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PRESERVICE SCIENCE TEACHERS' AND THEIR CONCEPTIONS ON NATURE OF SCIENCE

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Abstract

Understanding the Nature of Science is a most relevant factor for improving scientific literacy. In Science curriculum Nature of Science(NOS) place is very important and it is increasingly worldwide. It is now therefore important that teachers understand NOS so that intended learning outcomes become visible in the classroom .Preservice teachers also need an opportunity to expand knowledge and understanding about nature of science(NOS).Scientific literacy demands student's understandings of science concepts help them to make informed decisions about scientifically -based personal and social matter.

Research shows that K-12 students, Undergraduate students and even Preservice Science teacher facing problems in their classroom transaction regarding NOS concepts. The lack of concentrated NOS instruction allows to develop misconceptions On NOS. This NOS misconceptions lead to problematic beliefs such as the following: Science can prove or disprove the supernatural. Science is ultimate authority and science and scientists should not be trusted. Further inadequate NOS understanding is the primary cause for the students belief pattern on science and their faith.

Key words: *Preservice Science Teachers, Nature of Science ,conceptions ,Scientific literacy*

INTRODUCTION

Science is the investigation and interpretation of natural phenomena which occur in our daily life. It is one way of describing, classifying, and understanding our universe. For students to become scientifically literate, they need "to engage in the discourses about science" (Eastwell, 2002), so developing an understanding of the nature of science (NOS), including both its strengths and limitations, is an integral component in a "Science for All" curriculum.

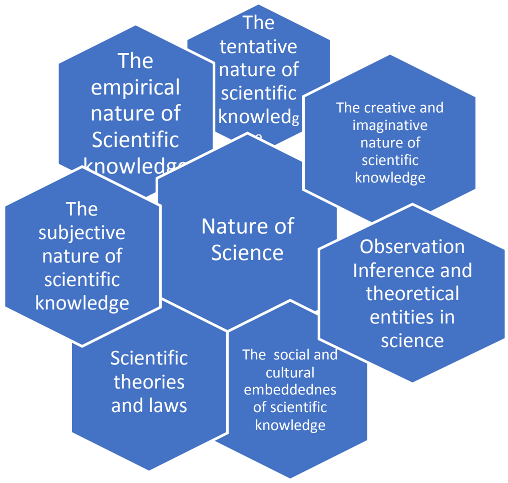
"Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observation" *James B. Conant.*

In broad terms, the discipline of science is characterised by its central commitment to evidence as the basis of justified belief about material causes and the rational means of resolving controversy (Siegel, 1989). Science is also progressive and universal *(Good & Shymansky, 2001). However, at the level of fine detail, scientists, philosophers, and science educators differ in their opinions about NOS (Fourez, 1989; Lederman, 1986; Meichtry, 1993).* For the purposes of school science, though, considerations at this level of sophistication are not necessary and would, in fact, be inappropriate *(Abd-El-Khalick & Boujaoude, 1997).*

Nature of Science: Science is a dynamic, expanding body of knowledge covering ever new domains of experience. How is this knowledge generated? What is the so-called scientific method? As with many complex things in life, the scientific method is perhaps more easily discerned than defined. But broadly speaking, it involves several interconnected steps: observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models, deducing their consequences: verification or falsification of theories through observations and controlled experiments and thus arriving at the principles, theories and laws governing the physical world. There is no strict order in these various steps. Sometimes, a theory may suggest a new experiment; at other times a Speculation and conjecture also have a place in science, but ultimately, a scientific theory, to be acceptable, must be verified by relevant observations and /or experiments. The laws of science are never viewed as fixed external subject to modification in the light of new observations, experiments and analysis.

Aspects of Nature of Science

Science is a process for producing knowledge**.** The process depends both on making careful observations of phenomena and on inventing theories for making sense out of those observations .Change in knowledge is inevitable because new observations may challenge prevailing theories. The means used to develop these ideas are particular ways of observe ,thinking, experimenting, and validating.



(Fig.2: Pictorial Representation of all the Aspects of NOS)

1) The empirical nature of scientific knowledge: Science gives us ample scope to explore the nature with the help of perceptual apparatus .Observation helps in the validation of natural phenomena .Generally ,scientist do not have clear access to natural phenomena. They depend on the observation done by different sense organs and instruments to interpret the observation ,and with the help of this they elaborate and deduce the theoretical framework of natural phenomena. Observation and inference are two theoretical entities of science. The term observation stands for the descriptive statement directly accessible natural process through the senses of human or instrument with which they can understand differences, relationships, functioning of different natural phenomena.

2) The tentative nature of scientific knowledge: The contribution of science toward developing and sustaining human life on earth is a well established argument .There is a general notion that scientific knowledge once gained cannot be changed however this notion is not correct. Scientific knowledge is accurate and long-lasting but never absolute .In light of discovery and experience it is susceptible to change. The ever-evolving gives a lot of new dimensions to look at reinterpret the already established theory .This tentative nature of scientific knowledge reaches the social and cultural aspect of science and creates new dimensions of research and establishes new knowledge. There is place for logical argument that creates a way for new research and puts a check on the authenticity of the already established knowledge. Law is a statement of natural phenomena and it is accountable for every change of the phenomena it states. The law can never be absolute and it is prone to changes.

In contrast to common belief the laws ,scientific hypotheses and theories are not proven .It always depends on the supporting empirical evidence *(Popper,1963).*

3) The creative and Imaginative Nature of Scientific Knowledge: The creative and imaginative nature of science plays a very crucial role in the development of science as it provides an opportunity for scientists to see phenomena beyond the limit of empirical evidence .The creative and imaginative nature of science gives scope to study the universe and its natural phenomena like weather forecasts ,the discovery of the structure atoms ,periodic table, and many more.

4) The Social and Cultural Embeddedness of Scientific Knowledge: Science has a dynamic structure and function the supports human civilisation of earth. Scientific knowledge is the result of the social and cultural interaction of people. Scientists are part of these social and cultural aspects of society .Scientific knowledge is strongly influenced by different ideas that are incorporated in to a culture. It influences the intellectual sphere of people who work for the development of scientific knowledge .It includes social, political, socio economic factors ,philosophical and religious issues.

5) Difference between Observation and inference: Observation is crucial for the development of scientific knowledge .A precise and keen observation can lead to a successful result. Scientist first observes natural phenomena and then depending on that observation they make inferences .Observations are meant for details of directly accessible natural phenomena with the help of the senses. The inferences is drawn based on observation and always succeeds in the step of scientific procedure.

6) Difference between Scientific theories and Laws: Theories and laws are two terms whose relation is usually taken as the consecutive steps of a ladder. It is a common conception ,people think that in the light of new evidence a theory become law. But no such relation exist between theory and law.

7) The subjective nature of Scientific knowledge: All of the above mentioned NOS Aspects *(Fig-2)* are important for preservice teachers to know how to learn science and address their daily life issues. Thus, at this point ,we are aware of the importance of different aspects of NOS. There is a fast growing area of research to recognize NOS views of students at various at various educational levels ,from primary to university level, by using different methods and techniques to in turn empower the thinking skills.

Characteristics of the nature of science: Science education has defined tenets (characteristics) of the nature of science that are understandable by students and important for all citizens to know. William McComas and Joanne Olson analysed recent science education curriculum documents worldwide and identified 14 statements about the nature of science that are common to most curricula:

- Science is an attempt to explain natural phenomena.
- Scientific knowledge, while durable, has a tentative character.
- People from all cultures contribute to science.
- Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments and scepticism.
- There is no one way to do science – therefore, there is no universal step-by-step scientific method
- New knowledge must be reported clearly and openly.
- Scientists require accurate record-keeping, peer review and reproducibility.
- Observations are theory laden.
- Scientists are creative.
- Over the centuries, science builds in both an evolutionary and a revolutionary way.
- Science is part of social and cultural traditions.
- Science and technology impact each other.
- Scientific ideas are affected by the social and historical setting.
- Laws and theories serve different roles in science – therefore, students should note that theories do not become laws even with additional evidence.

Why teach the Nature of Science?

Matthews (1994) states that the liberal tradition in education, which views education, as opposed to schooling or vocational training, as one where "science education is not just an education or training in science, although of course, it must be this, but also an education about science."

Longbottom and Butler (1999), in their paper titled "Why teach science?", develop what may be called the "democratic argument" for science. If science – the first, if not the only, rational means of thought that a student is exposed to – is taught with a style that does not, for example, emphasise the general tentativeness of scientific ideas and its human and creative aspect, would it be any wonder that generations will be brought up to believe that there is one "right answer", which cannot Scientific literacy, the evergreen aim of science education, deserves special mention in this age where the calls are for reengineering the economic machinery for the 'knowledge based economy', and to make use of the science and technology to "pursue knowledge for the prosperity of Singapore" *(A*STAR, 2002).*

Laugksch (2000), cites *Thomas (1987),* who writes that "as economies become more ``knowledge-based'', the quality of human resources is increasingly seen as the most important economic asset of modern societies. Scientifically literate individuals may therefore be in a favourable position to exploit new job opportunities and be able to take advantage of technical developments in the workplace." To develop scientifically literate individuals, it should be recognised that the history and nature of science forms an integral part of science, and that its teaching should be purposefully integrated into the curriculum. It is a good news for parties concerned with science performance appears to be that teaching the NOS has a positive effect. McComas et al. (1998), in their summary of research, results from *Songer and Linn (1991),* where a comparison was made between two courses in thermodynamics. Students taught with a view of science as a dynamic body of knowledge acquired a more integrated understanding as compared to the other group, which held the view that science was a static body of knowledge. This result is by no means unique. Recent evidence for such improvement in science performance can be found in, for example, *Rudolph and Stewart (1998),* and *Lin, Hung, and Hung (2002). Nelson, Nickels, and Beard (1998)* also report positive outcomes in integrating NOS with the teaching of biological evolution, a topic that has been receiving much opposition for most of its almost 150 year history. With such reasons to back an increased emphasis on the Nature of Science as a curriculum objective, perhaps the question we should actually be asking ourselves should be: Why not Teach the Nature of Science.

What is needed to teach the Nature of Science?

Lederman (1992), in his well cited review, traces the development of research into teachers' and students' views of the NOS over much of the 20th century. When NOS-type objectives were to be included into the curriculum, it was found that the teachers' views were not well-developed, and thus attempts were made to correct this. Much later research found that teachers' informed NOS views, while necessary for teaching, were not sufficient indicators of teachers' abilities to conduct science lessons infused with history and nature of science. Typical of this line of thought were findings from *Tobin and McRobbie (1997), Mellado (1997), Bell, Lederman, and Abd-ElKhalick (2000), and Schwartz and Lederman (2002).* In this paper, we find that this necessary condition is not even met in our local sample of pre-service teachers.

Teaching and learning in reference to NOS can contribute to epistemic insight, that is, NOS-related pedagogies can help us recognize how and why we should understand science and the power and limitations of science *(Erduran & Kaya, 2018).*

Research found that teacher NOS views play a central role in student understanding of the NOS and that improving pre-service teachers' understanding of the NOS is an important first step in improving student understanding of the NOS *(Abd-El-Khalick & Lederman, 2000; Bell et al., 2011; Osborne et al., 2003)*. To improve pre-service teacher views of the NOS, the first step was typically to assess pre-service teacher views of the NOS (Lederman, 1992). Such investigations can introduce teacher-trainers to the view of the NOS held by pre-service teachers and help teacher-trainers prepare their own teaching.

McComas (Citation2004) refers to the definition and scope of NOS as the "rules of the game" (p. 25) which have led to the knowledge production and the evaluation of truth claims in the natural world. His definition states that NOS includes learning about how science functions, viewing scientists at work, and reviewing their interactions in a community. The presence of NOS is very prominent in the new curriculum and is an overarching feature. Ten NOS learning outcomes are split across four 'elements' of NOS: i) understanding of science, ii) investigation of science, iii) communicating in science, and iv) science in society.

Science teachers: Science teachers play a key role in forming the image of science that is held by the general public and therefore their knowledge about the nature of science is important *(Gallagher, 1991). Hodson (1985)* argues that, although to be a skilled scientist does not require an understanding of arguments in the philosophy of science, it is essential for science teachers. *Schwartz and Lederman (2002)* feel that that in order to teach the nature of science effectively a teacher must not only have a firm understanding of the nature of science, but also knowledge of effective pedagogical practices relative to the nature of science. *Matthews (in Moss, 2001),* however, warns against too high expectations and proposes modest goals when teaching the nature of science, saying that it is unrealistic to expect teachers or students to become competent philosophers of science. Research has demonstrated the complexity of the transfer of nature of science knowledge into instructional behaviours. This transfer is influenced by a variety of contextual and personal factors including classroom management, constraints of the curriculum or institution, time, concerns for student motivation and ability, and teaching experience *(Abd-El-Khalick, Bell & Lederman, 1998; Bell, Lederman & Abd-El-Khalick, 2000; Hodson, 1993; Lederman et al., 2002).* Other factors affecting transferability relate to teachers nature of science content knowledge and subject-specific pedagogical knowledge, such as teachers discomfort with their understanding of the nature of science and ability to assess students conceptions about the nature of science *(Schwartz & Lederman, 2002).* However, in-depth explorations of teachers development of nature of science knowledge, instructional intentions, and approaches to nature of science instruction have not been the focus of much research *(Schwartz & Lederman, 2002).*

What we do know though is that teachers tend to promote a view of science as simply the collection of data, leading to the formulation of a hypothesis, testing it, and then forming a general principle, as if all observations will be the same. This approach appears to assume that we all observe the same things in the same way and suggests that many teachers "subscribe to the inductivist view of science, a view long-abandoned by philosophers" *Hodson (1986: 216).* This is despite a number of calls for "a reconsideration of the epistemological basis of the science curriculum in the light of contemporary views in the philosophy … of science" and the fact that it has been shown that teachers understanding of the nature of science can be enhanced by appropriate in-service education *(Hodson, 1986: 216.*

A number of researchers in science education accept that dealing with the problems associated with „border crossings as learners move from their home language to the language of instruction to science language are of utmost importance for achieving scientific literacy and teachers are encouraged to get their learners to learn to be able to talk and argue to learn science *(Yore & Treagust, 2006).* Learners must also learn to read science and read to learn science, just as they must learn to write science and write to learn science. They must learn about metaphors and analogies that help explain science, and learn to use metaphors and analogies to explain what they learn and understand about science, all of which are skills that are at the heart of what is required for higher levels of school success.

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