫಾರಸು ವ್ಯವಸ್ಥೆಗಳು ಅವುಗಳ ತರಬೇತಿ ಡೇಟಾದಲ್ಲಿ ಇರುವ ಪೂರ್ವಾಗ್ರಹಗಳನ್ನು ತಿಳಿಯದೆ ಪುನರಾವರ್ತಿಸಬಹುದು. ಆದ್ದರಿಂದ, ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳು ಲಿಂಗ, ಸಾಮಾಜಿಕ–ಆರ್ಥಿಕ ಪರಿಸ್ಥಿತಿಗಳು, ಭಾಷೆ, ಜನಾಂಗೀಯತೆ, ವಿಕಲಚೇತನ ಅಥವಾ ಇತರ ಗುಣಲಕ್ಷಣಗಳ ಆಧಾರದ ಮೇಲೆ ಎಐ ವ್ಯವಸ್ಥೆಗಳಲ್ಲಿ ಸಂಭವಿಸಬಹುದಾದ ತಾರತಮ್ಯವನ್ನು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಪರಿಶೀಲಿಸಬೇಕು. ಇಂತಹ

ಅಪಾಯಗಳನ್ನು ಕಡಿಮೆ ಮಾಡಲು ನಿಯಮಿತ ಪರಿಶೋಧನೆ (auditing) ಮತ್ತು ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆ ಅತ್ಯಗತ್ಯ.

- **ಭಾಗವಹಿಸುವಿಕೆಯ ಹಕ್ಕು:** ಆರ್ಟಿಕಲ್ 12 ತಮ್ಮ ಮೇಲೆ ಪ್ರಭಾವ ಬೀರುವ ವಿಷಯಗಳಲ್ಲಿ ತಮ್ಮ ಅಭಿಪ್ರಾಯಗಳನ್ನು ವ್ಯಕ್ತಪಡಿಸುವ ಮಕ್ಕಳ ಹಕ್ಕನ್ನು ಗುರುತಿಸುತ್ತದೆ. ಪರಿಣಾಮವಾಗಿ, ಮಕ್ಕಳನ್ನು ಎಐ–ಸಕ್ರಿಯಗೊಳಿಸಿದ ಶೈಕ್ಷಣಿಕ ವ್ಯವಸ್ಥೆಗಳ ನಿಷ್ಕ್ರಿಯ ಬಳಕೆದಾರರನ್ನಾಗಿ ಮಾತ್ರ ನೋಡಬಾರದು. ಸೂಕ್ತವಾದಾಗ, ಅವರ ಅನುಭವಗಳು ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆಗಳು ಡಿಜಿಟಲ್ ಕಲಿಕಾ ತಂತ್ರಜ್ಞಾನಗಳ ವಿನ್ಯಾಸ, ಮೌಲ್ಯಮಾಪನ ಮತ್ತು ಅನುಷ್ಠಾನಕ್ಕೆ ಮಾಹಿತಿಯನ್ನು ಒದಗಿಸಬೇಕು. ವಯಸ್ಸಿಗೆ ಸೂಕ್ತವಾದ ಭಾಗವಹಿಸುವಿಕೆಯು ತಂತ್ರಜ್ಞಾನವು ಕೇವಲ ವಯಸ್ಕರ ಅಥವಾ ಸಾಂಸ್ಥಿಕ ದೃಷ್ಟಿಕೋನದಿಂದ ವಿನ್ಯಾಸಗೊಳ್ಳದೆ ಮಕ್ಕಳ ನೈಜ ಅಗತ್ಯಗಳಿಗೆ ಸ್ಪಂದಿಸುವುದನ್ನು ಮಾಡಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ.
- **ರಕ್ಷಣೆಯ ಹಕ್ಕು :** ಆರ್ಟಿಕಲ್ 19 ಹಿಂಸೆ, ಶೋಷಣೆ ಮತ್ತು ದೌರ್ಜನ್ಯದಿಂದ ರಕ್ಷಣೆ ನೀಡುತ್ತದೆ. ಎಐ–ಬೆಂಬಲಿತ ವಿಷಯ ಶೋಧನೆ (content filtering), ಬೆದರಿಕೆ ಪತ್ತೆ ಮತ್ತು ವರದಿ ಮಾಡುವ ಕಾರ್ಯವಿಧಾನಗಳು ಈ ಉದ್ದೇಶಕ್ಕೆ ಕೊಡುಗೆ ನೀಡುತ್ತವೆ. ಆದಾಗ್ಯೂ, ಸ್ವಯಂಚಾಲಿತ ವ್ಯವಸ್ಥೆಗಳು ಶಿಕ್ಷಕರು, ಶಾಲಾ ಅಧಿಕಾರಿಗಳು, ಪೋಷಕರು ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣಾ ಏಜೆನ್ಸಿಗಳ ಸಕ್ರಿಯ ಮೇಲ್ವಿಚಾರಣೆಯೊಂದಿಗೆ ಕಾರ್ಯನಿರ್ವಹಿಸಬೇಕು. ತಂತ್ರಜ್ಞಾನವು ಸಂಕೇತಗಳನ್ನು ಗುರುತಿಸಬಹುದು, ಆದರೆ ಸೂಕ್ತವಾದ ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ನಿರ್ಧರಿಸಲು ಜವಾಬ್ದಾರಿಯುತ ಮಾನವ ಹಸ್ತಕ್ಷೇಪವು ಅಗತ್ಯವಾಗಿರುತ್ತದೆ. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಣದಲ್ಲಿ ಎಐ ಸುತ್ತಲಿನ ನೈತಿಕ ಪ್ರಶ್ನೆಯು ನಿರ್ದಿಷ್ಟ ತಂತ್ರಜ್ಞಾನವು ತಾಂತ್ರಿಕವಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತದೆಯೇ ಎಂಬುದು ಮಾತ್ರವಲ್ಲ; ಬದಲಿಗೆ, ತಂತ್ರಜ್ಞಾನವು ಮಕ್ಕಳ ಮೂಲಭೂತ ಹಕ್ಕುಗಳಿಗೆ ಧಕ್ಕೆ ತರದಂತೆ ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತದೆಯೇ ಎಂಬುದಾಗಿದೆ. ಈ ಹಕ್ಕು ಆಧಾರಿತ ವಿಧಾನವು ಎಐ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣಕ್ಕೆ ಅಗತ್ಯವಾದ ಅಡಿಪಾಯವನ್ನು ಒದಗಿಸುತ್ತದೆ.

6. ಎಐ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಕುರಿತು ಅಂತರರಾಷ್ಟ್ರೀಯ ದೃಷ್ಟಿಕೋನಗಳ: ಜಾಗತಿಕ ನೀತಿ ವಾತಾವರಣವು ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ಗೌರವಿಸುವ ರೀತಿಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಬೇಕು ಮತ್ತು ಬಳಸಬೇಕು ಎಂಬುದನ್ನು ಹೆಚ್ಚಾಗಿ ಗುರುತಿಸುತ್ತಿದೆ. ಮಕ್ಕಳಿಗಾಗಿ ಎಐ ಕುರಿತು **ಯುನಿಸೆಫ್** ನೀತಿ ಮಾರ್ಗದರ್ಶನವು ಮಗು–ಕೇಂದ್ರಿತ ವಿನ್ಯಾಸ, ಸೌಷ್ಠವತೆ, ಸುರಕ್ಷತೆ, ನ್ಯಾಯಸಮ್ಮತತೆ, ಪಾರದರ್ಶಕತೆ ಮತ್ತು ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆಯನ್ನು ಒತ್ತು ನೀಡುತ್ತದೆ. ಈ ತತ್ವಗಳು ಎಐ ಅನ್ನು ಜವಾಬ್ದಾರಿಯುತವಾಗಿ ಸಂಯೋಜಿಸಲು ಬಯಸುವ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳಿಗೆ ಪ್ರಮುಖ ಅಡಿಪಾಯವನ್ನು ಒದಗಿಸುತ್ತವೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ನೈತಿಕತೆಯ ಕುರಿತಾದ **ಯುನೆಸ್ಕೋದ** ಶಿಫಾರಸು ಅಂತೆಯೇ ಎಐ ಅಭಿವೃದ್ಧಿ ಮತ್ತು ಬಳಕೆಯಲ್ಲಿ ನೈತಿಕ ಆಡಳಿತ ಮತ್ತು ಮಾನವ ಹಕ್ಕುಗಳ ರಕ್ಷಣೆಯನ್ನು ಒತ್ತು ನೀಡುತ್ತದೆ. ಶೈಕ್ಷಣಿಕ ಸನ್ನಿವೇಶಗಳಲ್ಲಿ, ಈ ತತ್ವಗಳು ವಿಶೇಷವಾಗಿ

ಮುಖ್ಯವಾಗಿವೆ ಏಕೆಂದರೆ ಮಕ್ಕಳು ಸೂಕ್ಷ್ಮ ಸನ್ನಿವೇಶದಲ್ಲಿರುವ ಜನಸಂಖ್ಯೆಯಾಗಿದ್ದಾರೆ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ನಿರ್ಧಾರಗಳು ಅವರ ಅಭಿವೃದ್ಧಿ ಮತ್ತು ಅವಕಾಶಗಳ ಮೇಲೆ ದೀರ್ಘಕಾಲೀನ ಪರಿಣಾಮಗಳನ್ನು ಬೀರಬಹುದು. ಆದ್ದರಿಂದ, ಅಂತರರಾಷ್ಟ್ರೀಯ ನೀತಿ ಬೆಳವಣಿಗೆಗಳು ಎಐ ಆಡಳಿತವು ತಾಂತ್ರಿಕ ದಕ್ಷತೆಯನ್ನು ಮೀರಿ ಸುರಕ್ಷತೆ, ಸಮಗ್ರತೆ, ಪಾರದರ್ಶಕತೆ, ಜವಾಬ್ದಾರಿ ಮತ್ತು ಮಾನವ ಹಕ್ಕುಗಳ ಆಧಾರಿತ ವಿಶಾಲ ಚೌಕಟ್ಟಿನತ್ತ ಸಾಗಬೇಕು ಎಂದು ಸೂಚಿಸುತ್ತವೆ. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣಕ್ಕಾಗಿ, ತಾಂತ್ರಿಕ ಸಾಮರ್ಥ್ಯದ ಜೊತೆಗೆ ನೈತಿಕ ಮತ್ತು ಹಕ್ಕು ಆಧಾರಿತ ಸಾಮರ್ಥ್ಯವೂ ಇರಬೇಕು ಎಂದರ್ಥ.

7. **ಭಾರತೀಯ ಕಾನೂನು ಮತ್ತು ನೀತಿ ಸನ್ನಿವೇಶ: ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020** ಶೈಕ್ಷಣಿಕ ಲಭ್ಯತೆ, ಗುಣಮಟ್ಟ ಮತ್ತು ಕಲಿಕೆಯ ಅವಕಾಶಗಳನ್ನು ಸುಧಾರಿಸುವಲ್ಲಿ ತಂತ್ರಜ್ಞಾನದ ಪಾತ್ರವನ್ನು ಒತ್ತು ನೀಡುತ್ತದೆ. ಆದಾಗ್ಯೂ, ತಂತ್ರಜ್ಞಾನ–ಚಾಲಿತ ಶಿಕ್ಷಣವು ಗೌಪ್ಯತೆ, ಸಮಾನತೆ, ಸುರಕ್ಷತೆ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗೆ ಸಂಬಂಧಿಸಿದ ಕಳವಳಗಳನ್ನು ಅದೇ ಸಮಯದಲ್ಲಿ ಪರಿಹರಿಸಬೇಕು. **ಡಿಜಿಟಲ್ ವೈಯಕ್ತಿಕ ಡೇಟಾ ಸಂರಕ್ಷಣಾ ಕಾಯ್ದೆ, 2023** ವಿಶೇಷವಾಗಿ ಪ್ರಸ್ತುತವಾಗಿದೆ ಏಕೆಂದರೆ ಶೈಕ್ಷಣಿಕ ತಂತ್ರಜ್ಞಾನಗಳು ಮಕ್ಕಳಿಗೆ ಸಂಬಂಧಿಸಿದ ಮಾಹಿತಿಯನ್ನು ಹೆಚ್ಚಾಗಿ ಸಂಸ್ಕರಿಸುತ್ತವೆ. ಪೋಷಕರ ಸಮ್ಮತಿ ಮತ್ತು ಮಕ್ಕಳ ಡೇಟಾಗೆ ಸಂಬಂಧಿಸಿದ ನಿರ್ಬಂಧಗಳನ್ನು ಜವಾಬ್ದಾರಿಯುತ ಶೈಕ್ಷಣಿಕ ತಂತ್ರಜ್ಞಾನ ಅಳವಡಿಕೆಯಲ್ಲಿ ಪ್ರಮುಖ ಪರಿಗಣನೆಗಳಾಗಿವೆ, ಮಕ್ಕಳ ರಕ್ಷಣಾ ಶಾಸನಗಳು ಮತ್ತು ಮಾಹಿತಿ–ತಂತ್ರಜ್ಞಾನ ನಿಯಮಗಳು ಆನ್‌ಲೈನ್ ಕಿರುಕುಳ, ಹಾನಿಕಾರಕ ವಿಷಯ ಮತ್ತು ಡಿಜಿಟಲ್ ಮೂಲಕ ಸುಗಮಗೊಳಿಸಲಾದ ಶೋಷಣೆಗೆ ಸ್ಪಂದಿಸಲು ಕಾನೂನು ಚೌಕಟ್ಟನ್ನು ಒದಗಿಸುತ್ತವೆ. ಪರಿಣಾಮವಾಗಿ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ತಾಂತ್ರಿಕ ಜ್ಞಾನ, ಕಾನೂನು ಜಾಗೃತಿ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ತತ್ವಗಳನ್ನು ಒಟ್ಟುಗೂಡಿಸುವ ಸ್ಥಳವಾಗಬೇಕು.

8. **ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ರಕ್ಷಣೆಗಾಗಿ ಎಐ ಬಳಕೆ**. ಎಐ ಹಲವಾರು ಪರಸ್ಪರ ಸಂಪರ್ಕಿತ ಕಾರ್ಯವಿಧಾನಗಳ ಮೂಲಕ ಮಕ್ಕಳ ರಕ್ಷಣೆಯನ್ನು ಮಾಡುತ್ತದೆ.

❖ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ, ಭಾಗವಹಿಸುವಿಕೆ ಅಥವಾ ಗಮನ ಹರಿಸಬೇಕಾದ ಇತರ ಸೂಚಕಗಳಲ್ಲಿನ ದಿಢೀರ್ ಬದಲಾವಣೆಗಳನ್ನು ಗುರುತಿಸಲು ಶಾಲಾ ದಾಖಲೆಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಬಹುದು. ಹಾಜರಾತಿಯಲ್ಲಿನ ನಿರಂತರ ಗೈರುಹಾಜರಿ ಅಥವಾ ಶಾಲಾ ಭಾಗವಹಿಸುವಿಕೆಯಲ್ಲಿನ ಅಸ್ಪಷ್ಟ ಬದಲಾವಣೆಗಳನ್ನು ಗುರುತಿಸಲು ಸಹಾಯ ಮಾಡಬಹುದು.

❖ ಶಾಲಾ ವೇದಿಕೆಗಳಲ್ಲಿ ನಿಂದನೀಯ ಅಥವಾ ಬೆದರಿಕೆಯೊಡ್ಡುವ ಭಾಷೆಯನ್ನು ಗುರುತಿಸುವ ಮೂಲಕ ಮತ್ತು ಹಾನಿಕಾರಕ ವಿಷಯಗಳನ್ನು ಶೋಧಿಸುವ ಮೂಲಕ ಎಐ ಆನ್‌ಲೈನ್ ಸುರಕ್ಷತೆಯನ್ನು ಬೆಂಬಲಿಸುತ್ತದೆ. ಇಂತಹ ಕಾರ್ಯವಿಧಾನಗಳು ಡಿಜಿಟಲ್ ಕಿರುಕುಳಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಮಾದರಿಗಳನ್ನು ಗುರುತಿಸುವಲ್ಲಿ ಸಂಸ್ಥೆಗಳಿಗೆ ಸಹಾಯ ಮಾಡಬಹುದು. ಆದಾಗ್ಯೂ, ಸ್ವಯಂಚಾಲಿತ ಮೇಲ್ವಿಚಾರಣೆಯು ಗೌಪ್ಯತೆ, ಸಮ್ಮಿತಿ (proportionality) ಮತ್ತು ಸಿಂಧುವಾದ ಶೈಕ್ಷಣಿಕ ಉದ್ದೇಶಗಳಿಗೆ ಸಂಬಂಧಿಸಿದ ಸ್ಪಷ್ಟ ನಿಯಮಗಳಿಂದ ನಿಯಂತ್ರಿಸಲ್ಪಡಬೇಕು.

- ಅನಾಮಧೇಯ ವರದಿ ವ್ಯವಸ್ಥೆಗಳು ಮಕ್ಕಳಿಗೆ ತಮ್ಮ ಕಳವಳಗಳನ್ನು ಸಂವಹನ ಮಾಡಲು ಹೆಚ್ಚುವರಿ ಮಾರ್ಗಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ಎಐ–ಬೆಂಬಲಿತ ಚಾಟ್‌ಬಾಟ್‌ಗಳು ವರದಿ ಮಾಡುವ ಕಾರ್ಯವಿಧಾನಗಳಿಗೆ ನಿರಂತರ ಲಭ್ಯತೆ ಮತ್ತು ಬಹುಭಾಷಾ ಸಂವಹನವನ್ನು ಒದಗಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿವೆ. ಭಾರತದಂತಹ ಬಹುಭಾಷಾ ಸನ್ನಿವೇಶಗಳಲ್ಲಿ, ಪ್ರಾದೇಶಿಕ–ಭಾಷಾ ಬಳಕೆ ಭಾಷಾ ಅಡೆತಡೆಗಳನ್ನು ಎದುರಿಸುವ ಮಕ್ಕಳಿಗೆ ವರದಿ ಮಾಡುವ ವ್ಯವಸ್ಥೆಗಳನ್ನು ಹೆಚ್ಚು ಲಭ್ಯವಾಗುವಂತೆ ಮಾಡುತ್ತದೆ.
- ಭಾವನಾತ್ಮಕ ಸಂಕಟದ ಆರಂಭಿಕ ಸೂಚಕಗಳನ್ನು ಗುರುತಿಸಲು ಮತ್ತು ಪ್ರಕರಣಗಳನ್ನು ಸೂಕ್ತ ಕೌನ್ಸಿಲಿಂಗ್ ಸೇವೆಗಳತ್ತ ನಿರ್ದೇಶಿಸಲು ಎಐ ನೆರವಾಗುತ್ತದೆ. ಆದಾಗ್ಯೂ, ಎಐ ಅನ್ನು ಅರ್ಹ ಮಾನಸಿಕ ಆರೋಗ್ಯ ವೃತ್ತಿಪರರಿಗೆ ಪರ್ಯಾಯವೆಂದು ಪರಿಗಣಿಸಬಾರದು. ಅದರ ಪಾತ್ರವು ಬೆಂಬಲವಾಗಿ ಮಾತ್ರ ಇರಬೇಕು, ಶಿಕ್ಷಕರು ಹೆಚ್ಚಿನ ವೃತ್ತಿಪರ ಗಮನ ಅಗತ್ಯವಿರುವ ಪರಿಸ್ಥಿತಿಗಳನ್ನು ಗುರುತಿಸಲು ಸಹಾಯ ಮಾಡಬೇಕು.

9. ಎಐ ಅಳವಡಿಕೆಯ ಪ್ರಯೋಜನಗಳು ಮತ್ತು ಸವಾಲುಗಳು.

ಪ್ರಯೋಜನಗಳು: ಮಕ್ಕಳ ರಕ್ಷಣೆಯಲ್ಲಿ ಎಐನ ಸಂಭಾವ್ಯ ಪ್ರಯೋಜನಗಳು ಗಣನೀಯವಾಗಿವೆ. ಎಐ ಅಪಾಯಗಳನ್ನು ಗುರುತಿಸುವಲ್ಲಿನ ವಿಳಂಬವನ್ನು ಕಡಿಮೆ ಮಾಡುತ್ತದೆ, ಸಕ್ರಿಯ ಹಸ್ತಕ್ಷೇಪವನ್ನು ಬೆಂಬಲಿಸುತ್ತದೆ, ಸಾಕ್ಷ್ಯಾಧಾರಿತ ನಿರ್ಧಾರ–ತೆಗೆದುಕೊಳ್ಳುವಿಕೆಯನ್ನು ಸುಧಾರಿಸುತ್ತದೆ, ಹೆಚ್ಚಿನ ಸಂಖ್ಯೆಯ ದೂರುಗಳನ್ನು ನಿರ್ವಹಿಸುವ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಭದ್ರತಾ ಭಾವನೆಯನ್ನು ಬಲಪಡಿಸುತ್ತದೆ. ಈ ಅನುಕೂಲಗಳು ಹೆಚ್ಚು ಸ್ಪಂದಿಸುವ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳನ್ನು ನಿರ್ಮಿಸಲು ಕೊಡುಗೆ ನೀಡುತ್ತವೆ.

ಸವಾಲುಗಳು: ಪ್ರತಿಯೊಂದು ತಾಂತ್ರಿಕ ಪ್ರಯೋಜನದ ಜೊತೆಗೆ ಅದಕ್ಕೆ ಅನುಗುಣವಾದ ಅಪಾಯಗಳೂ ಇರುತ್ತವೆ. ಸಿಸಿಟಿವಿ ದೃಶ್ಯಾವಳಿಗಳು, ಆಡಿಯೋ ರೆಕಾರ್ಡಿಂಗ್‌ಗಳು ಮತ್ತು ನಡವಳಿಕೆಯ ಮಾಹಿತಿಯ ಸಂಗ್ರಹಣೆಯು ಗಂಭೀರ ಗೌಪ್ಯತೆಯ ಕಳವಳಗಳನ್ನು ಸೃಷ್ಟಿಸಬಹುದು. ತರಬೇತಿ ಡೇಟಾ ಅಪೂರ್ಣವಾಗಿದ್ದಾಗ ಅಥವಾ ಅಸಮರ್ಪಕವಾಗಿದ್ದಾಗ ಆಲ್ಗಾರಿದಮಿಕ್ ಪೂರ್ವಾಗ್ರಹವು ತಾರತಮ್ಯದ ಫಲಿತಾಂಶಗಳನ್ನು ನೀಡಬಹುದು. ಇದಲ್ಲದೆ, ಮೂಲಸೌಕರ್ಯಗಳ ಅಸಮಾನ ಲಭ್ಯತೆಯು ಉತ್ತಮ ಸಂಪನ್ಮೂಲ ಹೊಂದಿರುವ ಶಾಲೆಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಅಥವಾ ಆರ್ಥಿಕವಾಗಿ ಹಿಂದುಳಿದ ಸಂಸ್ಥೆಗಳ ನಡುವಿನ ಡಿಜಿಟಲ್ ವಿಭಜನೆಯನ್ನು (digital divide) ಹೆಚ್ಚಿಸಬಹುದು. ಮೂಲಸೌಕರ್ಯದ ಮಿತಿಗಳು ಮತ್ತೊಂದು ಪ್ರಮುಖ ಸವಾಲನ್ನು ಒಡ್ಡುತ್ತವೆ. ಸಮಾನ ಶಿಕ್ಷಣದ ಗುರಿಗೆ ವಿರುದ್ಧವಾಗಬಹುದು. ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವೂ ಅಷ್ಟೇ ಮುಖ್ಯವಾಗಿದೆ. ಎಐ ಉಪಕರಣಗಳು ಲಭ್ಯವಿದ್ದರೂ ಸಹ, ಶಿಕ್ಷಕರು ಎಐ–ರಚಿತ ವರದಿಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಲು, ಸುಳ್ಳು ಎಚ್ಚರಿಕೆಗಳನ್ನು ಗುರುತಿಸಲು, ಆಲ್ಗಾರಿದಮಿಕ್ ಮಿತಿಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಅಥವಾ ಡಿಜಿಟಲ್ ಬೆದರಿಕೆಗಳಿಗೆ ಸೂಕ್ತವಾಗಿ ಸ್ಪಂದಿಸಲು ಕಷ್ಟಪಡಬಹುದು. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ತತ್ಸಮಾನ ಹೂಡಿಕೆ ಮಾಡದೆ ಬರೀ ತಂತ್ರಜ್ಞಾನ ಹೂಡಿಕೆ ಮಾಡುವುದರಿಂದ ಸೀಮಿತ ಶೈಕ್ಷಣಿಕ ಮತ್ತು ರಕ್ಷಣಾತ್ಮಕ ಫಲಿತಾಂಶಗಳು

ಬರಬಹುದು. ಶೈಕ್ಷಣಿಕ ಮೌಲ್ಯವನ್ನು ಲಭ್ಯತೆ, ಸಮಾನತೆ, ಗೌಪ್ಯತೆ, ಸುರಕ್ಷತೆ, ನೈತಿಕ ಆಡಳಿತ, ಶಿಕ್ಷಕರ ಸಿದ್ಧತೆ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳಿಗೆ ಸಂಬಂಧಿಸಿದಂತೆ ಮೌಲ್ಯಮಾಪನ ಮಾಡಬೇಕು.

10.ಎಐ ಯುಗದಲ್ಲಿ ಮಕ್ಕಳ ರಕ್ಷಣೆಗೆ ಅಡಿಪಾಯವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ.

ಎಐ ಮಕ್ಕಳ ರಕ್ಷಣೆಯನ್ನು ಮಾಡುವಲ್ಲಿ ಪ್ರಮುಖ ಪಾತ್ರವಹಿಸುತ್ತದೆ, ಆದರೆ ತಂತ್ರಜ್ಞಾನವೊಂದೇ ಸುರಕ್ಷಿತ ಶೈಕ್ಷಣಿಕ ವಾತಾವರಣವನ್ನು ಸೃಷ್ಟಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ. ಶಿಕ್ಷಕರ ಪಾತ್ರ ಅತ್ಯಗತ್ಯವಾಗಿದೆ ಏಕೆಂದರೆ ಅವರು ಮಕ್ಕಳ ನಡವಳಿಕೆಯನ್ನು ವಿಶ್ಲೇಷಿಸುತ್ತಾರೆ, ಸಂಬಂಧಗಳನ್ನು ನಿರ್ಮಿಸುತ್ತಾರೆ, ವೃತ್ತಿಪರ ತೀರ್ಪು ನೀಡುತ್ತಾರೆ ಮತ್ತು ಸೂಕ್ತವಾದ ಹಸ್ತಕ್ಷೇಪಗಳನ್ನು ಮಾಡುತ್ತಾರೆ. ಬದಲಾಗುತ್ತಿರುವ ಡಿಜಿಟಲ್ ವಾತಾವರಣಕ್ಕೆ ಅನುಗುಣವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವು ವಿಕಸನಗೊಳ್ಳಬೇಕು. ಎಐ ಯುಗದಲ್ಲಿ, ಶಿಕ್ಷಣತಜ್ಞರು ಮಾಹಿತ ಒದಗಿಸುವ ಸಾಂಪ್ರದಾಯಿಕ ಪಾತ್ರದಿಂದ "ಡಿಜಿಟಲ್ ರಕ್ಷಕರು" (Digital Protectors) ಎಂಬ ವಿಶಾಲ ಪಾತ್ರದತ್ತ ಹಂತ ಹಂತವಾಗಿ ಸಾಗಬೇಕು. ಈ ಪಾತ್ರವು ಮಕ್ಕಳು ತಂತ್ರಜ್ಞಾನವನ್ನು ಜವಾಬ್ದಾರಿಯುತವಾಗಿ ಬಳಸಲು ಸಹಾಯ ಮಾಡುವುದು, ಡಿಜಿಟಲ್ ಅಪಾಯಗಳನ್ನು ಗುರುತಿಸುವುದು, ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯನ್ನು ರಕ್ಷಿಸುವುದು, ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್ ಮತ್ತು ಆನ್‌ಲೈನ್ ಶೋಷಣೆಯನ್ನು ಗುರುತಿಸುವುದು, ಎಐ–ರಚಿತ ಮಾಹಿತಿಯನ್ನು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ವಿಶ್ಲೇಷಿಸುವುದು ಮತ್ತು ತಾಂತ್ರಿಕ ಅಭ್ಯಾಸಗಳು ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ಗೌರವಿಸುವುದನ್ನು ಖಚಿತಪಡಿಸಿಕೊಳ್ಳುವುದನ್ನು ಒಳಗೊಂಡಿರುತ್ತದೆ. ಇಂತಹ ರೂಪಾಂತರಕ್ಕೆ ಪೂರ್ವ–ಸೇವಾ ಮತ್ತು ಸೇವಾ–ನಿರತ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಎರಡರಲ್ಲೂ ಬದಲಾವಣೆಗಳ ಅಗತ್ಯವಿದೆ. ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಕಾರ್ಯಕ್ರಮವು ತಂತ್ರಜ್ಞಾನವನ್ನು ಪ್ರತ್ಯೇಕ ತಾಂತ್ರಿಕ ವಿಷಯವಾಗಿ ನೋಡುವ ಬದಲು ಎಐ ಸಾಕ್ಷರತೆಯನ್ನು ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಶಿಕ್ಷಣದೊಂದಿಗೆ ಸಂಯೋಜಿಸಬೇಕು.

11.ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಪಠ್ಯಕ್ರಮದ ಸಂಯೋಜನೆ.

ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಪಠ್ಯಕ್ರಮವು ಗಓಅಖಅ, ಪೋಕ್ಸೋ (POCSO) ಕಾಯ್ದೆ ಮತ್ತು ಆರ್‌ಟಿಇ (RTE) ಕಾಯ್ದೆ ಸೇರಿದಂತೆ ಮಕ್ಕಳ ರಕ್ಷಣಾ ಕಾನೂನುಗಳ ವ್ಯವಸ್ಥಿತ ಜ್ಞಾನವನ್ನು ಒದಗಿಸಬೇಕು. ಇಂತಹ ಕಾನೂನು ಜ್ಞಾನವು ಮಕ್ಕಳ ರಕ್ಷಣೆಗೆ ಸ್ಪಂದಿಸುವಾಗ ಶಿಕ್ಷಕರಿಗೆ ತಮ್ಮ ಜವಾಬ್ದಾರಿಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಸಹಾಯ ಮಾಡುತ್ತದೆ. ಕಾನೂನು ಜ್ಞಾನದ ಜೊತೆಗೆ, ಶಿಕ್ಷಕರಿಗೆ ಮೆಷಿನ್ ಲರ್ನಿಂಗ್, ನ್ಯಾಚುರಲ್ ಲ್ಯಾಂಗ್ವೇಜ್ ಪ್ರೊಸೆಸಿಂಗ್ ಮತ್ತು ಡೇಟಾ ಅನಾಲಿಟಿಕ್ಸ್‌ನಂತಹ ಎಐ ಪರಿಕಲ್ಪನೆಗಳ ಮೂಲಭೂತ ತಿಳುವಳಿಕೆ ಅಗತ್ಯವಿದೆ. ಪ್ರತಿಯೊಬ್ಬ ಶಿಕ್ಷಕನನ್ನು ಕಂಪ್ಯೂಟರ್ ಜ್ಞಾನಿಯನ್ನಾಗಿ ಮಾಡುವುದು ಇದರ ಉದ್ದೇಶವಲ್ಲ, ಬದಲಿಗೆ ಎಐ ವ್ಯವಸ್ಥೆಗಳ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಮೌಲ್ಯಮಾಪನವನ್ನು ಸಕ್ರಿಯಗೊಳಿಸಲು ಅಗತ್ಯವಾದ ಪರಿಕಲ್ಪನಾ ತಿಳುವಳಿಕೆಯನ್ನು ಒದಗಿಸುವುದಾಗಿದೆ. ಪಠ್ಯಕ್ರಮವು ಸೈಬರ್ ಸುರಕ್ಷತೆಯನ್ನು ಸಹ ಒಳಗೊಂಡಿರಬೇಕು; ಇದರಲ್ಲಿ ಇಂಟರ್ನೆಟ್ ಸುರಕ್ಷತೆ, ಫಿಶಿಂಗ್ ಜಾಗೃತಿ, ಡಿಜಿಟಲ್ ಬೆದರಿಕೆಗಳು, ಪಾಸ್‌ವರ್ಡ್ ಭದ್ರತೆ ಮತ್ತು ಸೈಬರ್ ಘಟನೆಗಳಿಗೆ

ಸೂಕ್ತವಾದ ಪ್ರತಿಕ್ರಿಯೆಗಳು ಸೇರಿವೆ. ಶಿಕ್ಷಕರು ಅಲ್ಗಾರಿದಮಿಕ್ ಪೂರ್ವಾಗ್ರಹ, ಗೌಪ್ಯತೆ, ಪಾರದರ್ಶಕತೆ, ಜವಾಬ್ದಾರಿ ಮತ್ತು ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆಯನ್ನು ಕಾಯ್ದುಕೊಳ್ಳುವ ಪ್ರಾಮುಖ್ಯತೆಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಬೇಕು. "ಹ್ಯೂಮನ್–ಇನ್–ದಿ–ಲೂಪ್" (ನಿರ್ಧಾರಗಳಲ್ಲಿ ಮಾನವನ ಉಪಸ್ಥಿತಿ) ತತ್ವವು ವಿಶೇಷವಾಗಿ ಮುಖ್ಯವಾಗಿದೆ ಏಕೆಂದರೆ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣೆಯ ನಿರ್ಧಾರಗಳನ್ನು ಸಂಪೂರ್ಣವಾಗಿ ಸ್ವಯಂಚಾಲಿತ ವ್ಯವಸ್ಥೆಗಳಿಗೆ ವಹಿಸಿಕೊಡಬಾರದು. ಅಂತೆಯೇ ಶಿಕ್ಷಕರ ತರಬೇತಿಯಲ್ಲಿ ಡಿಜಿಟಲ್ ಪೌರತ್ವವನ್ನು ಸೇರಿಸಬೇಕು, ಇದರಿಂದ ಶಿಕ್ಷಣತಜ್ಞರು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಜವಾಬ್ದಾರಿಯುತ ಆನ್‌ಲೈನ್ ನಡವಳಿಕೆ, ಇತರರಿಗೆ ಗೌರವ, ಸೂಕ್ತವಾದ ಸಂವಹನ ಅಭ್ಯಾಸಗಳು ಮತ್ತು ಡಿಜಿಟಲ್ ಪರಿಣಾಮಗಳ ಜಾಗೃತಿಯನ್ನು ಬೆಳೆಸಲು ಸಹಾಯ ಮಾಡಬಹುದು. ಅಂತಿಮವಾಗಿ, ಕೇಸ್ ಸ್ಟಡಿಗಳು ಮತ್ತು ಕ್ರಿಯಾ ಸಂಶೋಧನೆಯ ಸೈದ್ಧಾಂತಿಕ ಜ್ಞಾನವನ್ನು ನೈಜ ಶೈಕ್ಷಣಿಕ ಸನ್ನಿವೇಶಗಳೊಂದಿಗೆ ಸಂಪರ್ಕಿಸಬಹುದು. ಶಿಕ್ಷಕ ತರಬೇತಿದಾರರು ಸೈಬರ್ ಬುಲ್ಲಿಯಿಂಗ್, ಗೌಪ್ಯತೆ, ಹಾನಿಕಾರಕ ವಿಷಯ, ಎಐ ಪೂರ್ವಾಗ್ರಹ ಮತ್ತು ಡಿಜಿಟಲ್ ಸುರಕ್ಷತೆಯನ್ನು ಒಳಗೊಂಡ ಪ್ರಾಯೋಗಿಕ ಪ್ರಕರಣಗಳನ್ನು ಪರಿಶೀಲಿಸಬೇಕು ಮತ್ತು ಸೂಕ್ತವಾದ ಹಸ್ತಕ್ಷೇಪ ತಂತ್ರಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಬೇಕು.

12.ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಪ್ರಾಯೋಗಿಕ ಅನುಷ್ಠಾನ

ಪಠ್ಯಕ್ರಮದ ಜ್ಞಾನವು ಪ್ರಾಯೋಗಿಕ ಅನುಭವದಿಂದ ಬೆಂಬಲಿತವಾದಾಗ ಮಾತ್ರ ಅರ್ಥಪೂರ್ಣವಾಗುತ್ತದೆ. ಆದ್ದರಿಂದ, ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಸಿಮ್ಯುಲೇಶನ್‌ಗಳು (simulations), ಕಾರ್ಯಾಗಾರಗಳು, ಕ್ಷೇತ್ರ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಸಮಸ್ಯೆ–ಆಧಾರಿತ ಕಲಿಕೆಯ ಮೂಲಕ ತರಬೇತಿದಾರರಿಗೆ ಎಐ ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣೆಯ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಅನ್ವಯಿಸಲು ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸಬೇಕು. ಶಾಲಾ ಸುರಕ್ಷತಾ ಯೋಜನೆಗಳ ಅಭಿವೃದ್ಧಿಯು ಒಂದು ಪ್ರಾಯೋಗಿಕ ವಿಧಾನವಾಗಿದೆ. ಗೌಪ್ಯತೆ ಮತ್ತು ನೈತಿಕ ಸುರಕ್ಷತೆಗಳನ್ನು ಕಾಯ್ದುಕೊಳ್ಳುವಾಗ ಎಐ ಉಪಕರಣಗಳನ್ನು ಶಾಲಾ ಮಟ್ಟದ ಸುರಕ್ಷತಾ ವ್ಯವಸ್ಥೆಗಳಲ್ಲಿ ಹೇಗೆ ಸೇರಿಸಬಹುದು ಎಂಬುದನ್ನು ತೋರಿಸುವ ಮಾದರಿ ಚೌಕಟ್ಟುಗಳನ್ನು ಶಿಕ್ಷಕ ತರಬೇತಿದಾರರು ವಿನ್ಯಾಸಗೊಳಿಸಬಹುದು. ಅದೇ ರೀತಿ, ಚಾಟ್‌ಬಾಟ್ ಸಿಮ್ಯುಲೇಶನ್‌ಗಳು ಅನಾಮಧೇಯ ವರದಿ ಕಾರ್ಯವಿಧಾನಗಳು ಮತ್ತು ತುರ್ತು ಹೆಚ್ಚಳ ಪ್ರಕ್ರಿಯೆಗಳನ್ನು (emergency escalation procedures) ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತವೆ. ಇಂತಹ ಚಟುವಟಿಕೆಗಳು ಸ್ವಯಂಚಾಲಿತ ವ್ಯವಸ್ಥೆಗಳ ಶಕ್ತಿ ಮತ್ತು ಮಿತಿಗಳೆರಡನ್ನೂ ಗುರುತಿಸಲು ಶಿಕ್ಷಕರಿಗೆ ಸಹಾಯ ಮಾಡುತ್ತವೆ. ಪ್ರಾಯೋಗಿಕ ಕಾರ್ಯಾಗಾರಗಳು ತರಬೇತಿದಾರರಿಗೆ ವಿಷಯ ಶೋಧನೆ, ಸೈಬರ್ ಸುರಕ್ಷತಾ ಎಚ್ಚರಿಕೆಗಳು, ಡಿಜಿಟಲ್–ಅಪಾಯ ಗುರುತಿಸುವಿಕೆ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಡೇಟಾ ನಿರ್ವಹಣೆಯನ್ನು ಪರಿಚಯಿಸಬಹುದು. ನೈತಿಕ ಕೇಸ್ ಚರ್ಚೆಗಳು ಶಾಲೆಗಳಲ್ಲಿ ಮುಖ ಗುರುತಿಸುವಿಕೆ (facial recognition) ಮತ್ತು ಕಣ್ಗಾವಲು ತಂತ್ರಜ್ಞಾನಗಳ ಬಳಕೆ ಸೇರಿದಂತೆ ಕಠಿಣ ಪ್ರಶ್ನೆಗಳ ಬಗ್ಗೆ ವಿಮರ್ಶಾತ್ಮಕ ಆಲೋಚನೆಯನ್ನು ಮತ್ತಷ್ಟು ಪ್ರೋತ್ಸಾಹಿಸಬಹುದು. ಕ್ಷೇತ್ರ ಮೌಲ್ಯಮಾಪನಗಳು

ಮತ್ತೊಂದು ಅಮೂಲ್ಯವಾದ ಅವಕಾಶವನ್ನು ಒದಗಿಸುತ್ತವೆ. ತರಬೇತಿದಾರರು ಸ್ಥಳೀಯ ಶಾಲೆಗಳಲ್ಲಿನ ಡಿಜಿಟಲ್ ಮೂಲಸೌಕರ್ಯ ಮತ್ತು ಸೈಬರ್ ಸುರಕ್ಷತಾ ಅಭ್ಯಾಸಗಳನ್ನು ಪರಿಶೀಲಿಸಬಹುದು ಹಾಗೂ ಸಂಪರ್ಕ, ಯಂತ್ರಾಂಶ, ಗೌಪ್ಯತೆ ರಕ್ಷಣೆ ಮತ್ತು ಶಿಕ್ಷಕರ ಸಿದ್ಧತೆಯಲ್ಲಿನ ಕೊರತೆಗಳನ್ನು ಗುರುತಿಸಬಹುದು. ಇಂತಹ ಕ್ಷೇತ್ರ ಆಧಾರಿತ ಅನುಭವಗಳು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣವನ್ನು ನೈಜ ಶಾಲಾ ಪರಿಸ್ಥಿತಿಗಳೊಂದಿಗೆ ಸಂಪರ್ಕಿಸಲು ಸಹಾಯ ಮಾಡುತ್ತವೆ.

13.ನೀತಿ ಶಿಫಾರಸುಗಳು

1. **ಕಡ್ಡಾಯ ಪಠ್ಯಕ್ರಮ ಸಂಯೋಜನೆ:** ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ನಿಯಂತ್ರಣ ಮಂಡಳಿಗಳು ಶಿಕ್ಷಕರ ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮದಲ್ಲಿ ಎಐ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಮಕ್ಕಳ ಹಕ್ಕುಗಳು, ಡೇಟಾ ಗೌಪ್ಯತೆ ಮತ್ತು ಎಐ ನೈತಿಕತೆಯ ಕಡ್ಡಾಯ ವಿಷಯಗಳನ್ನು ಸಂಯೋಜಿಸುವುದನ್ನು ಪರಿಗಣಿಸಬೇಕು. ಬಿ.ಎಡ್ ಮಟ್ಟದಲ್ಲಿ, ಎಐ, ಸೈಬರ್ ಸುರಕ್ಷತೆ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳಿಗೆ ಸಂಬಂಧಿಸಿದ ನಿರ್ದಿಷ್ಟ ಘಟಕಗಳನ್ನು ಐಸಿಟಿ ಮತ್ತು ಮಕ್ಕಳ ಅಭಿವೃದ್ಧಿಯ ಭಾಗಗಳೊಂದಿಗೆ ಸಂಯೋಜಿಸಬಹುದು.
2. **ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ:** ಪೂರ್ವ–ಸೇವಾ ಶಿಕ್ಷಣವೊಂದೇ ತ್ವರಿತ ತಾಂತ್ರಿಕ ಬದಲಾವಣೆಯ ವೇಗವನ್ನು ಪರಿಹರಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ. ಆದ್ದರಿಂದ, ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತಿರುವ ಶಿಕ್ಷಕರು ಡಿಜಿಟಲ್ ಸುರಕ್ಷತೆ, ಎಐ ಅನ್ವಯಗಳು, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಡೇಟಾ ಗೌಪ್ಯತೆ ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣೆಯ ಮೇಲೆ ಗಮನ ಹರಿಸುವ ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ ಕಾರ್ಯಕ್ರಮಗಳನ್ನು ನಿಯಮಿತವಾಗಿ ಪಡೆಯಬೇಕು.
3. **ಎಐ–ಚಾಲಿತ ಶಾಲಾ ವರದಿ ಮಾಡುವ ಚೌಕಟ್ಟು** : ಮಕ್ಕಳು ತಮ್ಮ ಸಮಸ್ಯೆಗಳನ್ನು ಸುರಕ್ಷಿತವಾಗಿ ತಿಳಿಸಲು ಅನುವು ಮಾಡಿಕೊಡುವ ಬಹುಭಾಷಾ ಮತ್ತು ಲಭ್ಯವಿರುವ ವರದಿ ಮಾಡುವ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಶಾಲೆಗಳು ಅನ್ವೇಷಿಸಬಹುದು. ಎಐ–ಬೆಂಬಲಿತ ವ್ಯವಸ್ಥೆಗಳು ವರದಿಗಳನ್ನು ವರ್ಗೀಕರಿಸಲು ಮತ್ತು ತಕ್ಷಣದ ಗಮನ ಅಗತ್ಯವಿರುವ ಪ್ರಕರಣಗಳನ್ನು ಗುರುತಿಸಲು ಸಹಾಯ ಮಾಡುತ್ತವೆ. ಆದಾಗ್ಯೂ, ಯಾವುದೇ ರೀತಿಯ ವ್ಯವಸ್ಥೆಯು ಸ್ಪಷ್ಟವಾಗಿ ವ್ಯಾಖ್ಯಾನಿಸಲಾದ ಮಾನವ ಹಸ್ತಕ್ಷೇಪದ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಒಳಗೊಂಡಿರಬೇಕು. ಹೆಚ್ಚಿನ ಅಪಾಯದ ವರದಿಗಳನ್ನು ಅಧಿಕೃತ ಸಿಬ್ಬಂದಿ ಪರಿಶೀಲಿಸಬೇಕು ಮತ್ತು ಅಗತ್ಯವಿದ್ದಲ್ಲಿ, ಸೂಕ್ತ ಮಕ್ಕಳ ರಕ್ಷಣಾಧಿಕಾರಿಗಳಿಗೆ ಉಲ್ಲೇಖಿಸಬೇಕು.
4. **ರಾಜ್ಯ–ಮಟ್ಟದ ನೀತಿ ಮಾರ್ಗದರ್ಶಿ ಸೂತ್ರಗಳು** : ರಾಜ್ಯ ಮಟ್ಟದ ಶೈಕ್ಷಣಿಕ ಅಧಿಕಾರಿಗಳು ಶಾಲೆಗಳಲ್ಲಿ ಎಐ ಮತ್ತು ಡಿಜಿಟಲ್ ಸುರಕ್ಷತಾ ವ್ಯವಸ್ಥೆಗಳ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಗಾಗಿ ಏಕೀಕೃತ ಮಾರ್ಗದರ್ಶಿ ಸೂತ್ರಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಬೇಕು. ಇಂತಹ ಮಾರ್ಗದರ್ಶಿ ಸೂತ್ರಗಳು ವಿಷಯ ಶೋಧನೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಕಣ್ಗಾವಲು ತಂತ್ರಜ್ಞಾನಗಳು, ಡೇಟಾ ಆಡಳಿತ ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣೆಯ ಜವಾಬ್ದಾರಿಗಳನ್ನು ಪರಿಹರಿಸಬೇಕು. ಮುಖ ಗುರುತಿಸುವಿಕೆ ಮತ್ತು ಸಿಸಿಟಿವಿ ತಂತ್ರಜ್ಞಾನಗಳ ಬಗ್ಗೆ ನಿರ್ದಿಷ್ಟ ಎಚ್ಚರಿಕೆ

ಅಗತ್ಯವಿದೆ. ಅವುಗಳ ಬಳಕೆಯು ಶೈಕ್ಷಣಿಕ ಮತ್ತು ಭೌತಿಕ ಭದ್ರತಾ ಉದ್ದೇಶಗಳಿಗೆ ಮಾತ್ರ ಸ್ಪಷ್ಟವಾಗಿ ಸೀಮಿತವಾಗಿರಬೇಕು, ಜೊತೆಗೆ ಮಕ್ಕಳ ಅನಗತ್ಯ ಪ್ರೊಫೈಲಿಂಗ್ ವಿರುದ್ಧ ಸೂಕ್ತ ಸುರಕ್ಷತೆಗಳನ್ನು ಹೊಂದಿರಬೇಕು. ಶಾಲೆಗಳಲ್ಲಿ ನಿರ್ದಿಷ್ಟ ಮಕ್ಕಳ ರಕ್ಷಣಾ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಸ್ಥಾಪಿಸುವುದು ಸಾಂಸ್ಥಿಕ ಹೊಣೆಗಾರಿಕೆಯನ್ನು ಮತ್ತಷ್ಟು ಬಲಪಡಿಸುತ್ತದೆ.

5. **ನೈತಿಕ ಮಾನದಂಡಗಳು ಮತ್ತು ಡೇಟಾ ಗೌಪ್ಯತೆ** : ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳು ಬಲವಾದ ಡೇಟಾ–ಆಡಳಿತ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಸ್ಥಾಪಿಸಬೇಕು. ಸೂಕ್ತ ಸಮ್ಮತಿ ಮತ್ತು ಭದ್ರತೆಗಳೊಂದಿಗೆ, ಸಿಂಧುವಾದ ಮತ್ತು ಅಗತ್ಯ ಉದ್ದೇಶಗಳಿಗಾಗಿ ಮಾತ್ರ ಮಕ್ಕಳ ಡೇಟಾವನ್ನು ಸಂಗ್ರಹಿಸಬೇಕು. ವಾಣಿಜ್ಯ ಶೋಷಣೆ, ಅನಗತ್ಯ ಗುರಿ–ಆಧಾರಿತ ಜಾಹೀರಾತುಗಳು ಮತ್ತು ಮಕ್ಕಳ ಶೈಕ್ಷಣಿಕ ಹಾಗೂ ನಡವಳಿಕೆಯ ಡೇಟಾದ ಅನಧಿಕೃತ ಹಂಚಿಕೆಯನ್ನು ತಡೆಯಬೇಕು. ಡೇಟಾ ಕನಿಷ್ಠೀಕರಣ ಮತ್ತು ಗೌಪ್ಯತೆ–ಆಧಾರಿತ ವಿನ್ಯಾಸದ (privacy–by–design) ತತ್ವಗಳು ಶೈಕ್ಷಣಿಕ ತಂತ್ರಜ್ಞಾನ ವ್ಯವಸ್ಥೆಗಳ ಪ್ರಮಾಣಿತ ಅಗತ್ಯತೆಗಳಾಗಬೇಕು.

14.**ಉಪಸಂಹಾರ** (Conclusion):

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು (AI) ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಅಪಾಯಗಳ ಗುರುತಿಸುವಿಕೆ, ಲಭ್ಯತೆಯ ಸುಧಾರಣೆ ಮತ್ತು ಮಕ್ಕಳ ರಕ್ಷಣಾ ವಿಧಾನಗಳನ್ನು ಬಲಪಡಿಸುವ ಮೂಲಕ ಸಮಕಾಲೀನ ಶಿಕ್ಷಣದಲ್ಲಿ ಪ್ರಮುಖ ಪಾತ್ರ ವಹಿಸುತ್ತಿದೆ. ಅದು ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ಎಷ್ಟು ಮಟ್ಟಿಗೆ ರಕ್ಷಿಸುತ್ತದೆ ಎಂಬುದರ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿದೆ. UNCRC, ಯುನಿಸೆಫ್, ಯುನೆಸ್ಕೋ ಮಾರ್ಗದರ್ಶನಗಳು ಹಾಗೂ ಭಾರತದ NEP 2020 ಮತ್ತು ಆಕಆಕ ಕಾಯ್ದೆ, 2023 ರಂತಹ ಕಾನೂನುಗಳು ಜವಾಬ್ದಾರಿಯುತ ಡಿಜಿಟಲ್ ರೂಪಾಂತರದ ಅಗತ್ಯವನ್ನು ಒತ್ತುಕೊಡುತ್ತವೆ. ಈ ತಾಂತ್ರಿಕ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ ಅತ್ಯಂತ ನಿರ್ಣಾಯಕವಾಗಿದೆ. ಶಿಕ್ಷಕರು ಕೇವಲ ಡಿಜಿಟಲ್ ಉಪಕರಣಗಳ ಬಳಕೆದಾರರಲ್ಲ; ಅವರು ಮಾರ್ಗದರ್ಶಕರು, ರಕ್ಷಕರು ಮತ್ತು ವಿಶ್ಲೇಷಕರು. ಆದ್ದರಿಂದ, B.Ed. ಪಠ್ಯಕ್ರಮದಲ್ಲಿ ಂಖ ನೈತಿಕತೆ, ಸೈಬರ್ ಸುರಕ್ಷತೆ, ಡೇಟಾ ಗೌಪ್ಯತೆ, ಡಿಜಿಟಲ್ ಪೌರತ್ವ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ಸಂಯೋಜಿಸಿ ಶಿಕ್ಷಕರನ್ನು 'ಡಿಜಿಟಲ್ ರಕ್ಷಕರು' ಆಗಿ ಸಿದ್ಧಪಡಿಸಬೇಕಿದೆ. ಅಂತಿಮವಾಗಿ, ಶಿಕ್ಷಣದಲ್ಲಿ ಂಖ ಯ ಮುಖ್ಯ ಉದ್ದೇಶ ಮಾನವ ನಿರ್ಣಯವನ್ನು ಬದಲಾಯಿಸುವುದಲ್ಲ, ಬದಲಿಗೆ ಶಿಕ್ಷಕರ ಮಾನವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬಲಪಡಿಸುವುದಾಗಿದೆ. ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆ, ಅನುಕಂಪ, ವೃತ್ತಿಪರ ಜವಾಬ್ದಾರಿ, ಸಮಾನತೆ ಮತ್ತು ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಗೌರವವು ಂಖ ಶಿಕ್ಷಣದ ಕೇಂದ್ರವಾಗಿ ಉಳಿಯಬೇಕು. ತಾಂತ್ರಿಕ ರೂಪಾಂತರದ ಕೇಂದ್ರದಲ್ಲಿ ಈ ತತ್ವಗಳನ್ನು ಇರಿಸಿದಾಗ ಮಾತ್ರ ಪ್ರತಿಯೊಂದು ಮಗುವಿಗೆ ಸುರಕ್ಷಿತ, ಸಮಾನ, ಸಮಗ್ರ ಮತ್ತು ಮಾನವೀಯವಾದ ಡಿಜಿಟಲ್ ಶೈಕ್ಷಣಿಕ ಭವಿಷ್ಯವನ್ನು ಖಚಿತಪಡಿಸಿಕೊಳ್ಳಲು ಸಾಧ್ಯ.

15.ಪರಾಮರ್ಶಿತ ಗ್ರಂಥಗಳು.

ಇಂಟೆಕ್ ಓಪನ್. (2026). ಚಿಲ್ಡ್ರನ್ಸ್ ರೈಟ್ಸ್ ಇನ್ ದಿ ಏಜ್ ಆಫ್ ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜನ್ಸ್.

ಇಂಟೆಕ್ ಓಪನ್.

ಐಐಟಿಎಂ ಪ್ರವರ್ತಕ್. (2026). ಎಐ ಫಾರ್ ಕೆ12 ಟೀಚರ್ಸ್ ಸರ್ಟಿಫಿಕೇಶನ್ ಕೋರ್ಸ್.

ಎಲೆಕ್ಟ್ರಾನಿಕ್ಸ್ ಮತ್ತು ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ ಸಚಿವಾಲಯ. (n.d.). ಮಾಹಿತಿ ಭದ್ರತಾ ಜಾಗೃತಿ (ಐಎಸ್ಇಎ) ಕಾರ್ಯಕ್ರಮ. ಭಾರತ ಸರ್ಕಾರ.

ಒಇಸಿಡಿ. (n.d.). ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜನ್ಸ್ ಇನ್ ಎಜುಕೇಶನ್. *ಒಇಸಿಡಿ ಪಬ್ಲಿಷಿಂಗ್.*

ಕರ್ನಾಟಕ ಸರ್ಕಾರ. (2026). ಎಐ ಶಿಕ್ಷಕರ ಸುತ್ತೋಲೆ (2026–27). *ಶಾಲಾ ಶಿಕ್ಷಣ ಮತ್ತು ಸಾಕ್ಷರತಾ ಇಲಾಖೆ, ಕರ್ನಾಟಕ ಸರ್ಕಾರ.*

ಕಾನೂನು ಮತ್ತು ನ್ಯಾಯ ಸಚಿವಾಲಯ, ಭಾರತ ಸರ್ಕಾರ. (2023). ಡಿಜಿಟಲ್ ವೈಯಕ್ತಿಕ ಡೇಟಾ ಸಂರಕ್ಷಣಾ ಕಾಯಿದೆ, ೨೦೨೩ (ಕಾಯಿದೆ ಸಂಖ್ಯೆ 22/2023). ದಿ ಗಝೆಟ್ ಆಫ್ ಇಂಡಿಯಾ.
https://www.meity.gov.in/writereaddata/files/Digital%20Personal%20Data%20Protection%20Act%202023.pdf

ಜಗನ್ನಾಥ ಕೆ. ಡಾಂಗೆ., ಪಾಂಡುರಂಗಪ್ಪ ಬಿ.ಎಸ್ ಮತ್ತು ರತ್ನಾ. ಎಂ., (6 November 2025).ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಪೋಷಣೆ ಮತ್ತು ರಕ್ಷಣೆ. ಹೊಯ್ಸಳ ದಿನಪತ್ರಿಕೆ. ಚಿತ್ರದುರ್ಗ.

ಪಾಂಡುರಂಗಪ್ಪ ಬಿ ಎಸ್., ರತ್ನಾ ಎಂ., ಮತ್ತು ದೇವರಾಜು (2026) ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರಿಗೆ ಬೇಕಿದೆ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಅರಿವು. ರಾಜ್ಯಮಟ್ಟದ ಸೆಮಿನರ್. ಹಾಸನ.

ಭಾರತ ಸರ್ಕಾರ. (2012). ಲೈಂಗಿಕ ಅಪರಾಧಗಳಿಂದ ಮಕ್ಕಳ ರಕ್ಷಣೆ (ಪೋಕ್ಸೋ) ಕಾಯಿದೆ, 2012 *(ಸಂಖ್ಯೆ 32/2012). ದಿ ಗಝೆಟ್ ಆಫ್ ಇಂಡಿಯಾ.*

ಭಾರತ ಸರ್ಕಾರ. (2020). ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ ೨೦೨೦. *ಮಾನವ ಸಂಪನ್ಮೂಲ ಅಭಿವೃದ್ಧಿ ಸಚಿವಾಲಯ.*
https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

ಭಾರತೀಯ ಸಂಸತ್ತು. (2000). ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ ಕಾಯಿದೆ, ೨೦೦೦ ಮತ್ತು ಮಧ್ಯವರ್ತಿ ಮಾರ್ಗಸೂಚಿಗಳು ಮತ್ತು ಡಿಜಿಟಲ್ ಮೀಡಿಯಾ ಎಥಿಕ್ಸ್ ಕೋಡ್ ನಿಯಮಗಳು, ೨೦೨೧.

ಭಾರತೀಯ ಸಂಸತ್ತು. (2009). ಉಚಿತ ಮತ್ತು ಕಡ್ಡಾಯ ಶಿಕ್ಷಣಕ್ಕಾಗಿ ಮಕ್ಕಳ ಹಕ್ಕು (ಆರ್ಟಿಇ) ಕಾಯಿದೆ, 2009 *(ಸಂಖ್ಯೆ 35/2009). ದಿ ಗಝೆಟ್ ಆಫ್ ಇಂಡಿಯಾ.*

ಯುಎನ್ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಸಮಿತಿ. (2021). ಡಿಜಿಟಲ್ ಪರಿಸರಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಕುರಿತು ಸಾಮಾನ್ಯ ವಿವರಣೆ ಸಂಖ್ಯೆ ೨೫ (2021) *(*CRC/C/GC/25*). ವಿಶ್ವಸಂಸ್ಥೆ.*
https://www.ohchr.org/en/documents/general-comments-and-recommendations/general-comment-no-25-2021-childrens-rights-relation

ಯುಎನ್ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಸಮಿತಿ. (2026). ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಮಗುವಿನ ಹಕ್ಕುಗಳ ಜಂಟಿ ಹೇಳಿಕೆ. ವಿಶ್ವಸಂಸ್ಥೆ.

ಯುನೆಸ್ಕೋ. (2021). ಆರ್ಟಿಫಿಷಿಯಲ್ ಇಂಟೆಲಿಜನ್ಸ್‌ನ ನೈತಿಕತೆಯ ಶಿಫಾರಸು. *ವಿಶ್ವಸಂಸ್ಥೆಯ ಶೈಕ್ಷಣಿಕ, ವೈಜ್ಞಾನಿಕ ಮತ್ತು ಸಾಂಸ್ಕೃತಿಕ ಸಂಸ್ಥೆ.* https://unesdoc.unesco.org/ark:/48223/pf0000381137

ಯುನೆಸ್ಕೋ. (2023). ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ ಜೆನೆರೇಟಿವ್ ಎಐಗಾಗಿ ಮಾರ್ಗದರ್ಶನ. ಯುನೆಸ್ಕೋ.

ಯುನೆಸ್ಕೋ. (2025). ಎಐ ಆಡಳಿತದಲ್ಲಿ ಮಕ್ಕಳ ಹಕ್ಕುಗಳನ್ನು ಹೇಗೆ ಸಂಯೋಜಿಸಬೇಕು? ಯುನೆಸ್ಕೋ.

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ರಾಷ್ಟ್ರೀಯ ಇಂಧನ ವಿಭಾಗ – ಇಂಡಿಯಾಎಐ. (2023). ರಾಷ್ಟ್ರೀಯ ಎಐ ಆಡಳಿತ ಮಾರ್ಗಸೂಚಿಗಳು. ಎಲೆಕ್ಟ್ರಾನಿಕ್ಸ್ ಮತ್ತು ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ ಸಚಿವಾಲಯ, *ಭಾರತ ಸರ್ಕಾರ.*

ರಾಷ್ಟ್ರೀಯ ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ರಕ್ಷಣಾ ಆಯೋಗ. (n.d.). ಮಾರ್ಗದರ್ಶಿಸೂತ್ರಗಳು ಮತ್ತು ಪ್ರಕಟಣೆಗಳು. ಎನ್‌ಸಿಪಿಸಿಆರ್. ವಿಶ್ವ ಸಂಸ್ಥೆಯ ಮಹಾಸಭೆ. (1989). ಮಕ್ಕಳ ಹಕ್ಕುಗಳ ಸಮಾವೇಶ. *ಯುನೈಟೆಡ್ ನೇಷನ್ಸ್, ಟ್ರೀಟಿ ಸೀರೀಸ್,* 1577(3),3–178. https://www.ohchr.org/en/instrumentsmechanisms/instruments/convention-rights-child

ವಿಶ್ವ ಸಂಸ್ಥೆಯ ಮಹಾಸಭೆ. (2024). ಸುಸ್ಥಿರ ಅಭಿವೃದ್ಧಿಗಾಗಿ ಸುರಕ್ಷಿತ, ಭದ್ರ ಮತ್ತು ವಿಶ್ವಾಸಾರ್ಹ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ವ್ಯವಸ್ಥೆಗಳ ಅವಕಾಶಗಳನ್ನು ಬಳಸಿಕೊಳ್ಳುವುದು *(ನಿರ್ಣಯ* A/RES/78/265). ವಿಶ್ವಸಂಸ್ಥೆ.

ಶಿಕ್ಷಾ ಕೋಪೈಲಟ್ ಸ್ಟಡಿ. (2025). ಕರ್ನಾಟಕದಲ್ಲಿ ಪಾಠ ಯೋಜನೆಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಶಿಕ್ಷಕರು ಮತ್ತು ಎಐ ಸಹಯೋಗ *[ಪೂರ್ವ ಮುದ್ರಣ].*

ಸರ್ಕಾರಿ ಸುತ್ತೋಲೆ. (2026). ೦೫ ಶಿಕ್ಷಕರ ಸುತ್ತೋಲೆ (2026–27). ಶಾಲಾ ಶಿಕ್ಷಣ ಮತ್ತು ಸಾಕ್ಷರತಾ ಇಲಾಖೆ, ಕರ್ನಾಟಕ ಸರ್ಕಾರ.

ಸ್ಕೀಲ್ ಇಂಡಿಯಾ ಇಂಡಿಯಾ ಡಿಜಿಟಲ್ ಹಬ್. (2026). ಸೋರ್ (SOAR) – ಎಐ ಫಾರ್ ಎಜುಕೇಟರ್ಸ್.

"ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ಭವಿಷ್ಯದ ಶಿಕ್ಷಣ"

ಡಾ. ಪೂರ್ಣಿಮಾ ಬಿ
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕ, ರಾಜೀವ್ ಗಾಂಧಿ ಕಾಲೇಜ್ ಆಫ್ ಎಜುಕೇಶನ್, ಭದ್ರಾವತಿ, ಶಿವಮೊಗ್ಗ

ಸಾರಾಂಶ

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನವು ವಿಜ್ಞಾನ, ತಂತ್ರಜ್ಞಾನ, ಮಾಹಿತಿ ಮತ್ತು ಸಂವಹನ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ವೇಗವಾಗಿ ಬದಲಾಗುತ್ತಿರುವ ಕಾಲಘಟ್ಟವಾಗಿದೆ. ಈ ಬದಲಾವಣೆಗಳು ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ಸ್ವರೂಪ, ಬೋಧನಾ ವಿಧಾನ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯ ಮೇಲೂ ಮಹತ್ವದ ಪರಿಣಾಮ ಬೀರಿವೆ. ಸಾಂಪ್ರದಾಯಿಕ ಶಿಕ್ಷಣದಲ್ಲಿ ಶಿಕ್ಷಕರು ಮುಖ್ಯವಾಗಿ ಜ್ಞಾನವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ನೀಡುವವರಾಗಿದ್ದರೆ, ಆಧುನಿಕ ಶಿಕ್ಷಣದಲ್ಲಿ ಅವರ ಪಾತ್ರವು ಮಾರ್ಗದರ್ಶಕ, ಸಲಹೆಗಾರ, ಪ್ರೇರಕ, ತಂತ್ರಜ್ಞಾನ ಬಳಕೆದಾರ, ಸಂಶೋಧಕ, ಸೃಜನಶೀಲ ಚಿಂತನೆಯ ಬೆಂಬಲಿಗ ಮತ್ತು ಉತ್ತಮ ನಾಗರಿಕರನ್ನು ರೂಪಿಸುವ ವ್ಯಕ್ತಿಯಾಗಿ ವಿಸ್ತರಿಸಿದೆ. ಇಂದಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಇಂಟರ್ನೆಟ್, ಸ್ಮಾರ್ಟ್‌ಫೋನ್, ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳು ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಕ ಅಪಾರ ಪ್ರಮಾಣದ ಮಾಹಿತಿಗೆ ಸುಲಭವಾಗಿ ಪ್ರವೇಶ ಹೊಂದಿದ್ದಾರೆ. ಹೀಗಾಗಿ ಶಿಕ್ಷಕರು ಜ್ಞಾನದ ಏಕೈಕ ಮೂಲವಾಗಿರುವುದಕ್ಕಿಂತ ಮಾಹಿತಿಯನ್ನು ಹುಡುಕಲು, ಪರಿಶೀಲಿಸಲು, ವಿಶ್ಲೇಷಿಸಲು ಮತ್ತು ಜವಾಬ್ದಾರಿಯಿಂದ ಬಳಸಲು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕಾಗಿದೆ. ಈ ಲೇಖನವು ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದಲ್ಲಿ ಶಿಕ್ಷಕರ ಬದಲಾಗುತ್ತಿರುವ ಪಾತ್ರವನ್ನು ಪರಿಕಲ್ಪನಾತ್ಮಕವಾಗಿ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. ತಂತ್ರಜ್ಞಾನ ಬಳಕೆ, ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಶಿಕ್ಷಣ, ಸೃಜನಶೀಲತೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ಸಂವಹನ, ಸಹಕಾರ, ಮೌಲ್ಯ ಶಿಕ್ಷಣ, ಜೀವನ ಕೌಶಲ್ಯ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿಯ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಶಿಕ್ಷಕರ ಜವಾಬ್ದಾರಿಗಳನ್ನು ಚರ್ಚಿಸಲಾಗಿದೆ. ಜೊತೆಗೆ ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರು ಎದುರಿಸುತ್ತಿರುವ ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಜವಾಬ್ದಾರಿಗಳನ್ನೂ ಪರಿಗಣಿಸಲಾಗಿದೆ. ತಂತ್ರಜ್ಞಾನ ಮತ್ತು AI ಶಿಕ್ಷಕರನ್ನು ಬದಲಿಸುವ ಸಾಧನಗಳಲ್ಲ; ಬದಲಾಗಿ ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ವೃದ್ಧಿಸುವ ಸಹಾಯಕ ಸಾಧನಗಳಾಗಬೇಕು ಎಂಬುದು ಲೇಖನದ ಪ್ರಮುಖ ನಿಲುವಾಗಿದೆ.

ಮುಖ್ಯ ಪದಗಳು: *ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನ, ಶಿಕ್ಷಕರ ಪಾತ್ರ, ಡಿಜಿಟಲ್ ಶಿಕ್ಷಣ, ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ತಂತ್ರಜ್ಞಾನ, ಸೃಜನಶೀಲತೆ, ಜೀವನ ಕೌಶಲ್ಯ.*

ಪರಿಚಯ: ಶಿಕ್ಷಣವು ಸಮಾಜದ ಬದಲಾವಣೆಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ನಿರಂತರವಾಗಿ ರೂಪಾಂತರಗೊಳ್ಳುವ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ. ಪ್ರಾಚೀನ ಗುರುಕುಲ ಪದ್ಧತಿಯಲ್ಲಿ ಶಿಕ್ಷಕ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ನಡುವೆ ನಿಕಟ ಸಂಬಂಧವಿದ್ದು, ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಶೈಕ್ಷಣಿಕ ಜ್ಞಾನದ ಜೊತೆಗೆ ಯೋಗ, ಧ್ಯಾನ, ನೈತಿಕ ಮೌಲ್ಯಗಳು, ಕರಕುಶಲತೆ ಮತ್ತು ಜೀವನ ಕೌಶಲ್ಯಗಳನ್ನು ಕಲಿಸಲಾಗುತ್ತಿತ್ತು. ನಂತರದ ಅವಧಿಯಲ್ಲಿ ನೇರ ಉಪನ್ಯಾಸ, ಕಂಠಪಾಠ, ಪಠ್ಯಪುಸ್ತಕ, ಬೋರ್ಡ್, ಪರೀಕ್ಷೆ ಮತ್ತು ಅಂಕಗಳ ಆಧಾರಿತ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆ ಬೆಳೆಯಿತು. ಕ್ರಮೇಣ ಕಂಪ್ಯೂಟರ್, ಇಂಟರ್ನೆಟ್, ಪ್ರೊಜೆಕ್ಟರ್ ಮತ್ತು ಇ–ಪುಸ್ತಕಗಳು ಶಿಕ್ಷಣದ ಭಾಗವಾದವು. ಪ್ರಸ್ತುತ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪ್ರವೇಶವು ಶಿಕ್ಷಣದ ಮತ್ತೊಂದು ಪ್ರಮುಖ ಪರಿವರ್ತನೆಯ ಹಂತವಾಗಿದೆ.

ಇಂದಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಹಿಂದಿನ ಪೀಳಿಗೆಯ ವಿದ್ಯಾರ್ಥಿಗಳಿಗಿಂತ ಹೆಚ್ಚಿನ ಪ್ರಮಾಣದ ಮಾಹಿತಿಗೆ ಪ್ರವೇಶ ಹೊಂದಿದ್ದಾರೆ. ಆದ್ದರಿಂದ ಶಿಕ್ಷಕರ ಪಾತ್ರವೂ ಬದಲಾಗುವುದು ಅನಿವಾರ್ಯವಾಗಿದೆ. ಶಿಕ್ಷಕರು ಕೇವಲ ಪಠ್ಯಪುಸ್ತಕದ ವಿಷಯವನ್ನು ವಿವರಿಸುವವರಾಗಿರದೆ, ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಜ್ಞಾನವನ್ನು ಅನ್ವಯಿಸುವ, ಪ್ರಶ್ನಿಸುವ, ವಿಶ್ಲೇಷಿಸುವ ಮತ್ತು ಹೊಸ ಜ್ಞಾನವನ್ನು ಸೃಷ್ಟಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಬೇಕು.

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದ ಶಿಕ್ಷಣದ ಸ್ವರೂಪ:

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದ ಶಿಕ್ಷಣವು ಕೇವಲ ಪರೀಕ್ಷೆಯಲ್ಲಿ ಹೆಚ್ಚಿನ ಅಂಕಗಳನ್ನು ಗಳಿಸುವುದಕ್ಕೆ ಸೀಮಿತವಾಗಿಲ್ಲ. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಜ್ಞಾನವನ್ನು ನೈಜ ಜೀವನದ ಸಮಸ್ಯೆಗಳಿಗೆ ಅನ್ವಯಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಿಕೊಳ್ಳುವುದು ಮುಖ್ಯವಾಗಿದೆ. ಸೃಜನಶೀಲತೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ಸಮಸ್ಯೆ ಪರಿಹಾರ, ಸಂವಹನ, ಸಹಕಾರ, ತಂತ್ರಜ್ಞಾನ ಜ್ಞಾನ, ಸ್ವಯಂ ಕಲಿಕೆ ಮತ್ತು ಸಾಮಾಜಿಕ–ನೈತಿಕ ಮೌಲ್ಯಗಳು ಆಧುನಿಕ ಶಿಕ್ಷಣದ ಪ್ರಮುಖ ಅಂಶಗಳಾಗಿವೆ. ಇಂತಹ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಿದ್ಧ ಉತ್ತರಗಳನ್ನು ನೀಡುವುದಕ್ಕಿಂತ ಸಮಸ್ಯೆಗಳನ್ನು ಪರಿಹರಿಸಲು ಮತ್ತು ಸ್ವತಃ ಉತ್ತರಗಳನ್ನು ಕಂಡುಕೊಳ್ಳಲು ಅವಕಾಶ ನೀಡಬೇಕು. ಶಿಕ್ಷಕ–ಕೇಂದ್ರಿತ ಶಿಕ್ಷಣದಿಂದ ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಶಿಕ್ಷಣದತ್ತ ಸಾಗುವಿಕೆ ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಬದಲಾವಣೆಯಾಗಿದೆ. UNESCO (2021) ಭವಿಷ್ಯದ ಶಿಕ್ಷಣದಲ್ಲಿ ಮಾನವೀಯ ಸಂಬಂಧ, ಸಹಕಾರ ಮತ್ತು ಸಾಮಾಜಿಕ ಜವಾಬ್ದಾರಿಯನ್ನು ತಂತ್ರಜ್ಞಾನ ಪ್ರಗತಿಯೊಂದಿಗೆ ಸಮನ್ವಯಗೊಳಿಸುವ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ.

ಶಿಕ್ಷಕರು ಜ್ಞಾನ ಬೋಧಕರಿಂದ ಮಾರ್ಗದರ್ಶಕರಾಗುವುದು:

ಸಾಂಪ್ರದಾಯಿಕ ತರಗತಿಯಲ್ಲಿ ಶಿಕ್ಷಕರು ಮಾತನಾಡಿ, ವಿದ್ಯಾರ್ಥಿಗಳು ಕೇಳಿ, ಟಿಪ್ಪಣಿ ಬರೆದು ಮತ್ತು ಪರೀಕ್ಷೆಯಲ್ಲಿ ಉತ್ತರಿಸುವ ವಿಧಾನ ಸಾಮಾನ್ಯವಾಗಿತ್ತು. ಆದರೆ ಇಂದಿನ ಶಿಕ್ಷಣದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳು ಕಲಿಕೆಯ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಸಕ್ರಿಯವಾಗಿ ಭಾಗವಹಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ.

ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ:

- ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳಲು ಪ್ರೋತ್ಸಾಹಿಸಬೇಕು;
- ಸ್ವತಂತ್ರವಾಗಿ ಯೋಚಿಸಲು ಅವಕಾಶ ನೀಡಬೇಕು;
- ಸಮಸ್ಯೆಗಳನ್ನು ಪರಿಹರಿಸಲು ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು;
- ವಿದ್ಯಾರ್ಥಿಗಳ ಆಸಕ್ತಿ ಮತ್ತು ಸಾಮರ್ಥ್ಯವನ್ನು ಗುರುತಿಸಬೇಕು;
- ಸ್ವಯಂ ಕಲಿಕೆಯ ಅಭ್ಯಾಸ ಬೆಳೆಸಬೇಕು.

ಹೀಗಾಗಿ ಶಿಕ್ಷಕರು ಕೇವಲ **"ಪಾಠ ಬೋಧಿಸುವವರು"** ಆಗಿರದೆ **"ಕಲಿಕೆಯ ಮಾರ್ಗದರ್ಶಕರು"** ಆಗಬೇಕು. ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯ ವೇಗ ಮತ್ತು ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಬದಲಾಯಿಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರಬೇಕು.

ತಂತ್ರಜ್ಞಾನ ಬಳಕೆಯಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ:

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದ ಪ್ರಮುಖ ಲಕ್ಷಣವೆಂದರೆ ತಂತ್ರಜ್ಞಾನದ ವೇಗವಾದ ಬೆಳವಣಿಗೆ.

ಕಂಪ್ಯೂಟರ್, ಇಂಟರ್ನೆಟ್, ಸ್ಮಾರ್ಟ್ ಬೋರ್ಡ್, ಶೈಕ್ಷಣಿಕ ಅಪ್ಲಿಕೇಶನ್‌ಗಳು, ಆನ್‌ಲೈನ್ ತರಗತಿಗಳು ಮತ್ತು ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳು ಶಿಕ್ಷಣದ ಅವಿಭಾಜ್ಯ ಭಾಗಗಳಾಗಿವೆ. ಶಿಕ್ಷಕರು ತಂತ್ರಜ್ಞಾನವನ್ನು ಬಳಸಿಕೊಂಡು ವೀಡಿಯೊ, ಡಿಜಿಟಲ್ ಪ್ರಸ್ತುತಿ, ಆನ್‌ಲೈನ್ ಪರೀಕ್ಷೆ, ಇ–ಪುಸ್ತಕ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಚಟುವಟಿಕೆಗಳ ಮೂಲಕ ಬೋಧನೆಯನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿಸಬಹುದು. ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನವು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ತರಗತಿಯ ಹೊರತಾಗಿಯೂ ಕಲಿಯುವ ಅವಕಾಶವನ್ನು ಒದಗಿಸುತ್ತದೆ. ಆದರೆ ತಂತ್ರಜ್ಞಾನವೇ ಶಿಕ್ಷಣದ ಉದ್ದೇಶವಾಗಬಾರದು. ಅದು ಶಿಕ್ಷಣದ ಗುರಿಗಳನ್ನು ಸಾಧಿಸಲು ಬಳಸುವ ಸಾಧನವಾಗಬೇಕು. AI ಮತ್ತು ಇತರ ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನಗಳ ಬಳಕೆಯಲ್ಲಿ ಶಿಕ್ಷಕರು ಶಿಕ್ಷಣಶಾಸ್ತ್ರೀಯ ಉದ್ದೇಶ, ವಿದ್ಯಾರ್ಥಿಗಳ ಅಗತ್ಯ ಮತ್ತು ನೈತಿಕತೆಯನ್ನು ಗಮನಿಸಬೇಕು. ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ ಂಖ ಬಳಕೆಯ ಕುರಿತು ನಡೆದ ಸಂಶೋಧನೆಗಳು ತಂತ್ರಜ್ಞಾನವು ಕಲಿಕೆ ಮತ್ತು ಬೋಧನೆಯ ಹಲವು ಆಯಾಮಗಳಿಗೆ ಸಹಕಾರಿಯಾಗಬಹುದು ಎಂದು ಸೂಚಿಸುತ್ತವೆ (Bond et al., 2024).

ಸೃಜನಶೀಲತೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಯ ಅಭಿವೃದ್ಧಿ:

ಇಂದಿನ ಜ್ಞಾನಾಧಾರಿತ ಸಮಾಜದಲ್ಲಿ ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ರೂಪಿಸುವ ಸಾಮರ್ಥ್ಯ ಅತ್ಯಂತ ಮುಖ್ಯವಾಗಿದೆ. ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ವ್ಯಕ್ತಪಡಿಸಲು, ಪ್ರಯೋಗ ಮಾಡಲು ಮತ್ತು ತಪ್ಪುಗಳಿಂದ ಕಲಿಯಲು ಅವಕಾಶ ನೀಡಬೇಕು. **"ಏಕೆ?", "ಹೇಗೆ?", "ಇನ್ನೊಂದು** ರೀತಿಯಲ್ಲಿ ಸಾಧ್ಯವೇ?" ಮುಂತಾದ ಪ್ರಶ್ನೆಗಳ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳ ಚಿಂತನೆಯನ್ನು ವಿಸ್ತರಿಸಬಹುದು. ಚಿತ್ರಕಲೆ, ಬರವಣಿಗೆ, ಮಾದರಿ ತಯಾರಿಕೆ, ಯೋಜನಾ ಕಾರ್ಯ ಮತ್ತು ಪ್ರಯೋಗಗಳಂತಹ ಚಟುವಟಿಕೆಗಳು ಸೃಜನಶೀಲತೆಯನ್ನು ಉತ್ತೇಜಿಸುತ್ತವೆ. ಇಂಟರ್ನೆಟ್ ಮತ್ತು ಂಖ ಮೂಲಕ ಅಪಾರ ಪ್ರಮಾಣದ ಮಾಹಿತಿ ಲಭ್ಯವಿರುವುದರಿಂದ ಮಾಹಿತಿಯ ನಿಖರತೆಯನ್ನು ಪರಿಶೀಲಿಸುವ ಸಾಮರ್ಥ್ಯವೂ ಅಗತ್ಯವಾಗಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಮಾಹಿತಿಯನ್ನು ಸ್ವೀಕರಿಸುವ ಮೊದಲು ಅದರ ಮೂಲ, ನಿಖರತೆ ಮತ್ತು ಪ್ರಸ್ತುತತೆಯನ್ನು ಪರಿಶೀಲಿಸಲು ಶಿಕ್ಷಕರು ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು. Generative AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ಮಾಹಿತಿಯ ಪರಿಶೀಲನೆ ವಿಶೇಷವಾಗಿ ಮುಖ್ಯವಾಗಿದೆ (Miao & Holmes, 2023).

ಸಂವಹನ ಮತ್ತು ಸಹಕಾರದ ಕೌಶಲ್ಯ:

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದಲ್ಲಿ ಉತ್ತಮ ಸಂವಹನ ಮತ್ತು ತಂಡದೊಂದಿಗೆ ಕೆಲಸ ಮಾಡುವ ಸಾಮರ್ಥ್ಯ ಅತ್ಯಂತ ಅಗತ್ಯವಾಗಿದೆ. ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಭಾಷಣ, ಸೆಮಿನಾರ್, ಚರ್ಚೆ, ಗುಂಪು ಕಾರ್ಯ ಮತ್ತು ಪ್ರಸ್ತುತಿಗಳಂತಹ ಚಟುವಟಿಕೆಗಳನ್ನು ಒದಗಿಸಬೇಕು. ಇಂತಹ ಚಟುವಟಿಕೆಗಳ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ:

- ಆತ್ಮವಿಶ್ವಾಸ;
- ನಾಯಕತ್ವ;
- ಸಹಕಾರ;

- ಜವಾಬ್ದಾರಿ;
- ಪರಸ್ಪರ ಗೌರವ;
- ಹೊಂದಾಣಿಕೆ

ಮುಂತಾದ ಗುಣಗಳು ಬೆಳೆಯುತ್ತವೆ.

ವಿದ್ಯಾರ್ಥಿಗಳ ಅಭಿಪ್ರಾಯಗಳನ್ನು ಗೌರವದಿಂದ ಕೇಳುವುದು ಮತ್ತು ಭಿನ್ನಾಭಿಪ್ರಾಯಗಳನ್ನು ಆರೋಗ್ಯಕರ ರೀತಿಯಲ್ಲಿ ಚರ್ಚಿಸಲು ಅವಕಾಶ ನೀಡುವುದು ಶಿಕ್ಷಕರ ಪ್ರಮುಖ ಜವಾಬ್ದಾರಿಯಾಗಿದೆ.

ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಶಿಕ್ಷಣ ಮತ್ತು ವೈಯಕ್ತಿಕ ಅಗತ್ಯಗಳು:

ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕೆಯ ವೇಗ, ಆಸಕ್ತಿ, ಗ್ರಹಣ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಸಾಮರ್ಥ್ಯ ವಿಭಿನ್ನವಾಗಿರುತ್ತದೆ. ಆದ್ದರಿಂದ ಎಲ್ಲಾ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಒಂದೇ ರೀತಿಯ ಬೋಧನಾ ವಿಧಾನವನ್ನು ಅನುಸರಿಸುವುದಕ್ಕಿಂತ ಅವರ ವೈಯಕ್ತಿಕ ಅಗತ್ಯಗಳನ್ನು ಗುರುತಿಸುವುದು ಮುಖ್ಯವಾಗಿದೆ. ನಿಧಾನವಾಗಿ ಕಲಿಯುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೆಚ್ಚುವರಿ ವಿವರಣೆ ಮತ್ತು ಅಭ್ಯಾಸ ನೀಡಬೇಕು. ಪ್ರತಿಭಾವಂತ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಹೆಚ್ಚಿನ ಸವಾಲಿನ ಚಟುವಟಿಕೆಗಳನ್ನು ನೀಡಬೇಕು. ಪ್ರತಿಯೊಬ್ಬ ವಿದ್ಯಾರ್ಥಿಗೂ ತರಗತಿ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಭಾಗವಹಿಸಲು ಅವಕಾಶ ನೀಡಬೇಕು. ಂಖ ಆಧಾರಿತ ಕಲಿಕಾ ವ್ಯವಸ್ಥೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವಿಷಯ ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ಒದಗಿಸುವ ಸಾಧ್ಯತೆಯನ್ನು ಹೊಂದಿವೆ (Bond et al., 2024). ಆದಾಗ್ಯೂ, ವಿದ್ಯಾರ್ಥಿಯ ಭಾವನಾತ್ಮಕ, ಸಾಮಾಜಿಕ ಮತ್ತು ನೈತಿಕ ಅಗತ್ಯಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವಲ್ಲಿ ಶಿಕ್ಷಕರ ಮಾನವೀಯ ಪಾತ್ರವನ್ನು ಯಾವುದೇ ತಂತ್ರಜ್ಞಾನ ಸಂಪೂರ್ಣವಾಗಿ ಬದಲಾಯಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ.

1. ಮೌಲ್ಯ ಶಿಕ್ಷಣ, ಜೀವನ ಕೌಶಲ್ಯ ಮತ್ತು ಉತ್ತಮ ನಾಗರಿಕರ ನಿರ್ಮಾಣ:

ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಜ್ಞಾನ ಎಷ್ಟೇ ಅಭಿವೃದ್ಧಿಯಾದರೂ ಮಾನವೀಯ ಮೌಲ್ಯಗಳಿಲ್ಲದ ಶಿಕ್ಷಣ ಅಪೂರ್ಣವಾಗಿದೆ. ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಪ್ರಾಮಾಣಿಕತೆ, ಶಿಸ್ತು, ಸಹಾನುಭೂತಿ, ಸಹಿಷ್ಣುತೆ, ಜವಾಬ್ದಾರಿ, ದೇಶಪ್ರೇಮ, ಪರಿಸರ ಪ್ರಜ್ಞೆ ಮತ್ತು ಇತರರನ್ನು ಗೌರವಿಸುವ ಮನೋಭಾವವನ್ನು ಬೆಳೆಸಬೇಕು. ಅದೇ ರೀತಿ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸಮಯ ನಿರ್ವಹಣೆ, ಸಮಸ್ಯೆ ಪರಿಹಾರ, ನಿರ್ಧಾರ ತೆಗೆದುಕೊಳ್ಳುವಿಕೆ, ಆತ್ಮವಿಶ್ವಾಸ, ತಂಡದಲ್ಲಿ ಕೆಲಸ ಮಾಡುವುದು ಮತ್ತು ಭಾವನೆಗಳನ್ನು ನಿಯಂತ್ರಿಸುವಂತಹ ಜೀವನ ಕೌಶಲ್ಯಗಳನ್ನು ಕಲಿಸಬೇಕು. ಶಿಕ್ಷಣದ ಉದ್ದೇಶ ಕೇವಲ ಉದ್ಯೋಗ ಪಡೆಯಲು ಅಗತ್ಯವಾದ ಜ್ಞಾನ ನೀಡುವುದಲ್ಲ. ಉತ್ತಮ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ನಾಗರಿಕರನ್ನು ರೂಪಿಸುವುದೂ ಶಿಕ್ಷಣದ ಪ್ರಮುಖ ಉದ್ದೇಶವಾಗಿದೆ. ಶಿಕ್ಷಕರು ಸಂವಿಧಾನದ ಮೌಲ್ಯಗಳು, ಹಕ್ಕುಗಳು ಮತ್ತು ಕರ್ತವ್ಯಗಳು, ಪ್ರಜಾಪ್ರಭುತ್ವ ಮತ್ತು ಸಾಮಾಜಿಕ ಜವಾಬ್ದಾರಿಯ ಬಗ್ಗೆ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಅರಿವು ಮೂಡಿಸಬೇಕು.

2. AI ಯುಗದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ ಮತ್ತು ಸವಾಲುಗಳು:

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಸೃಷ್ಟಿಸಿದೆ. ಂಖ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ

ಮಾಹಿತಿ, ವಿವರಣೆ, ಅಭ್ಯಾಸ, ಭಾಷಾ ಸಹಾಯ ಮತ್ತು ವೈಯಕ್ತಿಕ ಕಲಿಕೆಗೆ ನೆರವಾಗಬಹುದು. ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ ಸಂಶೋಧನೆ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಪಠ್ಯಕ್ರಮ ವಿನ್ಯಾಸ, ಮೌಲ್ಯಮಾಪನ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿ ಸೇವೆಗಳಲ್ಲಿಯೂ ಂಖ ಬಳಕೆಯ ಸಾಧ್ಯತೆಗಳಿವೆ (Crompton & Burke, 2023). ಆದರೆ ಂಖ ಬಳಕೆಯಿಂದ ಕೆಲವು ಸವಾಲುಗಳೂ ಎದುರಾಗುತ್ತವೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ಂಖಯನ್ನು ಅತಿಯಾಗಿ ಅವಲಂಬಿಸಿದರೆ ಸ್ವತಂತ್ರ ಚಿಂತನೆ ಮತ್ತು ಸೃಜನಶೀಲತೆ ಕುಂಠಿತವಾಗಬಹುದು. ಂಖಯಿಂದ ಸಿದ್ಧಪಡಿಸಿದ ವಿಷಯವನ್ನು ಸ್ವಂತ ಕೆಲಸವೆಂದು ಸಲ್ಲಿಸುವುದು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಸವಾಲಾಗಬಹುದು. ಂಖ ನೀಡುವ ಮಾಹಿತಿಯ ನಿಖರತೆ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ ಮತ್ತು ನೈತಿಕ ಬಳಕೆಯ ಪ್ರಶ್ನೆಗಳನ್ನೂ ಪರಿಗಣಿಸಬೇಕು. ಆದ್ದರಿಂದ ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಂಖಯನ್ನು ಜವಾಬ್ದಾರಿಯಿಂದ ಬಳಸಲು, ಮಾಹಿತಿಯನ್ನು ಪರಿಶೀಲಿಸಲು, ಸ್ವಂತ ಚಿಂತನೆಗೆ ಆದ್ಯತೆ ನೀಡಲು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಯನ್ನು ಕಾಪಾಡಲು ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು. UNESCO ಯ ಮಾರ್ಗದರ್ಶನವು ಶಿಕ್ಷಣದಲ್ಲಿ Generative AI ಬಳಕೆಯನ್ನು ಮಾನವ–ಕೇಂದ್ರಿತ, ಸುರಕ್ಷಿತ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ರೀತಿಯಲ್ಲಿ ನಿರ್ವಹಿಸುವ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ (Miao & Holmes, 2023).

3. ನಿರಂತರ ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ, ಶಿಕ್ಷಕ–ವಿದ್ಯಾರ್ಥಿ ಸಂಬಂಧ ಮತ್ತು ಸಮಾಪನ:

ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದಲ್ಲಿ ಜ್ಞಾನ ಮತ್ತು ತಂತ್ರಜ್ಞಾನ ನಿರಂತರವಾಗಿ ಬದಲಾಗುತ್ತಿರುವುದರಿಂದ ಶಿಕ್ಷಕರು ನಿರಂತರವಾಗಿ ಕಲಿಯುವ ಮನೋಭಾವವನ್ನು ಹೊಂದಿರಬೇಕು. ಹೊಸ ಬೋಧನಾ ವಿಧಾನಗಳು, ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನ, AI, ಸಂಶೋಧನಾ ವಿಧಾನಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಬೆಳವಣಿಗೆಗಳ ಕುರಿತು ಶಿಕ್ಷಕರು ತಮ್ಮ ಜ್ಞಾನವನ್ನು ನವೀಕರಿಸಿಕೊಳ್ಳಬೇಕು. ಶಿಕ್ಷಕರು ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮಗಳು, ಕಾರ್ಯಾಗಾರಗಳು, ಸಂಶೋಧನಾ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ವೃತ್ತಿಪರ ಕಲಿಕಾ ಸಮುದಾಯಗಳಲ್ಲಿ ಭಾಗವಹಿಸಬೇಕು. "ಉತ್ತಮ ಶಿಕ್ಷಕನು ಜೀವನಪೂರ್ತಿ ಕಲಿಯುವ ವ್ಯಕ್ತಿ" ಎಂಬ ತತ್ವವು ಇಂದಿನ ಸಂದರ್ಭದಲ್ಲಿ ಹೆಚ್ಚು ಪ್ರಸ್ತುತವಾಗಿದೆ. ಅದೇ ಸಮಯದಲ್ಲಿ ಶಿಕ್ಷಕ–ವಿದ್ಯಾರ್ಥಿ ಸಂಬಂಧದ ಮಾನವೀಯ ಆಯಾಮವನ್ನು ಉಳಿಸಿಕೊಳ್ಳುವುದು ಅಗತ್ಯವಾಗಿದೆ. ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಪ್ರಶ್ನೆಗಳನ್ನು ಮುಕ್ತವಾಗಿ ಕೇಳಲು ಮತ್ತು ಸಮಸ್ಯೆಗಳನ್ನು ಹಂಚಿಕೊಳ್ಳಲು ಸುರಕ್ಷಿತ ಹಾಗೂ ಸ್ನೇಹಪೂರ್ಣ ವಾತಾವರಣವನ್ನು ಶಿಕ್ಷಕರು ನಿರ್ಮಿಸಬೇಕು.

4. ಉಪಸಂಹಾರ:

ಒಟ್ಟಿನಲ್ಲಿ, ಇಪ್ಪತ್ತೊಂದನೇ ಶತಮಾನದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರವು ಅತ್ಯಂತ ವಿಶಾಲ ಮತ್ತು ಬಹುಮುಖಿವಾಗಿದೆ. ಶಿಕ್ಷಕರು ಕೇವಲ ಪಠ್ಯಪುಸ್ತಕದ ವಿಷಯವನ್ನು ಬೋಧಿಸುವವರಲ್ಲ; ಅವರು ಮಾರ್ಗದರ್ಶಕರು, ಪ್ರೇರಕರು, ಸಲಹೆಗಾರರು, ತಂತ್ರಜ್ಞಾನ ಬಳಕೆದಾರರು, ಸಂಶೋಧಕರು, ಮೌಲ್ಯಗಳ ಬೋಧಕರು ಮತ್ತು ಭವಿಷ್ಯದ ಸಮಾಜದ ನಿರ್ಮಾತೃಗಳು. ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಣವನ್ನು ಪರಿವರ್ತಿಸುತ್ತಿದ್ದರೂ, ಶಿಕ್ಷಕರ ಮಾನವೀಯ ಸ್ಪರ್ಶ, ನೈತಿಕ ಮಾರ್ಗದರ್ಶನ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಮಗ್ರ ವ್ಯಕ್ತಿತ್ವ ವಿಕಾಸಕ್ಕೆ ಅವು ಸಂಪೂರ್ಣ ಪರ್ಯಾಯವಾಗುವುದಿಲ್ಲ. ಆದ್ದರಿಂದ ಂಖ

ಮತ್ತು ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನವನ್ನು ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಾಗಿ ನೋಡುವ ಬದಲು ಶಿಕ್ಷಕರು ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೆಚ್ಚಿಸುವ ಸಾಧನಗಳಾಗಿ ಬಳಸಬೇಕು. ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರು ಜ್ಞಾನ, ತಂತ್ರಜ್ಞಾನ, ಸೃಜನಶೀಲತೆ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ಮೌಲ್ಯಗಳು ಮತ್ತು ಮಾನವೀಯತೆಯ ಸಮನ್ವಯದೊಂದಿಗೆ ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಭವಿಷ್ಯದ ಸವಾಲುಗಳಿಗೆ ಸಿದ್ಧಗೊಳಿಸಬೇಕು. ಹೀಗೆ ರೂಪುಗೊಳ್ಳುವ ಶಿಕ್ಷಕರು ಕೇವಲ ಉತ್ತಮ ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಮಾತ್ರವಲ್ಲದೆ, ಜವಾಬ್ದಾರಿಯುತ, ಸೃಜನಶೀಲ, ನೈತಿಕ ಮತ್ತು ಉತ್ತಮ ನಾಗರಿಕರನ್ನು ರೂಪಿಸುವಲ್ಲಿ ಪ್ರಮುಖ ಪಾತ್ರ ವಹಿಸುತ್ತಾರೆ.

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ರಿಷಿಕೇಶ್, ಬಿ. ಎಸ್. (2018). ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ನಿರ್ವಹಣೆ: ನೀತಿ, ಅನುಷ್ಠಾನ ಮತ್ತು ಪರ್ಯಾಯಗಳು. ಅಜೀಂ ಪ್ರೇಮ್‌ಜಿ ವಿಶ್ವವಿದ್ಯಾಲಯ.

ಕರ್ಣಿ, ಮುರಳೀಧರ; ಮೊಹಮ್ಮದ್, ಮುಜೀಬ್ ಶೈಕ್; ಮತ್ತು ಶ್ರೀನಿವಾಸ, ಕೆ. ಜಿ. (2023). ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಬೋಧನೆ ಮತ್ತು ಕಲಿಕೆಯಲ್ಲಿ ಪರಿಚಯಿಸಲು ಆರಂಭಿಕ ಮಾರ್ಗದರ್ಶಿ. Springer. ಈ ಕೃತಿಯು AI ಆಧಾರಿತ ಕಲಿಕೆ, ಶಿಕ್ಷಕರ ಪಾತ್ರ ಮತ್ತು ಬೋಧನಾ–ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯ ಮೇಲೆ AIಯ ಪ್ರಭಾವವನ್ನು ಒಳಗೊಂಡಿದೆ.

ಶರತ್‌ಬಾಬು, ವೇಮುಲಾ, & ಸುರೇಶ್, ಅನಗಂಟಿ. (2026). ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ–ಸಿದ್ಧ ಶಿಕ್ಷಕರು: ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣ ಮತ್ತು ವೃತ್ತಿಪರ ಅಭಿವೃದ್ಧಿ. Artificial Intelligence and the Changing Landscape of Indian Education. ಈ ಅಧ್ಯಾಯವು AI ಯುಗದ ಶಿಕ್ಷಕರಿಗೆ ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ಬೋಧನಾ ನಾವೀನ್ಯತೆ ಮತ್ತು ನೈತಿಕ ಅರಿವು ಅಗತ್ಯವೆಂದು ವಿವರಿಸುತ್ತದೆ.

ಕರ್ನಾಟಕ ಶಾಲಾ ಶಿಕ್ಷಣ ಇಲಾಖೆ. (2026). ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಶಿಕ್ಷಣ ಮತ್ತು ಕೌಶಲ್ಯಾಧಾರಿತ ಶಿಕ್ಷಣದ ಅನುಷ್ಠಾನ. 2026–27ನೇ ಸಾಲಿನಲ್ಲಿ AI ಆಧಾರಿತ ಕಲಿಕೆಯನ್ನು ವಿಸ್ತರಿಸುವ ಕುರಿತು ರಾಜ್ಯದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿನ ಬೆಳವಣಿಗೆಗಳನ್ನು ಇದು ಪ್ರತಿಬಿಂಬಿಸುತ್ತದೆ.

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆ: ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು ಮತ್ತು ನೈತಿಕ ಆಯಾಮಗಳು

ಡಾ. ರಂಗಸ್ವಾಮಿ. ಐ.ಜೆ.,
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು, ಕುವೆಂಪು ಶತಮಾನೋತ್ಸವ ಶಿಕ್ಷಣ ಮಹಾವಿದ್ಯಾಲಯ, ಶಿವಮೊಗ್ಗ.

ಸಾರಾಂಶ

ಇಂದಿನ ಜ್ಞಾನಾಧಾರಿತ ಸಮಾಜದಲ್ಲಿ ಉನ್ನತ ಶಿಕ್ಷಣದ ಗುಣಮಟ್ಟವನ್ನು ನಿರ್ಧರಿಸುವ ಪ್ರಮುಖ ಅಂಶಗಳಲ್ಲಿ ಸಂಶೋಧನೆ ಪ್ರಮುಖ ಸ್ಥಾನವನ್ನು ಹೊಂದಿದೆ. ವಿಶೇಷವಾಗಿ ಡಾಕ್ಟರೇಟ್ ಹಂತದ ಸಂಶೋಧನೆಯು ಹೊಸ ಜ್ಞಾನವನ್ನು ಸೃಷ್ಟಿಸುವುದು, ಅಸ್ತಿತ್ವದಲ್ಲಿರುವ ಜ್ಞಾನವನ್ನು ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಪರಿಶೀಲಿಸುವುದು ಮತ್ತು ಸಾಮಾಜಿಕ, ಶೈಕ್ಷಣಿಕ ಹಾಗೂ ತಾಂತ್ರಿಕ ಸಮಸ್ಯೆಗಳಿಗೆ ಪರಿಹಾರಗಳನ್ನು ಕಂಡುಕೊಳ್ಳುವುದನ್ನು ಒಳಗೊಂಡಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence–AI) ಮತ್ತು ಜನರೇಟಿವ್ AI ತಂತ್ರಜ್ಞಾನಗಳ ಬೆಳವಣಿಗೆಯಿಂದ ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆಯ ಹಲವು ಹಂತಗಳಲ್ಲಿ ಹೊಸ ಸಾಧ್ಯತೆಗಳು ಉದ್ಭವಿಸಿವೆ (Zawacki-Richter et al., 2019; Dwivedi et al., 2023).

ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಗುರುತಿಸುವಿಕೆ, ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆ, ಸಂಶೋಧನಾ ವಿಧಾನ ಆಯ್ಕೆ, ದತ್ತಾಂಶ ಸಂಘಟನೆ ಮತ್ತು ವಿಶ್ಲೇಷಣೆ, ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆ ಹಾಗೂ ಸಂಶೋಧನಾ ಪ್ರಗತಿ ಮೇಲ್ವಿಚಾರಣೆ ಮುಂತಾದ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ AI ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸಬಹುದು (Kasneci et al., 2023; Miao & Holmes, 2023). ಆದರೆ AI ಅನ್ನು ಸಂಶೋಧಕರ ಪರ್ಯಾಯವಾಗಿ ಪರಿಗಣಿಸುವುದು ಸೂಕ್ತವಲ್ಲ. ಸಂಶೋಧನೆಯ ಅಂತಿಮ ನಿರ್ಧಾರ, ವಿಮರ್ಶಾತ್ಮಕ ವಿಶ್ಲೇಷಣೆ, ಮೂಲತತ್ವ, ನೈತಿಕ ಜವಾಬ್ದಾರಿ ಮತ್ತು ವೈಜ್ಞಾನಿಕ ಹೊಣೆಗಾರಿಕೆ ಸಂಶೋಧಕರದ್ದೇ ಆಗಿರಬೇಕು (UNESCO, 2021; Miao & Holmes, 2023).

ಈ ಲೇಖನವು ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ AI ಬಳಕೆಯ ಅವಕಾಶಗಳು, ಸವಾಲುಗಳು, ಸಂಶೋಧನಾ ನೈತಿಕತೆ ಮತ್ತು ಮಾನವ–ಕೇಂದ್ರಿತ ಬಳಕೆಯ ಅಗತ್ಯವನ್ನು ಚರ್ಚಿಸುತ್ತದೆ.

ಪ್ರಮುಖ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಜನರೇಟಿವ್ AI, ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆ, ಸಂಶೋಧನಾ ನೈತಿಕತೆ, ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆ.*

1. ಪರಿಚಯ: ಉನ್ನತ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ಜ್ಞಾನವನ್ನು ಪ್ರಸಾರ ಮಾಡುವ ಕೇಂದ್ರಗಳಷ್ಟೇ ಅಲ್ಲದೆ, ಹೊಸ ಜ್ಞಾನವನ್ನು ಸೃಷ್ಟಿಸುವ ಪ್ರಮುಖ ಸಂಶೋಧನಾ ಕೇಂದ್ರಗಳಾಗಿವೆ. ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯು ಶೈಕ್ಷಣಿಕ, ಸಾಮಾಜಿಕ, ಆರ್ಥಿಕ ಮತ್ತು ತಾಂತ್ರಿಕ ಅಭಿವೃದ್ಧಿಗೆ ಮಹತ್ವದ ಕೊಡುಗೆ ನೀಡುತ್ತದೆ. ಸಂಶೋಧನಾ ಗುಣಮಟ್ಟವು ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಸ್ಪಷ್ಟತೆ, ಸೂಕ್ತ ಸಂಶೋಧನಾ ವಿಧಾನ, ದತ್ತಾಂಶದ ಗುಣಮಟ್ಟ, ವಿಶ್ಲೇಷಣಾ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಸಂಶೋಧನಾ ನೈತಿಕತೆಯ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿರುತ್ತದೆ (Löfström & Pyhältö, 2012).

ಭಾರತದಲ್ಲಿ ಡಾಕ್ಟರೇಟ್ ಪದವಿ ಪ್ರಧಾನದ ಕನಿಷ್ಠ ಮಾನದಂಡಗಳು ಮತ್ತು ಪ್ರಕ್ರಿಯೆಗಳನ್ನು UGC Ph.D. Regulations, 2022 ನಿಯಂತ್ರಿಸುತ್ತದೆ. ಈ ನಿಯಮಗಳು ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆ,

ಸಂಶೋಧನಾ ಪ್ರಾಮಾಣಿಕತೆ ಮತ್ತು ಪ್ರಬಂಧದ ಮೂಲತತ್ವಕ್ಕೆ ಮಹತ್ವ ನೀಡುತ್ತವೆ (University Grants Commission, 2022).

ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆಗೆ ಹೊಸ ಆಯಾಮವನ್ನು ನೀಡುತ್ತಿದೆ. AI ಉಪಕರಣಗಳು ದೊಡ್ಡ ಪ್ರಮಾಣದ ಮಾಹಿತಿಯನ್ನು ಸಂಘಟಿಸಲು, ಪಠ್ಯವನ್ನು ವಿಶ್ಲೇಷಿಸಲು, ಕಲ್ಪನೆಗಳನ್ನು ರೂಪಿಸಲು ಮತ್ತು ಬರವಣಿಗೆಯನ್ನು ಸುಧಾರಿಸಲು ಸಹಾಯ ಮಾಡಬಹುದು (Zawacki-Richter et al., 2019; Kasneci et al., 2023). ಆದಾಗ್ಯೂ, AI ಬಳಕೆಯೊಂದಿಗೆ ನಿಖರತೆ, ಗೌಪ್ಯತೆ, ಮೂಲತತ್ವ, ಪಾರದರ್ಶಕತೆ, ಪ್ಲೇಜರಿಸಂ ಮತ್ತು ಹೊಣೆಗಾರಿಕೆಯಂತಹ ಪ್ರಶ್ನೆಗಳೂ ಉದ್ಭವಿಸುತ್ತವೆ (UNESCO, 2021; Miao & Holmes, 2023).

ಆದ್ದರಿಂದ ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಂಖಯನ್ನು **"ಪರ್ಯಾಯ ಸಂಶೋಧಕ"**ನಾಗಿ ಅಲ್ಲದೆ **"ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನ"**ವಾಗಿ ಬಳಸುವುದು ಹೆಚ್ಚು ಸೂಕ್ತವಾಗಿದೆ.

2. ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಅಗತ್ಯತೆ

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯು ದೀರ್ಘಕಾಲೀನ ಮತ್ತು ಬಹುಹಂತದ ಪ್ರಕ್ರಿಯೆಯಾಗಿದೆ. ಸಂಶೋಧಕರು ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯನ್ನು ಗುರುತಿಸುವುದರಿಂದ ಪ್ರಬಂಧ ಸಲ್ಲಿಸುವವರೆಗೆ ವಿವಿಧ ಹಂತಗಳಲ್ಲಿ ಮಾಹಿತಿ ಸಂಗ್ರಹಣೆ, ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ನಿರ್ಧಾರಗಳನ್ನು ಕೈಗೊಳ್ಳಬೇಕಾಗುತ್ತದೆ. ಈ ಪ್ರಕ್ರಿಯೆಯಲ್ಲಿ ಂಖ ಹಲವು ರೀತಿಯಲ್ಲಿ ಸಹಾಯಕವಾಗಬಹುದು (Dwivedi et al., 2023; Kasneci et al., 2023).

AI ಅನ್ನು ಈ ಕೆಳಗಿನ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಬಳಸಬಹುದಾಗಿದೆ.

1. ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯನ್ನು ಗುರುತಿಸುವುದು
2. ಸಂಬಂಧಿತ ಸಾಹಿತ್ಯವನ್ನು ಹುಡುಕುವುದು ಮತ್ತು ಸಂಘಟಿಸುವುದು
3. ಸಂಶೋಧನಾ ಉದ್ದೇಶಗಳನ್ನು ರೂಪಿಸುವಲ್ಲಿ ಸಹಾಯ ಪಡೆಯುವುದು
4. ಸಂಶೋಧನಾ ವಿಧಾನಗಳ ಕುರಿತು ಪ್ರಾಥಮಿಕ ಮಾರ್ಗದರ್ಶನ ಪಡೆಯುವುದು
5. ಸಂಶೋಧನಾ ಉಪಕರಣಗಳ ಪ್ರಾಥಮಿಕ ವಿನ್ಯಾಸ
6. ದತ್ತಾಂಶವನ್ನು ಸಂಘಟಿಸುವುದು ಮತ್ತು ವಿಶ್ಲೇಷಿಸುವುದು
7. ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆಯನ್ನು ಸುಧಾರಿಸುವುದು
8. ಉಲ್ಲೇಖಗಳು ಮತ್ತು ಗ್ರಂಥಸೂಚಿಯನ್ನು ನಿರ್ವಹಿಸುವುದು
9. ಸಂಶೋಧನಾ ಪ್ರಗತಿಯನ್ನು ಮೇಲ್ವಿಚಾರಣೆ ಮಾಡುವುದು
10. ಸಂಶೋಧನಾ ನೈತಿಕತೆಯ ಕುರಿತು ಜಾಗೃತಿ ಮೂಡಿಸುವುದು.

ಆದಾಗ್ಯೂ AI ಒದಗಿಸುವ ಮಾಹಿತಿಯನ್ನು ಸಂಶೋಧಕರು ಸ್ವತಂತ್ರವಾಗಿ ಪರಿಶೀಲಿಸಬೇಕು. AI ಉತ್ಪಾದಿಸುವ ಮಾಹಿತಿಯಲ್ಲಿ ದೋಷಗಳು ಅಥವಾ ಅಸ್ತಿತ್ವದಲ್ಲಿರದ ಉಲ್ಲೇಖಗಳು ಕಂಡುಬರುವ

ಸಾಧ್ಯತೆ ಇರುವುದರಿಂದ ಮೂಲ ದಾಖಲೆಗಳ ಪರಿಶೀಲನೆ ಅತ್ಯಗತ್ಯವಾಗಿದೆ (Dwivedi et al., 2023; Kasneci et al., 2023).

3. ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಗುರುತಿಸುವಿಕೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಯಾವುದೇ ಸಂಶೋಧನೆಯ ಮೊದಲ ಹಂತವೆಂದರೆ ಸೂಕ್ತ ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯನ್ನು ಗುರುತಿಸುವುದು. ಸಂಶೋಧನಾ ಕ್ಷೇತ್ರದಲ್ಲಿ ಈಗಾಗಲೇ ನಡೆದಿರುವ ಅಧ್ಯಯನಗಳು, ಸಂಶೋಧನಾ ಅಂತರಗಳು ಮತ್ತು ಪ್ರಸ್ತುತ ಸಮಸ್ಯೆಗಳನ್ನು ಗುರುತಿಸಲು AI ಆಧಾರಿತ ಸಾಧನಗಳು ಸಹಾಯಕವಾಗಬಹುದು (Zawacki-Richter et al., 2019).

ಸಂಶೋಧಕರು ತಮ್ಮ ಕ್ಷೇತ್ರಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಪ್ರಮುಖ ಪದಗಳನ್ನು AI ವ್ಯವಸ್ಥೆಗಳಲ್ಲಿ ಬಳಸುವುದರ ಮೂಲಕ ವಿವಿಧ ಸಂಶೋಧನಾ ವಿಷಯಗಳ ಕುರಿತು ಪ್ರಾಥಮಿಕ ಮಾಹಿತಿಯನ್ನು ಪಡೆಯಬಹುದು. ಇದರಿಂದ ಸಂಶೋಧನಾ ಕ್ಷೇತ್ರದ ವ್ಯಾಪ್ತಿ ಮತ್ತು ಸಾಧ್ಯವಿರುವ ಸಂಶೋಧನಾ ಅಂತರಗಳನ್ನು ಗುರುತಿಸಲು ನೆರವಾಗಬಹುದು.

ಆದರೆ AI ಸೂಚಿಸಿದ ಯಾವುದೇ ವಿಷಯವನ್ನು ನೇರವಾಗಿ ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯಾಗಿ ಸ್ವೀಕರಿಸಬಾರದು. ಅಂತಿಮ ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯನ್ನು ಸಂಶೋಧಕರು ತಮ್ಮ ವಿಷಯಜ್ಞಾನ, ಹಿಂದಿನ ಸಂಶೋಧನೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಯ ಆಧಾರದ ಮೇಲೆ ನಿರ್ಧರಿಸಬೇಕು (Miao & Holmes, 2023).

4. ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆಯು ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯ ಪ್ರಮುಖ ಹಂತವಾಗಿದೆ. ಸಂಬಂಧಿತ ಪುಸ್ತಕಗಳು, ಸಂಶೋಧನಾ ಲೇಖನಗಳು, ವರದಿಗಳು ಮತ್ತು ಹಿಂದಿನ ಪ್ರಬಂಧಗಳನ್ನು ಗುರುತಿಸಿ ಅವುಗಳ ವಿಷಯವನ್ನು ವ್ಯವಸ್ಥಿತವಾಗಿ ವಿಶ್ಲೇಷಿಸುವ ಅಗತ್ಯವಿದೆ.

AI ಸಾಧನಗಳು ದೊಡ್ಡ ಪ್ರಮಾಣದ ಸಾಹಿತ್ಯವನ್ನು ವರ್ಗೀಕರಿಸಲು, ಪ್ರಮುಖ ವಿಷಯಗಳನ್ನು ಗುರುತಿಸಲು ಮತ್ತು ಪರಸ್ಪರ ಸಂಬಂಧಿತ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಸಹಾಯ ಮಾಡಬಹುದು (Zawacki-Richter et al., 2019; Kasneci et al., 2023).

ಆದರೆ AI ಸೃಷ್ಟಿಸಿದ ಉಲ್ಲೇಖಗಳನ್ನು ಮೂಲ ಸಂಶೋಧನಾ ಲೇಖನ ಅಥವಾ ಅಧಿಕೃತ ದಾಖಲೆಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸುವುದು ಅತ್ಯಗತ್ಯ. ಅಸ್ತಿತ್ವದಲ್ಲಿಲ್ಲದ ಅಥವಾ ತಪ್ಪಾದ ಉಲ್ಲೇಖಗಳನ್ನು ಬಳಸುವುದರಿಂದ ಸಂಶೋಧನೆಯ ವಿಶ್ವಾಸಾರ್ಹತೆ ಹಾನಿಗೊಳಗಾಗಬಹುದು (Dwivedi et al., 2023).

5. ಸಂಶೋಧನಾ ವಿಧಾನದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಸಂಶೋಧನಾ ವಿಧಾನವನ್ನು ಆಯ್ಕೆ ಮಾಡುವಾಗ ಸಂಶೋಧನಾ ಸಮಸ್ಯೆ, ಉದ್ದೇಶಗಳು,

ಮಾದರಿ, ದತ್ತಾಂಶದ ಸ್ವರೂಪ ಮತ್ತು ಅಧ್ಯಯನದ ವಿನ್ಯಾಸವನ್ನು ಪರಿಗಣಿಸಬೇಕು. AI ವಿವಿಧ ಸಂಶೋಧನಾ ವಿಧಾನಗಳ ನಡುವಿನ ವ್ಯತ್ಯಾಸಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಮತ್ತು ಪ್ರಾಥಮಿಕ ಮಾರ್ಗದರ್ಶನ ಪಡೆಯಲು ಸಹಾಯಕವಾಗಬಹುದು (Kasneci et al., 2023).

ಉದಾಹರಣೆಗೆ, ಪ್ರಮಾಣಾತ್ಮಕ, ಗುಣಾತ್ಮಕ ಅಥವಾ ಮಿಶ್ರ ವಿಧಾನಗಳ ಲಕ್ಷಣಗಳನ್ನು ಹೋಲಿಸಲು ಂಖ ಬಳಸಬಹುದು. ಆದರೆ ಅಂತಿಮ ವಿಧಾನಾತ್ಮಕ ನಿರ್ಧಾರವನ್ನು ಸಂಶೋಧಕರು ಮತ್ತು ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕರು ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಆಧಾರದ ಮೇಲೆ ಕೈಗೊಳ್ಳಬೇಕು.

6. ಸಂಶೋಧನಾ ಉಪಕರಣಗಳ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಪ್ರಶ್ನಾವಳಿ, ಸಂದರ್ಶನ ವೇಳಾಪಟ್ಟಿ, ಅವಲೋಕನ ಪಟ್ಟಿಗಳು ಮತ್ತು ಇತರ ಸಂಶೋಧನಾ ಉಪಕರಣಗಳ ಪ್ರಾಥಮಿಕ ವಿನ್ಯಾಸದಲ್ಲಿ AI ಸಹಾಯಕವಾಗಬಹುದು. ಪ್ರಶ್ನೆಗಳ ಭಾಷೆಯನ್ನು ಸರಳಗೊಳಿಸುವುದು, ಪುನರಾವರ್ತಿತ ಪ್ರಶ್ನೆಗಳನ್ನು ಗುರುತಿಸುವುದು ಮತ್ತು ವಿಷಯಾಧಾರಿತ ವಿಭಾಗಗಳನ್ನು ರೂಪಿಸುವಲ್ಲಿ ಇದು ನೆರವಾಗಬಹುದು.

ಆದರೆ AI ಸೃಷ್ಟಿಸಿದ ಉಪಕರಣವು ಸ್ವಯಂಚಾಲಿತವಾಗಿ ಮಾನ್ಯ (valid) ಅಥವಾ ವಿಶ್ವಾಸಾರ್ಹ (reliable) ಎಂದು ಪರಿಗಣಿಸಲಾಗುವುದಿಲ್ಲ. ತಜ್ಞರ ಅಭಿಪ್ರಾಯ, ಪೈಲಟ್ ಅಧ್ಯಯನ ಮತ್ತು ಸೂಕ್ತ ಸಂಖ್ಯಾಶಾಸ್ತ್ರೀಯ ವಿಧಾನಗಳ ಮೂಲಕ ಉಪಕರಣದ ಗುಣಮಟ್ಟವನ್ನು ಪರಿಶೀಲಿಸಬೇಕು.

7. ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆಯು ಪ್ರಮುಖ ಹಂತವಾಗಿದೆ. ದೊಡ್ಡ ಪ್ರಮಾಣದ ದತ್ತಾಂಶವನ್ನು ಸಂಘಟಿಸುವುದು, ವರ್ಗೀಕರಿಸುವುದು ಮತ್ತು ಕೆಲವು ವಿಶ್ಲೇಷಣಾ ಪ್ರಕ್ರಿಯೆಗಳನ್ನು ವೇಗಗೊಳಿಸುವಲ್ಲಿ AI ಆಧಾರಿತ ಸಾಧನಗಳು ಸಹಾಯ ಮಾಡಬಹುದು (Dwivedi et al., 2023).

ಆದರೆ AI ನೀಡಿದ ಸಂಖ್ಯಾಶಾಸ್ತ್ರೀಯ ಫಲಿತಾಂಶಗಳನ್ನು ಸಂಶೋಧಕರು ಸ್ವತಃ ಪರಿಶೀಲಿಸಬೇಕು. ಫಲಿತಾಂಶಗಳು ಸಂಶೋಧನಾ ಉದ್ದೇಶಗಳಿಗೆ ಹೇಗೆ ಸಂಬಂಧಿಸುತ್ತವೆ ಎಂಬುದನ್ನು ಅರ್ಥೈಸಿ ಅಂತಿಮ ವ್ಯಾಖ್ಯಾನವನ್ನು ನೀಡುವುದು ಸಂಶೋಧಕರ ಜವಾಬ್ದಾರಿಯಾಗಿದೆ.

8. ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

AI ಸಾಧನಗಳನ್ನು ವ್ಯಾಕರಣ ದೋಷಗಳನ್ನು ಸರಿಪಡಿಸಲು, ವಾಕ್ಯಗಳನ್ನು ಸ್ಪಷ್ಟಗೊಳಿಸಲು, ಶೈಕ್ಷಣಿಕ ಭಾಷೆಯನ್ನು ಸುಧಾರಿಸಲು ಮತ್ತು ಲೇಖನದ ರಚನೆಯನ್ನು ವ್ಯವಸ್ಥಿತಗೊಳಿಸಲು ಬಳಸಬಹುದು (Kasneci et al., 2023).

AI ಉಪಕರಣಗಳನ್ನು ಬಳಸಿಕೊಂಡು:

- ವ್ಯಾಕರಣ ದೋಷಗಳನ್ನು ಸರಿಪಡಿಸಬಹುದು;

- ವಾಕ್ಯಗಳನ್ನು ಸ್ಪಷ್ಟಗೊಳಿಸಬಹುದು;
- ಶೈಕ್ಷಣಿಕ ಭಾಷೆಯನ್ನು ಸುಧಾರಿಸಬಹುದು;
- ಪಠ್ಯದ ರಚನೆಯನ್ನು ವ್ಯವಸ್ಥಿತಗೊಳಿಸಬಹುದು;
- ಸಾರಾಂಶವನ್ನು ರೂಪಿಸಲು ಸಹಾಯ ಪಡೆಯಬಹುದು.

ಆದರೆ ಸಂಶೋಧನೆಯ ಮೂಲ ಆಲೋಚನೆ, ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ತೀರ್ಮಾನಗಳು ಸಂಶೋಧಕರ ಸ್ವಂತ ಬೌದ್ಧಿಕ ಕೊಡುಗೆಯಾಗಿರಬೇಕು. AI ರಚಿಸಿದ ವಿಷಯವನ್ನು ಪರಿಶೀಲಿಸದೆ ನೇರವಾಗಿ ಬಳಸುವುದು ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆಗೆ ಸಂಬಂಧಿಸಿದ ಸಮಸ್ಯೆಗಳನ್ನು ಉಂಟುಮಾಡಬಹುದು (Miao & Holmes, 2023).

9. ಸಂಶೋಧನಾ ನೈತಿಕತೆ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಸಂಶೋಧನಾ ನೈತಿಕತೆಯ ಮಹತ್ವ ಇನ್ನಷ್ಟು ಹೆಚ್ಚುತ್ತದೆ. ಸಂಶೋಧನೆಯ ಮೂಲತತ್ವ, ಕೃತಿಚೌರ್ಯ, ತಪ್ಪು ಉಲ್ಲೇಖಗಳು, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಪಾರದರ್ಶಕತೆ ಮತ್ತು ಹೊಣೆಗಾರಿಕೆ ಪ್ರಮುಖ ವಿಷಯಗಳಾಗಿವೆ (UNESCO, 2021).

UGC ನಿಯಮಗಳ ಪ್ರಕಾರ ಸಂಶೋಧನಾ ಪ್ರಾಮಾಣಿಕತೆ Ph.D. ಸಂಶೋಧನೆಯ ಅವಿಭಾಜ್ಯ ಭಾಗವಾಗಿದೆ ಮತ್ತು ಪ್ರಬಂಧದ ಮೂಲತತ್ವವನ್ನು ಖಚಿತಪಡಿಸುವ ವ್ಯವಸ್ಥೆಗಳು ಇರಬೇಕು (University Grants Commission, 2022). ಆದ್ದರಿಂದ AI ಬಳಕೆಯು ಸಂಶೋಧಕರ ಮೂಲ ಬೌದ್ಧಿಕ ಕೊಡುಗೆಯನ್ನು ಮರೆಮಾಡುವ ರೀತಿಯಲ್ಲಿ ಇರಬಾರದು.

AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಕೆಳಗಿನ ಅಂಶಗಳನ್ನು ಗಮನಿಸಬೇಕು:

- ಸಂಶೋಧನೆಯ ಮೂಲತತ್ವವನ್ನು ಕಾಪಾಡುವುದು.
- ಕೃತಿಚೌರ್ಯ ತಪ್ಪಿಸುವುದು.
- ಅಸ್ತಿತ್ವದಲ್ಲಿಲ್ಲದ ಉಲ್ಲೇಖಗಳನ್ನು ಬಳಸಬಾರದು.
- AI ನೀಡಿದ ಮಾಹಿತಿಯನ್ನು ಮೂಲ ದಾಖಲೆಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸುವುದು.
- ವೈಯಕ್ತಿಕ ಅಥವಾ ಸಂವೇದನಾಶೀಲ ದತ್ತಾಂಶದ ಗೌಪ್ಯತೆಯನ್ನು ಕಾಪಾಡುವುದು.
- ಅಗತ್ಯವಿದ್ದಲ್ಲಿ AI ಬಳಕೆಯ ಕುರಿತು ಪಾರದರ್ಶಕತೆಯನ್ನು ಕಾಯ್ದುಕೊಳ್ಳುವುದು.
- ಸಂಶೋಧನೆಯ ಅಂತಿಮ ಜವಾಬ್ದಾರಿಯನ್ನು ಸಂಶೋಧಕರೇ ವಹಿಸುವುದು.

UNESCOನ AI ನೈತಿಕತೆಯ ಶಿಫಾರಸುಗಳು ಪಾರದರ್ಶಕತೆ, ಗೌಪ್ಯತೆ, ಹೊಣೆಗಾರಿಕೆ ಮತ್ತು ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆಗೆ ವಿಶೇಷ ಮಹತ್ವ ನೀಡುತ್ತವೆ (UNESCO, 2021). UNESCOನ ಜನರೇಟಿವ್ AI ಮಾರ್ಗದರ್ಶನವೂ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ ಮಾನವ–ಕೇಂದ್ರಿತ ಹಾಗೂ ಜವಾಬ್ದಾರಿಯುತ

ಬಳಕೆಯನ್ನು ಒತ್ತಿಹೇಳುತ್ತದೆ (Miao & Holmes, 2023).

10. ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕರ ಪಾತ್ರ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕರ ಪಾತ್ರ ಅತ್ಯಂತ ಮಹತ್ವದ್ದಾಗಿದೆ. ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಆಯ್ಕೆ, ವಿಧಾನ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ, ಬರವಣಿಗೆ ಮತ್ತು ಸಂಶೋಧನಾ ನೈತಿಕತೆಯಂತಹ ವಿಷಯಗಳಲ್ಲಿ ಮಾರ್ಗದರ್ಶಕರು ಶೈಕ್ಷಣಿಕ ಮಾರ್ಗದರ್ಶನ ನೀಡುತ್ತಾರೆ.

AI ಮಾರ್ಗದರ್ಶಕರ ಪರ್ಯಾಯವಾಗದೆ ಪೂರಕ ತಂತ್ರಜ್ಞಾನವಾಗಿರಬೇಕು. ಸಂಶೋಧಕ, ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕ, AI ಸಾಧನಗಳು ಮತ್ತು ಸಂಸ್ಥೆಯ ಸಂಶೋಧನಾ ನೈತಿಕತೆ-ಇವುಗಳ ಸಮನ್ವಯದಿಂದ ಸಂಶೋಧನೆಯ ಗುಣಮಟ್ಟವನ್ನು ಸುಧಾರಿಸಬಹುದು (Miao & Holmes, 2023).

11. AI ಆಧಾರಿತ ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನಾ ಮಾಹಿತಿ ವ್ಯವಸ್ಥೆ

ವಿಶ್ವವಿದ್ಯಾಲಯಗಳು AI ಆಧಾರಿತ ಡಿಜಿಟಲ್ ಸಂಶೋಧನಾ ಮಾಹಿತಿ ವ್ಯವಸ್ಥೆಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುವ ಸಾಧ್ಯತೆಯನ್ನು ಪರಿಗಣಿಸಬಹುದು. ಇಂತಹ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ವಿಶ್ವವಿದ್ಯಾಲಯದ Ph.D. ನಿಯಮಗಳು, UGC ಮಾರ್ಗಸೂಚಿಗಳು, ಸಂಶೋಧನಾ ಪ್ರಗತಿ, ಸಂಶೋಧನಾ ನೈತಿಕತೆ, ಕಾರ್ಯಾಗಾರಗಳು ಮತ್ತು ಪ್ರಬಂಧ ಸಲ್ಲಿಕೆಯ ಹಂತಗಳಂತಹ ಮಾಹಿತಿಯನ್ನು ಒದಗಿಸಬಹುದು.

ಭಾರತದಲ್ಲಿ Ph.D. ಪದವಿಗೆ ಸಂಬಂಧಿಸಿದ ಕನಿಷ್ಠ ಮಾನದಂಡಗಳು UGC Ph.D. Regulations, 2022ರೊಂದಿಗೆ ಸಂಬಂಧ ಹೊಂದಿರುವುದರಿಂದ, ಯಾವುದೇ AI ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಯನ್ನು ಅಧಿಕೃತ UGC ಮತ್ತು ಸಂಬಂಧಿತ ವಿಶ್ವವಿದ್ಯಾಲಯದ ದಾಖಲೆಗಳೊಂದಿಗೆ ನಿರಂತರವಾಗಿ ನವೀಕರಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ (University Grants Commission, 2022).

12. ಮೂಲ ಸಂಶೋಧನಾ ಅರಿವು ಮತ್ತು AI ಆಧಾರಿತ ಪರಿಹಾರಗಳ ನಡುವಿನ ಸಂಬಂಧ

AI ಆಧಾರಿತ ಪರಿಹಾರಗಳು ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆಗೆ ವೇಗ ಮತ್ತು ಮಾಹಿತಿಯ ಲಭ್ಯತೆಯನ್ನು ಒದಗಿಸಬಹುದು. ಆದರೆ ಸಂಶೋಧನೆಯ ಮೂಲ ಸಮಸ್ಯೆಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು, ಅದರ ಸಾಮಾಜಿಕ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಹಿನ್ನೆಲೆಯನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು ಹಾಗೂ ಸೂಕ್ತ ನಿರ್ಧಾರ ತೆಗೆದುಕೊಳ್ಳುವುದು ಮಾನವ ಸಂಶೋಧಕರ ಜವಾಬ್ದಾರಿಯಾಗಿದೆ.

ಸಂಶೋಧನಾ ಕ್ಷೇತ್ರ	ಅಧ್ಯಯನದಲ್ಲಿ ಕಂಡುಬಂದ ಅಗತ್ಯ	AI ಆಧಾರಿತ ಸಾಧ್ಯ ಪರಿಹಾರ
ವಿಶ್ವವಿದ್ಯಾಲಯದ ಅಧಿಸೂಚನೆಗಳ ಅರಿವು	ಅಧಿಸೂಚನೆಗಳ ಕುರಿತು ಅರಿವು ಹೆಚ್ಚಿಸುವ ಅಗತ್ಯ	AI ಆಧಾರಿತ ಅಧಿಸೂಚನೆ ವ್ಯವಸ್ಥೆ
Ph.D. ನಿಯಮಾವಳಿ	ನಿಯಮಗಳ ಕುರಿತು ನಿರಂತರ ಅರಿವು	AI ನಿಯಮಾವಳಿ ಮಾಹಿತಿ ಸಹಾಯಕ
ಸಂಶೋಧನಾ ಪ್ರಗತಿ	ಪ್ರಗತಿ ಪರಿಶೀಲನೆಯ ಅಗತ್ಯ	AI ಪ್ರಗತಿ ಟ್ರ್ಯಾಕಿಂಗ್ ವ್ಯವಸ್ಥೆ

ಸಂಶೋಧನಾ ವಿಧಾನ	ವಿಧಾನಾತ್ಮಕ ತರಬೇತಿಯ ಅಗತ್ಯ	AI ಸಂಶೋಧನಾ ವಿಧಾನ ಕಲಿಕಾ ಸಹಾಯಕ
ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆ	ಹೆಚ್ಚಿನ ಸಾಹಿತ್ಯವನ್ನು ವ್ಯವಸ್ಥಿತವಾಗಿ ಪರಿಶೀಲಿಸುವ ಅಗತ್ಯ	AI ಸಾಹಿತ್ಯ ಸಂಘಟನೆ ಮತ್ತು ವಿಶ್ಲೇಷಣೆ
ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆ	ಬರವಣಿಗೆ ಮತ್ತು ಉಲ್ಲೇಖ ನಿರ್ವಹಣೆಯ ಅಗತ್ಯ	AI ಬರವಣಿಗೆ ಸಹಾಯಕ
ಸಂಶೋಧನಾ ನೈತಿಕತೆ	ನೈತಿಕ ಅರಿವಿನ ಅಗತ್ಯ	AI ನೈತಿಕತೆ ಕಲಿಕಾ ಘಟಕ
ಪೂರ್ವ–ವೈವಾ ಸಿದ್ಧತೆ	ಸಂಶೋಧಕರ ಸಿದ್ಧತೆಯ ಅಗತ್ಯ	AI ಆಧಾರಿತ ಪ್ರಶ್ನೋತ್ತರ ಅಭ್ಯಾಸ

AI ನೀಡುವ ಉತ್ತರವನ್ನು ಅಂತಿಮ ಸತ್ಯವೆಂದು ಪರಿಗಣಿಸದೆ, ಅದನ್ನು ಒಂದು ಪ್ರಾಥಮಿಕ ಮಾಹಿತಿ ಅಥವಾ ಸಹಾಯಕ ಸಲಹೆಯಾಗಿ ಪರಿಗಣಿಸುವುದು ಸೂಕ್ತ (Miao & Holmes, 2023).

13. AI ಆಧಾರಿತ ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನಾ ಚೌಕಟ್ಟು

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ AI ಬಳಕೆಯನ್ನು ಕೆಳಗಿನ ಕ್ರಮದಲ್ಲಿ ಪರಿಗಣಿಸಬಹುದು:

ಸಂಶೋಧನಾ ಅರಿವು → AI ಸಾಕ್ಷರತೆ → ಸಂಶೋಧನಾ ಸಮಸ್ಯೆ ಗುರುತಿಸುವಿಕೆ → ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆ → ಸಂಶೋಧನಾ ವಿಧಾನ → ದತ್ತಾಂಶ ಸಂಗ್ರಹಣೆ → ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ → ಮಾನವೀಯ ವ್ಯಾಖ್ಯಾನ → ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆ → ಸಂಶೋಧನಾ ನೈತಿಕತೆ → ಪ್ರಗತಿ ಮೇಲ್ವಿಚಾರಣೆ → ಪೂರ್ವ–ವೈವಾ ಸಿದ್ಧತೆ → ಸಂಶೋಧನಾ ಗುಣಮಟ್ಟ.

ಈ ಚೌಕಟ್ಟಿನಲ್ಲಿ AI ಪ್ರತಿಯೊಂದು ಹಂತದಲ್ಲಿಯೂ ಸಹಾಯಕ ಪಾತ್ರ ವಹಿಸಬಹುದು. ಆದರೆ ಅಂತಿಮ ನಿರ್ಧಾರ, ವಿಮರ್ಶಾತ್ಮಕ ಪರಿಶೀಲನೆ ಮತ್ತು ಹೊಣೆಗಾರಿಕೆ ಸಂಶೋಧಕರದ್ದೇ ಆಗಿರಬೇಕು (UNESCO, 2021; Miao & Holmes, 2023).

14. AI ಬಳಕೆಯ ಪ್ರಮುಖ ಪ್ರಯೋಜನಗಳು

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ ಸೂಕ್ತ ರೀತಿಯಲ್ಲಿ AI ಬಳಸುವುದರಿಂದ:

- ಸಂಶೋಧನಾ ಕಾರ್ಯದಲ್ಲಿ ಸಮಯ ಉಳಿತಾಯವಾಗಬಹುದು.
- ದೊಡ್ಡ ಪ್ರಮಾಣದ ಮಾಹಿತಿಯನ್ನು ಸಂಘಟಿಸಲು ಸಹಾಯವಾಗಬಹುದು.
- ಸಾಹಿತ್ಯವನ್ನು ವರ್ಗೀಕರಿಸಲು ನೆರವಾಗಬಹುದು.
- ಸಂಶೋಧನಾ ವಿಧಾನಗಳ ಕುರಿತು ಪ್ರಾಥಮಿಕ ಮಾರ್ಗದರ್ಶನ ಪಡೆಯಬಹುದು.
- ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆಯ ಭಾಷಾ ಗುಣಮಟ್ಟವನ್ನು ಸುಧಾರಿಸಬಹುದು.
- ಸಂಶೋಧನಾ ಪ್ರಗತಿಯನ್ನು ವ್ಯವಸ್ಥಿತವಾಗಿ ಮೇಲ್ವಿಚಾರಣೆ ಮಾಡಬಹುದು.
- ಸಂಶೋಧಕರ ಡಿಜಿಟಲ್ ಸಂಶೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಬಹುದು.

ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ AI ಬಳಕೆಯ ಸಾಧ್ಯತೆಗಳ ಕುರಿತು ಹಿಂದಿನ ಅಧ್ಯಯನಗಳು ಸಹ ಇಂತಹ ಸಹಾಯಕ ಪಾತ್ರವನ್ನು ಗುರುತಿಸಿವೆ (Zawacki-Richter et al., 2019; Kasneci et al., 2023).

15. AI ಬಳಕೆಯ ಸವಾಲುಗಳು

AI ಬಳಕೆಯು ಹಲವು ಪ್ರಯೋಜನಗಳನ್ನು ಹೊಂದಿದ್ದರೂ ಕೆಲವು ಸವಾಲುಗಳೂ ಇವೆ. AI ಕೆಲವೊಮ್ಮೆ ತಪ್ಪಾದ ಮಾಹಿತಿ, ಅಪೂರ್ಣ ವಿವರಣೆ ಅಥವಾ ತಪ್ಪಾದ ಉಲ್ಲೇಖಗಳನ್ನು ನೀಡಬಹುದು. ಆದ್ದರಿಂದ ಸಂಶೋಧಕರು AI ಮೇಲಿನ ಸಂಪೂರ್ಣ ಅವಲಂಬನೆಯನ್ನು ತಪ್ಪಿಸಬೇಕು (Dwivedi et al., 2023). ಇದಲ್ಲದೆ, ದತ್ತಾಂಶ ಗೌಪ್ಯತೆ, ಬೌದ್ಧಿಕ ಸ್ವತ್ತಿನ ಹಕ್ಕು, ಪ್ಲೇಜರಿಸಂ, ಮೂಲತತ್ವ, ಪಾರದರ್ಶಕತೆ ಮತ್ತು AI ಬಳಕೆಯ ಹೊಣೆಗಾರಿಕೆ ಪ್ರಮುಖ ನೈತಿಕ ಪ್ರಶ್ನೆಗಳಾಗಿವೆ (UNESCO, 2021; Miao & Holmes, 2023).

ಆದ್ದರಿಂದ **"AI ಬಳಕೆ"**ಗಿಂತ **"ಜವಾಬ್ದಾರಿಯುತ AI ಬಳಕೆ"** ಹೆಚ್ಚು ಮುಖ್ಯವಾಗಿದೆ.

16. ಶಿಫಾರಸುಗಳು

ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯಲ್ಲಿ AIಯನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಬಳಸಲು ಕೆಳಗಿನ ಕ್ರಮಗಳನ್ನು ಪರಿಗಣಿಸಬಹುದು:

1. ವಿಶ್ವವಿದ್ಯಾಲಯಗಳಲ್ಲಿ AI ಮತ್ತು ಸಂಶೋಧನಾ ಕೌಶಲ್ಯಗಳ ಕುರಿತು ತರಬೇತಿ ಕಾರ್ಯಕ್ರಮಗಳನ್ನು ಆಯೋಜಿಸಬೇಕು.
2. ಸಂಶೋಧಕರಿಗಾಗಿ AI ಸಾಕ್ಷರತಾ ಕಾರ್ಯಾಗಾರಗಳನ್ನು ನಡೆಸಬೇಕು.
3. AI ಬಳಕೆ ಮತ್ತು ಸಂಶೋಧನಾ ನೈತಿಕತೆಯ ಕುರಿತು ಪ್ರತ್ಯೇಕ ಮಾರ್ಗದರ್ಶನ ನೀಡಬೇಕು.
4. AI ಸೃಷ್ಟಿಸಿದ ಮಾಹಿತಿಯನ್ನು ಮೂಲ ದಾಖಲೆಗಳೊಂದಿಗೆ ಪರಿಶೀಲಿಸುವ ಕೌಶಲ್ಯ ಬೆಳೆಸಬೇಕು.
5. ಸಂಶೋಧನಾ ದತ್ತಾಂಶದ ಗೌಪ್ಯತೆ ಮತ್ತು ಭದ್ರತೆಯನ್ನು ಖಚಿತಪಡಿಸಬೇಕು.
6. ಸಂಶೋಧನಾ ಸಂಸ್ಥೆಗಳು AI ಬಳಕೆಗೆ ಸ್ಪಷ್ಟ ಮಾರ್ಗಸೂಚಿಗಳನ್ನು ರೂಪಿಸಬೇಕು.
7. ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕರಿಗೂ ಜವಾಬ್ದಾರಿಯುತ AI ಬಳಕೆಯ ಕುರಿತು ತರಬೇತಿ ನೀಡಬೇಕು.
8. AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಸಂಶೋಧಕರ ಮೂಲ ಬೌದ್ಧಿಕ ಕೊಡುಗೆಯನ್ನು ಸ್ಪಷ್ಟವಾಗಿ ಕಾಪಾಡಬೇಕು.
9. ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು UGC ಮಾರ್ಗಸೂಚಿಗಳಿಗೆ ಅನುಗುಣವಾಗಿ AI ಬಳಕೆಯನ್ನು ನಿರ್ವಹಿಸಬೇಕು (University Grants Commission, 2022).
10. AIಯನ್ನು ಸಂಶೋಧಕರ ಮತ್ತು ಮಾರ್ಗದರ್ಶಕರ ಪರ್ಯಾಯವಾಗಿ ಬಳಸದೆ ಸಹಾಯಕ ತಂತ್ರಜ್ಞಾನವಾಗಿ ಬಳಸಬೇಕು (Miao & Holmes, 2023).

ಈ ಶಿಫಾರಸುಗಳು AIಯನ್ನು ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆಯಲ್ಲಿ ಮಾನವ–ಕೇಂದ್ರಿತ, ಸುರಕ್ಷಿತ, ಸಮಾನ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ರೀತಿಯಲ್ಲಿ ಬಳಸುವ ಅಗತ್ಯವನ್ನು ಒತ್ತಿಹೇಳುವ ಅಂತರರಾಷ್ಟ್ರೀಯ ಮಾರ್ಗಸೂಚಿಗಳಿಗೆ ಹೊಂದಿಕೆಯಾಗುತ್ತವೆ (Miao & Holmes, 2023; UNESCO, 2021).

17. ಉಪಸಂಹಾರ

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬೆಳವಣಿಗೆಯು ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯ ಸ್ವರೂಪದಲ್ಲಿ ಮಹತ್ವದ ಬದಲಾವಣೆಗಳನ್ನು ತರಬಲ್ಲ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ. ಸಂಶೋಧನಾ ಸಮಸ್ಯೆಯ ಗುರುತಿಸುವಿಕೆಯಿಂದ ಸಾಹಿತ್ಯ ಪರಿಶೀಲನೆ, ಸಂಶೋಧನಾ ವಿಧಾನ, ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಬರವಣಿಗೆಯವರೆಗೆ AI ಸಂಶೋಧಕರಿಗೆ ವಿವಿಧ ಹಂತಗಳಲ್ಲಿ ಸಹಾಯ ಮಾಡಬಹುದು (Dwivedi et al., 2023; Kasneci et al., 2023).

ಆದರೆ AIಯನ್ನು ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆಯ ಅಂತಿಮ ನಿರ್ಧಾರಕವಾಗಿ ಪರಿಗಣಿಸುವುದು ಸೂಕ್ತವಲ್ಲ. ಸಂಶೋಧಕರ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ವಿಷಯಜ್ಞಾನ, ವೈಜ್ಞಾನಿಕ ವಿವೇಚನೆ, ಸಂಶೋಧನಾ ನೈತಿಕತೆ ಮತ್ತು ಹೊಣೆಗಾರಿಕೆ ಅತ್ಯಗತ್ಯವಾಗಿವೆ. UNESCOನ ಮಾನವ–ಕೇಂದ್ರಿತ AI ದೃಷ್ಟಿಕೋನವು ಸಹ ಮಾನವ ಮೇಲ್ವಿಚಾರಣೆ, ಪಾರದರ್ಶಕತೆ, ಗೌಪ್ಯತೆ ಮತ್ತು ಹೊಣೆಗಾರಿಕೆಗೆ ಮಹತ್ವ ನೀಡುತ್ತದೆ (UNESCO, 2021; Miao & Holmes, 2023).

ಹೀಗಾಗಿ ಭವಿಷ್ಯದ ಡಾಕ್ಟರೇಟ್ ಸಂಶೋಧನೆಯು ಕೇವಲ **"ಡಿಜಿಟಲ್ ಸಂಶೋಧನೆ"**ಯಿಂದ **"ಜವಾಬ್ದಾರಿಯುತ AI–ಸಹಾಯಕ ಸಂಶೋಧನೆ"**ಯತ್ತ ಸಾಗಬೇಕಾಗಿದೆ. AI ಸಂಶೋಧನಾ ಪ್ರಕ್ರಿಯೆಯನ್ನು ವೇಗಗೊಳಿಸಬಹುದು; ಆದರೆ ಸಂಶೋಧನೆಯ ಗುಣಮಟ್ಟವನ್ನು ನಿರ್ಧರಿಸುವುದು ಸಂಶೋಧಕರ ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ನೈತಿಕತೆ ಮತ್ತು ವೈಜ್ಞಾನಿಕ ಹೊಣೆಗಾರಿಕೆಯೇ ಆಗಿದೆ.

"AI ಸಂಶೋಧನೆಯ ವೇಗವನ್ನು ಹೆಚ್ಚಿಸಬಹುದು; ಆದರೆ ಸಂಶೋಧನೆಯ ಗುಣಮಟ್ಟವನ್ನು ನಿರ್ಧರಿಸುವುದು ಸಂಶೋಧಕರ ವಿವೇಚನೆ, ನೈತಿಕತೆ ಮತ್ತು ವೈಜ್ಞಾನಿಕ ಹೊಣೆಗಾರಿಕೆಯಾಗಿದೆ."

ಪರಾಮರ್ಶಿತ ಗ್ರಂಥಗಳು

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ನಗರ ಹಾಗೂ ಗ್ರಾಮೀಣ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳು ಹೊಂದಿರುವ ಮೌಲ್ಯಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗಳ ವ್ಯತ್ಯಾಸ ಕುರಿತು ಅಧ್ಯಯನ

ಡಾ. ರವಿ ಹೆಚ್
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು, ಕುಮದ್ವತಿ ಶಿಕ್ಷಣ ಮಹಾವಿದ್ಯಾಲಯ, ಶಿಕಾರಿಪುರ

ಸಾರಾಂಶ

ಶಿಕ್ಷಣವು ವ್ಯಕ್ತಿಯ ಸರ್ವಾಂಗೀಣ ಅಭಿವೃದ್ಧಿ, ಜ್ಞಾನಾರ್ಜನೆ ಮತ್ತು ಉಜ್ವಲ ಭವಿಷ್ಯಕ್ಕೆ ಭದ್ರ ಬುನಾದಿಯಾಗಿದೆ. ಇದು ತಾರ್ಕಿಕ ಚಿಂತನೆ, ವ್ಯಕ್ತಿತ್ವ ವಿಕಸನ, ಸಾಮಾಜಿಕ ಜವಾಬ್ದಾರಿ ಮತ್ತು ಆರ್ಥಿಕ ಸ್ವಾವಲಂಬನೆಗೆ ದಾರಿಯಾಗಿದೆ. ಉತ್ತಮ ಸಮಾಜ ನಿರ್ಮಾಣ, ಅಜ್ಞಾನ ನಿರ್ಮೂಲನೆ ಮತ್ತು ಜೀವನದ ಸವಾಲುಗಳನ್ನು ಎದುರಿಸುವ ಶಕ್ತಿಯನ್ನು ಶಿಕ್ಷಣ ನೀಡುತ್ತದೆ, ಹಾಗೆಯೇ ಮಾನವನ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಶಿಕ್ಷಣಕ್ಕೆ ವಿಶೇಷ ಪ್ರಾಧಾನ್ಯವಿದೆ. ಮಾನವನ ವ್ಯತ್ಯಾಸವು ರೂಪಗೊಳ್ಳುವ ಅವಧಿಯಲ್ಲಿ ಶಿಕ್ಷಣವು ಹೆಚ್ಚು ಪ್ರಭಾವ ಬೀರುತ್ತದೆ, ಶಿಕ್ಷಣವು ಮಾನವನ ಮನೋಸ್ಥೈರ್ಯಕ್ಕೆ, ಊಹಾಶಕ್ತಿಗೆ ಹಾಗೂ ಜಿಜ್ಞಾಸೆಗೆ ನೂತನ ರೂಪವನ್ನು ತಂದುಕೊಡುತ್ತದೆ, ಪ್ರಕೃತಿದತ್ತವಾದ ಈ ಪ್ರಜ್ಞೆಯನ್ನು ಅನುಭವದತ್ತ ಅವಶ್ಯಕತೆಗಳ ಸಾಧನದಿಂದ ಸೂಕ್ತ ರೀತಿಯಲ್ಲಿ ನಿಯಂತ್ರಿಸುವ ವ್ಯವಸ್ಥೆಯೇ ಶಿಕ್ಷಣ. ಈ ಸಾಧನೆಯನ್ನು ಪೂರೈಸುವಲ್ಲಿ ಮಾಧ್ಯಮಿಕ ಶಿಕ್ಷಣ ಮಹತ್ವದ ಸ್ಥಾನವನ್ನು ಪಡೆದಿದೆ.

ಶಿಕ್ಷಣವು ವ್ಯಕ್ತಿಯ ಜೀವನವನ್ನು ರೂಪಿಸುವ ಮಹಾಶಕ್ತಿಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಮಾನವನ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಶಿಕ್ಷಣಕ್ಕೆ ವಿಶೇಷ ಪ್ರಾಧಾನ್ಯವಿದೆ. ರಾಷ್ಟ್ರದ ಪ್ರಗತಿ ಮತ್ತು ಬೆಳವಣಿಗೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾನಸಿಕ ಮತ್ತು ದೈಹಿಕ ಶಕ್ತಿಯ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿದೆ. ಮಾರ್ಗರೆಟ್ ಮಿಲನ್ ಅಭಿಪ್ರಾಯ ಪಡುವಂತೆ "ತಾರುಣ್ಯಾವಸ್ಥೆಯ ಮಕ್ಕಳು ಒಳ್ಳೆಯ ವಯಸ್ಕರಾಗಹುದು ಅಥವಾ ಕೆಟ್ಟವರಾಗಬಹುದು" ತಾರುಣ್ಯಾವಸ್ಥೆಯಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸೂಕ್ತ ಪರಿಸರವನ್ನು ದೊರಕಿಸಿಕೊಟ್ಟು ಒಳ್ಳೆಯ ವಯಸ್ಕರನ್ನಾಗಿ ಮಾಡಬೇಕು ವಾಸ್ತವವಾಗಿ ಅವರನ್ನು ನೈತಿಕತೆಯುಳ್ಳ ವ್ಯಕ್ತಿಗಳನ್ನಾಗಿ ಪರಿವರ್ತಿಸಬೇಕಾಗಿದೆ. ಈ ಪ್ರಕ್ರಿಯೆಯೊಳಗೆ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಬುದ್ಧಿಶಕ್ತಿಯೊಡನೆ ಉತ್ತಮ ಮೌಲ್ಯಗಳನ್ನು ಅಳವಡಿಸಿಕೊಂಡು ಉನ್ನತ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಪಡೆದು ಜೀವನದಲ್ಲಿ ತಮ್ಮ ಗುರಿಯಡೆಗೆ ಸಾಗುವುದು ಸೂಕ್ತವಾಗಿದೆ.

ಯಾವುದೇ ಒಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯು ಉನ್ನತ ಮಟ್ಟಕ್ಕೇರಿದೆ ಎಂದರೆ ತಾವು ಹೊಂದಿದ ಬುದ್ಧಿಶಕ್ತಿ ಹಾಗೂ ಅವರು ಅಳವಡಿಸಿಕೊಂಡ ಮೌಲ್ಯಗಳು ಕಾರಣವಾಗಬಹುದು. ಹಾಗೆಯೇ ಅವರು ದಾಖಲಾದ ಶಾಲೆಯ ಪರಿಸರ ಹಾಗೂ ತಮಗೆ ಸಿಕ್ಕ ಸೌಲಭ್ಯಗಳ ಪ್ರಭಾವದಿಂದ ವ್ಯತ್ಯಾಸ ಕಂಡು ಬರಬಹುದು. ಈ ಕಾರಣದಿಂದ ಪ್ರಸ್ತುತ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳಲ್ಲಿ ಪ್ರಮುಖವಾಗಿ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ವಿದ್ಯಾರ್ಥಿಗಳ ಶಾಲೆಗಳಲ್ಲಿ ಅಧ್ಯಯನ ಕೈಗೊಂಡ ವಿದ್ಯಾರ್ಥಿಗಳ ಮೌಲ್ಯಗಳು, ಹಾಗೂ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗಳು, ಹೇಗೆ ಸಂಭಂದಿಸಿವೆ ಹಾಗೂ ವ್ಯತ್ಯಾಸ ಹೊಂದಿದೆ ಎಂಬುದನ್ನು ತಿಳಿಯಬೇಕಾಗಿದೆ ಈ ಹಿನ್ನಲೆಯಲ್ಲಿ ಪ್ರಸ್ತುತ ಅಧ್ಯಯನ ಕೈಗೊಳ್ಳುವುದು ಅಗತ್ಯವಾಗಿದೆ.

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವು ಶಿಕಾರಿಪುರ ತಾಲ್ಲೂಕಿನ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ 9ನೇ ತರಗತಿಯ 200 ವಿದ್ಯಾರ್ಥಿಗಳ ಮೌಲ್ಯಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಮಟ್ಟದ ಶೇಕಡಾವಾರು ವಿಶ್ಲೇಷಣೆಯನ್ನು ವಿವರಣಾತ್ಮಕ ವಿಧಾನದೊಂದಿಗೆ ಸಂಖ್ಯಾಶಾಸ್ತ್ರದ ಶೇಕಡಾವಾರು, ಸರಾಸರಿ ಮತ್ತು ಮಾನಕ ವಿಚಲನೆ ತಂತ್ರಗಳ ಮೂಲಕ ಮಾಡಲಾಗಿದೆ. ಅಲ್ಲದೆ ಈ ಅಧ್ಯಯನದ ಸಾಧನವಾಗಿ ರವಿ ಹೆಚ್ ಮತ್ತು ಡಾ. ಜಗದೀಶ್ ಬಿ ರವರರ 'ವೈಯಕ್ತಿಕ ಮೌಲ್ಯ ಪ್ರಶ್ನಾವಳಿ'ಯನ್ನು ಬಳಸಿಕೊಳ್ಳಲಾಗಿದೆ.

ಕೀ ಪದಗಳು : ನಗರ ಹಾಗೂ ಗ್ರಾಮೀಣ ವಸತಿ ಮತ್ತು ವಸತಿ ರಹಿತ ಶಾಲೆಗಳು, ಶಿಕ್ಷಣ, ಮಾಧ್ಯಮಿಕ ಶಿಕ್ಷಣ, ಮೌಲ್ಯಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಇತ್ಯಾದಿ.

ಪೀಠಿಕೆ :

ರಾಷ್ಟ್ರದ ಪ್ರಗತಿ ಮತ್ತು ಬೆಳವಣಿಗೆಯು ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾನಸಿಕ ಮತ್ತು ದೈಹಿಕ ಶಕ್ತಿಯ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿದೆ. **ಮಾರ್ಗೇಟ್ ಮಿಲನ್** ಅಭಿಪ್ರಾಯ ಪಡುವಂತೆ ''ತಾರುಣ್ಯಾವಸ್ಥೆಯ ಮಕ್ಕಳು ಒಳ್ಳೆಯವರಾಗಹುದು ಅಥವಾ ಕೆಟ್ಟವರಾಗಬಹುದು, ತಾರುಣ್ಯವ್ಯವಸ್ಥೆಯಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಸೂಕ್ತ ಪರಿಸರವನ್ನು ದೊರಕಿಸಿಕೊಟ್ಟು ಒಳ್ಳೆಯ ವಯಸ್ಕರನ್ನಾಗಿ ಮಾಡಬೇಕು ಮತ್ತು ವಾಸ್ತವದಲ್ಲಿ ಅವರನ್ನು ನೈತಿಕತೆಯುಳ್ಳ ವ್ಯಕ್ತಿಗಳನ್ನಾಗಿ ಪರಿವರ್ತಿಸಬೇಕಾಗಿದೆ. ಈ ಪ್ರಕ್ರಿಯೆಯೊಳಗೆ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಬುದ್ಧಿಶಕ್ತಿಯೊಡನೆ ಉತ್ತಮ ಮೌಲ್ಯಗಳನ್ನು ಅಳವಡಿಸಿಕೊಂಡು ಉನ್ನತ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಪಡೆದು ಜೀವನದಲ್ಲಿ ತಮ್ಮ ಗುರಿಯಡೆಗೆ ಸಾಗುವುದು ಸೂಕ್ತವಾಗಿದೆ". ಎಂದಿದ್ದಾರೆ.

ಯಾವುದೇ ಒಬ್ಬ ವಿದ್ಯಾರ್ಥಿಯ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯು ಉನ್ನತ ಮಟ್ಟಕ್ಕೇರಿದೆ ಎಂದರೆ ತಾವು ಹೊಂದಿದ ಬುದ್ಧಿಶಕ್ತಿ ಹಾಗೂ ಅವರು ಅಳವಡಿಸಿಕೊಂಡ ಮೌಲ್ಯಗಳು ಕಾರಣವಾಗಬಹುದು. ಹಾಗೆಯೇ ಅವರು ದಾಖಲಾದ ಶಾಲೆಯ ಪರಿಸರ ಹಾಗೂ ತಮಗೆ ಸಿಕ್ಕ ಸೌಲಭ್ಯಗಳ ಪ್ರಭಾವದಿಂದ ವ್ಯತ್ಯಾಸ ಕಂಡು ಬರಬಹುದು. ಈ ಕಾರಣದಿಂದ ಪ್ರಸ್ತುತ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಮೌಲ್ಯಗಳು ಹಾಗೂ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗಳು ಯಾವ ಪ್ರಮಾಣದಲ್ಲಿದೆ ಹಾಗೂ ವ್ಯತ್ಯಾಸ ಹೊಂದಿದೆ ಎಂಬುದನ್ನು ತಿಳಿಯಬೇಕಾದ ಹಿನ್ನಲೆಯಲ್ಲಿ ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ಕೈಗೊಳ್ಳಲಾಗಿದೆ.

ಮೌಲ್ಯಗಳು ಸೈದ್ಧಾಂತಿಕ ಹಿನ್ನಲೆ :

ಮೌಲ್ಯ ಎಂದರೆ ಒಂದು ನೆಲೆಯಲ್ಲಿ ಮಾನವನ ಬದುಕಿನ ಆದರ್ಶಗುಣ, ಸ್ವಭಾವ ಎಂದು ಹೇಳಬಹುದು. ಮೌಲ್ಯ ಎಂದರೆ ಪರಿಶುದ್ಧ ಜೀವನ ಮಾರ್ಗ. ಅದು ವ್ಯಕ್ತಿ ಮತ್ತು ಸಮಾಜದ ನಡುವಿನ ಆರೋಗ್ಯಕರ ಸಂಬಂಧ, ನಮ್ಮ ವರ್ತನೆ, ಕ್ರಿಯೆ ಹಾಗೂ ವ್ಯಕ್ತತ್ವವನ್ನು ನಿಯಂತ್ರಿಸುವ ಬುದುಕಿನ ಚಾಲಕ ಶಕ್ತಿ, ವ್ಯಕ್ತಿಯ ಮನೋದೈಹಿಕ ಸ್ವಾಸ್ಥ್ಯಕ್ಕೆ ಕಾರಣವಾಗಬುದಾದ ಮಾರ್ಗದರ್ಶಕ ಸೂತ್ರವಾಗಿದೆ.

ಜಾನ್ ಡೂಯಿಯವರ ಪ್ರಕಾರ "ಯಾವುದಾರೂ ವಸ್ತು ಅಥವಾ ವಿಷಯವನ್ನು ಮತ್ತೊಂದರೊಡನೆ ಹೋಲಿಸಿ ಅದರ ಬೆಲೆ ನಿರ್ಣಯಿಸುವ ಮೂಲಕ ಉತ್ತಮವಾದುದೆಂದು ಪರಿಗಣಿಸುವ ಕ್ರಿಯೆಯೇ ಮೌಲ್ಯ".

ಪಠ್ಯವಸ್ತು, ಪಠ್ಯಪುಸ್ತಕ, ಶಾಲಾ ವಾತಾವರಣ, ಶಿಕ್ಷಕ ಹೀಗೆ ಶಾಲಾ ಪರಿಸರದ ಮೂಲಕ ಯೋಗ್ಯವಾದ ಮೌಲ್ಯವನ್ನು ಅಳವಡಿಸಿ ಸಮಾಜ ಯೋಗ್ಯ ಸದಸ್ಯರನ್ನು ಹೊರಹೊಮ್ಮುವಂತೆ ಮಾಡುತ್ತವೆ. ಜೊತೆಗೆ ತಪ್ಪು ಹೆಜ್ಜೆ ಇಡುತ್ತಿರುವ ಯುವ ಜನಾಂಗವನ್ನು ಕೂಲಂಕುಶವಾಗಿ ಚರ್ಚಿಸಿ ಅವರನ್ನು ಸರಿಯಾದ ದಾರಿಯತ್ತ ಕೊಂಡೊಯ್ಯುತ್ತದೆ. ಮನುಷ್ಯರ ಭವಿಷ್ಯದ ಸಂಕೀರ್ಣ ಸಮಸ್ಯಾತ್ಮಕ ಜೀವನವನ್ನು ಎದುರಿಸುವಂತೆ ಮಾಡುತ್ತದೆ. ಹಾಗೂ ಮಾನವರು ಸ್ವಾವಲಂಬಿಗಳಾಗುವಂತೆ ಮಾಡುತ್ತ ಜೀವನದ ಮಟ್ಟವನ್ನು ಹೆಚ್ಚಿಸುತ್ತವೆ. ಇವು ವ್ಯಕ್ತಿಯ ಸರ್ವತೋಮುಖ ಅಭಿವೃದ್ದಿಗೆ ಪೂರಕವಾದ ಅಂಶಗಳಾಗಿವೆ.

ವ್ಯಕ್ತಿಯ ಆತ್ಮ ಸಾಕ್ಷಾತ್ಕಾರಕ್ಕೆ ಈ ಮೌಲ್ಯಗಳು ಸಹಾಯಕವಾಗುತ್ತವೆ. ಆದಿ ಶಂಕರಾಚಾರ್ಯರ 'ಆತ್ಮದ ಅರಿವೇ ಶಿಕ್ಷಣ' ಎನ್ನುವ ಮಾತುಗಳು ಆಧ್ಯಾತ್ಮಿಕ ಮೌಲ್ಯಗಳ ಮಹತ್ವ ಬಿಂಬಿಸಿವೆ. ಗಾಂಧೀಜಿ,

ಸ್ವಾಮಿ ವಿವೇಕಾನಂದ ಹಾಗೂ ಅರವಿಂದರ ಆಧ್ಯಾತ್ಮಿಕ ವಿಚಾರಗಳು ಸಹ ಪ್ರಸ್ತುತ ದಿನಗಳಂದು ಎಂದಿಗಿಂತಲೂ ಇಂದು ಈ ಮೌಲ್ಯಗಳ ಅಗತ್ಯತೆಯನ್ನು ಎತ್ತಿ ಹಿಡಿದಿವೆ. ಹೀಗೆ ಮನುಷ್ಯನ ಬದುಕನ್ನೇ ನಿರ್ಧರಿಸುವ ಮೌಲ್ಯಗಳು ಪ್ರತಿಯೊಬ್ಬರಲ್ಲಿ ಹಾಸು ಹೊಕ್ಕಾಗಿರಬೇಕು. ಅದಕ್ಕೆ ಮಾರ್ಗದರ್ಶನದ ಅಗತ್ಯವಿದೆ. ಆ ಮಾರ್ಗದರ್ಶನ ಶಿಕ್ಷಣದಿಂದ ಮಾತ್ರ ಸಾಧ್ಯ.

ಮನುಷ್ಯನಲ್ಲಿರುವ ಪ್ರಾಣಿ ಗುಣವನ್ನು ಸಂಸ್ಕರಿಸಿ ಮಾನವೀಯ ಗುಣಗಳನ್ನು ಬೆಳೆಸುವುದು ಹಾಗೂ ಮನುಷ್ಯನನ್ನು ಪರಿಪೂರ್ಣ ಶ್ರೇಷ್ಠ ವ್ಯಕ್ತಿಯನ್ನಾಗಿ ರೂಪಗೊಳಿಸುವುದೇ ಶಿಕ್ಷಣದ ಅಂತಿಮ ಗುರಿ. ಮನುಷ್ಯನು ಶಿಕ್ಷಣದಿಂದ ಸಂಸ್ಕಾರಗೊಂಡು ಮರುಹುಟ್ಟು ಪಡೆಯಬೇಕು. ಮನುಷ್ಯನ ಜೀವನ ಕೇವಲ ಹುಟ್ಟು – ಸಾವು ಅಷ್ಟೇ ಅಲ್ಲ, ಅವನ ಬದುಕು ಸಾರ್ಥಕವಾಗಬೇಕು. ಆ ಸಾರ್ಥಕ ಬದುಕಿಗೆ ಮೌಲ್ಯಗಳು ಅಗತ್ಯವಾಗಿ ಬೇಕು. ಆದರೆ ಇತ್ತೀಚಿನ ವರ್ಷಗಳಲ್ಲಿ ಶಿಕ್ಷಣದಲ್ಲಿ ಮಾಹಿತಿ ಮತ್ತು ತಂತ್ರಜ್ಞಾನಕ್ಕೆ ಉಚ್ಚ ಸ್ಥಾನವನ್ನು ನೀಡಲಾಗಿದ್ದು ಶಿಕ್ಷಣವು ಮಾಹಿತಿ ಅಥವಾ ಜ್ಞಾನವನ್ನು ಮಾರಾಟ ಮಾಡುವ ಉದ್ಯಮವಾಗಿ ಮಾರ್ಪಟ್ಟಿದೆ.

ಜ್ಞಾನದ ವೈಭವೀಕರಣ ಮತ್ತು ಜ್ಞಾನದ ವಾಣಿಜ್ಜೀಕರಣ ಎಲ್ಲಡೆ ಕಾಣುತ್ತಿದೆ. ಜಗತ್ತಿನ ನೋವು ನಿವಾರಣೆಗೆ ಮತ್ತು ಉನ್ನತಿಗಾಗಿ ಜ್ಞಾನ ಎಂಬುದು ಶಿಕ್ಷಣದ ಆದರ್ಶ. ಆದರೆ ಶಿಕ್ಷಣದಲ್ಲಿ ವಿದ್ಯಾರ್ಥಿಗಳ ಮಾಹಿತಿ ಸಂಗ್ರಹಣೆ ಮತ್ತು ಉನ್ನತಿಯನ್ನಷ್ಟೇ ಪರಿಗಣಿಸಿ ವ್ಯಕ್ತಿತ್ವ ವಿಕಾಸದ ಅಂಶಗಳಾದ ಶಾರೀರಿಕ ವಿಕಾಸ, ಭಾವನಾತ್ಮಕತೆ, ಸಾಮಾಜಿಕ, ಸಾಂಸ್ಕೃತಿಕ ಹಾಗೂ ನೈತಿಕ ಅಂಶಗಳು, ಮನೋಭಾವ, ಆಸಕ್ತಿ, ಸಹ ಮಾನವರ ಬಗ್ಗೆ ಕಾಳಜಿ, ಸಂವೇದನೆ, ಯೋಗ್ಯ ಹವ್ಯಾಸಗಳು ಇನ್ನಿತರ ಉತ್ತಮ ಮೌಲ್ಯಗಳನ್ನು ಬೆಳೆಸುವುದು ಗಣನೀಯವಾಗಿದೆ. ಈ ಹಿನ್ನಲೆಯಲ್ಲಿ ಶಿಕ್ಷಣದಲ್ಲಿ ಮೌಲ್ಯಗಳ ಅಳವಡಿಕೆ ಅವಶ್ಯವೇಷ್ಟೆಂಬುದನ್ನು ತಿಳಿಯಬಹುದು.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ :

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಎಂಬುದು ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಅತ್ಯಂತ ಪ್ರಮುಖವಾದ ಪರಿಕಲ್ಪನೆ. ವಿದ್ಯಾರ್ಥಿಯ ಜ್ಞಾನ, ಕೌಶಲ್ಯ, ಮನೋಭಾವ ಮತ್ತು ಸಾಮರ್ಥ್ಯಗಳನ್ನು ಅಳೆಯುವ ಪ್ರಮುಖ ಮಾನದಂಡವಾಗಿ ಇದು ಕಾರ್ಯನಿರ್ವಹಿಸುತ್ತದೆ. ಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಪ್ರಗತಿಯನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಮತ್ತು ಅವರ ಭವಿಷ್ಯ ರೂಪಿಸಲು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಮುಖ್ಯ ಪಾತ್ರ ವಹಿಸುತ್ತದೆ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಅರ್ಥ :

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಎಂದರೆ ವಿದ್ಯಾರ್ಥಿಯು ಶಾಲೆಯಲ್ಲಿ ಅಥವಾ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಯಲ್ಲಿ ಕಲಿತ ವಿಷಯಗಳ ಮೇಲೆ ಪಡೆದಿರುವ ಜ್ಞಾನ ಮತ್ತು ಅದನ್ನು ಪ್ರದರ್ಶಿಸುವ ಸಾಮರ್ಥ್ಯ. ಇದು ವಿದ್ಯಾರ್ಥಿಯ ಶ್ರಮ, ಬುದ್ಧಿಮತ್ತೆ, ಪರಿಸರ ಮತ್ತು ಶಿಕ್ಷಕರ ಮಾರ್ಗದರ್ಶನದ ಫಲಿತಾಂಶವಾಗಿದೆ. ಸರಳವಾಗಿ ಹೇಳುವುದಾದರೆ, ವಿದ್ಯಾರ್ಥಿಯು ಪಠ್ಯಕ್ರಮದಲ್ಲಿ ಎಷ್ಟು ಮಟ್ಟಿಗೆ ಯಶಸ್ಸು ಸಾಧಿಸಿದ್ದಾನೆ ಎಂಬುದನ್ನು ಸೂಚಿಸುವುದು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಕೇವಲ ಅಂಕಗಳು ಅಥವಾ ಶ್ರೇಣಿಗಳ ಮೂಲಕ ಮಾತ್ರ ಅಳೆಯಲಾಗುವುದಿಲ್ಲ; ಅದು ವಿದ್ಯಾರ್ಥಿಯ ಸಮಗ್ರ ಅಭಿವೃದ್ಧಿಯನ್ನು ಸೂಚಿಸುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಯ ಚಿಂತನೆ, ಸಮಸ್ಯೆ ಪರಿಹಾರ

ಸಾಮರ್ಥ್ಯ, ಸಂವಹನ ಕೌಶಲ್ಯ ಮತ್ತು ಸೃಜನಾತ್ಮಕತೆಯೂ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಭಾಗವಾಗಿವೆ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ವ್ಯಾಖ್ಯೆಗಳು :

ವಿವಿಧ ಶಿಕ್ಷಣ ತಜ್ಞರು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ವಿಭಿನ್ನ ರೀತಿಯಲ್ಲಿ ವ್ಯಾಖ್ಯಾನಿಸಿದ್ದಾರೆ:

1. ಕ್ರೋ ಮತ್ತು ಕ್ರೋ ಅವರ ಪ್ರಕಾರ – **"ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಎಂದರೆ ವಿದ್ಯಾರ್ಥಿಯು ಶಿಕ್ಷಣದ ಮೂಲಕ ಪಡೆದಿರುವ ಜ್ಞಾನ ಮತ್ತು ಕೌಶಲ್ಯಗಳನ್ನು ಪ್ರದರ್ಶಿಸುವ ಸಾಮರ್ಥ್ಯ".**

2. ಬ್ಲೂಮ್ ಅವರ ಪ್ರಕಾರ – **"ಶೈಕ್ಷಣಿಕ ಸಾಧನೆವು ಜ್ಞಾನ, ಗ್ರಹಿಕೆ, ಅನ್ವಯ, ವಿಶ್ಲೇಷಣೆ, ಸಂಯೋಜನೆ ಮತ್ತು ಮೌಲ್ಯಮಾಪನದಂತಹ ವಿವಿಧ ಮಾನಸಿಕ ಮಟ್ಟಗಳನ್ನು ಒಳಗೊಂಡಿರುತ್ತದೆ".**

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಪ್ರಾಮುಖ್ಯತೆ :

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ವಿದ್ಯಾರ್ಥಿಯ ಜೀವನದಲ್ಲಿ ಬಹಳ ಮಹತ್ವವನ್ನು ಹೊಂದಿದೆ. ಅದರ ಪ್ರಾಮುಖ್ಯತೆಯನ್ನು ಕೆಳಗಿನಂತೆ ವಿವರಿಸಬಹುದು:

1. ವೈಯಕ್ತಿಕ ಅಭಿವೃದ್ಧಿ : ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ವಿದ್ಯಾರ್ಥಿಯ ವ್ಯಕ್ತಿತ್ವವನ್ನು ರೂಪಿಸುತ್ತದೆ. ಉತ್ತಮ ಸಾಧನೆ ಆತ್ಮವಿಶ್ವಾಸವನ್ನು ಹೆಚ್ಚಿಸುತ್ತದೆ ಮತ್ತು ಜೀವನದಲ್ಲಿ ಯಶಸ್ಸು ಸಾಧಿಸಲು ಪ್ರೇರೇಪಿಸುತ್ತದೆ.

2. ಭವಿಷ್ಯದ ಅವಕಾಶಗಳು : ಉತ್ತಮ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಉತ್ತಮ ಉದ್ಯೋಗ ಮತ್ತು ಉನ್ನತ ಶಿಕ್ಷಣದ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತದೆ. ಇದು ವಿದ್ಯಾರ್ಥಿಯ ಭವಿಷ್ಯವನ್ನು ನಿರ್ಧರಿಸುವ ಪ್ರಮುಖ ಅಂಶವಾಗಿದೆ.

3. ಸಾಮಾಜಿಕ ಸ್ಥಾನಮಾನ : ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಸಮಾಜದಲ್ಲಿ ಗೌರವ ಮತ್ತು ಸ್ಥಾನಮಾನವನ್ನು ಹೆಚ್ಚಿಸುತ್ತದೆ. ಶಿಕ್ಷಣ ಪಡೆದ ವ್ಯಕ್ತಿಗಳು ಸಮಾಜದಲ್ಲಿ ಹೆಚ್ಚಿನ ಪ್ರಭಾವವನ್ನು ಹೊಂದಿರುತ್ತಾರೆ.

4. ಆರ್ಥಿಕ ಅಭಿವೃದ್ಧಿ : ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ವ್ಯಕ್ತಿಯ ಆರ್ಥಿಕ ಸ್ಥಿತಿಯನ್ನು ಸುಧಾರಿಸುತ್ತದೆ. ಉತ್ತಮ ಶಿಕ್ಷಣವು ಉತ್ತಮ ಉದ್ಯೋಗಾವಕಾಶಗಳಿಗೆ ದಾರಿ ಮಾಡಿಕೊಡುತ್ತದೆ.

5. ರಾಷ್ಟ್ರೀಯ ಅಭಿವೃದ್ಧಿ : ಒಳ್ಳೆಯ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಹೊಂದಿರುವ ನಾಗರಿಕರು ದೇಶದ ಅಭಿವೃದ್ಧಿಗೆ ಕೊಡುಗೆ ನೀಡುತ್ತಾರೆ. ಶಿಕ್ಷಣವು ದೇಶದ ಆರ್ಥಿಕ ಮತ್ತು ಸಾಮಾಜಿಕ ಪ್ರಗತಿಗೆ ಆಧಾರವಾಗಿದೆ.

6. ಸೃಜನಶೀಲತೆ ಮತ್ತು ನವೀನತೆ : ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಸೃಜನಶೀಲತೆ ಮತ್ತು ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ಉತ್ತೇಜಿಸುತ್ತದೆ. ಇದು ವೈಜ್ಞಾನಿಕ ಮತ್ತು ತಾಂತ್ರಿಕ ಅಭಿವೃದ್ಧಿಗೆ ಸಹಕಾರಿ.

ಶಾಲಾ ವಿದ್ಯಾರ್ಥಿಗಳ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಮಾಪನಗಳು :

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಅಳೆಯಲು ಹಲವು ವಿಧಾನಗಳನ್ನು ಬಳಸಲಾಗುತ್ತದೆ. ಅವುಗಳಲ್ಲಿ ಕೆಲವು ಮುಖ್ಯವಾದವುಗಳು:

1. **ಪರೀಕ್ಷೆಗಳು ;** ಪರೀಕ್ಷೆಗಳು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಅಳೆಯುವ ಪ್ರಮುಖ ಸಾಧನವಾಗಿದೆ. ವಾರ್ಷಿಕ ಪರೀಕ್ಷೆಗಳು, ಅರ್ಧವಾರ್ಷಿಕ ಪರೀಕ್ಷೆಗಳು ಮತ್ತು ತರಗತಿ ಪರೀಕ್ಷೆಗಳು ವಿದ್ಯಾರ್ಥಿಯ ಜ್ಞಾನವನ್ನು ಅಳೆಯುತ್ತವೆ.
2. **ನಿರಂತರ ಮೌಲ್ಯಮಾಪನ ;** ಇದು ವಿದ್ಯಾರ್ಥಿಯ ಪ್ರಗತಿಯನ್ನು ನಿರಂತರವಾಗಿ ಗಮನಿಸುವ ವಿಧಾನವಾಗಿದೆ. ಇದರಲ್ಲಿ ಗೃಹಕಾರ್ಯ, ಪ್ರಾಜೆಕ್ಟ್‌ಗಳು, ಪ್ರಸ್ತುತಿಕೆಗಳು ಮತ್ತು ತರಗತಿ ಚಟುವಟಿಕೆಗಳು ಒಳಗೊಂಡಿವೆ.

3. **ಶ್ರೇಣಿಗಳು** ; ವಿದ್ಯಾರ್ಥಿಯ ಸಾಧನೆಯನ್ನು ಶ್ರೇಣಿಗಳ ಮೂಲಕ ಅಳೆಯಲಾಗುತ್ತದೆ. ಉದಾಹರಣೆಗೆ A, B, C ಇತ್ಯಾದಿ.
4. **ಪ್ರಮಾಣಿತ ಪರೀಕ್ಷೆಗಳು** ; ಇವು ವಿದ್ಯಾರ್ಥಿಗಳ ಸಾಮರ್ಥ್ಯವನ್ನು ಸಾಮಾನ್ಯ ಮಾನದಂಡಗಳ ಆಧಾರದ ಮೇಲೆ ಅಳೆಯುವ ಪರೀಕ್ಷೆಗಳಾಗಿವೆ.
5. **ಪೋರ್ಟ್‌ಫೋಲಿಯೊ** ; ವಿದ್ಯಾರ್ಥಿಯ ಕೆಲಸಗಳ ಸಂಗ್ರಹವನ್ನು ಪೋರ್ಟ್‌ಫೋಲಿಯೊ ಎಂದು ಕರೆಯಲಾಗುತ್ತದೆ. ಇದು ವಿದ್ಯಾರ್ಥಿಯ ಪ್ರಗತಿಯನ್ನು ಸಮಗ್ರವಾಗಿ ತೋರಿಸುತ್ತದೆ.
6. **ಶಿಕ್ಷಕರ ಮೌಲ್ಯಮಾಪನ** ; ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಯ ವರ್ತನೆ, ಭಾಗವಹಿಸುವಿಕೆ ಮತ್ತು ಕೌಶಲ್ಯಗಳನ್ನು ಗಮನಿಸಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡುತ್ತಾರೆ.
7. **ಸ್ವಯಂ ಮೌಲ್ಯಮಾಪನ** ; ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮದೇ ಸಾಧನೆಯನ್ನು ತಾವು ಮೌಲ್ಯಮಾಪನ ಮಾಡುವುದೂ ಸಹ ಮುಖ್ಯವಾಗಿದೆ.
8. **ಸಹಪಾಠಿಗಳ ಮೌಲ್ಯಮಾಪನ** ; ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಸಹಪಾಠಿಗಳ ಕಾರ್ಯಗಳನ್ನು ಮೌಲ್ಯಮಾಪನ ಮಾಡುವುದರಿಂದ ಕಲಿಕೆಯ ಗುಣಮಟ್ಟ ಹೆಚ್ಚುತ್ತದೆ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗೆ ಪ್ರಭಾವ ಬೀರುವ ಅಂಶಗಳು :

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಗೆ ಹಲವಾರು ಅಂಶಗಳು ಪ್ರಭಾವ ಬೀರುತ್ತವೆ: ಅವುಗಳಲ್ಲಿ ಪ್ರಮುಖವಾಗಿ ಕುಟುಂಬದ ಹಿನ್ನೆಲೆ, ಆರ್ಥಿಕ ಸ್ಥಿತಿ, ಶಾಲೆಯ ವಾತಾವರಣ, ಶಿಕ್ಷಕರ ಗುಣಮಟ್ಟ, ವಿದ್ಯಾರ್ಥಿಯ ಆಸಕ್ತಿ ಮತ್ತು ಪ್ರೇರಣೆ, ಸ್ನೇಹಿತರ ಪ್ರಭಾವ, ಆರೋಗ್ಯ ಮತ್ತು ಪೌಷ್ಟಿಕತೆ ಮುಂತಾದವು.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಸುಧಾರಿಸುವ ಮಾರ್ಗಗಳು

ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಪ್ರೇರಣೆ ನೀಡುವುದು, ಉತ್ತಮ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಬಳಸುವುದು, ಪೋಷಕರ ಸಹಕಾರ, ವೈಯಕ್ತಿಕ ಗಮನ, ತಂತ್ರಜ್ಞಾನ ಬಳಕೆ, ಸಮಯ ನಿರ್ವಹಣೆಯನ್ನು ರೂಢಿಸುವುದರ ಮೂಲಕ ಮಕ್ಕಳ ಶೈಕ್ಷಣಿಕ ಸಾದನೆಯನ್ನು ಸುಧಾರಿಸಬಹುದು.

ಒಟ್ಟಾರೆಯಾಗಿ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ವಿದ್ಯಾರ್ಥಿಯ ಜೀವನದ ಪ್ರಮುಖ ಅಂಶವಾಗಿದೆ. ಇದು ಕೇವಲ ಅಂಕಗಳು ಅಥವಾ ಶ್ರೇಣಿಗಳ ಮೂಲಕ ಮಾತ್ರ ಅಳೆಯಲಾಗುವುದಿಲ್ಲ; ಅದು ವಿದ್ಯಾರ್ಥಿಯ ಸಮಗ್ರ ಅಭಿವೃದ್ಧಿಯನ್ನು ಸೂಚಿಸುತ್ತದೆ. ವಿದ್ಯಾರ್ಥಿಗಳ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಹೆಚ್ಚಿಸಲು ಶಿಕ್ಷಕರು, ಪೋಷಕರು ಮತ್ತು ಸಮಾಜವು ಒಟ್ಟಾಗಿ ಕೆಲಸ ಮಾಡಬೇಕು. ಸರಿಯಾದ ಮಾರ್ಗದರ್ಶನ ಮತ್ತು ಪ್ರೇರಣೆಯ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳು ತಮ್ಮ ಸಾಮರ್ಥ್ಯವನ್ನು ಸಂಪೂರ್ಣವಾಗಿ ಬಳಸಿಕೊಳ್ಳಬಹುದು. ಇದೇ ಕಾರಣಕ್ಕೆ, ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ಹೃದಯವಾಗಿದೆ ಮತ್ತು ಅದು ವಿದ್ಯಾರ್ಥಿಗಳ ಭವಿಷ್ಯವನ್ನು ರೂಪಿಸುವ ಪ್ರಮುಖ ಸಾಧನವಾಗಿದೆ.

ಅಧ್ಯಯನದ ಪ್ರಾಮುಖ್ಯತೆ :

ಇಂದಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಬುದ್ಧಿಶಕ್ತಿಯ ಕೊರತೆಯಿಲ್ಲದೇ ಉತ್ತಮ ಶೈಕ್ಷಣಿಕ ಸಾದನೆಯನ್ನು ಮಾಡುತ್ತಿದ್ದಾರೆ. ಆದರೆ ಮೌಲ್ಯಗಳ ಅಳವಡಿಕೆಯಲ್ಲಿ ತಾತ್ಸಾರವಿರುವುದು ಮೇಲ್ನೋಟಕ್ಕೆ ಕಂಡುಬರುತ್ತಿದೆ.

ಪ್ರತಿಯೊಬ್ಬ ಮನುಷ್ಯನು ಉತ್ತಮ ಬುದ್ಧಿಶಕ್ತಿಯಿಂದಲೇ ಹುಟ್ಟುತ್ತಾನೆ. ಆದರೆ ಅವನ ಬೆಳವಣಿಗೆಯ ಹಂತದಲ್ಲಿ ಕಲಿಕೆಗೆ ತಕ್ಕಂತೆ ಬುದ್ಧಿಶಕ್ತಿ ಪರಿವರ್ತನೆಯಾಗುವ ಸಾಧ್ಯತೆ ಕಂಡುಬರುವುದು. ಇಂತಹ ಬುದ್ಧಿಶಕ್ತಿಯನ್ನು ಧನಾತ್ಮಕ ಮೌಲ್ಯಗಳ ಕಡೆಗೆ ಬೆಳೆಸಬೇಕಾಗಿದೆ. ಹಾಗಾದಾಗ ಮಾತ್ರ ರಾಷ್ಟ್ರದ ಪ್ರಗತಿಗೆ ಪೂರಕವಾಗುತ್ತದೆ. ಈ ಹಿನ್ನಲೆಯಲ್ಲಿ ಮೌಲ್ಯಗಳು ಮಾಧ್ಯಮಿಕ ಶಿಕ್ಷಣ ಪಡೆಯುವ ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಹೇಗೆ ಮೇಳೈಸಿದೆ ಎಂಬುದನ್ನು ಪ್ರಸ್ತುತ ಅಧ್ಯಯನದಿಂದ ತಿಳಿಯಬಹುದಾಗಿದೆ.

ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು :

1. ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.
2. ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.
3. ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.
4. ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

ಅಧ್ಯಯನದ ವ್ಯಾಪ್ತಿ :

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನಕ್ಕೆ ಸರಳ ಯಾದೃಚ್ಚಿಕ ಪ್ರತಿಚಯನದ ಮೂಲಕ ಶಿಕಾರಿಪುರ ತಾಲ್ಲೂಕಿನ 2 ವಸತಿ ಪ್ರೌಢಶಾಲೆಯ ತಲಾ 50 ರಂತೆ 100 ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಹಾಗೂ 2 ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ತಲಾ 50 ರಂತೆ 100 ವಿದ್ಯಾರ್ಥಿಗಳಂತೆ 9ನೇ ತರಗತಿಯ ಒಟ್ಟು 200 ವಿದ್ಯಾರ್ಥಿಗಳನ್ನು ಅಧ್ಯಯನಕ್ಕೆ ಒಳಪಡಿಸಲಾಗಿದೆ.

ಅದ್ಯಯನದ ವಿಧಾನ ;

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನಕ್ಕೆ ವಿವರಣಾತ್ಮಕ ಸಂಶೋಧನಾ ವಿಧಾನವನ್ನು ಬಳಸಲಾಗಿದೆ. ಅದಕ್ಕಾಗಿ ಚಲಕವಾದ ಮೌಲ್ಯಗಳನ್ನು ಪರೀಕ್ಷಿಸಲು ರವಿ ಹೆಚ್ ಮತ್ತು ಡಾ. ಜಗದೀಶ ಬಿ ರವರು ಅಭಿವೃದ್ಧಿಪಡಿಸಿದ **"ವೈಯಕ್ತಿಕ ಮೌಲ್ಯ ಪ್ರಶ್ನಾವಳಿ"**ಯನ್ನು ಬಳಸಿಕೊಳ್ಳಲಾಗಿದೆ. ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯನ್ನು ಪರೀಕ್ಷಿಸಲು ವಿದ್ಯಾರ್ಥಿಗಳ ಅಂತಿಮ ಪರೀಕ್ಷೆಯ ಅಂಕಗಳನ್ನು ಆಯಾ ಶಾಲೆಗಳ ಮುಖ್ಯೋಪಾಧ್ಯಾಯರಿಂದ ಮಾಹಿತಿಯನ್ನು ಪಡೆದು ಬಳಸಿಕೊಳ್ಳಲಾಗಿದೆ. ಅಲ್ಲದೆ ಫಲಿತಾಂಶ ವಿಶ್ಲೇಷಣೆಗೆ ಸಂಖ್ಯಾಶಾಸ್ತ್ರದ ಸರಾಸರಿ, ಮಾನಕ ವಿಚಲನೆ ಮತ್ತು 't' ಪರೀಕ್ಷಣ ತಂತ್ರಗಳನ್ನು ಉಪಯೋಗಿಸಿಕೊಳ್ಳಲಾಗಿದೆ.

ಅಧ್ಯಯನದ ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ಅರ್ಥೈಸುವಿಕೆ :

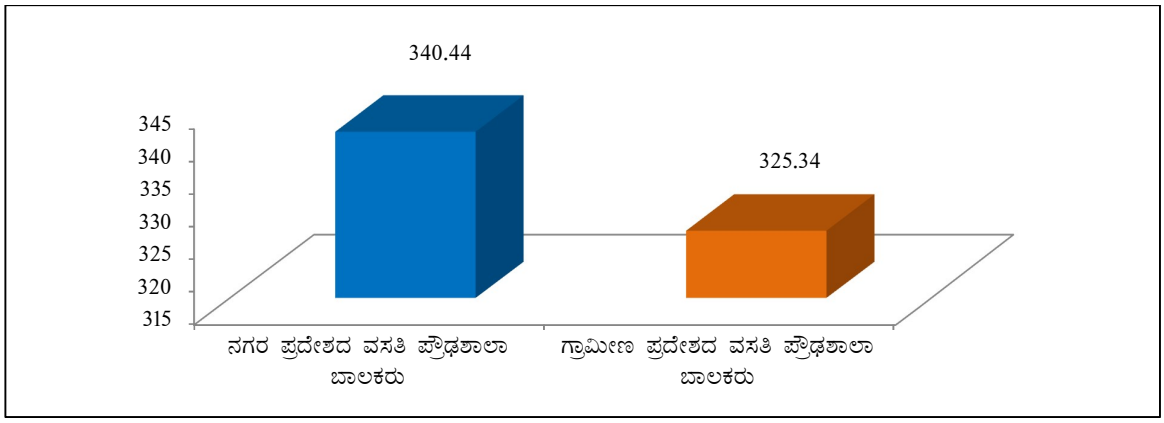
ಉದ್ದೇಶ : 1. ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

ಕೋಷ್ಟಕ : 1 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ

ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಕೋಷ್ಟಕ.

ಮೌಲ್ಯಗಳು					
ಶಾಲೆಗಳು	**ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂಖ್ಯೆ**	**ಸರಾಸರಿ**	**ಮಾನಕ ವಿಚಲನೆ**	**ಟಿ ಮೌಲ್ಯ**	**ಲಕ್ಷಾರ್ಹತೆ**
ನಗರ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರು	50	340.44	18.47244	4.114	0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿದೆ.
ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರು	50	325.34	18.23387		

ಆಲೇಖ : 1 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಸ್ತಂಭಲೇಖ.



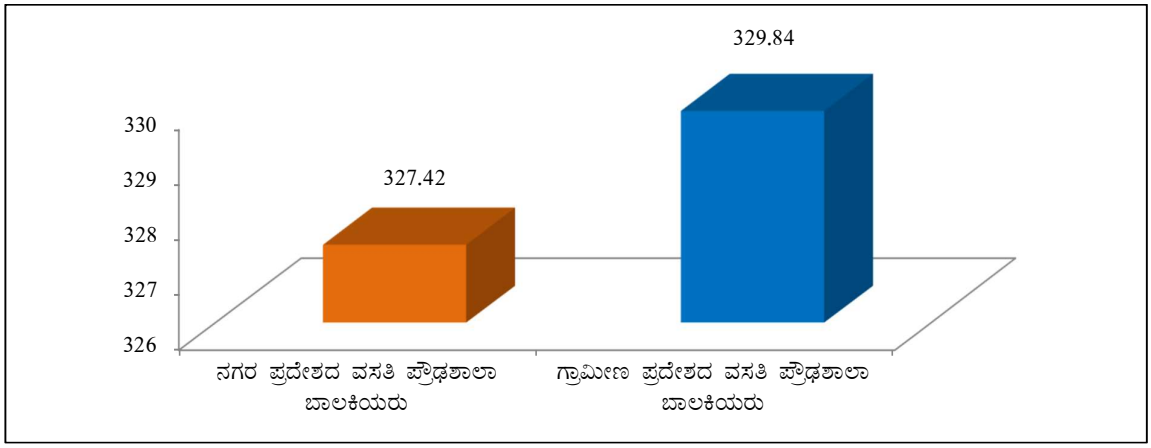
ಮೇಲಿನ ಕೋಷ್ಟಕ 1ರಲ್ಲಿ ಬಂದಂತಹ 'ಟಿ' ಮೌಲ್ಯವು 4.114 ಆಗಿದ್ದು, ಇದು ಸೈದ್ಧಾಂತಿಕ ಬೆಲೆ 1.96 ಕ್ಕಿಂತ ಹೆಚ್ಚಾಗಿರುವುದರಿಂದ 0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿದೆ. ಅದರಂತೆ ನಗರ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ಬೆಲೆಯಲ್ಲಿ ವ್ಯತ್ಯಾಸವಿದೆ. ಅಂದರೆ ಮೌಲ್ಯಗಳ ಸರಾಸರಿಯಲ್ಲಿ ನಗರ ಪ್ರದೇಶದ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಮೌಲ್ಯ ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ಪ್ರೌಢಶಾಲೆ ಬಾಲಕರ ಮೌಲ್ಯಕ್ಕಿಂತ ಹೆಚ್ಚಾಗಿದೆ. ಅಂದರೆ ಎರಡೂ ಶಾಲೆಗಳ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ನಡುವೆ ಮಹತ್ವಪೂರ್ಣ ವ್ಯತ್ಯಾಸವಿದೆ ಎಂದು ಈ ಅಧ್ಯಯನದಿಂದ ತಿಳಿದು ಬಂದಿದೆ.

ಉದ್ದೇಶ : 2. ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

ಕೋಷ್ಟಕ : 2 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಕೋಷ್ಟಕ.

ಮೌಲ್ಯಗಳು					
ಶಾಲೆಗಳು	**ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂಖ್ಯೆ**	**ಸರಾಸರಿ**	**ಮಾನಕ ವಿಚಲನೆ**	**ಟಿ ಮೌಲ್ಯ**	**ಲಕ್ಷಾರ್ಹತೆ**
ನಗರ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರು	50	327.42	24.62129	.560	0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ.
ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರು	50	329.84	18.07508		

ಆಲೇಖ : 2 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಸ್ತಂಭಲೇಖ.



ಮೇಲಿನ ಕೋಷ್ಟಕ 2ರಲ್ಲಿ ಬಂದಂತಹ 'ಟಿ' ಮೌಲ್ಯವು .560 ಆಗಿದ್ದು, ಇದು ಸೈದ್ಧಾಂತಿಕ ಬೆಲೆ 1.96 ಕ್ಕಿಂತ ಕಡಿಮೆಯಾಗಿರುವುದರಿಂದ 0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ. ಅದರಂತೆ, **ನಗರ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ಬೆಲೆಯಲ್ಲಿ ವ್ಯತ್ಯಾಸವಿಲ್ಲ.** ಅಂದರೆ ಮೌಲ್ಯಗಳ ಸರಾಸರಿಯಲ್ಲಿ ನಗರ ಪ್ರದೇಶದ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ಪ್ರೌಢಶಾಲೆ ಬಾಲಕಿಯರ

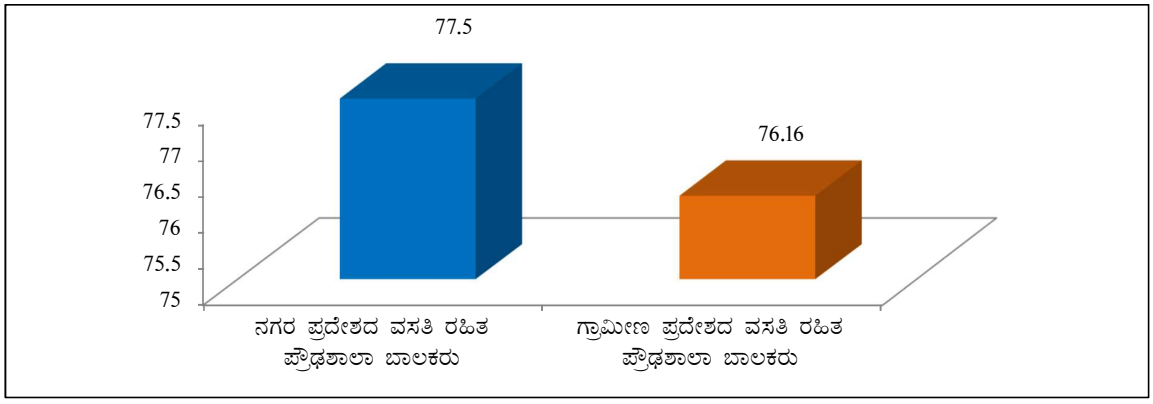
ಮೌಲ್ಯಗಳ ನಡುವೆ ಯಾವುದೇ ಹೆಚ್ಚಿನ ವ್ಯತ್ಯಾಸವಿಲ್ಲ ಎಂದು ಈ ಅಧ್ಯಯನದಿಂದ ತಿಳಿದು ಬಂದಿದೆ.

ಉದ್ದೇಶ : 3. ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

ಕೋಷ್ಟಕ : 3 ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಸುವ ಕೋಷ್ಟಕ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ					
ಶಾಲೆಗಳು	**ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂಖ್ಯೆ**	**ಸರಾಸರಿ**	**ಮಾನಕ ವಿಚಲನೆ**	**ಟಿ ಮೌಲ್ಯ**	**ಲಕ್ಷಾರ್ಹತೆ**
ನಗರ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರು	50	77.50	8.55057	.889	0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ.
ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರು	50	76.16	6.36111		

ಆಲೇಖ : 3 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಸ್ತಂಭಲೇಖ.



ಮೇಲಿನ ಕೋಷ್ಟಕ 3ರಲ್ಲಿ ಬಂದಂತಹ 'ಟಿ' ಮೌಲ್ಯವು .889 ಆಗಿದ್ದು, ಇದು ಸೈದ್ಧಾಂತಿಕ ಬೆಲೆ 1.96 ಕ್ಕಿಂತ ಕಡಿಮೆಯಾಗಿರುವುದರಿಂದ 0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ. ಅದರಂತೆ, **ನಗರ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ಬೆಲೆಯಲ್ಲಿ ವ್ಯತ್ಯಾಸವಿಲ್ಲ.** ಅಂದರೆ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿಯಲ್ಲಿ ನಗರ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ನಡುವೆ ಯಾವುದೇ ಮಹತ್ವಪೂರ್ಣ

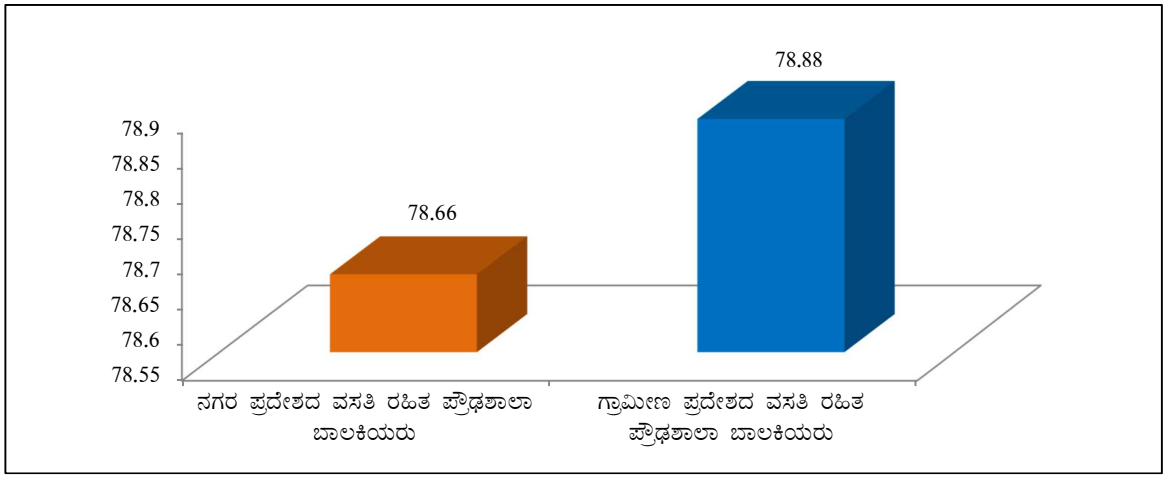
ವ್ಯತ್ಯಾಸವಿಲ್ಲ ಎಂದು ಈ ಅಧ್ಯಯನದಿಂದ ತಿಳಿದು ಬಂದಿದೆ.

ಉದ್ದೇಶ : 4. ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

ಕೋಷ್ಟಕ : 4 ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಸುವ ಕೋಷ್ಟಕ.

ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ					
ಶಾಲೆಗಳು	**ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂಖ್ಯೆ**	**ಸರಾಸರಿ**	**ಮಾನಕ ವಿಚಲನೆ**	**ಟಿ ಮೌಲ್ಯ**	**ಲಕ್ಷಾರ್ಹತೆ**
ನಗರ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರು	50	78.66	6.87085	.162	0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ.
ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರು	50	78.88	6.72382		

ಆಲೇಖ : 4 ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯುವ ಸ್ತಂಭಲೇಖ.



ಮೇಲಿನ ಕೋಷ್ಟಕ 4ರಲ್ಲಿ ಬಂದಂತಹ 'ಟಿ' ಮೌಲ್ಯವು .162 ಆಗಿದ್ದು, ಇದು ಸೈದ್ಧಾಂತಿಕ ಬೆಲೆ 1.96ಕ್ಕಿಂತ ಕಡಿಮೆಯಾಗಿರುವುದರಿಂದ 0.05 ಮಟ್ಟದಲ್ಲಿ ಲಕ್ಷಾರ್ಹತೆಯನ್ನು ಹೊಂದಿಲ್ಲ. ಅದರಂತೆ, **ನಗರ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳು ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ**

ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ಬೆಲೆಯಲ್ಲಿ ವ್ಯತ್ಯಾಸವಿಲ್ಲ. ಅಂದರೆ ಶೈಕ್ಷಣಿಕ ಸಾದನೆಯ ಸರಾಸರಿಯಲ್ಲಿ ನಗರ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ನಡುವೆ ಯಾವುದೇ ಮಹತ್ವಪೂರ್ಣ ವ್ಯತ್ಯಾಸವಿಲ್ಲ ಎಂದು ಈ ಅಧ್ಯಯನದಿಂದ ತಿಳಿದು ಬಂದಿದೆ.

ಶೈಕ್ಷಣಿಕ ನಿಹಿತಾರ್ಥಗಳು :

1. ಪ್ರಸ್ತುತ ಅದ್ಯಯನದಿಂದ ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯಬಹುದಾಗಿದೆ.
2. ಪ್ರಸ್ತುತ ಅದ್ಯಯನದಿಂದ ನಗರ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ಪ್ರೌಢಶಾಲಾ ಬಾಲಕಿಯರ ಮೌಲ್ಯಗಳ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯಬಹುದಾಗಿದೆ.
3. ಪ್ರಸ್ತುತ ಅದ್ಯಯನದಿಂದ ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯಬಹುದಾಗಿದೆ.
4. ಪ್ರಸ್ತುತ ಅದ್ಯಯನದಿಂದ ನಗರ ಪ್ರದೇಶ ಮತ್ತು ಗ್ರಾಮೀಣ ಪ್ರದೇಶದ ವಸತಿ ರಹಿತ ಪ್ರೌಢಶಾಲೆಗಳ ಬಾಲಕಿಯರ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಸರಾಸರಿ ನಡುವಿನ ವ್ಯತ್ಯಾಸವನ್ನು ತಿಳಿಯಬಹುದಾಗಿದೆ.

ಉಪಸಂಹಾರ :

ನಮ್ಮ ದೇಶವು ಶ್ರೀಮಂತವಾದ ಸಾಂಸ್ಕೃತಿಕ ಪರಂಪರೆಯನ್ನು ಹೊಂದಿದೆ. ವಿಶಿಷ್ಟ ರೀತಿಯ ಜೀವನಪರ ಹಾಗೂ ಮಾನವೀಯ ದ್ರವ್ಯಗಳು ಮತ್ತು ಸಂದೇಶಗಳನ್ನು ಒಳಗೊಂಡಿದೆ. ಈ ಸಾಂಸ್ಕೃತಿಕ – ಧಾರ್ಮಿಕ ಬಹುರೂಪತೆ, ವೈವಿದ್ಯಮಯವಾದ ಭೌಗೋಳಿಕ ಪರಂಪರೆಯನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳು ಅರ್ಥಮಾಡಿಕೊಂಡು ನಡೆಯಬೇಕಾಗಿದೆ. ಈ ರೀತಿಯಲ್ಲಿ ಮನುಷ್ಯ ಪರಿಸರದೊಂದಿಗೆ ಸಾಮರಸ್ಯವಾಗಿ ಬೆಳೆದಿರುವುದನ್ನು, ವೈವಿಧ್ಯತೆಯಲ್ಲಿ ಏಕತೆಯನ್ನು ಕಾಯ್ದುಕೊಂಡು ಬಂದಿರುವ ವಿಧಾನವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವ ಸಲುವಾಗಿ ಶಿಕ್ಷಣದಲ್ಲಿ ಮೌಲ್ಯಗಳನ್ನು ಅಳವಡಿಸುವುದು ಅವಶ್ಯ. "ಇಂದಿನ ಮಕ್ಕಳೇ ಮುಂದಿನ ಪ್ರಜೆಗಳು" ಎಂಬುದನ್ನು ಅರಿತು ಉತ್ತಮ ಸಮಾಜ ಹಾಗೂ ದೇಶದ ನಿರ್ಮಾಣಕ್ಕೆ ಉತ್ತಮ ವ್ಯಕ್ತಿಗಳನ್ನು ತಯಾರು ಮಾಡುವ ಹೊಣೆ ಶಿಕ್ಷಣದ ಮೇಲಿರುವುದರಿಂದ ಪ್ರತಿಯೊಂದು ಶಾಲೆ, ಕಾಲೇಜುಗಳು ಮಕ್ಕಳಲ್ಲಿ ನೈತಿಕತೆಯೊಂದಿಗೆ ಶೈಕ್ಷಣಿಕ ಸಾಧನೆಯ ಮಟ್ಟವನ್ನು ಸುಧಾರಿಸುವಲ್ಲಿ ಮಹತ್ವದ ಹೆಜ್ಜೆಯನ್ನಿಟ್ಟು ಉತ್ತಮ ಜೀವನ ರೂಪಿಸಿಕೊಳ್ಳಲು ಸರ್ವರೀತಿಯಿಂದ ಪ್ರಯತ್ನಿಸಬೇಕಾಗಿದೆ.

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ಸುಜಾತ. ಆರ್.
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು, ಕನ್ನಡ ವಿಭಾಗ, ಎನ್.ಇ.ಎಸ್. ಇನ್‌ಸ್ಟಿಟ್ಯೂಟ್ ಆಫ್ ಅಡ್ವಾನ್ಸ್ಡ್ ಸ್ಟಡೀಸ್, ಜೆ.ಎನ್.ಎನ್.ಸಿ.ಇ. ಕ್ಯಾಂಪಸ್, ನವಲೆ, ಶಿವಮೊಗ್ಗ
ಡಾ. ಲಕ್ಷ್ಮಣ.ಕೆ
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು., ಎಸ್.ಆರ್.ಎಂ.ಎನ್. ಕಾಲೇಜು, ಶಿವಮೊಗ್ಗ

ಪೀಠಿಕೆ

ಕನ್ನಡವು ಭಾರತದ ಪ್ರಾಚೀನ ಮತ್ತು ಶ್ರೀಮಂತ ದ್ರಾವಿಡ ಭಾಷೆಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಸುಮಾರು ಎರಡು ಸಾವಿರ ವರ್ಷಗಳಿಗೂ ಹೆಚ್ಚಿನ ಇತಿಹಾಸ, ಸಮೃದ್ಧ ಸಾಹಿತ್ಯ ಪರಂಪರೆ, ವೈವಿಧ್ಯಮಯ ಜನಪದ ಸಂಸ್ಕೃತಿ ಹಾಗೂ ವಿಶಿಷ್ಟ ಭಾಷಾ ವೈಶಿಷ್ಟ್ಯಗಳನ್ನು ಹೊಂದಿರುವ ಕನ್ನಡಕ್ಕೆ ಶಾಸ್ತ್ರೀಯ ಭಾಷೆಯ ಸ್ಥಾನಮಾನ ದೊರೆತಿದೆ. ಕನ್ನಡ ಸಾಹಿತ್ಯದ ಶ್ರೀಮಂತಿಕೆಗೆ ಎಂಟು ಜ್ಞಾನಪೀಠ ಪ್ರಶಸ್ತಿಗಳ ಸಾಧನೆಯೂ ಸಾಕ್ಷಿಯಾಗಿದೆ. ರಾಜಾಶ್ರಯ, ಜನಾಶ್ರಯ ಮತ್ತು ಸಾಹಿತಿಗಳ ಕೊಡುಗೆಯಿಂದ ಕನ್ನಡವು ಕಾಲದಿಂದ ಕಾಲಕ್ಕೆ ಬೆಳೆಯುತ್ತ ಬಂದಿದೆ.

ಭಾಷೆ ಎನ್ನುವುದು ಕೇವಲ ಸಂವಹನದ ಸಾಧನವಲ್ಲ. ಅದು ಒಂದು ಸಮುದಾಯದ ಇತಿಹಾಸ, ಸಂಸ್ಕೃತಿ, ಸಾಮಾಜಿಕ ಬದುಕು, ಜ್ಞಾನ, ಭಾವನೆ ಮತ್ತು ಚಿಂತನೆಯ ಪ್ರತಿಬಿಂಬವಾಗಿದೆ. ಆದ್ದರಿಂದ ಕನ್ನಡದ ಉಳಿವು ಮತ್ತು ಬೆಳವಣಿಗೆಗೆ ಕನ್ನಡ ಕಲಿಕೆಗೆ ವಿಶೇಷ ಮಹತ್ವವಿದೆ. ಆದರೆ ಜಾಗತೀಕರಣ, ಆಂಗ್ಲ ಭಾಷೆಯ ಹೆಚ್ಚುತ್ತಿರುವ ಪ್ರಭಾವ, ಖಾಸಗಿ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳ ವಿಸ್ತರಣೆ, ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಕುಸಿತ, ಉದ್ಯೋಗದ ಕುರಿತ ತಪ್ಪು ಕಲ್ಪನೆ, ಡಿಜಿಟಲ್ ಕ್ಷೇತ್ರದಲ್ಲಿ ಕನ್ನಡದ ಸೀಮಿತ ಬಳಕೆ ಹಾಗೂ ಗಡಿಭಾಗಗಳ ಭಾಷಾ ಪರಿಸ್ಥಿತಿಗಳು ಕನ್ನಡ ಕಲಿಕೆಗೆ ಹಲವು ಸವಾಲುಗಳನ್ನು ತಂದಿವೆ.

ಇದೇ ಸಂದರ್ಭದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (ಂಡಿಣುಜಿuಛಿiಚಿಟ ಖಟಿಣಜಟಟುರಜಟಿಛಿಜ–ಂಖ) ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಹೊಸ ಸಾಧ್ಯತೆಗಳನ್ನು ತೆರೆದಿದೆ. ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಭಾಷಾ ಅಭ್ಯಾಸ, ವ್ಯಾಕರಣ ತಿದ್ದುಪಡಿ, ಧ್ವನಿ ಗುರುತಿಸುವಿಕೆ, ಭಾಷಾಂತರ, ಪಠ್ಯ ರಚನೆ ಹಾಗೂ ತಕ್ಷಣದ ಪ್ರತಿಕ್ರಿಯೆ ಮುಂತಾದ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಎಐ ಬಳಕೆಯಾಗುತ್ತಿದೆ. ಕನ್ನಡ ಕಲಿಕೆಯನ್ನು ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನದೊಂದಿಗೆ ಜೋಡಿಸುವ ಮೂಲಕ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ಸುಲಭ, ಆಸಕ್ತಿದಾಯಕ ಮತ್ತು ಪರಿಣಾಮಕಾರಿಯಾಗಿಸಬಹುದು. ಆದರೆ ಎಐಯ ಬಳಕೆಯಲ್ಲಿಯೂ ಭಾಷಾ ನಿಖರತೆ, ದತ್ತಾಂಶದ ಕೊರತೆ, ಸಾಂಸ್ಕೃತಿಕ ಸೂಕ್ಷ್ಮತೆ, ಗೌಪ್ಯತೆ ಮತ್ತು ಅತಿಯಾದ ಅವಲಂಬನೆಯಂತಹ ಸವಾಲುಗಳಿವೆ.

ಹೀಗಾಗಿ ಕನ್ನಡ ಕಲಿಕೆಯ ಪ್ರಸ್ತುತ ಸವಾಲುಗಳನ್ನು ಗುರುತಿಸಿ, ಅವುಗಳಿಗೆ ಸೂಕ್ತ ಪರಿಹಾರಗಳನ್ನು ಕಂಡುಕೊಳ್ಳುವುದರ ಜೊತೆಗೆ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಕನ್ನಡದ ಅಭಿವೃದ್ಧಿಗೆ ಪೂರಕವಾಗಿ ಬಳಸುವುದು ಇಂದಿನ ಅಗತ್ಯವಾಗಿದೆ.

ಮಾತೃಭಾಷೆಯ ಮಹತ್ವ

ಮಗುವಿನ ಮೊದಲ ಕಲಿಕೆಯ ಪ್ರಕ್ರಿಯೆ ಮನೆಯಲ್ಲಿಯೇ ಆರಂಭವಾಗುತ್ತದೆ. ಕುಟುಂಬದ

ಸದಸ್ಯರೊಂದಿಗೆ ನಡೆಯುವ ಸಂವಹನ, ಸುತ್ತಮುತ್ತಲಿನ ಪರಿಸರದ ಪರಿಚಯ, ಅನುಭವಗಳ ಹಂಚಿಕೆ ಹಾಗೂ ಭಾವನೆಗಳ ಅಭಿವ್ಯಕ್ತಿ ಸಾಮಾನ್ಯವಾಗಿ ಮಾತೃಭಾಷೆಯ ಮೂಲಕವೇ ನಡೆಯುತ್ತದೆ. ಹೀಗಾಗಿ ಮಗುವಿನ ಬೌದ್ಧಿಕ, ಭಾವನಾತ್ಮಕ ಮತ್ತು ಸೃಜನಾತ್ಮಕ ಬೆಳವಣಿಗೆಯಲ್ಲಿ ಮಾತೃಭಾಷೆಯ ಪಾತ್ರ ಮಹತ್ವದ್ದಾಗಿದೆ.

ಮಾತೃಭಾಷೆಯ ಮೂಲಕ ಕಲಿಯುವಾಗ ಮಗು ಹೊಸ ವಿಷಯಗಳನ್ನು ತನ್ನ ಅನುಭವಗಳೊಂದಿಗೆ ಸುಲಭವಾಗಿ ಸಂಬಂಧಿಸಿಕೊಳ್ಳುತ್ತದೆ. ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಹಾಗೂ ತನ್ನದೇ ಆದ ರೀತಿಯಲ್ಲಿ ಆಲೋಚಿಸಲು ಮಾತೃಭಾಷೆ ಸಹಕಾರಿಯಾಗುತ್ತದೆ. ವಿಶೇಷವಾಗಿ ಪ್ರಾಥಮಿಕ ಶಿಕ್ಷಣದಲ್ಲಿ ಮಗುವಿಗೆ ಪರಿಚಿತವಾದ ಭಾಷೆಯ ಮೂಲಕ ವಿಷಯಜ್ಞಾನ ನೀಡುವುದರಿಂದ ಕಲಿಕೆಯ ಸಹಜತೆ ಹೆಚ್ಚುತ್ತದೆ.

ಇದರಿಂದ ಇಂಗ್ಲಿಷ್ ಅಥವಾ ಇತರ ಭಾಷೆಗಳನ್ನು ಕಲಿಯಬಾರದು ಎಂಬ ಅರ್ಥವಿಲ್ಲ. ಇಂದಿನ ಜಾಗತಿಕ ಸಂದರ್ಭದಲ್ಲಿ ಇಂಗ್ಲಿಷ್ ಸೇರಿದಂತೆ ಹಲವು ಭಾಷೆಗಳ ಜ್ಞಾನ ಅಗತ್ಯವಾಗಿದೆ. ಆದರೆ ಒಂದು ಭಾಷೆಯನ್ನು ಕಲಿಯುವುದು ಮತ್ತು ಆ ಭಾಷೆಯಲ್ಲಿಯೇ ಎಲ್ಲ ವಿಷಯಗಳನ್ನು ಕಲಿಯುವುದು ಒಂದೇ ಅಲ್ಲ. ಮಾತೃಭಾಷೆಯಲ್ಲಿ ಬಲವಾದ ಜ್ಞಾನವನ್ನು ಬೆಳೆಸಿಕೊಂಡು ಇತರ ಭಾಷೆಗಳನ್ನೂ ಕಲಿಯುವ ಬಹುಭಾಷಾ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆ ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿದೆ.

ಕನ್ನಡ ಕಲಿಕೆ ಎದುರಿಸುತ್ತಿರುವ ಪ್ರಮುಖ ಸವಾಲುಗಳು

1. **ಆಂಗ್ಲ ಮಾಧ್ಯಮದ ಹೆಚ್ಚುತ್ತಿರುವ ಪ್ರಭಾವ:** ಇಂದಿನ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಆಂಗ್ಲ ಮಾಧ್ಯಮಕ್ಕೆ ಹೆಚ್ಚಿನ ಬೇಡಿಕೆ ಕಂಡುಬರುತ್ತಿದೆ. ಇಂಗ್ಲಿಷ್ ಕಲಿತರೆ ಉತ್ತಮ ಉದ್ಯೋಗ, ಉತ್ತಮ ಜೀವನ ಮತ್ತು ಉತ್ತಮ ಭವಿಷ್ಯ ದೊರೆಯುತ್ತದೆ ಎಂಬ ನಂಬಿಕೆ ಪೋಷಕರಲ್ಲಿ ಬಲವಾಗಿದೆ. ಇದರಿಂದ ಅನೇಕ ಪೋಷಕರು ಪ್ರಾಥಮಿಕ ಹಂತದಿಂದಲೇ ಮಕ್ಕಳನ್ನು ಆಂಗ್ಲ ಮಾಧ್ಯಮ ಶಾಲೆಗಳಿಗೆ ಸೇರಿಸಲು ಆಸಕ್ತಿ ತೋರುತ್ತಿದ್ದಾರೆ.

   ಇಂಗ್ಲಿಷ್ ಭಾಷೆಯ ಕಲಿಕೆ ಅಗತ್ಯವಾದರೂ, ಅದರ ಕಾರಣದಿಂದ ಕನ್ನಡ ಕಲಿಕೆಯನ್ನು ಕಡೆಗಣಿಸುವುದು ಸಮಸ್ಯೆಗೆ ಕಾರಣವಾಗಬಹುದು. ಮಗು ವಿಷಯವನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದಕ್ಕಿಂತ ಅಪರಿಚಿತ ಭಾಷೆಯ ಪದಗಳನ್ನು ಕಂಠಪಾಠ ಮಾಡುವ ಪರಿಸ್ಥಿತಿ ನಿರ್ಮಾಣವಾದರೆ ಕಲಿಕೆಯ ಸಹಜತೆ ಕುಂಠಿತವಾಗಬಹುದು.

2. **ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಕುಸಿತ:** ಕನ್ನಡ ಕಲಿಕೆಗೆ ಪ್ರಮುಖ ಆಧಾರವಾಗಿರುವ ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳು ಹಲವು ಸಮಸ್ಯೆಗಳನ್ನು ಎದುರಿಸುತ್ತಿವೆ. ಕೆಲವು ಸರ್ಕಾರಿ ಶಾಲೆಗಳಲ್ಲಿ ಮೂಲಸೌಕರ್ಯಗಳ ಕೊರತೆ, ವಿದ್ಯಾರ್ಥಿಗಳ ಸಂಖ್ಯೆ ಕಡಿಮೆಯಾಗುವುದು, ಆಧುನಿಕ ತಂತ್ರಜ್ಞಾನದ ಸೀಮಿತ ಬಳಕೆ ಹಾಗೂ ಕೆಲವು ಪ್ರದೇಶಗಳಲ್ಲಿ ಶಿಕ್ಷಕರ ಕೊರತೆ ಕಂಡುಬರುತ್ತಿದೆ.

   ಖಾಸಗಿ ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು ತಂತ್ರಜ್ಞಾನ, ಇಂಗ್ಲಿಷ್ ಭಾಷಾ ತರಬೇತಿ, ಕೌಶಲ್ಯಾಭಿವೃದ್ಧಿ ಮತ್ತು ವಿವಿಧ ಪಠ್ಯೇತರ ಚಟುವಟಿಕೆಗಳಿಗೆ ಹೆಚ್ಚಿನ ಒತ್ತು ನೀಡುತ್ತಿರುವುದರಿಂದ ಪೋಷಕರು ಅವುಗಳತ್ತ ಆಕರ್ಷಿತರಾಗುತ್ತಿದ್ದಾರೆ. ಪರಿಣಾಮವಾಗಿ ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಮೇಲಿನ ವಿಶ್ವಾಸ ಕೆಲವು ಕಡೆ

ಕಡಿಮೆಯಾಗುತ್ತಿದೆ.

3. **ಕನ್ನಡದಲ್ಲಿ ಕಲಿತರೆ ಉದ್ಯೋಗಾವಕಾಶ ಕಡಿಮೆಯಾಗುತ್ತವೆ ಎಂಬ ಭಾವನೆ:** ಉದ್ಯೋಗ ಕ್ಷೇತ್ರದಲ್ಲಿ ಇಂಗ್ಲಿಷ್ ಭಾಷೆಯ ಬಳಕೆ ಹೆಚ್ಚಿರುವುದರಿಂದ ಕನ್ನಡ ಮಾಧ್ಯಮದಲ್ಲಿ ಕಲಿತ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಉದ್ಯೋಗಾವಕಾಶಗಳು ಕಡಿಮೆಯಾಗುತ್ತವೆ ಎಂಬ ಆತಂಕವಿದೆ. ವಿಜ್ಞಾನ, ತಂತ್ರಜ್ಞಾನ, ವೈದ್ಯಕೀಯ, ಇಂಜಿನಿಯರಿಂಗ್, ವಾಣಿಜ್ಯ ಮತ್ತು ಕಂಪ್ಯೂಟರ್ ಶಿಕ್ಷಣದ ಬಹುತೇಕ ಸಂಪನ್ಮೂಲಗಳು ಇಂಗ್ಲಿಷ್‌ನಲ್ಲಿರುವುದೂ ಈ ಭಾವನೆಗೆ ಕಾರಣವಾಗಿದೆ.
   ಆದರೆ ಉದ್ಯೋಗಕ್ಕೆ ಕೇವಲ ಶಿಕ್ಷಣದ ಮಾಧ್ಯಮವೇ ನಿರ್ಣಾಯಕವಲ್ಲ. ವಿಷಯಜ್ಞಾನ, ಭಾಷಾ ಸಾಮರ್ಥ್ಯ, ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯ, ಸಂವಹನ ಸಾಮರ್ಥ್ಯ ಮತ್ತು ವ್ಯಕ್ತಿತ್ವದ ಬೆಳವಣಿಗೆಯೂ ಪ್ರಮುಖವಾಗಿವೆ. ಆದ್ದರಿಂದ ಕನ್ನಡ ಮಾಧ್ಯಮದೊಂದಿಗೆ ಇಂಗ್ಲಿಷ್ ಹಾಗೂ ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯಗಳನ್ನು ಸಮನ್ವಯಗೊಳಿಸುವುದು ಅಗತ್ಯ.

4. **ಡಿಜಿಟಲ್ ಕ್ಷೇತ್ರದಲ್ಲಿ ಕನ್ನಡದ ಸೀಮಿತ ಬಳಕೆ:** ಇಂದಿನ ಮಕ್ಕಳ ಕಲಿಕೆಯ ಬಹುಪಾಲು ಡಿಜಿಟಲ್ ಸಾಧನಗಳೊಂದಿಗೆ ಸಂಬಂಧಿಸಿದೆ. ಆದರೆ ಇಂಗ್ಲಿಷ್‌ಗೆ ಹೋಲಿಸಿದರೆ ಕನ್ನಡದಲ್ಲಿ ಗುಣಮಟ್ಟದ ಡಿಜಿಟಲ್ ಪಠ್ಯ, ವೀಡಿಯೊ, ಆನ್‌ಲೈನ್ ಕೋರ್ಸ್, ಶೈಕ್ಷಣಿಕ ಆ್ಯಪ್ ಮತ್ತು ಇತರ ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳು ಇನ್ನಷ್ಟು ಹೆಚ್ಚಾಗಬೇಕಾಗಿದೆ.
   ಡಿಜಿಟಲ್ ಜಗತ್ತಿನಲ್ಲಿ ಕನ್ನಡದ ಬಳಕೆ ವಿಸ್ತರಿಸದಿದ್ದರೆ ಹೊಸ ತಲೆಮಾರಿನ ವಿದ್ಯಾರ್ಥಿಗಳು ಕನ್ನಡಕ್ಕಿಂತ ಇಂಗ್ಲಿಷ್ ಆಧಾರಿತ ಡಿಜಿಟಲ್ ಜ್ಞಾನಕ್ಕೆ ಹೆಚ್ಚು ಅವಲಂಬಿತರಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ.

5. **ಗಡಿಭಾಗಗಳಲ್ಲಿ ಕನ್ನಡ ಕಲಿಕೆಯ ಸವಾಲು:** ಕರ್ನಾಟಕದ ಗಡಿಭಾಗಗಳಲ್ಲಿ ನೆರೆಯ ರಾಜ್ಯಗಳ ಭಾಷೆಗಳ ಪ್ರಭಾವ ಸಹಜವಾಗಿಯೇ ಇದೆ. ಮರಾಠಿ, ತೆಲುಗು, ತಮಿಳು ಮತ್ತು ಮಲಯಾಳಂ ಭಾಷೆಗಳ ಬಳಕೆ ಕೆಲವು ಪ್ರದೇಶಗಳಲ್ಲಿ ಹೆಚ್ಚಾಗಿದೆ. ಬಹುಭಾಷಾ ಪರಿಸರವು ಒಂದು ರೀತಿಯಲ್ಲಿ ಸಾಂಸ್ಕೃತಿಕ ಸಂಪತ್ತಾದರೂ, ಕನ್ನಡದ ಕಲಿಕೆ ಮತ್ತು ಬಳಕೆಗೆ ಸೂಕ್ತ ಪ್ರೋತ್ಸಾಹ ದೊರೆಯದಿದ್ದರೆ ಕನ್ನಡದ ಪ್ರಾಬಲ್ಯ ಕಡಿಮೆಯಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ.

6. **ಪೋಷಕರ ಮನೋಭಾವ:** ಮಕ್ಕಳ ಶಿಕ್ಷಣದಲ್ಲಿ ಪೋಷಕರ ಮನೋಭಾವ ಮಹತ್ವದ ಪಾತ್ರ ವಹಿಸುತ್ತದೆ. ಕನ್ನಡ ಮಾಧ್ಯಮವನ್ನು ಕಡಿಮೆ ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಣದೊಂದಿಗೆ ಸಂಬಂಧಿಸುವುದು ಅಥವಾ ಕನ್ನಡದಲ್ಲಿ ಕಲಿತರೆ ಭವಿಷ್ಯದಲ್ಲಿ ಅವಕಾಶಗಳು ಕಡಿಮೆಯಾಗುತ್ತವೆ ಎಂದು ಭಾವಿಸುವುದು ಕನ್ನಡ ಕಲಿಕೆಗೆ ಅಡ್ಡಿಯಾಗಿದೆ.
   ಆದ್ದರಿಂದ ಪೋಷಕರಿಗೆ ಮಾತೃಭಾಷೆಯ ಶಿಕ್ಷಣದ ಮಹತ್ವ ಹಾಗೂ ಕನ್ನಡ ಮಾಧ್ಯಮದೊಂದಿಗೆ ಇತರ ಭಾಷೆ ಮತ್ತು ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯಗಳನ್ನು ಕಲಿಯುವ ಸಾಧ್ಯತೆಗಳ ಕುರಿತು ಅರಿವು ಮೂಡಿಸಬೇಕು.

ಕನ್ನಡ ಕಲಿಕೆಯನ್ನು ಬಲಪಡಿಸುವ ಮಾರ್ಗೋಪಾಯಗಳು

ಕನ್ನಡ ಕಲಿಕೆಯ ಸಮಸ್ಯೆಗಳನ್ನು ಕೇವಲ ಸರ್ಕಾರದ ಜವಾಬ್ದಾರಿಯಾಗಿ ನೋಡುವ ಬದಲು ಸರ್ಕಾರ,

ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು, ಶಿಕ್ಷಕರು, ಪೋಷಕರು, ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ಸಮಾಜದ ಸಹಭಾಗಿತ್ವದ ಮೂಲಕ ಪರಿಹರಿಸಬೇಕು.

1. ಪ್ರಾಥಮಿಕ ಶಿಕ್ಷಣದಲ್ಲಿ ಕನ್ನಡಕ್ಕೆ ಆದ್ಯತೆ: ಪ್ರಾಥಮಿಕ ಹಂತದಲ್ಲಿ ಮಕ್ಕಳಿಗೆ ವಿಷಯಜ್ಞಾನವನ್ನು ಮಾತೃಭಾಷೆಯ ಮೂಲಕ ನೀಡಲು ಹೆಚ್ಚಿನ ಒತ್ತು ನೀಡಬೇಕು. ಕನ್ನಡದ ಜೊತೆಗೆ ಇಂಗ್ಲಿಷ್ ಸೇರಿದಂತೆ ಇತರ ಭಾಷೆಗಳನ್ನು ಕ್ರಮಬದ್ಧವಾಗಿ ಕಲಿಸುವ ಬಹುಭಾಷಾ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯನ್ನು ಬೆಳೆಸಬೇಕು.
2. ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಗುಣಮಟ್ಟ ಹೆಚ್ಚಿಸುವುದು: ಸರ್ಕಾರಿ ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳಿಗೆ ಉತ್ತಮ ಕಟ್ಟಡ, ಗ್ರಂಥಾಲಯ, ಪ್ರಯೋಗಾಲಯ, ಕಂಪ್ಯೂಟರ್, ಇಂಟರ್ನೆಟ್, ಸ್ಮಾರ್ಟ್ ತರಗತಿಗಳು ಹಾಗೂ ಆಧುನಿಕ ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಒದಗಿಸಬೇಕು. ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಯೆಂದರೆ ಹಳೆಯ ಮಾದರಿಯ ಶಿಕ್ಷಣ ಎಂಬ ಮನೋಭಾವವನ್ನು ಬದಲಿಸಿ, ಅವುಗಳನ್ನು ಆಧುನಿಕ ಶಿಕ್ಷಣದ ಕೇಂದ್ರಗಳಾಗಿ ರೂಪಿಸಬೇಕು.
3. ಕನ್ನಡದಲ್ಲಿ ಗುಣಮಟ್ಟದ ಪಠ್ಯಸಾಮಗ್ರಿ: ವಿಜ್ಞಾನ, ಗಣಿತ, ತಂತ್ರಜ್ಞಾನ, ವಾಣಿಜ್ಯ, ವೈದ್ಯಕೀಯ, ಕಾನೂನು ಮುಂತಾದ ವಿಷಯಗಳಿಗೆ ಸರಳ ಮತ್ತು ಗುಣಮಟ್ಟದ ಕನ್ನಡ ಪಠ್ಯಸಾಮಗ್ರಿಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಬೇಕು. ಮುದ್ರಿತ ಪುಸ್ತಕಗಳ ಜೊತೆಗೆ ಇ–ಪುಸ್ತಕ, ವೀಡಿಯೊ ಪಾಠ, ಧ್ವನಿ ಪಾಠ ಮತ್ತು ಸಂವಾದಾತ್ಮಕ ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳನ್ನು ರೂಪಿಸಬೇಕು.
4. ಕನ್ನಡದೊಂದಿಗೆ ಇಂಗ್ಲಿಷ್ ಮತ್ತು ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯ: ಕನ್ನಡ ಮಾಧ್ಯಮ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಉತ್ತಮ ಇಂಗ್ಲಿಷ್ ಭಾಷಾ ಕೌಶಲ್ಯ, ಕಂಪ್ಯೂಟರ್ ಜ್ಞಾನ, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ಸಂವಹನ ಕೌಶಲ್ಯ ಮತ್ತು ಉದ್ಯೋಗ ಕೌಶಲ್ಯಗಳನ್ನು ನೀಡಬೇಕು. ಕನ್ನಡ ಮತ್ತು ಇಂಗ್ಲಿಷ್ ಪರಸ್ಪರ ವಿರೋಧಿಗಳಲ್ಲ ಎಂಬ ಮನೋಭಾವ ಬೆಳೆಸಬೇಕು.
5. ಶಿಕ್ಷಕರ ತರಬೇತಿ: ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಿಕ್ಷಕರಿಗೆ ಆಧುನಿಕ ಬೋಧನಾ ವಿಧಾನಗಳು, ಡಿಜಿಟಲ್ ತಂತ್ರಜ್ಞಾನ, ಎಐ ಉಪಕರಣಗಳು ಮತ್ತು ಹೊಸ ಕಲಿಕಾ ಮಾದರಿಗಳ ಕುರಿತು ನಿರಂತರ ತರಬೇತಿ ನೀಡಬೇಕು. ತಂತ್ರಜ್ಞಾನವನ್ನು ಬಳಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರುವ ಶಿಕ್ಷಕರು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕೆಯನ್ನು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ರೂಪಿಸಬಹುದು.
6. ಪೋಷಕರಲ್ಲಿ ಜಾಗೃತಿ: ಮಾತೃಭಾಷೆಯ ಮೂಲಕ ಕಲಿಕೆಯ ಪ್ರಯೋಜನ, ಕನ್ನಡ ಮಾಧ್ಯಮದ ಅವಕಾಶಗಳು ಮತ್ತು ಕನ್ನಡದೊಂದಿಗೆ ಇತರ ಭಾಷೆಗಳನ್ನು ಕಲಿಯುವ ಸಾಧ್ಯತೆಗಳ ಕುರಿತು ಪೋಷಕರಲ್ಲಿ ಜಾಗೃತಿ ಮೂಡಿಸಬೇಕು. ಕನ್ನಡ ಮಾಧ್ಯಮವು ಉದ್ಯೋಗಕ್ಕೆ ಅಡ್ಡಿಯಲ್ಲ ಎಂಬ ನಂಬಿಕೆಯನ್ನು ಬೆಳೆಸುವುದು ಅಗತ್ಯ.
7. ಗಡಿನಾಡಿನಲ್ಲಿ ವಿಶೇಷ ಕ್ರಮ: ಗಡಿಭಾಗಗಳಲ್ಲಿ ಕನ್ನಡ ಶಾಲೆಗಳು, ಗ್ರಂಥಾಲಯಗಳು, ಸಾಂಸ್ಕೃತಿಕ ಕಾರ್ಯಕ್ರಮಗಳು, ಕನ್ನಡ ಕಲಿಕಾ ಶಿಬಿರಗಳು ಹಾಗೂ ಭಾಷಾ ಚಟುವಟಿಕೆಗಳಿಗೆ ಹೆಚ್ಚಿನ ಪ್ರೋತ್ಸಾಹ

ನೀಡಬೇಕು. ಸ್ಥಳೀಯ ಬಹುಭಾಷಾ ಪರಿಸರವನ್ನು ಗೌರವಿಸುತ್ತಲೇ ಕನ್ನಡ ಕಲಿಕೆಗೆ ಸೂಕ್ತ ಅವಕಾಶ ಕಲ್ಪಿಸಬೇಕು.

ಕನ್ನಡ ಕಲಿಕೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಸಾಧ್ಯತೆಗಳು

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬೆಳವಣಿಗೆ ಕನ್ನಡ ಕಲಿಕೆಗೆ ಹೊಸ ದಾರಿಗಳನ್ನು ತೆರೆದಿದೆ. ಎಐಯನ್ನು ಸರಿಯಾದ ರೀತಿಯಲ್ಲಿ ಬಳಸಿದರೆ ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಕಲಿಕಾ ವ್ಯವಸ್ಥೆಗಳನ್ನು ರೂಪಿಸಬಹುದು.

1) ವೈಯಕ್ತಿಕ ಕಲಿಕೆ: ವಿದ್ಯಾರ್ಥಿಯ ಕಲಿಕಾ ಮಟ್ಟವನ್ನು ಗುರುತಿಸಿ, ಅವನಿಗೆ ಅಥವಾ ಅವಳಿಗೆ ಅನುಗುಣವಾದ ಪಾಠ, ಪ್ರಶ್ನೆ, ಅಭ್ಯಾಸ ಮತ್ತು ಪುನರಾವರ್ತನಾ ಚಟುವಟಿಕೆಗಳನ್ನು ಎಐ ಮೂಲಕ ರೂಪಿಸಬಹುದು.

2) ಸಂವಾದಾತ್ಮಕ ಕನ್ನಡ ಕಲಿಕೆ: ಎಐ ಆಧಾರಿತ ಸಂವಾದ ವ್ಯವಸ್ಥೆಗಳ ಮೂಲಕ ವಿದ್ಯಾರ್ಥಿಗಳು ಕನ್ನಡದಲ್ಲಿ ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳಿ ಉತ್ತರಗಳನ್ನು ಪಡೆಯಬಹುದು. ಕನ್ನಡದಲ್ಲಿ ಸಂಭಾಷಣೆ ನಡೆಸುವ ಮೂಲಕ ಮಾತನಾಡುವ ಕೌಶಲ್ಯವನ್ನು ಅಭ್ಯಾಸ ಮಾಡಬಹುದು.

3) ಉಚ್ಚಾರಣೆ ಸುಧಾರಣೆ: ಧ್ವನಿ ಗುರುತಿಸುವ ತಂತ್ರಜ್ಞಾನದಿಂದ ವಿದ್ಯಾರ್ಥಿಯ ಉಚ್ಚಾರಣೆಯನ್ನು ಪರಿಶೀಲಿಸಿ ತಪ್ಪುಗಳನ್ನು ಗುರುತಿಸಲು ಹಾಗೂ ಸರಿಯಾದ ಉಚ್ಚಾರಣೆಯ ಮಾದರಿಯನ್ನು ನೀಡಲು ಸಾಧ್ಯ.

4) ವ್ಯಾಕರಣ ಮತ್ತು ಬರವಣಿಗೆ: ವಿದ್ಯಾರ್ಥಿಗಳು ಬರೆದ ವಾಕ್ಯಗಳಲ್ಲಿನ ವ್ಯಾಕರಣದೋಷ, ಪದಪ್ರಯೋಗದ ಸಮಸ್ಯೆ ಮತ್ತು ವಾಕ್ಯರಚನೆಯ ದೋಷಗಳನ್ನು ಗುರುತಿಸಿ ತಿದ್ದುಪಡಿ ಸೂಚಿಸಲು ಎಐ ಸಹಾಯ ಮಾಡಬಹುದು.

5) ಪದಸಂಪತ್ತಿ ವೃದ್ಧಿ: ಹೊಸ ಪದಗಳ ಅರ್ಥ, ಸಮಾನಾರ್ಥಕ ಮತ್ತು ವಿರೋಧಾರ್ಥಕ ಪದಗಳು, ನುಡಿಗಟ್ಟುಗಳು, ಗಾದೆಗಳು ಹಾಗೂ ಅವುಗಳ ಬಳಕೆಯ ಉದಾಹರಣೆಗಳನ್ನು ವಿದ್ಯಾರ್ಥಿಯ ಮಟ್ಟಕ್ಕೆ ಅನುಗುಣವಾಗಿ ನೀಡಬಹುದು.

6) ಭಾಷಾಂತರ: ಕನ್ನಡದಿಂದ ಇತರ ಭಾಷೆಗಳಿಗೆ ಹಾಗೂ ಇತರ ಭಾಷೆಗಳಿಂದ ಕನ್ನಡಕ್ಕೆ ಪ್ರಾಥಮಿಕ ಭಾಷಾಂತರ ಮಾಡಲು ಎಐ ನೆರವಾಗಬಹುದು. ಆದರೆ ಸಾಹಿತ್ಯಿಕ ಅಥವಾ ಅಧಿಕೃತ ಭಾಷಾಂತರದಲ್ಲಿ ಮಾನವ ತಜ್ಞರ ಪರಿಶೀಲನೆ ಅಗತ್ಯ.

7) ವಿಶೇಷ ಅಗತ್ಯಗಳಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ನೆರವು: ಪಠ್ಯವನ್ನು ಧ್ವನಿಯಾಗಿ ಓದಿಕೊಡುವುದು, ಧ್ವನಿಯನ್ನು ಪಠ್ಯವಾಗಿ ಪರಿವರ್ತಿಸುವುದು ಮತ್ತು ಕಠಿಣ ವಿಷಯವನ್ನು ಸರಳ ಭಾಷೆಯಲ್ಲಿ ವಿವರಿಸುವುದು ಮುಂತಾದ ಕಾರ್ಯಗಳ ಮೂಲಕ ವಿಶೇಷ ಅಗತ್ಯಗಳಿರುವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಎಐ ನೆರವಾಗಬಹುದು.

8) ಶಿಕ್ಷಕರಿಗೆ ಸಹಾಯಕ ಸಾಧನ: ಪಾಠಯೋಜನೆ, ಪ್ರಶ್ನೆಪತ್ರಿಕೆ, ಅಭ್ಯಾಸ ಪತ್ರಿಕೆ, ಚರ್ಚಾ ವಿಷಯಗಳು ಮತ್ತು ಪುನರಾವರ್ತನಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು ಎಐ ಶಿಕ್ಷಕರಿಗೆ ಸಹಾಯಕವಾಗಬಹುದು. ಇದರಿಂದ ಶಿಕ್ಷಕರ ಸಮಯ ಉಳಿತಾಯವಾಗಬಹುದು.

ಕನ್ನಡ ಕಲಿಕೆಯಲ್ಲಿ ಎಐ ಬಳಕೆಯ ಸವಾಲುಗಳು

ಎಐ ಕನ್ನಡ ಕಲಿಕೆಗೆ ಹಲವು ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸಿದರೂ ಅದರ ಬಳಕೆಯಲ್ಲಿ ಎಚ್ಚರಿಕೆ ಅಗತ್ಯ.

- ಮೊದಲನೆಯದಾಗಿ, ಕನ್ನಡಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಗುಣಮಟ್ಟದ ಡಿಜಿಟಲ್ ದತ್ತಾಂಶದ ಪ್ರಮಾಣ ಮತ್ತು ವೈವಿಧ್ಯ ಇನ್ನಷ್ಟು ಹೆಚ್ಚಬೇಕಾಗಿದೆ. ಸಾಹಿತ್ಯ, ಪಠ್ಯಪುಸ್ತಕ, ಮಾತುಕತೆ, ಉಪಭಾಷೆ, ಜನಪದ ಮತ್ತು ತೈಕ್ಷಣಿಕ ವಿಷಯಗಳ ಸಮತೋಲನದ ದತ್ತಾಂಶ ಅಗತ್ಯ.
- ಎರಡನೆಯದಾಗಿ, ಕನ್ನಡದ ಉಪಭಾಷೆಗಳು, ಗಾದೆಗಳು, ನುಡಿಗಟ್ಟುಗಳು, ಸಾಂಸ್ಕೃತಿಕ ಸಂದರ್ಭಗಳು ಮತ್ತು ಸಾಹಿತ್ಯಿಕ ಶೈಲಿಗಳನ್ನು ಎಐ ಯಾವಾಗಲೂ ಸರಿಯಾಗಿ ಅರ್ಥೈಸಿಕೊಳ್ಳುವುದಿಲ್ಲ. ಹೀಗಾಗಿ ಎಐ ನೀಡುವ ಉತ್ತರಗಳಲ್ಲಿ ಭಾಷಾ ಅಥವಾ ಸಾಂಸ್ಕೃತಿಕ ದೋಷಗಳ ಸಾಧ್ಯತೆ ಇದೆ.
- ಮೂರನೆಯದಾಗಿ, ಎಐ ಕೆಲವೊಮ್ಮೆ ತಪ್ಪು ಮಾಹಿತಿ ಅಥವಾ ತಪ್ಪಾದ ಭಾಷಾಂತರ ನೀಡಬಹುದು. ಆದ್ದರಿಂದ ಎಐ ನೀಡುವ ವಿಷಯವನ್ನು ಪರಿಶೀಲಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಬೆಳೆಸಬೇಕು.
- ನಾಲ್ಕನೆಯದಾಗಿ, ಎಐಯ ಮೇಲೆ ಅತಿಯಾದ ಅವಲಂಬನೆ ವಿದ್ಯಾರ್ಥಿಗಳ ಸ್ವತಂತ್ರ ಚಿಂತನೆ, ಬರವಣಿಗೆ ಮತ್ತು ಸೃಜನಶೀಲತೆಯನ್ನು ದುರ್ಬಲಗೊಳಿಸಬಹುದು. ವಿದ್ಯಾರ್ಥಿಗಳು ಸ್ವತಃ ಓದಿ, ಯೋಚಿಸಿ, ಬರೆಯುವ ಅಭ್ಯಾಸವನ್ನು ಮುಂದುವರಿಸಬೇಕು.
- ಐದನೆಯದಾಗಿ, ಡಿಜಿಟಲ್ ಸಾಧನಗಳು ಮತ್ತು ಇಂಟರ್ನೆಟ್ ಸೌಲಭ್ಯಗಳ ಅಸಮಾನತೆಯಿಂದ ಗ್ರಾಮೀಣ ಮತ್ತು ಆರ್ಥಿಕವಾಗಿ ಹಿಂದುಳಿದ ವಿದ್ಯಾರ್ಥಿಗಳು ತಂತ್ರಜ್ಞಾನಾಧಾರಿತ ಕಲಿಕೆಯಿಂದ ವಂಚಿತರಾಗುವ ಸಾಧ್ಯತೆಯಿದೆ.
- ಆರನೆಯದಾಗಿ, ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿ, ಧ್ವನಿ, ಬರಹ ಮತ್ತು ಕಲಿಕಾ ದಾಖಲೆಗಳ ಸುರಕ್ಷತೆಗೆ ಆದ್ಯತೆ ನೀಡಬೇಕು. ಎಐ ಆಧಾರಿತ ಶಿಕ್ಷಣದಲ್ಲಿ ಗೌಪ್ಯತೆ ಮತ್ತು ನೈತಿಕತೆಯನ್ನು ನಿರ್ಲಕ್ಷಿಸಬಾರದು.

ಕನ್ನಡ ಮತ್ತು ಎಐ: ಸಮನ್ವಯದ ಅಗತ್ಯ

ಕನ್ನಡ ಮತ್ತು ಎಐ ಪರಸ್ಪರ ಪರ್ಯಾಯಗಳಲ್ಲ. ಕನ್ನಡವು ಜ್ಞಾನ, ಸಂಸ್ಕೃತಿ ಮತ್ತು ಮಾನವ ಅನುಭವದ ಭಾಷೆಯಾಗಿದ್ದರೆ, ಎಐ ಆ ಜ್ಞಾನವನ್ನು ಹೊಸ ತಂತ್ರಜ್ಞಾನಗಳ ಮೂಲಕ ಕಲಿಯಲು ಮತ್ತು ಹಂಚಿಕೊಳ್ಳಲು ನೆರವಾಗುವ ಸಾಧನವಾಗಿದೆ.

ಎಐ ವೇಗವಾಗಿ ಉತ್ತರ ನೀಡಬಹುದು; ಆದರೆ ಶಿಕ್ಷಕರ ಮಾನವೀಯ ಮಾರ್ಗದರ್ಶನ, ಪ್ರೋತ್ಸಾಹ,

ಮೌಲ್ಯಬೋಧನೆ ಮತ್ತು ಸಾಂಸ್ಕೃತಿಕ ಅರಿವಿಗೆ ಅದು ಪರ್ಯಾಯವಾಗಲು ಸಾಧ್ಯವಿಲ್ಲ. ಆದ್ದರಿಂದ ಎಐಯನ್ನು ಶಿಕ್ಷಕರ ಬದಲಿಗೆ ಬಳಸದೆ, ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೆಚ್ಚಿಸುವ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸಬೇಕು.

ಕನ್ನಡದ ಭವಿಷ್ಯವನ್ನು ಕೇವಲ ಭಾವನಾತ್ಮಕ ಅಭಿಮಾನದಿಂದ ಉಳಿಸಲು ಸಾಧ್ಯವಿಲ್ಲ. ಕನ್ನಡವು ವಿಜ್ಞಾನ, ತಂತ್ರಜ್ಞಾನ, ಡಿಜಿಟಲ್ ಮಾಧ್ಯಮ, ಉದ್ಯೋಗ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಕ್ಷೇತ್ರಗಳಲ್ಲಿಯೂ ಸಕ್ರಿಯವಾಗಿ ಬಳಕೆಯಾಗಬೇಕು. ಕನ್ನಡದಲ್ಲಿ ಗುಣಮಟ್ಟದ ಎಐ ಸಾಧನಗಳು ಅಭಿವೃದ್ಧಿಯಾದಾಗ ಹೊಸ ತಲೆಮಾರಿನ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಕನ್ನಡದಲ್ಲಿಯೇ ಜ್ಞಾನ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಪಡೆಯುವ ಅವಕಾಶ ಹೆಚ್ಚುತ್ತದೆ.

ಸಮಾರೋಪ

ಕನ್ನಡವು ಕೇವಲ ಒಂದು ಭಾಷೆಯಲ್ಲ; ಅದು ಕನ್ನಡಿಗರ ಇತಿಹಾಸ, ಸಂಸ್ಕೃತಿ, ಸಾಹಿತ್ಯ, ಜನಪದ ಮತ್ತು ಸಾಮಾಜಿಕ ಬದುಕಿನ ಜೀವಂತ ಪ್ರತಿಬಿಂಬವಾಗಿದೆ. ಇಂತಹ ಶ್ರೀಮಂತ ಭಾಷೆಯನ್ನು ಮುಂದಿನ ಪೀಳಿಗೆಗೆ ಪರಿಣಾಮಕಾರಿಯಾಗಿ ತಲುಪಿಸುವುದು ಪ್ರತಿಯೊಬ್ಬರ ಜವಾಬ್ದಾರಿಯಾಗಿದೆ.

ಇಂದು ಕನ್ನಡ ಕಲಿಕೆಯ ಮುಂದೆ ಆಂಗ್ಲ ಮಾಧ್ಯಮದ ಪ್ರಭಾವ, ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಕುಸಿತ, ಉದ್ಯೋಗದ ಕುರಿತ ತಪ್ಪು ಕಲ್ಪನೆ, ಡಿಜಿಟಲ್ ಸಂಪನ್ಮೂಲಗಳ ಕೊರತೆ, ಪೋಷಕರ ಮನೋಭಾವ ಮತ್ತು ಗಡಿಭಾಗಗಳ ಭಾಷಾ ಪರಿಸ್ಥಿತಿ ಮುಂತಾದ ಹಲವು ಸವಾಲುಗಳಿವೆ. ಇವುಗಳನ್ನು ಪರಿಹರಿಸಲು ಕನ್ನಡ ಮಾಧ್ಯಮ ಶಾಲೆಗಳ ಗುಣಮಟ್ಟ ಹೆಚ್ಚಿಸುವುದು, ಉತ್ತಮ ಪಠ್ಯಸಾಮಗ್ರಿಗಳನ್ನು ರೂಪಿಸುವುದು, ಶಿಕ್ಷಕರಿಗೆ ತರಬೇತಿ ನೀಡುವುದು, ಪೋಷಕರಲ್ಲಿ ಜಾಗೃತಿ ಮೂಡಿಸುವುದು ಹಾಗೂ ಕನ್ನಡದೊಂದಿಗೆ ಇಂಗ್ಲಿಷ್ ಮತ್ತು ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯಗಳನ್ನು ಸಮನ್ವಯಗೊಳಿಸುವುದು ಅಗತ್ಯ.

ಇದೇ ಸಂದರ್ಭದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಕನ್ನಡ ಕಲಿಕೆಗೆ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತಿದೆ. ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಭಾಷಾ ಅಭ್ಯಾಸ, ಉಚ್ಚಾರಣೆ, ವ್ಯಾಕರಣ, ಪದಸಂಪತ್ತಿ, ಭಾಷಾಂತರ ಮತ್ತು ಡಿಜಿಟಲ್ ಪಠ್ಯಸಾಮಗ್ರಿಗಳ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಎಐ ಪರಿಣಾಮಕಾರಿ ಸಾಧನವಾಗಬಹುದು. ಆದರೆ ಎಐಯ ಬಳಕೆಯಲ್ಲಿ ಭಾಷಾ ನಿಖರತೆ, ಸಾಂಸ್ಕೃತಿಕ ಸೂಕ್ಷ್ಮತೆ, ದತ್ತಾಂಶದ ಗುಣಮಟ್ಟ, ಗೌಪ್ಯತೆ ಮತ್ತು ಅತಿಯಾದ ಅವಲಂಬನೆಯಂತಹ ಸಮಸ್ಯೆಗಳನ್ನು ಗಮನದಲ್ಲಿಟ್ಟುಕೊಳ್ಳಬೇಕು.

ಆದ್ದರಿಂದ **"ಕನ್ನಡದಲ್ಲಿ ಜ್ಞಾನ, ಇತರ ಭಾಷೆಗಳಲ್ಲಿ ವ್ಯಾಪಕ ಸಂಪರ್ಕ ಮತ್ತು ಎಐಯ ಮೂಲಕ ಸುಲಭ ಕಲಿಕೆ"** ಎಂಬ ಸಮತೋಲನದ ದೃಷ್ಟಿಕೋನವನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳುವುದು ಇಂದಿನ ಅಗತ್ಯವಾಗಿದೆ. ಕನ್ನಡವನ್ನು ಕೇವಲ ಭಾವನೆಯ ಭಾಷೆಯಾಗಿ ಉಳಿಸದೆ, ಜ್ಞಾನ, ಶಿಕ್ಷಣ, ಉದ್ಯೋಗ, ವಿಜ್ಞಾನ, ತಂತ್ರಜ್ಞಾನ ಮತ್ತು ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಭಾಷೆಯಾಗಿ ಬೆಳೆಸಬೇಕು.

ಕನ್ನಡದ ಭವಿಷ್ಯವು ಕೇವಲ ಸರ್ಕಾರದ ನೀತಿಗಳ ಮೇಲೆ ಅವಲಂಬಿತವಾಗಿಲ್ಲ. ಮನೆ, ಶಾಲೆ, ಸಮಾಜ, ಶಿಕ್ಷಣ ಸಂಸ್ಥೆಗಳು, ಶಿಕ್ಷಕರು, ಪೋಷಕರು, ವಿದ್ಯಾರ್ಥಿಗಳು ಮತ್ತು ತಂತ್ರಜ್ಞಾನ ಕ್ಷೇತ್ರದ ಸಹಭಾಗಿತ್ವದಿಂದ ಮಾತ್ರ ಕನ್ನಡದ ಕಲಿಕೆ ಮತ್ತು ಬಳಕೆಯನ್ನು ಬಲಪಡಿಸಲು ಸಾಧ್ಯ. ತಂತ್ರಜ್ಞಾನವನ್ನು ಕನ್ನಡದ ಪರ್ಯಾಯವಾಗಿ ನೋಡದೆ, ಕನ್ನಡದ ಬೆಳವಣಿಗೆಗೆ ಪೂರಕವಾದ ಸಾಧನವಾಗಿ ಬಳಸಿದಾಗ ಮಾತ್ರ

ಡಿಜಿಟಲ್ ಯುಗದಲ್ಲಿಯೂ ಕನ್ನಡ ತನ್ನ ವೈಶಿಷ್ಟ್ಯ ಮತ್ತು ಅಸ್ತಿತ್ವವನ್ನು ಮತ್ತಷ್ಟು ಬಲಪಡಿಸಿಕೊಳ್ಳಲು ಸಾಧ್ಯ.

ಪರಾಮರ್ಶನ ಗ್ರಂಥಗಳು

ಫಾಲಾಕ್ಷ – ಆಧುನಿಕ ಕರ್ನಾಟಕದ ಇತಿಹಾಸ.

ಪಾಟೀಲ ಪುಟ್ಟಪ್ಪ – ಗೋಕಾಕ್ ಹೋರಾಟದ ಕಥೆ.

ಡಾ. ಹಾ.ಮಾ. ನಾಯಕ – ಕನ್ನಡವನ್ನು ಕಟ್ಟುವ ಕೆಲಸ, ಐ.ಬಿ.ಎಚ್. ಪ್ರಕಾಶನ, ಬೆಂಗಳೂರು.

ವಿನಯ್ ಕುಮಾರ್. ಎಸ್.ಎಸ್. – ಭಾಷೆ ಮತ್ತು ಶಿಕ್ಷಣದ ಬಗ್ಗೆ ಕುವೆಂಪು ಮಾತು, ಡಿಸೆಂಬರ್ ೨೯, ೨೦೧೭.

ಕನ್ನಡ ಭಾಷೆ ಮತ್ತು ಶಿಕ್ಷಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಅಂತರ್ಜಾಲ ಸಂಪನ್ಮೂಲಗಳು.

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಒಂದು ಬೋಧನಾ ಸಾಧನವಾಗಿ: ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಮೇಲೆ ಅದರ ಪ್ರಭಾವ

ನಾಗನಗೌಡ ದುಂಡಪ್ಪಗೌಡ ಚಿನ್ನಪ್ಪಗೌಡರ
ಸಂಶೋಧನಾರ್ಥಿ, ಶಿಕ್ಷಣ ವಿಭಾಗ, ಕಿತ್ತೂರು ರಾಣಿ ಚನ್ನಮ್ಮ ವಿಶ್ವವಿದ್ಯಾಲಯ ಬೆಳಗಾವಿ
ಡಾ. ಭಾರತಿ ವಾಯ್ ಖಾಸನಿಸ್,
ಸಂಶೋಧನಾ ಮಾರ್ಗದರ್ಶಕರು, ಶಿಕ್ಷಣ ವಿಭಾಗ, ಕಿತ್ತೂರು ರಾಣಿ ಚನ್ನಮ್ಮ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

ಸಾರಾಂಶ

ಸಮಕಾಲೀನ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence–AI) ಬೋಧನೆ–ಕಲಿಕೆಯ ಪ್ರಕ್ರಿಯೆಯನ್ನು ಪರಿವರ್ತಿಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರುವ ಪ್ರಮುಖ ತಾಂತ್ರಿಕ ಆವಿಷ್ಕಾರವಾಗಿ ಹೊರಹೊಮ್ಮುತ್ತಿದೆ. ವಿಶೇಷವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಸಂದರ್ಭದಲ್ಲಿ, ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನವನ್ನು ವಿಸ್ತರಿಸುವುದು, ಪರಿಕಲ್ಪನಾತ್ಮಕ ತಿಳುವಳಿಕೆಯನ್ನು ಆಳಗೊಳಿಸುವುದು, ವೈವಿಧ್ಯಮಯ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳುವುದು, ಪರಿಣಾಮಕಾರಿ ಪಾಠಯೋಜನೆಗಳನ್ನು ರೂಪಿಸುವುದು, ಗುಣಮಟ್ಟದ ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸುವುದು ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿಗಳ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಬೋಧನಾ ಪ್ರಕ್ರಿಯೆಯನ್ನು ವಿನ್ಯಾಸಗೊಳಿಸುವಲ್ಲಿ ಂಐ ಮಹತ್ವದ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಕಾರ್ಯನಿರ್ವಹಿಸುವ ಸಾಧ್ಯತೆಯನ್ನು ಹೊಂದಿದೆ. ಈ ಲೇಖನವು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಪಾತ್ರ ಹಾಗೂ ಅದರ ಶೈಕ್ಷಣಿಕ ಪರಿಣಾಮಗಳನ್ನು ದ್ವಿತೀಯ ದತ್ತಾಂಶದ ಆಧಾರದ ಮೇಲೆ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. ಅಧ್ಯಯನವು ವರ್ಣನಾತ್ಮಕ ಮತ್ತು ವಿಶ್ಲೇಷಣಾತ್ಮಕ ಸಂಶೋಧನಾ ವಿನ್ಯಾಸವನ್ನು ಅನುಸರಿಸಿದ್ದು, ಸಂಶೋಧನಾ ಲೇಖನಗಳು, ಸರ್ಕಾರಿ ವರದಿಗಳು, ಶಿಕ್ಷಣ ನೀತಿ ದಾಖಲೆಗಳು, NCERT ಹಾಗೂ ಗಓಇಖಅಔ ಸೇರಿದಂತೆ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳ ಪ್ರಕಟಣೆಗಳು ಮತ್ತು AI – ಶಿಕ್ಷಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಲಭ್ಯವಿರುವ ಅಧ್ಯಯನಗಳನ್ನು ಆಧಾರವಾಗಿಸಿಕೊಂಡಿದೆ. ಲಭ್ಯವಿರುವ ಸಾಹಿತ್ಯದ ವಿಷಯಾಧಾರಿತ ವಿಶ್ಲೇಷಣೆಯು AI ಯ ಸಮರ್ಪಕ ಬಳಕೆಯು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯಾಧಾರಿತ ತಿಳುವಳಿಕೆ, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ಪಾಠಯೋಜನಾ ಕೌಶಲ್ಯ, ಬೋಧನಾ ನವೀನತೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ವೃತ್ತಿಪರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಬಲಪಡಿಸುವ ಮಹತ್ವದ ಅವಕಾಶವನ್ನು ಒದಗಿಸುತ್ತದೆ ಎಂಬುದನ್ನು ಸೂಚಿಸುತ್ತದೆ.

ಮುಖ್ಯ ಪದಗಳು: *ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ, ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು, ವಿಷಯ ಜ್ಞಾನ, ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, AI ಆಧಾರಿತ ಶಿಕ್ಷಣ*

ಪರಿಚಯ

21ನೇ ಶತಮಾನದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯು ತಂತ್ರಜ್ಞಾನಾಧಾರಿತ ಪರಿವರ್ತನೆಯ ಮಹತ್ವದ ಹಂತವನ್ನು ಪ್ರವೇಶಿಸಿದ್ದು, ಡಿಜಿಟಲ್ ಕಲಿಕೆ, ಆನ್ಲೈನ್ ಶಿಕ್ಷಣ, ಸ್ಮಾರ್ಟ್ ತರಗತಿಗಳು, ಕಲಿಕಾ ನಿರ್ವಹಣಾ ವ್ಯವಸ್ಥೆಗಳು ಮತ್ತು ವಿವಿಧ ಡಿಜಿಟಲ್ ಶೈಕ್ಷಣಿಕ ಸಂಪನ್ಮೂಲಗಳ ನಂತರ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ (Artificial Intelligence–AI) ಶಿಕ್ಷಣ ಕ್ಷೇತ್ರದಲ್ಲಿ ಹೊಸ ಸಾಧ್ಯತೆಗಳು ಹಾಗೂ ನವೀನ ಆಯಾಮಗಳನ್ನು

ತೆರೆದಿಡುತ್ತಿರುವ ಪ್ರಮುಖ ತಂತ್ರಜ್ಞಾನವಾಗಿ ಹೊರಹೊಮ್ಮಿದೆ. ಮಾನವನ ಚಿಂತನೆ, ಕಲಿಕೆ, ಭಾಷಾ ಸಂಸ್ಕರಣೆ, ಸಮಸ್ಯೆ ಪರಿಹಾರ, ವಿಶ್ಲೇಷಣೆ ಮತ್ತು ನಿರ್ಧಾರ ಕೈಗೊಳ್ಳುವಂತಹ ಕೆಲವು ಬೌದ್ಧಿಕ ಪ್ರಕ್ರಿಯೆಗಳನ್ನು ಗಣಕಯಂತ್ರಗಳು ನಿರ್ವಹಿಸುವಂತೆ ಮಾಡುವ ತಂತ್ರಜ್ಞಾನವೆಂದು AI ಅನ್ನು ಪರಿಗಣಿಸಬಹುದು. ಶಿಕ್ಷಣದ ಸಂದರ್ಭದಲ್ಲಿ AI ಕೇವಲ ಮಾಹಿತಿಯನ್ನು ಒದಗಿಸುವ ತಾಂತ್ರಿಕ ವ್ಯವಸ್ಥೆಯಾಗಿ ಮಾತ್ರವಲ್ಲದೆ, ಬೋಧನೆ–ಕಲಿಕೆಯ ಪ್ರಕ್ರಿಯೆಯನ್ನು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿ, ಸಂವಾದಾತ್ಮಕ, ವೈಯಕ್ತಿಕೀಕೃತ ಮತ್ತು ಕಲಿಕಾರ್ಥಿ ಕೇಂದ್ರಿತಗೊಳಿಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರುವ ಶೈಕ್ಷಣಿಕ ಸಾಧನವಾಗಿಯೂ ಮಹತ್ವ ಪಡೆದುಕೊಂಡಿದೆ.

ವಿಶೇಷವಾಗಿ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ಸಂದರ್ಭದಲ್ಲಿ ಇದರ ಪ್ರಸ್ತುತತೆ ಇನ್ನಷ್ಟು ಹೆಚ್ಚಾಗಿದೆ. ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರಾಗಲಿರುವ ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು ತಮ್ಮ ಬೋಧನಾ ವಿಷಯದಲ್ಲಿ ಸಮರ್ಪಕ ಮತ್ತು ಆಳವಾದ ಜ್ಞಾನವನ್ನು ಹೊಂದಿರುವುದರ ಜೊತೆಗೆ, ಆ ಜ್ಞಾನವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳ ವಯಸ್ಸು, ಸಾಮರ್ಥ್ಯ, ಆಸಕ್ತಿ ಮತ್ತು ಕಲಿಕಾ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಪರಿಣಾಮಕಾರಿಯಾಗಿ ರೂಪಾಂತರಿಸಿ ತಲುಪಿಸುವ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಿಕೊಳ್ಳಬೇಕಾಗಿದೆ.

ಅಧ್ಯಯನದ ಮಹತ್ವ:

ಶಿಕ್ಷಕರ ಗುಣಮಟ್ಟವೇ ಪರಿಣಾಮಕಾರಿ ಶಿಕ್ಷಣದ ಪ್ರಮುಖ ಆಧಾರವಾಗಿದ್ದು, ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರಾದ ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಲ್ಲಿ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಪರಿಣಾಮಕಾರಿ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸುವುದು ಅತ್ಯಂತ ಅಗತ್ಯವಾಗಿದೆ. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ವಿಷಯಾಧಾರಿತ ತಿಳುವಳಿಕೆ, ಪಾಠಯೋಜನೆ, ಬೋಧನಾ ಸಾಮಗ್ರಿ, ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಕಲಿಕೆ ಹಾಗೂ ಮೌಲ್ಯಮಾಪನವನ್ನು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ರೂಪಿಸಲು ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಒದಗಿಸುತ್ತಿದೆ. ಆದ್ದರಿಂದ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಂಖ ಯ ಸಮರ್ಪಕ ಬಳಕೆಯು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಜ್ಞಾನ, ಕೌಶಲ್ಯ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯವನ್ನು ಬಲಪಡಿಸುವಲ್ಲಿ ಮಹತ್ವದ್ದಾಗಿದೆ. ಅದೇ ಸಂದರ್ಭದಲ್ಲಿ ಂಖ ಬಳಕೆಯಿಂದ ಉಂಟಾಗಬಹುದಾದ ಅತಿಯಾದ ಅವಲಂಬನೆ, ಮಾಹಿತಿಯ ವಿಶ್ವಾಸಾರ್ಹತೆ ಮತ್ತು ನೈತಿಕ ಸವಾಲುಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಅಗತ್ಯವಾಗಿದೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಅಭಿವೃದ್ಧಿಯಲ್ಲಿ ಂಖ ಯ ಪಾತ್ರವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು ಸಮಕಾಲೀನ ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದ ದೃಷ್ಟಿಯಿಂದ ಅತ್ಯಂತ ಪ್ರಸ್ತುತ ಮತ್ತು ಅಗತ್ಯವಾದ ಸಂಶೋಧನಾ ಪ್ರಯತ್ನವಾಗಿದೆ.

ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳು:

1. ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಶಿಕ್ಷಣದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯನ್ನು ಬೋಧನಾ ಸಾಧನವಾಗಿ ಬಳಸುವ ಸಾಧ್ಯತೆಗಳನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.
2. ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಬಳಕೆಯು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನವನ್ನು ಹೆಚ್ಚಿಸುವಲ್ಲಿ ಹೊಂದಿರುವ ಪಾತ್ರವನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.

3. AI ಆಧಾರಿತ ಸಾಧನಗಳು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಮೇಲೆ ಬೀರುವ ಪ್ರಭಾವವನ್ನು ಪರಿಶೀಲಿಸುವುದು.
4. ಬೋಧನಾ ಯೋಜನೆ, ಬೋಧನಾ ವಿಧಾನ, ಕಲಿಕಾ ಸಾಮಗ್ರಿ ಮತ್ತು ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ AI ಯ ಬಳಕೆಯನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು.
5. ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಲ್ಲಿ AI ಆಧಾರಿತ ಬೋಧನೆಯ ಪರಿಣಾಮಕಾರಿ ಮತ್ತು ನೈತಿಕ ಬಳಕೆಗೆ ಸೂಕ್ತ ಸಲಹೆಗಳನ್ನು ನೀಡುವುದು.

ಸಾಹಿತ್ಯ ವಿಮರ್ಶೆ:

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಮತ್ತು ಶಿಕ್ಷಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಹಿಂದಿನ ಅಧ್ಯಯನಗಳು AI ಶಿಕ್ಷಣದ ವಿವಿಧ ಆಯಾಮಗಳ ಮೇಲೆ ಪರಿಣಾಮ ಬೀರುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಹೊಂದಿದೆ ಎಂದು ಸೂಚಿಸಿವೆ. ಂಖ ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವೈಯಕ್ತಿಕ ಕಲಿಕಾ ಅನುಭವಗಳನ್ನು ಒದಗಿಸುವುದು, ತ್ವರಿತ ಪ್ರತಿಕ್ರಿಯೆ ನೀಡುವುದು ಮತ್ತು ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಸುಲಭವಾಗಿ ಲಭ್ಯವಾಗುವಂತೆ ಮಾಡುವುದು ಸಾಧ್ಯವೆಂದು ಹಲವು ಅಧ್ಯಯನಗಳು ಸೂಚಿಸುತ್ತವೆ.

1. ಲಕಿನ್ ಮತ್ತು ಇತರರು (2016) ಅವರು ಶಿಕ್ಷಣದಲ್ಲಿ ಂಖ ಬಳಕೆಯು ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಬೋಧನಾ ಬೆಂಬಲ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಅನುಭವವನ್ನು ಸುಧಾರಿಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿದೆ ಎಂದು ವಿವರಿಸಿದ್ದಾರೆ. AI ಶಿಕ್ಷಕರನ್ನು ಬದಲಿಸುವ ಸಾಧನವಲ್ಲ; ಬದಲಾಗಿ ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿಸ್ತರಿಸುವ ತಂತ್ರಜ್ಞಾನವಾಗಬಹುದು ಎಂದು ಅವರ ಚರ್ಚೆಯಿಂದ ತಿಳಿಯುತ್ತದೆ.
2. ಜಾವಾಕಿ–ರಿಚ್ಚರ್ ಮತ್ತು ಇತರರು (2019) ಅವರು ಉನ್ನತ ಶಿಕ್ಷಣದಲ್ಲಿ AI ಬಳಕೆಗೆ ಸಂಬಂಧಿಸಿದ ಸಂಶೋಧನೆಗಳನ್ನು ಪರಿಶೀಲಿಸಿ, AI ಆಧಾರಿತ ವ್ಯವಸ್ಥೆಗಳು ವೈಯಕ್ತಿಕ ಕಲಿಕೆ, ಮೌಲ್ಯಮಾಪನ, ವಿದ್ಯಾರ್ಥಿ ಬೆಂಬಲ ಮತ್ತು ಆಡಳಿತಾತ್ಮಕ ಕಾರ್ಯಗಳಲ್ಲಿ ಉಪಯುಕ್ತವಾಗಬಹುದು ಎಂದು ಸೂಚಿಸಿದ್ದಾರೆ.
3. ಹೋಮ್ಸ್ ಮತ್ತು ಇತರರು (2019) ಅವರು ಶಿಕ್ಷಣದಲ್ಲಿ AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಶಿಕ್ಷಕರ ಪಾತ್ರ, ಮಾನವೀಯ ಮೌಲ್ಯಗಳು, ನೈತಿಕತೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿ ಕೇಂದ್ರಿತ ಕಲಿಕೆಗೆ ವಿಶೇಷ ಮಹತ್ವ ನೀಡಬೇಕೆಂದು ಒತ್ತಿಹೇಳಿದ್ದಾರೆ. AI ತಂತ್ರಜ್ಞಾನವನ್ನು ಬಳಸುವಾಗ ಮಾನವ ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ನಿರ್ಣಯ ಅತ್ಯಗತ್ಯವೆಂದು ಅವರು ಸೂಚಿಸಿದ್ದಾರೆ.
4. UNESCO (2023) ರಜಟಿಜಡಿಚಿಣುತಜ AI ಶಿಕ್ಷಣದಲ್ಲಿ ಹೊಸ ಅವಕಾಶಗಳನ್ನು ಸೃಷ್ಟಿಸಿದರೂ, ಗೌಪ್ಯತೆ, ಸಮಾನತೆ, ನೈತಿಕತೆ, ತಪ್ಪು ಮಾಹಿತಿ ಮತ್ತು ಮಾನವ ನಿಯಂತ್ರಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಸವಾಲುಗಳಿವೆ ಎಂದು ಸೂಚಿಸಿದೆ. ಆದ್ದರಿಂದ AI ಬಳಕೆಗೆ ಜವಾಬ್ದಾರಿಯುತ ಮತ್ತು ಮಾನವಕೇಂದ್ರಿತ ದೃಷ್ಟಿಕೋನ ಅಗತ್ಯವಾಗಿದೆ.

5. ರಾಷ್ಟ್ರೀಯ ಶಿಕ್ಷಣ ನೀತಿ 2020 ಶಿಕ್ಷಣದಲ್ಲಿ ತಂತ್ರಜ್ಞಾನ ಬಳಕೆ, ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ ಮತ್ತು ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯ ಅಭಿವೃದ್ಧಿಗೆ ಮಹತ್ವ ನೀಡುತ್ತದೆ. ಈ ದೃಷ್ಟಿಯಿಂದ ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಿಗೆ AI ಮತ್ತು ಡಿಜಿಟಲ್ ಪೆಡಗಾಜಿಯ ಕುರಿತು ಮೂಲಭೂತ ಜ್ಞಾನ ನೀಡುವುದು ಅಗತ್ಯವಾಗಿದೆ.

ಸಂಶೋಧನಾ ವಿಧಾನ:

a) ಸಂಶೋಧನಾ ವಿನ್ಯಾಸ

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವು ವರ್ಣನಾತ್ಮಕ, ವಿಶ್ಲೇಷಣಾತ್ಮಕ ಹಾಗೂ ದ್ವಿತೀಯ ದತ್ತಾಂಶ ಆಧಾರಿತ ಸಂಶೋಧನಾ ವಿನ್ಯಾಸವನ್ನು ಅಳವಡಿಸಿಕೊಂಡಿದೆ. ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ವಿಕಸನದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ (AI) ಪಾತ್ರ, ಶೈಕ್ಷಣಿಕ ಉಪಯುಕ್ತತೆ, ಸಾಧ್ಯತೆಗಳು ಹಾಗೂ ಸವಾಲುಗಳನ್ನು ಸಮಗ್ರವಾಗಿ ಅರ್ಥೈಸಿ ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ವಿಶ್ಲೇಷಿಸುವುದು ಈ ಅಧ್ಯಯನದ ಪ್ರಮುಖ ಉದ್ದೇಶವಾಗಿದೆ. ಅಧ್ಯಯನದಲ್ಲಿ ಯಾವುದೇ ನೇರ ಪ್ರಾಥಮಿಕ ದತ್ತಾಂಶವನ್ನು ಕ್ಷೇತ್ರಮಟ್ಟದಲ್ಲಿ ಸಂಗ್ರಹಿಸಲಾಗಿಲ್ಲ. ಬದಲಾಗಿ, ವಿಷಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಪ್ರಕಟಿತ ಸಂಶೋಧನಾ ಲೇಖನಗಳು, ಶೈಕ್ಷಣಿಕ ನಿಯತಕಾಲಿಕೆಗಳು, ಪುಸ್ತಕಗಳು, ಸಂಶೋಧನಾ ವರದಿಗಳು, ಸರ್ಕಾರಿ ನೀತಿ ದಾಖಲೆಗಳು, ರಾಷ್ಟ್ರೀಯ ಮತ್ತು ಅಂತರರಾಷ್ಟ್ರೀಯ ಶೈಕ್ಷಣಿಕ ಸಂಸ್ಥೆಗಳ ವರದಿಗಳು ಹಾಗೂ ಅಧಿಕೃತ ಶೈಕ್ಷಣಿಕ ಪ್ರಕಟಣೆಗಳನ್ನು ವಿಶ್ವಾಸಾರ್ಹ ದ್ವಿತೀಯ ದತ್ತಾಂಶದ ಮೂಲಗಳಾಗಿ ಪರಿಗಣಿಸಲಾಗಿದೆ.

b) ದತ್ತಾಂಶ ವಿಶ್ಲೇಷಣೆ

ಲಭ್ಯವಿರುವ ದ್ವಿತೀಯ ದತ್ತಾಂಶವನ್ನು ಅಧ್ಯಯನದ ಉದ್ದೇಶಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವ್ಯವಸ್ಥಿತವಾಗಿ ಪರಿಶೀಲಿಸಿ, AI ಮತ್ತು ವಿಷಯ ಜ್ಞಾನ, ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಪಾಠಯೋಜನೆ ಹಾಗೂ ಬೋಧನಾ ವಿನ್ಯಾಸ, ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳ ಸೃಜನಶೀಲ ಬಳಕೆ, ಮೌಲ್ಯಮಾಪನ ಮತ್ತು ವೈಯಕ್ತಿಕೀಕೃತ ಕಲಿಕೆ ಎಂಬ ಪ್ರಮುಖ ಆಯಾಮಗಳ ಅಡಿಯಲ್ಲಿ ವಿಷಯಾಧಾರಿತವಾಗಿ ವಿಶ್ಲೇಷಿಸಲಾಗಿದೆ. ಇದರೊಂದಿಗೆ AI ಬಳಕೆಯಿಂದ ಉಂಟಾಗಬಹುದಾದ ತಾಂತ್ರಿಕ, ನೈತಿಕ, ಶೈಕ್ಷಣಿಕ ಹಾಗೂ ವೃತ್ತಿಪರ ಸವಾಲುಗಳನ್ನೂ ವಿಮರ್ಶಾತ್ಮಕವಾಗಿ ಪರಿಗಣಿಸಲಾಗಿದೆ. ವಿವಿಧ ಮೂಲಗಳಿಂದ ಲಭ್ಯವಾದ ಮಾಹಿತಿಯಲ್ಲಿನ ಸಾಮ್ಯತೆಗಳು, ಪ್ರಮುಖ ಪ್ರವೃತ್ತಿಗಳು ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಪರಿಣಾಮಗಳನ್ನು ಹೋಲಿಕೆ ಮಾಡಿ, ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಹಾಗೂ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು AI ಹೇಗೆ ಪೂರಕವಾಗಿ ಬಲಪಡಿಸಬಲ್ಲದು ಎಂಬುದನ್ನು ನಿರೂಪಿಸಲಾಗಿದೆ.

c) ಅಧ್ಯಯನದ ವ್ಯಾಪ್ತಿ

ಅಧ್ಯಯನವು ಮುಖ್ಯವಾಗಿ ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದ AI ಬಳಕೆಯ ಶೈಕ್ಷಣಿಕ ಆಯಾಮಗಳ ಮೇಲೆ ಕೇಂದ್ರೀಕೃತವಾಗಿದೆ.

d) AI ಮತ್ತು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನ:

ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಆಧಾರಿತ ಸಾಧನಗಳು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಿಗೆ ವಿವಿಧ ವಿಷಯಗಳ ಕುರಿತು

ತ್ವರಿತ, ವೈವಿಧ್ಯಮಯ ಮತ್ತು ಸಂದರ್ಭೋಚಿತ ಮಾಹಿತಿಯನ್ನು ಅನ್ವೇಷಿಸಲು ಅವಕಾಶ ಕಲ್ಪಿಸುವ ಮೂಲಕ ಅವರ ವಿಷಯಾಧಾರಿತ ತಿಳುವಳಿಕೆಯನ್ನು ವಿಸ್ತರಿಸುವಲ್ಲಿ ಪೂರಕ ಪಾತ್ರ ವಹಿಸಬಲ್ಲವು. ನಿರ್ದಿಷ್ಟ ವಿಷಯ ಅಥವಾ ಪರಿಕಲ್ಪನೆಯ ಕುರಿತು ಸರಳ ವಿವರಣೆ, ಪರ್ಯಾಯ ವ್ಯಾಖ್ಯಾನಗಳು, ಉದಾಹರಣೆಗಳು, ಹೋಲಿಕೆಗಳು, ಪ್ರಶ್ನೋತ್ತರಗಳು ಹಾಗೂ ಹೆಚ್ಚುವರಿ ಅಧ್ಯಯನ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಪಡೆಯುವ ಮೂಲಕ ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು ತಮ್ಮ ವಿಷಯ ಜ್ಞಾನವನ್ನು ಇನ್ನಷ್ಟು ಆಳಗೊಳಿಸಬಹುದು. ವಿಶೇಷವಾಗಿ ಸಂಕೀರ್ಣ ಮತ್ತು ಅಮೂರ್ತ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಹಂತ ಹಂತವಾಗಿ ವಿವರಿಸುವುದು, ವಿವಿಧ ಕಲಿಕಾ ಮಟ್ಟಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವಿಷಯವನ್ನು ಮರುಸಂಘಟಿಸುವುದು ಹಾಗೂ ಒಂದೇ ವಿಷಯವನ್ನು ವಿಭಿನ್ನ ದೃಷ್ಟಿಕೋನಗಳಿಂದ ಅರ್ಥೈಸಿಕೊಳ್ಳಲು ನೆರವಾಗುವುದು AI ಯ ಪ್ರಮುಖ ಶೈಕ್ಷಣಿಕ ಸಾಧ್ಯತೆಗಳಾಗಿವೆ. ಈ ರೀತಿಯ ಬಳಕೆಯು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಸ್ವಯಂ–ಅಧ್ಯಯನ, ಜ್ಞಾನಾನ್ವೇಷಣೆ ಮತ್ತು ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆಗೆ ಉತ್ತೇಜನ ನೀಡುವ ಸಾಧ್ಯತೆಯನ್ನು ಹೊಂದಿದೆ. UNESCO 2024ರ AI Competency Framework for Teachers ಕೂಡ ಶಿಕ್ಷಕರು AI ಯ ತಾಂತ್ರಿಕ, ನೈತಿಕ ಮತ್ತು ಶೈಕ್ಷಣಿಕ ಆಯಾಮಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಂಡು ಅದನ್ನು ವಿವೇಚನಾಶೀಲವಾಗಿ ಬಳಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಿಕೊಳ್ಳಬೇಕೆಂದು ಒತ್ತಿಹೇಳುತ್ತದೆ.

ಇದಲ್ಲದೆ, AI ಯನ್ನು ವಿಷಯ ಜ್ಞಾನವನ್ನು ಬೋಧನಾ ಜ್ಞಾನವಾಗಿ ಪರಿವರ್ತಿಸುವ ಪೂರಕ ಸಾಧನವಾಗಿ ಬಳಸಬಹುದಾಗಿದೆ. ಉದಾಹರಣೆಗೆ, ವಿಜ್ಞಾನ ವಿಷಯದಲ್ಲಿ ಸಂಕೀರ್ಣ ವೈಜ್ಞಾನಿಕ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ದೈನಂದಿನ ಜೀವನದ ಉದಾಹರಣೆಗಳೊಂದಿಗೆ ವಿವರಿಸುವುದು, ಸಮಾಜ ವಿಜ್ಞಾನದಲ್ಲಿ ಐತಿಹಾಸಿಕ ಘಟನೆಗಳ ಕಾರಣ–ಪರಿಣಾಮ ಸಂಬಂಧಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು, ಗಣಿತದಲ್ಲಿ ಸಮಸ್ಯೆ ಪರಿಹಾರದ ವಿವಿಧ ವಿಧಾನಗಳನ್ನು ಪ್ರದರ್ಶಿಸುವುದು ಹಾಗೂ ಭಾಷಾ ವಿಷಯದಲ್ಲಿ ಪದಪ್ರಯೋಗ, ವ್ಯಾಕರಣ ಮತ್ತು ಅಭಿವ್ಯಕ್ತಿಯ ಪರ್ಯಾಯ ಮಾದರಿಗಳನ್ನು ರೂಪಿಸುವುದು ಸಾಧ್ಯ. ಇದರಿಂದ ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು ಕೇವಲ ಮಾಹಿತಿಯನ್ನು ಪಡೆದುಕೊಳ್ಳುವುದಕ್ಕಿಂತ, **“ಏನು ಬೋಧಿಸಬೇಕು?”**, **“ಹೇಗೆ ಬೋಧಿಸಬೇಕು?”** ಮತ್ತು **“ಯಾವ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ಯಾವ ರೀತಿಯಲ್ಲಿ ಬೋಧಿಸಬೇಕು?”** ಎಂಬ ಬೋಧನಾ ನಿರ್ಧಾರಗಳನ್ನು ಹೆಚ್ಚು ಸಮರ್ಥವಾಗಿ ರೂಪಿಸಿಕೊಳ್ಳಲು ಅವಕಾಶ ಪಡೆಯುತ್ತಾರೆ. UNESCO ಮಾರ್ಗಸೂಚಿಗಳ ಪ್ರಕಾರ, AI ಯನ್ನು ಪಠ್ಯಕ್ರಮ ವಿನ್ಯಾಸ, ಬೋಧನೆ, ಕಲಿಕೆ ಮತ್ತು ಸಂಶೋಧನಾ ಚಟುವಟಿಕೆಗಳಲ್ಲಿ ಸೃಜನಾತ್ಮಕವಾಗಿ ಬಳಸಬಹುದಾದರೂ, ಅದರ ಬಳಕೆ ಮಾನವಕೇಂದ್ರಿತ, ಸುರಕ್ಷಿತ, ಸಮಾನತಾಧಾರಿತ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತವಾಗಿರಬೇಕು.

ಹೀಗಾಗಿ, ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನವನ್ನು ವೃದ್ಧಿಸುವಲ್ಲಿ AI ಯ ಮಹತ್ವವು ಮಾಹಿತಿಯನ್ನು ವೇಗವಾಗಿ ಒದಗಿಸುವುದರಲ್ಲಿ ಮಾತ್ರವಲ್ಲ; ಮಾಹಿತಿಯನ್ನು ವಿಶ್ಲೇಷಿಸುವುದು, ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಆಳವಾಗಿ ಅರ್ಥೈಸಿಕೊಳ್ಳುವುದು, ವಿವಿಧ ದೃಷ್ಟಿಕೋನಗಳನ್ನು ಹೋಲಿಸುವುದು ಮತ್ತು ಅವುಗಳನ್ನು ಪರಿಣಾಮಕಾರಿ ಬೋಧನಾ ಅನುಭವವಾಗಿ ರೂಪಿಸುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸುವುದರಲ್ಲಿ ಅಡಗಿದೆ. ಈ ದೃಷ್ಟಿಯಿಂದ AI ಯನ್ನು ಸ್ವತಂತ್ರ ಜ್ಞಾನಮೂಲವಾಗಿ ಬಳಸುವುದಕ್ಕಿಂತ, ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಯ

ವಿಷಯಜ್ಞಾನ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ ಮತ್ತು ಶಿಕ್ಷಕರ ವೃತ್ತಿಪರ ನಿರ್ಣಯಕ್ಕೆ ಪೂರಕವಾಗುವ ಬುದ್ಧಿವಂತ ಮತ್ತು ಜವಾಬ್ದಾರಿಯುತ ಬೋಧನಾ ಸಹಾಯಕ ಸಾಧನವಾಗಿ ಬಳಸುವುದು ಹೆಚ್ಚು ಶೈಕ್ಷಣಿಕವಾಗಿ ಸೂಕ್ತವಾಗಿದೆ.

e) AI ಮತ್ತು ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ

ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವು ಕೇವಲ ವಿಷಯ ಜ್ಞಾನವನ್ನು ಹೊಂದಿರುವುದಕ್ಕೆ ಸೀಮಿತವಾಗದೆ, ಆ ಜ್ಞಾನವನ್ನು ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಮಟ್ಟ, ಆಸಕ್ತಿ, ಸಾಮರ್ಥ್ಯ ಮತ್ತು ವೈವಿಧ್ಯಮಯ ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ಅರ್ಥಪೂರ್ಣ, ಪರಿಣಾಮಕಾರಿ ಹಾಗೂ ಅನುಭವಾಧಾರಿತ ಕಲಿಕಾ ಪ್ರಕ್ರಿಯೆಯಾಗಿ ರೂಪಿಸುವ ಶಿಕ್ಷಕರ ಸಮಗ್ರ ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯವಾಗಿದೆ. ಈ ಸಾಮರ್ಥ್ಯದಲ್ಲಿ ಪಾಠಯೋಜನೆ ರೂಪಿಸುವುದು, ಸೂಕ್ತ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಆಯ್ಕೆಮಾಡುವುದು, ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳನ್ನು ವಿನ್ಯಾಸಗೊಳಿಸುವುದು, ತರಗತಿ ಸಂವಹನವನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ನಿರ್ವಹಿಸುವುದು, ವಿದ್ಯಾರ್ಥಿಗಳ ಕಲಿಕಾ ಪ್ರಗತಿಯನ್ನು ಗುರುತಿಸುವುದು ಹಾಗೂ ಸೂಕ್ತ ಪ್ರತಿಕ್ರಿಯೆ ಮತ್ತು ಮೌಲ್ಯಮಾಪನವನ್ನು ಒದಗಿಸುವಂತಹ ವಿವಿಧ ಆಯಾಮಗಳು ಒಳಗೊಂಡಿವೆ. ಈ ಹಿನ್ನೆಲೆಯಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಶಿಕ್ಷಕರ ಬೋಧನಾ ಸಾಮರ್ಥ್ಯವನ್ನು ಪೂರಕವಾಗಿ ಬಲಪಡಿಸಬಲ್ಲ ನವೀನ ಶೈಕ್ಷಣಿಕ ತಂತ್ರಜ್ಞಾನವಾಗಿ ಮಹತ್ವ ಪಡೆಯುತ್ತಿದೆ.

- ಪಾಠಯೋಜನೆ: ಕಲಿಕಾ ಉದ್ದೇಶಗಳು, ಬೋಧನಾ ಹಂತಗಳು, ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಮೌಲ್ಯಮಾಪನ ಪ್ರಶ್ನೆಗಳನ್ನು ರೂಪಿಸಲು AI ಸಹಾಯ ಮಾಡಬಹುದು.
- ಬೋಧನಾ ಸಾಮಗ್ರಿಗಳು: ಕಾರ್ಯಪತ್ರಿಕೆಗಳು, ಪ್ರಶ್ನೋತ್ತರಗಳು, ಚರ್ಚಾ ವಿಷಯಗಳು, ಉದಾಹರಣೆಗಳು ಮತ್ತು ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳನ್ನು ಸಿದ್ಧಪಡಿಸಲು AI ಬಳಸಬಹುದು.
- ವೈಯಕ್ತಿಕ ಕಲಿಕೆ: ವಿಭಿನ್ನ ಸಾಮರ್ಥ್ಯದ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ ವಿಭಿನ್ನ ಮಟ್ಟದ ಚಟುವಟಿಕೆಗಳನ್ನು ರೂಪಿಸಲು AI ಸಹಾಯ ಮಾಡಬಹುದು.
- ಮೌಲ್ಯಮಾಪನ: ಪ್ರಶ್ನೆಪತ್ರಿಕೆ, ರೂಪಣಾತ್ಮಕ ಮೌಲ್ಯಮಾಪನ (formative assessment) ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆಯ ಮಾದರಿಗಳನ್ನು ರೂಪಿಸಲು ಂಖ ಉಪಯುಕ್ತವಾಗಬಹುದು.
- ಸೃಜನಶೀಲತೆ: ಕಥೆ, ಉದಾಹರಣೆ, ಸಮಸ್ಯಾ ಆಧಾರಿತ ಕಲಿಕೆ ಮತ್ತು ಚಟುವಟಿಕೆ ಆಧಾರಿತ ಬೋಧನೆಗೆ ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ಪಡೆಯಲು AI ಸಹಾಯಕವಾಗಿದೆ.

ಈ ಕಾರಣಗಳಿಂದ AI ಯ ಸೂಕ್ತ ಬಳಕೆಯು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಬೋಧನಾ ಸಿದ್ಧತೆ ಮತ್ತು ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯವನ್ನು ಬಲಪಡಿಸುವ ಸಾಧ್ಯತೆ ಹೊಂದಿದೆ.

f) ವಿಶ್ಲೇಷಣಾತ್ಮಕ ಅವಲೋಕನದಿಂದ ಹೊರಹೊಮ್ಮಿದ ಅಂಶಗಳು

- **ವಿಷಯ ಜ್ಞಾನದಲ್ಲಿ ವೃದ್ಧಿ:** AI ಆಧಾರಿತ ಸಾಧನಗಳು ಬಿ.ಎಡ್. ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಿಗೆ ವಿವಿಧ ವಿಷಯಗಳ ಕುರಿತು ತ್ವರಿತವಾಗಿ ಮತ್ತು ವೈವಿಧ್ಯಮಯವಾಗಿ ಮಾಹಿತಿಯನ್ನು ಪಡೆಯಲು ನೆರವಾಗುವುದರಿಂದ ಅವರ ವಿಷಯಾಧಾರಿತ ತಿಳುವಳಿಕೆಯನ್ನು ವಿಸ್ತರಿಸುವಲ್ಲಿ ಪೂರಕವಾಗಿವೆ.
- **ಪರಿಕಲ್ಪನಾತ್ಮಕ ತಿಳುವಳಿಕೆಯ ಬಲವರ್ಧನೆ:** ಸಂಕೀರ್ಣ ಹಾಗೂ ಅಮೂರ್ತ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಸರಳ ವಿವರಣೆಗಳು, ಉದಾಹರಣೆಗಳು ಮತ್ತು ಪರ್ಯಾಯ ದೃಷ್ಟಿಕೋನಗಳ ಮೂಲಕ ಅರ್ಥೈಸಿಕೊಳ್ಳಲು AI ಸಹಕಾರಿಯಾಗಿದ್ದು, ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಆಳವಾದ ಕಲಿಕೆಗೆ ಅವಕಾಶ ಕಲ್ಪಿಸುತ್ತದೆ.
- **ಪಾಠಯೋಜನಾ ಸಾಮರ್ಥ್ಯದ ಅಭಿವೃದ್ಧಿ:** ಕಲಿಕಾ ಉದ್ದೇಶಗಳು, ಬೋಧನಾ ಹಂತಗಳು, ತರಗತಿ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಮೌಲ್ಯಮಾಪನ ವಿಧಾನಗಳನ್ನು ಒಳಗೊಂಡ ಪರಿಣಾಮಕಾರಿ ಪಾಠಯೋಜನೆಗಳನ್ನು ರೂಪಿಸುವಲ್ಲಿ AI ಉಪಯುಕ್ತ ಸಹಾಯಕ ಸಾಧನವಾಗಿದೆ.
- **ಬೋಧನಾ ಸಾಮರ್ಥ್ಯದ ಬಲವರ್ಧನೆ:** AI ಯ ಸಮರ್ಪಕ ಬಳಕೆಯು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಬೋಧನಾ ವಿಧಾನಗಳ ಆಯ್ಕೆ, ತರಗತಿ ಚಟುವಟಿಕೆಗಳ ವಿನ್ಯಾಸ, ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳ ಸಿದ್ಧತೆ ಮತ್ತು ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಬೋಧನೆಯನ್ನು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ರೂಪಿಸಲು ನೆರವಾಗುತ್ತದೆ.
- **ಸೃಜನಶೀಲತೆ ಮತ್ತು ನವೀನತೆಯ ಉತ್ತೇಜನ:** AI ವಿವಿಧ ಬೋಧನಾ ತಂತ್ರಗಳು, ಚಟುವಟಿಕೆಗಳು, ಉದಾಹರಣೆಗಳು ಮತ್ತು ಕಲಿಕಾ ಸಂಪನ್ಮೂಲಗಳ ಕುರಿತು ಹೊಸ ಆಲೋಚನೆಗಳನ್ನು ಒದಗಿಸುವ ಮೂಲಕ ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಸೃಜನಶೀಲ ಮತ್ತು ನವೀನ ಚಿಂತನೆಗೆ ಉತ್ತೇಜನ ನೀಡುತ್ತದೆ.
- **ವೈಯಕ್ತಿಕೀಕೃತ ಕಲಿಕೆಗೆ ಅವಕಾಶ:** ವಿದ್ಯಾರ್ಥಿಗಳ ವಿಭಿನ್ನ ಕಲಿಕಾ ಸಾಮರ್ಥ್ಯ, ವೇಗ ಮತ್ತು ಅಗತ್ಯಗಳಿಗೆ ಅನುಗುಣವಾಗಿ ವಿಷಯ ಹಾಗೂ ಚಟುವಟಿಕೆಗಳನ್ನು ರೂಪಿಸಲು AI ನೆರವಾಗುವುದರಿಂದ ಹೆಚ್ಚು ಕಲಿಕಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಬೋಧನೆಗೆ ಅವಕಾಶ ದೊರೆಯುತ್ತದೆ.
- **ಮೌಲ್ಯಮಾಪನ ಪ್ರಕ್ರಿಯೆಗೆ ಪೂರಕ:** ಪ್ರಶ್ನೆಗಳು, ಕಾರ್ಯಪತ್ರಿಕೆಗಳು, ರೂಪಣಾತ್ಮಕ ಮೌಲ್ಯಮಾಪನ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ಪ್ರತಿಕ್ರಿಯೆಯ ಮಾದರಿಗಳನ್ನು ಸಿದ್ಧಪಡಿಸುವಲ್ಲಿ AI ಸಹಾಯಕವಾಗಿದ್ದು, ಬೋಧನೆ–ಕಲಿಕೆಯ ನಿರಂತರ ಮೌಲ್ಯಮಾಪನವನ್ನು ಸುಗಮಗೊಳಿಸುತ್ತದೆ.
- **ಡಿಜಿಟಲ್ ಮತ್ತು ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯದ ಅಭಿವೃದ್ಧಿ:** AI ಯ ಜವಾಬ್ದಾರಿಯುತ ಬಳಕೆಯು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ಡಿಜಿಟಲ್ ಸಾಕ್ಷರತೆ, ತಂತ್ರಜ್ಞಾನಾಧಾರಿತ ಬೋಧನಾ ಕೌಶಲ್ಯ ಮತ್ತು ಭವಿಷ್ಯೋನ್ಮುಖ ವೃತ್ತಿಪರ ಸಾಮರ್ಥ್ಯವನ್ನು ಬಲಪಡಿಸುವ ಸಾಧ್ಯತೆಯನ್ನು ಹೊಂದಿದೆ.
- **ವಿಮರ್ಶಾತ್ಮಕ ಪರಿಶೀಲನೆಯ ಅಗತ್ಯತೆ:** AI ಒದಗಿಸುವ ಮಾಹಿತಿಯು ಸದಾ ನಿಖರವಾಗಿರುತ್ತದೆ ಎಂಬುದಿಲ್ಲ. ಆದ್ದರಿಂದ ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು ಮಾಹಿತಿಯ ಸತ್ಯಾಸತ್ಯತೆ, ವಿಶ್ವಾಸಾರ್ಹತೆ ಮತ್ತು ಪ್ರಸ್ತುತತೆಯನ್ನು ಪರಿಶೀಲಿಸುವ ವಿಮರ್ಶಾತ್ಮಕ ಸಾಮರ್ಥ್ಯವನ್ನು ಬೆಳೆಸಿಕೊಳ್ಳುವುದು ಅತ್ಯಗತ್ಯವಾಗಿದೆ.

g) ಶಿಫಾರಸುಗಳು ಮತ್ತು ಸಲಹೆಗಳು:

- ಬಿ.ಎಡ್. ಪಠ್ಯಕ್ರಮದಲ್ಲಿ AI ಕುರಿತ ಅಂಶಗಳನ್ನು ಅಳವಡಿಸುವುದು: ಇಂದಿನ ಶಿಕ್ಷಣದ ಬದಲಾದ ಸ್ವರೂಪವನ್ನು ಗಮನದಲ್ಲಿಟ್ಟುಕೊಂಡು, ಬಿ.ಎಡ್. ಪಠ್ಯಕ್ರಮದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯ ಮೂಲಭೂತ ಅರಿವು, ಅದರ ಶೈಕ್ಷಣಿಕ ಬಳಕೆ ಮತ್ತು ಮಿತಿಗಳಿಗೆ ಸಂಬಂಧಿಸಿದ ವಿಷಯಗಳಿಗೆ ಸೂಕ್ತ ಸ್ಥಾನ ನೀಡಬೇಕು.
- ಪ್ರಾಯೋಗಿಕ ತರಬೇತಿಗೆ ಹೆಚ್ಚಿನ ಒತ್ತು: ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಿಗೆ AI ಕುರಿತು ಕೇವಲ ಸೈದ್ಧಾಂತಿಕ ಮಾಹಿತಿ ನೀಡುವುದರ ಬದಲು, ಪಾಠಯೋಜನೆ ಸಿದ್ಧಪಡಿಸುವುದು, ಬೋಧನಾ ಸಾಮಗ್ರಿ ರೂಪಿಸುವುದು, ಪ್ರಶ್ನೆಪತ್ರಿಕೆ ಸಿದ್ಧಪಡಿಸುವುದು ಮತ್ತು ಕಲಿಕಾ ಚಟುವಟಿಕೆಗಳನ್ನು ವಿನ್ಯಾಸಗೊಳಿಸುವಂತಹ ಕಾರ್ಯಗಳಲ್ಲಿ AI ಬಳಸುವ ಪ್ರಾಯೋಗಿಕ ಅನುಭವ ಒದಗಿಸಬೇಕು.
- ವಿಷಯ ಜ್ಞಾನವನ್ನು ಬಲಪಡಿಸಲು AI ಬಳಕೆ: ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು AI ಮೂಲಕ ದೊರೆಯುವ ಮಾಹಿತಿಯನ್ನು ತಮ್ಮ ವಿಷಯಾಧಾರಿತ ಜ್ಞಾನದೊಂದಿಗೆ ಸಂಯೋಜಿಸಿಕೊಂಡು, ವಿಷಯದ ವಿವಿಧ ಆಯಾಮಗಳನ್ನು ಆಳವಾಗಿ ತಿಳಿದುಕೊಳ್ಳುವಂತೆ ಪ್ರೋತ್ಸಾಹಿಸಬೇಕು. ಇದರಿಂದ ಅವರ ವಿಷಯಪರ ಪರಿಣತಿ ಮತ್ತಷ್ಟು ವಿಸ್ತರಿಸಲು ಸಾಧ್ಯವಾಗುತ್ತದೆ.
- ಬೋಧನಾ ಸಾಮರ್ಥ್ಯಕ್ಕೆ ಪೂರಕವಾಗಿ ಬಳಸುವುದು: AICನ್ನು ಕೇವಲ ಮಾಹಿತಿ ಪಡೆಯುವ ಸಾಧನವಾಗಿ ಬಳಸುವುದಕ್ಕಿಂತ, ಪರಿಣಾಮಕಾರಿ ಪಾಠಯೋಜನೆ, ಸೂಕ್ತ ಬೋಧನಾ ವಿಧಾನಗಳ ಆಯ್ಕೆ, ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಚಟುವಟಿಕೆಗಳ ರೂಪಣೆ ಮತ್ತು ಕಲಿಕೆಯ ಮೌಲ್ಯಮಾಪನಕ್ಕೆ ಪೂರಕವಾಗುವ ರೀತಿಯಲ್ಲಿ ಬಳಸಬೇಕು.
- ನೈತಿಕ ಅರಿವಿಗೆ ಆದ್ಯತೆ: AI ಬಳಕೆಯ ಸಂದರ್ಭದಲ್ಲಿ ಕೃತಿಸ್ವಾಮ್ಯ, ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ, ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ಗೌಪ್ಯತೆ, ತಪ್ಪು ಮಾಹಿತಿ ಮತ್ತು ತಂತ್ರಜ್ಞಾನದ ದುರ್ಬಳಕೆಯಂತಹ ವಿಚಾರಗಳ ಕುರಿತು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳಿಗೆ ಸ್ಪಷ್ಟವಾದ ಅರಿವು ಮೂಡಿಸಬೇಕು.
- ಶಿಕ್ಷಕರ ಸ್ವತಂತ್ರ ಚಿಂತನೆಗೆ ಅವಕಾಶ: AI ನೀಡುವ ಉತ್ತರಗಳ ಮೇಲೆ ಸಂಪೂರ್ಣ ಅವಲಂಬಿತರಾಗದೆ, ಸ್ವಂತ ಅನುಭವ, ವಿಷಯ ಜ್ಞಾನ ಮತ್ತು ವೃತ್ತಿಪರ ವಿವೇಚನೆಯ ಆಧಾರದ ಮೇಲೆ ನಿರ್ಧಾರ ಕೈಗೊಳ್ಳುವ ಸಾಮರ್ಥ್ಯವನ್ನು ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳು ಬೆಳೆಸಿಕೊಳ್ಳಬೇಕು.

ಉಪಸಂಹಾರ: ಸಮಕಾಲೀನ ಶಿಕ್ಷಣದ ವೇಗವಾಗಿ ಬದಲಾಗುತ್ತಿರುವ ಸ್ವರೂಪದಲ್ಲಿ ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆಯು ಕೇವಲ ತಾಂತ್ರಿಕ ನವೀನತೆಯಾಗಿ ಉಳಿಯದೆ, ಬೋಧನೆ–ಕಲಿಕೆಯ ಗುಣಮಟ್ಟವನ್ನು ಪುನರ್ರೂಪಿಸುವ ಸಾಮರ್ಥ್ಯ ಹೊಂದಿರುವ ಮಹತ್ವದ ಶೈಕ್ಷಣಿಕ ಸಾಧನವಾಗಿ ರೂಪುಗೊಳ್ಳುತ್ತಿದೆ. ಈ ಅಧ್ಯಯನದ ದ್ವಿತೀಯ ದತ್ತಾಂಶ ಆಧಾರಿತ ವಿಶ್ಲೇಷಣೆಯಿಂದ, AI ಯ ಸಮರ್ಪಕ ಬಳಕೆಯು ಬಿ.ಎಡ್.

ಪ್ರಶಿಕ್ಷಣಾರ್ಥಿಗಳ ವಿಷಯ ಜ್ಞಾನವನ್ನು ವಿಸ್ತರಿಸುವುದು, ಸಂಕೀರ್ಣ ಪರಿಕಲ್ಪನೆಗಳನ್ನು ಸುಲಭವಾಗಿ ಗ್ರಹಿಸಲು ನೆರವಾಗುವುದು, ಪಾಠಯೋಜನೆ ಮತ್ತು ಕಲಿಕಾ ಸಾಮಗ್ರಿಗಳ ರೂಪಣೆಯನ್ನು ಸುಗಮಗೊಳಿಸುವುದು, ವೈವಿಧ್ಯಮಯ ಬೋಧನಾ ವಿಧಾನಗಳನ್ನು ಅಳವಡಿಸಿಕೊಳ್ಳಲು ಪ್ರೇರೇಪಿಸುವುದು ಹಾಗೂ ವಿದ್ಯಾರ್ಥಿ–ಕೇಂದ್ರಿತ ಬೋಧನೆ ಮತ್ತು ಮೌಲ್ಯಮಾಪನವನ್ನು ಪರಿಣಾಮಕಾರಿಗೊಳಿಸುವುದು ಮುಂತಾದ ಕ್ಷೇತ್ರಗಳಲ್ಲಿ ಗಮನಾರ್ಹ ಶೈಕ್ಷಣಿಕ ಸಾಧ್ಯತೆಗಳನ್ನು ಹೊಂದಿದೆ ಎಂಬುದು ಸ್ಪಷ್ಟವಾಗುತ್ತದೆ. ಅದೇ ಸಂದರ್ಭದಲ್ಲಿ, AI ಒದಗಿಸುವ ಮಾಹಿತಿಯನ್ನು ಪರಿಶೀಲಿಸದೆ ಸ್ವೀಕರಿಸುವುದು, ತಂತ್ರಜ್ಞಾನದ ಮೇಲಿನ ಅತಿಯಾದ ಅವಲಂಬನೆ, ಶೈಕ್ಷಣಿಕ ಪ್ರಾಮಾಣಿಕತೆ, ಗೌಪ್ಯತೆ, ಮಾಹಿತಿಯ ವಿಶ್ವಾಸಾರ್ಹತೆ ಮತ್ತು ನೈತಿಕ ಹೊಣೆಗಾರಿಕೆಯಂತಹ ಸವಾಲುಗಳು ಅದರ ಬಳಕೆಯಲ್ಲಿ ಎಚ್ಚರಿಕೆಯ ಅಗತ್ಯವನ್ನು ಸೂಚಿಸುತ್ತವೆ. ಆದ್ದರಿಂದ ಭವಿಷ್ಯದ ಶಿಕ್ಷಕರ ಸಿದ್ಧತೆಯಲ್ಲಿ AI ಸಾಕ್ಷರತೆಯನ್ನು ಕೇವಲ ತಾಂತ್ರಿಕ ಕೌಶಲ್ಯವಾಗಿ ನೋಡದೆ, ವಿಷಯಪರ ಪರಿಣತಿ, ಬೋಧನಾ ಸಾಮರ್ಥ್ಯ, ಡಿಜಿಟಲ್ ಕೌಶಲ್ಯ, ವಿಮರ್ಶಾತ್ಮಕ ಚಿಂತನೆ, ಸೃಜನಶೀಲತೆ ಮತ್ತು ನೈತಿಕ ವಿವೇಚನೆಗಳೊಂದಿಗೆ ಸಮನ್ವಯಗೊಳಿಸುವುದು ಅಗತ್ಯವಾಗಿದೆ.

ಒಟ್ಟಿನಲ್ಲಿ, AI ಯ ಮೌಲ್ಯವು ಅದು ಶಿಕ್ಷಕರ ಸ್ಥಾನವನ್ನು ಎಷ್ಟರ ಮಟ್ಟಿಗೆ ಪಡೆಯುತ್ತದೆ ಎಂಬುದರಲ್ಲಿ ಅಲ್ಲ; ಬದಲಾಗಿ ಶಿಕ್ಷಕರು ಅದನ್ನು ತಮ್ಮ ಜ್ಞಾನ, ಅನುಭವ ಮತ್ತು ವೃತ್ತಿಪರ ವಿವೇಚನೆಯೊಂದಿಗೆ ಎಷ್ಟರ ಮಟ್ಟಿಗೆ ಅರ್ಥಪೂರ್ಣವಾಗಿ ಬಳಸಿಕೊಳ್ಳುತ್ತಾರೆ ಎಂಬುದರಲ್ಲಿ ಅಡಗಿದೆ. ಹೀಗಾಗಿ, "ಕೃತಕ ಬುದ್ಧಿಮತ್ತೆ ಶಿಕ್ಷಕರ ಪರ್ಯಾಯವಲ್ಲ; ಶಿಕ್ಷಕರ ಸಾಮರ್ಥ್ಯವನ್ನು ವಿಸ್ತರಿಸುವ ಮತ್ತು ಬೋಧನೆಯನ್ನು ಹೆಚ್ಚು ಅರ್ಥಪೂರ್ಣ, ಸೃಜನಾತ್ಮಕ ಹಾಗೂ ಪರಿಣಾಮಕಾರಿಯಾಗಿಸುವ ಪೂರಕ ಸಾಧನ" ಎಂಬ ಸಮತೋಲನದ ದೃಷ್ಟಿಕೋನವನ್ನು ಶಿಕ್ಷಕರ ಶಿಕ್ಷಣದಲ್ಲಿ ಬೆಳೆಸುವುದು, ಭವಿಷ್ಯೋನ್ಮುಖ ಹಾಗೂ ಗುಣಮಟ್ಟದ ಶಿಕ್ಷಣ ವ್ಯವಸ್ಥೆಯ ನಿರ್ಮಾಣಕ್ಕೆ ಮಹತ್ವದ ಹೆಜ್ಜೆಯಾಗುತ್ತದೆ.

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