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E-CONTENT VIDEO MODULES AND SECONDARY SCHOOL SCIENCE: BRIDGING THE DIGITAL DIVIDE

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Abstract

The present study examined the effect of e-content video modules on the academic achievement and attitude towards science of Class IX students in CBSE-affiliated government-aided secondary schools in Ganjam district, Odisha. A quasi-experimental pre-test post-test non-equivalent control group design was employed. The sample comprised 120 students purposively selected from two matched schools, with 60 students each in the experimental and control groups. The experimental group received instruction through structured offline e-content video modules over eight weeks, while the control group underwent conventional chalk-and-talk teaching. Data were collected using a researcher-developed Science Achievement Test (SAT; KR-20 = 0.86) and the standardised Science Attitude Scale (Vaidya & Chandiramani, 1989). Independent samples t-tests and ANCOVA were applied for data analysis. Results revealed that the experimental group significantly outperformed the control group on both achievement ($t = 6.83$, $p < .001$, $d = 1.24$) and attitude ($t = 5.47$, $p < .001$, $d = 0.98$). Gender did not moderate the treatment effect. The findings confirmed that well-designed e-content video modules serve as effective tools for improving science learning outcomes and reducing the digital divide in resource-constrained educational settings.

Keywords: *e-content video modules, digital divide, science achievement, attitude towards science, quasi-experimental design*

1. Introduction

Indian secondary schools face a paradox: while near-universal enrollment at the elementary level has been achieved (UDISE+, 2022–23), the quality of science learning at the secondary

stage remains critically low. The National Achievement Survey (NAS, 2021) recorded mean science competency of only 40 per cent for Class X students nationally, with government school students performing significantly below their private school counterparts. The Annual Status of Education Report (ASER Centre, 2022) reinforced these concerns, revealing a widening gap between school attendance and substantive learning.

Within this context, the digital divide — defined by Warschauer and Matuchniak (2010) as differential access to, and quality of use of, digital technologies across social and economic groups — presents both a challenge and an opportunity. Government secondary schools in Odisha, where only 43.2 per cent have functional computer laboratories (UDISE+, 2022–23) and the tribal population constitutes 22.85 per cent (Census of India, 2011), exemplify this challenge. However, locally stored, offline-accessible e-content video modules offer a practical solution that does not depend on internet connectivity, making them particularly suitable for resource-constrained settings.

E-content video modules are theoretically grounded in three converging frameworks: Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML), which posits that learning is enhanced when verbal and visual information are coordinated to create coherent mental models; Sweller's (1988) Cognitive Load Theory, which identifies well-sequenced multimedia as a means of reducing extraneous cognitive load and freeing resources for deeper schema formation; and Vygotsky's (1978) concept of the Zone of Proximal Development, through which teacher-mediated digital content functions as structured scaffolding for learners.

The National Education Policy 2020 (Ministry of Education, 2020) has further amplified the relevance of this investigation. Chapter 23 of the NEP endorses platforms such as DIKSHA, SWAYAM, and e-Pathshala as national digital learning ecosystems, while cautioning that technology must function as a means of equity, not as a new source of stratification. The present study directly responds to this policy mandate by testing whether structured e-content video modules, delivered offline in government schools, can significantly improve science achievement and attitude among socioeconomically marginalised learners.

1.1 Objectives of the Study

The present investigation was guided by the following objectives:

1. To develop and validate offline e-content video modules aligned with the CBSE Class IX science curriculum.

2. To examine the effect of e-content video module-based instruction on science achievement of secondary school students.
3. To investigate the influence of e-content modules on students' attitude towards science.
4. To analyse whether gender moderates the effect of e-content modules on achievement and attitude.

1.2 Hypotheses

H01: There is no significant difference in post-test science achievement scores of students taught through e-content video modules and those taught through conventional instruction.

H02: There is no significant difference in post-test attitude scores of students taught through e-content video modules and those taught through conventional instruction.

H03: Gender does not significantly moderate the effect of instructional method on science achievement and attitude.

2. Review of Related Literature

The empirical and theoretical foundations of this study draw from three interconnected bodies of scholarship: multimedia learning psychology, technology-mediated science instruction, and digital equity research.

2.1 Multimedia Learning and Cognitive Frameworks

Mayer (2009) demonstrated that learning materials combining narration with relevant animation and visual diagrams reduce cognitive overload and promote the formation of coherent mental models — a process directly applicable to science education, where abstract processes such as cell division, particle motion, and electromagnetic induction are difficult to convey through text and blackboard diagrams alone. Complementing this, Sweller (1988) established that well-sequenced instructional content reduces extraneous cognitive load, freeing working memory for deeper processing. Vygotsky (1978) further argued that social interaction and mediated scaffolding — embodied in teacher-facilitated module delivery — enable learners to operate at the upper edge of their current capability, accelerating conceptual growth.

2.2 E-Content and Science Achievement: Empirical Evidence

In the Indian context, Kumar and Sharma (2019) conducted a quasi-experimental study with 240 Class X students in Rajasthan and found that students taught through animated e-content modules significantly outperformed conventionally taught peers ($p < .01$), attributing the

advantage to the visual representation of abstract scientific processes. Singh and Gupta (2020) similarly reported a Cohen's d of 0.78 in a Delhi government school study, indicating large positive effects of e-module instruction on Class VIII science achievement. Rao and Krishnamurthy (2021) extended this evidence to Andhra Pradesh, finding that video-based instruction narrowed the rural-urban achievement gap in physical science.

Internationally, Merchant, Goetz, Cifuentes, Keeney-Kennicutt, and Davis (2014) conducted a meta-analysis of 69 studies on game-based and digital simulation environments, reporting an overall effect size of d = 0.52 for science learning, with animated and interactive formats yielding the largest gains. Means, Toyama, Murphy, and Bakia (2013) further found that blended instructional models — combining digital content with face-to-face facilitation — produced significantly better learning outcomes than either purely online or purely conventional instruction. These findings directly motivated the teacher-mediated module delivery approach employed in the present study.

2.3 Attitude towards Science and ICT-Integrated Instruction

Osborne, Simon, and Collins (2003) identified students' attitude towards science as a significant predictor of achievement, subject continuation, and STEM career choice, documenting a consistent attitudinal decline during secondary schooling. Verma and Mehta (2022) found that ICT-integrated instruction significantly improved science attitude among Class IX students ($p < .001$), with particularly large attitudinal gains for girls when content was contextualised within culturally familiar Indian experiences. These findings underscore the dual importance of targeting both cognitive achievement and affective engagement through technology-based interventions.

2.4 Digital Divide and Localised E-Content

Van Dijk (2006) conceptualised the digital divide across three levels: first-level (access to hardware and connectivity), second-level (skill in using technology), and third-level (ability to convert technology use into tangible benefits). Indian education policy has responded through platforms such as DIKSHA and e-Pathshala, which incorporate offline functionality to address connectivity gaps (Ministry of Education, 2020). However, systematic evidence on the learning effectiveness of offline e-content in government secondary schools of eastern India remains sparse. Volman, van Eck, Heemskerk, and Kuiper (2005) additionally noted gender-differential effects in technology-based instruction, motivating the present study's examination of gender as a moderating variable. The present investigation directly addresses

the identified gap by testing the effectiveness of offline e-content modules in a government secondary school context in Odisha.

3. Research Method

3.1 Research Design

A quasi-experimental pre-test post-test non-equivalent control group design (Campbell & Stanley, 1963) was employed. This design was selected because intact classroom groups rather than individually randomised students were used, reflecting the ethical and administrative constraints of school-based research. The experimental group received e-content video module-based instruction; the control group continued with conventional chalk-and-talk teaching. The between-school placement of conditions was adopted to prevent treatment diffusion, as the digital modules could readily have been shared among students within the same school.

3.2 Population and Sample

The population comprised all Class IX students enrolled in government-aided CBSE-affiliated secondary schools in Ganjam district, Odisha. The sample consisted of 120 students (aged 14–15 years) drawn from two purposively selected schools matched on comparable socioeconomic profiles, school infrastructure, class size, and teacher qualifications, as verified through UDISE+ (2022–23) records. School A (n = 60; 32 boys, 28 girls) served as the experimental group; School B (n = 60; 30 boys, 30 girls) served as the control group. Purposive sampling (Creswell & Creswell, 2018) was used for school selection, and cluster sampling was used within each school — all students in two intact sections formed the sample. Pre-test equivalence between groups was confirmed statistically: SAT: $t(118) = 0.74$, $p = .46$; SAS: $t(118) = 0.61$, $p = .54$.

3.3 Tools for Data Collection

Science Achievement Test (SAT): A researcher-developed test comprising 50 items (30 MCQs, 10 short-answer, 5 long-answer; total = 70 marks), mapped to four NCERT Class IX science units across Bloom's Taxonomy levels of remembering, understanding, applying, and analysing. Item analysis yielded difficulty index 0.35–0.65 and discrimination index 0.30–0.60. Reliability (KR-20) = 0.86. Content validity established by an eight-expert panel (Content Validity Index = 0.91; Polit & Beck, 2006).

Science Attitude Scale (SAS): The standardised scale developed by Vaidya and Chandiramani (1989), comprising 45 Likert-type statements (5-point scale; range 45–225) covering interest in science, scientific curiosity, perceived relevance, career orientation, and perception of difficulty. Reported reliability: Cronbach's alpha = 0.88. Higher scores indicate more positive attitudes.

E-Content Video Modules: Eight offline video modules were developed by the researcher using the ADDIE instructional design model (Analysis, Design, Development, Implementation, Evaluation), guided by Mayer's (2009) multimedia design principles. Each module (18–22 minutes) covered one sub-unit of the four content areas: Matter in Our Surroundings, Motion and Force, The Fundamental Unit of Life, and Natural Resources. Each module comprised: an advance organiser segment (2–3 minutes), a primary instructional segment with narrated animation and diagrams (12–14 minutes), and a formative check segment (3–5 minutes). Narration was in English with Odia subtitles. CVI = 0.91.

3.4 Methodology

The intervention was conducted over eight weeks within regular school timetabled science periods (five periods per week, each 45 minutes). In the experimental group, the science teacher projected each module on the classroom screen, paused at designated discussion points, facilitated questions, and guided structured note-taking through a printed study guide. No conventional lecture was delivered during module sessions. A brief reflection worksheet (10 minutes) consolidated learning after each session. The control group received conventional instruction by equivalently qualified teachers using the NCERT textbook, blackboard diagrams, and occasional demonstrations. Both groups' teachers attended a one-day orientation before the study. Pre-tests were administered one week before the intervention; post-tests within one week of its completion.

3.5 Statistical Techniques

Data were analysed using IBM SPSS Statistics Version 26.0. Descriptive statistics were computed for all groups and instruments. The Shapiro-Wilk test confirmed approximate normality; Levene's test confirmed homogeneity of variance. Hypothesis H01 and H02 were tested using independent samples t-tests and ANCOVA with pre-test scores as covariates. Effect size was computed as Cohen's d (Cohen, 1988), with $d > 0.80$ classified as large. Hypothesis H03 was tested through two-way ANCOVA with instructional method and gender as between-subjects factors.

4. Results

Preliminary checks confirmed normality (Shapiro-Wilk, all $p > .05$) and variance homogeneity (Levene's test: SAT: $F = 1.23$, $p = .27$; SAS: $F = 0.89$, $p = .35$). Both groups were statistically equivalent at baseline on both instruments (SAT: $t = 0.74$, $p = .46$; SAS: $t = 0.61$, $p = .54$).

4.1 Science Achievement (H01)

Table 1 presents descriptive statistics for SAT scores. The experimental group registered a mean gain of 23.26 marks compared to 7.27 marks in the control group — a difference of nearly 16 marks on a 70-point test. The independent samples t-test confirmed a statistically significant post-test group difference ($t(118) = 6.83$, $p < .001$, two-tailed). ANCOVA with pre-test SAT as covariate corroborated this ($F(1,117) = 47.29$, $p < .001$, partial $\eta^2 = 0.29$). Cohen's $d = 1.24$ indicated a very large effect (Cohen, 1988). H01 was rejected.

Table 1: Science Achievement Test (SAT) Scores — Descriptive Statistics (Maximum Score = 70)

Group	n	Pre-test M	Pre-test SD	Post-test M	Post-test SD	Mean Gain
Experimental	60	28.47	5.83	51.73	6.41	23.26
Control	60	27.91	5.67	35.18	6.09	7.27
Difference	—	0.56	—	16.55	—	15.99

4.2 Attitude towards Science (H02)

Table 2 presents SAS descriptive statistics. The experimental group's mean attitude score increased from 141.23 to 172.84 (gain = 31.61 points), while the control group improved from 140.87 to only 151.36 (gain = 10.49 points). An independent samples t-test confirmed significant post-test group differences ($t(118) = 5.47$, $p < .001$). ANCOVA corroborated this ($F(1,117) = 30.14$, $p < .001$, partial $\eta^2 = 0.21$). Cohen's $d = 0.98$ indicated a large effect (Cohen, 1988). H02 was rejected.

Table 2: Science Attitude Scale (SAS) Scores — Descriptive Statistics (Score Range: 45–225)

Group	n	Pre-test M	Pre-test SD	Post-test M	Post-test SD	Mean Gain
Experimental	60	141.23	18.76	172.84	17.93	31.61
Control	60	140.87	19.14	151.36	18.54	10.49
Difference	—	0.36	—	21.48	—	21.12

4.3 Gender as Moderator (H03)

A two-way ANCOVA with instructional method and gender as between-subjects factors yielded a highly significant main effect of instructional method ($F(1,115) = 44.87$, $p < .001$, partial $\eta^2 = 0.27$). The main effect of gender was non-significant ($F(1,115) = 2.14$, $p = .146$), and the method-by-gender interaction was also non-significant ($F(1,115) = 1.89$, $p = .171$). H03 was retained. E-content video modules were equally effective for boys and girls. Table 3 summarises these results.

Table 3: Two-Way ANCOVA Results — Effect of Instructional Method and Gender

Source	df	F	p	Partial η^2	Interpretation
Instructional Method	1	44.87	< .001	0.27	Significant
Gender	1	2.14	.146	0.02	Non-significant
Method × Gender	1	1.89	.171	0.01	Non-significant
Error	115	—	—	—	—

5. Discussion

The findings of this study provide consistent and strong evidence that e-content video module-based instruction significantly improves both science achievement ($d = 1.24$) and attitude towards science ($d = 0.98$) among Class IX students in government-aided secondary schools of Odisha. These effect sizes substantially exceed Hattie's (2009) benchmark of $d = 0.40$ for educationally meaningful improvement, indicating that the intervention produced practically significant rather than merely statistically significant gains.

The achievement advantage is explicable through multiple converging mechanisms. The visual and animated representation of abstract science phenomena — particle behaviour, cell division, graphical representation of motion — reduced the cognitive effort required for conceptual understanding, consistent with Mayer's (2009) modality principle. The segmented module structure with advance organisers and embedded formative checks supported metacognitive engagement, consistent with Sweller's (1988) principle that reducing extraneous load liberates resources for schema formation. Furthermore, contextualising scientific phenomena within culturally familiar Odishan experiences — water purification, bullock cart mechanics, food fermentation — activated prior knowledge and enhanced perceived relevance, generating the intrinsic motivation that underpins both achievement and attitude gains. These findings resonate with Kumar and Sharma (2019) and Rao and Krishnamurthy (2021), who similarly documented significant achievement gains through technology-mediated instruction in Indian secondary science contexts.

The attitudinal improvement (d = 0.98) is particularly consequential. As Osborne, Simon, and Collins (2003) established, attitude towards science is a powerful predictor of subject continuation and STEM career aspiration — outcomes with direct national development implications. The present findings replicate and extend those of Verma and Mehta (2022), who found significant attitude gains through ICT-integrated instruction in Class IX students. The non-significant gender moderation finding adds an important equity dimension: contrary to Volman et al.'s (2005) concern that technology-mediated instruction may favour boys over girls, the present modules were equally effective for both genders. The narrative clarity, local contextualisation, and teacher-mediated delivery of the modules appear to have successfully neutralised potential gender-technology bias.

From a digital equity perspective, these results are especially significant. The schools in this study served predominantly first-generation learners from economically marginalised households in Ganjam district — precisely the population most severely affected by all three levels of the digital divide (van Dijk, 2006). The offline delivery through existing school infrastructure circumvented the first-level (connectivity) divide; teacher mediation addressed the second-level (skill) divide; and the significant learning gains demonstrate progress on the third-level (benefit-conversion) divide. These findings validate the policy logic underlying NEP 2020's endorsement of offline digital platforms such as DIKSHA and e-Pathshala (Ministry of Education, 2020) and provide empirical support for extending such provisions to semi-urban government secondary schools in eastern India.

6. Conclusion

The study demonstrated that structured, offline e-content video module-based instruction significantly enhanced science achievement (d = 1.24) and attitude towards science (d = 0.98) among Class IX students in government-aided CBSE secondary schools of Odisha, with equal effectiveness for boys and girls. The intervention addressed all three levels of the digital divide without requiring internet connectivity, validating its applicability in resource-constrained educational settings. Science teachers in government secondary schools, science curriculum designers at NCERT and SCERTs, and educational technology developers at DIKSHA and state content wings would benefit from applying the multimedia design principles empirically validated in this study. The findings offer direct evidence in support of NEP 2020's vision of technology-enhanced, equitable secondary education.

Limitations include the restriction to two schools in one district, an eight-week intervention period precluding long-term retention conclusions, absence of classroom observation for fidelity monitoring, and non-measurement of socioeconomic background as a covariate. Future research should replicate the study across multiple districts and states, incorporate longitudinal follow-up, examine differential effects across subject domains, and extend the inquiry to tribal and PVTG school populations to fully map equity implications.

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