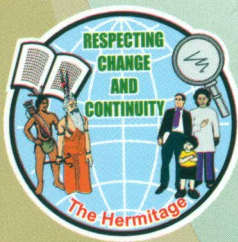


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UNDERSTANDING OF NATURE OF SCIENCE AND ITS DIFFERENT ASPECTS

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A B S T R A C T

Nature of Science (NOS) is considered as the integral part of the process of teaching and learning science. To have a proper understanding on the different aspects of NOS for pre-service teachers is crucial. Therefore, it is very important to know the level of understanding of pre-service teachers on NOS. This study was designed to know the level of understanding of pre-service teachers on the different aspects of NOS. This descriptive research deals with qualitative data collected by using the open ended questionnaire of tool VNOS-C and the given responses was interpreted and analyzed to understand the level of understanding of participants by assigning them score as naïve, transitional and informed level as described in the rubric of the tool.

Keywords : Nature of Science, Different Aspects of NOS, Knowledge and Understanding of Science, Pre-service Teachers.

Introduction

Since time immemorial knowledge of science has prime position in the life of human beings because it covers all most all the dimensions of human existence. According to the position paper National Focus Group on teaching of science (NCF, 2005) human beings always showed curiosity towards the world which surrounds them. The capacity of imagination and being curious lead one to investigate more, look for the meaningful explanation of any pattern and relations and try to seek answer of all the unexplained phenomena of the world. Science conveys the process of interacting with nature and deriving meaning to it to understand the different phenomena of our surroundings. Science is dynamic and it is an expanding body of knowledge which covers all the domains of new experience.

Now the question comes how this knowledge in science is generated? What do we understand by the scientific method? And this answer needs a number of interconnected steps, called as the methodology of scientific research like observation,

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making hypotheses, analysis, interpretation etc. All these finally gave results as the theory or law which govern the different systems of our world/ universe. Generally there is no strict order for all these steps, many a times a theory can suggest an experiment and vice-versa. With this every scientific theory/law must be verified with the relevant observations and /or experiments. Knowledge is never viewed as the fixed eternal truths. We can see that the most established universal laws of science are always described as provisional and subject to modification in the light of upcoming new observations, analysis and experiments (Abd-El-Khalick & Lederman, 2000).

It is an ongoing philosophical debate that methodology of science is same or different from the other fields of research. The neutrality and objectivity of science involves the sociological aspect and its analysis depends on different paradigm of knowledge i.e. psychological, sociological and philosophical analyses. Endeavour of science is self correcting and it produces reliable and objective public knowledge. Scientists are also part of the society they too have different experiences, values and bias. But, we believe their research, as scientists always do careful and systematic observation, they do research and challenge others' work with proper evidence and logic leading to the formation/generation of unbiased knowledge. However, sometimes science also comes under limitation while dealing with some complex system of nature.

With all these limitations science is unquestionably the most reliable and powerful knowledge system of our surroundings. So, the science can be explained as the body of knowledge, method and way of knowing. All these phenomena define the philosophical part of science known as Nature of Science (NOS). So, the NOS is the science as a way of knowing the inherent values, beliefs to scientific knowledge and its development (Lederman, 1992).

There are many scientists who disagree on the common definition of NOS. Still there are some common aspects on which many philosophers, historians and sociologists agree and these aspects are scientific knowledge is tentative, empirical, theory laden, partly the product of human interference, socially and culturally embedded, imagination and creativity, distinction between observation and inference, relationship of scientific theories and laws, etc (Smith, Lederman, Bell, McComas, & Clough, 1997).

Rationale of the Study

The NOS has been identified as paramount in science education reforms and an essential part that contribute to students' 'scientific literacy' (AAAS, 1993; NRC, 1996). What is meant by NOS is an issue that philosophers of science and science educators have disputed and there is no clear cut definition of NOS accepted by all. However, many researchers have operationally defined NOS for their own research purposes. NOS is the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development (Lederman, 1992). NOS convey an understanding on nature of scientific knowledge, scientific enterprise and not only scientific processes including the studies of scientists but also products of science. In other words, NOS includes nature of scientific knowledge and scientific processes, which is pertinent to collection and interpretation of data, related to the production of this knowledge.

This study focuses on the pre service teachers' understanding on different aspects of NOS. The construct NOS has been advocated as an important goal for students studying science for approximately 100 years (Central Association of Science and Mathematics Teachers, 1907). Most recently, NOS has been advocated as a critical educational outcome by various science education reform documents worldwide (Australia, Canada, South Africa, United Kingdom, and United States). The observation that NOS has been a perennial goal of science education is become a demand and is now receiving increased emphasis. Many studies revealed that the high school students, teachers, pre-service teachers and the general citizenry, do not possess (and never have possessed) adequate views of NOS.

There are many questions arises like, has anything been lost? Is it really important for students, teachers and the general citizenry to understand NOS? If students do not have good understandings of NOS than what would happen? A better understanding of NOS makes what difference? All these questions were answered many times through several studies but to have a more clear generalization more research is required in this field.

All the above arguments are important and noble reasons for why science educators value NOS as an instructional outcome. Understanding of NOS always considered as an important body of science education and science education research. The first assessment of teachers' conceptions (Anderson, 1950) was conducted prior to any assessment of students' conceptions. During this study the teachers were asked to give answer eight questions on scientific method, and it was found that both groups of teachers possessed serious misconceptions. King (1991) investigated pre-service teachers' knowledge of the history and philosophy of science data shows that the teachers have opinion that history and philosophy of science were not important, this leads to the failure of their teaching were they need to integrate the instructions.

Using various approaches researchers have tried to assess understanding of NOS among the pre-service teachers (Aguirre, Haggerty, and Linder, 1990; Liang et al. 2008; Liu and Lederman, 2007 and Yalvaç, Tekkaya, Çakýrođlu, and Kahyaođlu, 2007) and found that pre-service teachers did not possess adequate conceptions of the NOS.

The findings of several research emerged indicating that pre-service teachers lack understanding of NOS. It is very important that a teacher must have good understanding of NOS in order to communicate the same to their students and build the pillars for the development of nation and human being.

Objectives of the Study

In order to study the above mentioned issue the objective taken for the present study is:

- To find out the awareness of pre-service teachers on the different aspects as mentioned below of Nature of Science (NOS).

- a) Tentative nature of science
- b) Empirical nature of science
- c) Inference/ theoretical entities in science
- d) Methods of science
- e) Subjective/ Theory-laden nature of scientific knowledge
- f) Creative/Imaginative nature of scientific knowledge
- g) Theory & Laws
- h) Socio-cultural embeddedness of scientific knowledge

Research Question

To achieve the objective of the present study the research question is stated as :

- Do pre-service teachers have adequate understanding about different aspects of NOS?

Methodology

This descriptive research is done with the tool View of Nature of Science C (VNOS-C) by Abd-El-Khalick and Lederman, 2002. Sample consisted of 20 students of B.Ed degree course of Maulana Mazharul Haque Teachers Training College Samastipur, Bihar. The institute is selected by purposive sampling and the 20 pre-service teachers were incidentally selected as per the availability of them at the time of collection of data. The study was delimited to the pre-service teachers of Maulana Mazharul Haque Teachers Training College, Samastipur, Bihar.

The tool which was used in the present research study is the View of Nature of Science C (VNOS-C) by Abd-El-Khalick and Lederman, 2002. This is a standardized tool and it is an open ended questionnaire related to all aspects of NOS. It consists of 10 items. As per the prescribed format of the tool only 20% of the sample was taken for the follow up interview. The responses of pre-service teachers are scored into naïve, transitional, or informed based on the following criteria:-

Naïve: Pre-service teachers' response is not consistent with any part of NOS aspect.

Transitional: Pre-service teachers' response is consistent with some, but not all, parts of NOS.

Informed: Pre-service teachers' response is consistent and addresses all parts of NOS aspect.

Data Analysis and Interpretation

All the collected data is analyzed and score is assigned as per the rubric of the tool. The views given by the pre-service teachers are scored in three categories as

"informed", "transitional" and "Naïve". Data analysis was done with the help of the scoring rubrics of VNOS C. All the responses of the pre-service teachers were classified and analyzed on the basis of the different aspects of NOS and their views are derived and scored according to the rubric that is depicted in the table below.

Sl. No.	Aspects of NOS	Views of pre-service teachers	Score
1	Tentative nature of science	Theory never changes completely, only some modification occurs with new experiments. Law is universal and it cannot changes.	Naïve
2	Empirical nature of science	Science strictly depended on the experiments and facts/evidences. It only studies the environment and habits of organism. It is directly related to realistic world. Science is only about the study of facts and figures.	Naïve
3	Inference/ theoretical entities in science	Structure of atom is discovered by performing different experiments and scientist had seen the structure of atom inside microscope. Species represents a set of criteria of organisms identified by the scientist. These criteria is made on the different aspects like interbreeding, feeding habit, physical structure, etc	Naïve
4	Methods of science	Science is the collection of facts, obtained by observation and it is the only acquisition of information. Experiments develop the scientific knowledge. Experiment is a set of planned activity that can be done practically and it involves strict order of procedures. And it functions as a tool to prove the theory.	Naïve
5	Subjective / Theory-laden nature of scientific knowledge	Observation, data collection, drawing inference, experiments, and conclusion are Scientific methods. Because of individual differences scientist draw different conclusion from same set of data.	Transitional
6	Creative/Imaginative nature of scientific knowledge	Scientist uses creativity and imagination while doing experiments and investigations. Mostly they use creativity and imagination at the time of planning and data collection.	Transitional
7	Theory & Laws	After doing a number of experiments the scientists make theory and with the further research and evidences theory become law.	Naïve
8	Socio-cultural embeddedness of	Social and cultural aspects play no role and have no significance in the scientific knowledge.	Naïve

As seen in the table above, almost all the pre-service teachers agree that theory changes, but not completely only some modification is done by the advancement of the research. They explained that law is universal; all these concepts are Naïve concepts. They do not have the right perspective about the tentative nature of science. Even some pre-service teachers explained that theory never changes. Informed view is everything in science is expected to change with new evidences and interpretation of that evidence. Scientific knowledge is although reliable and durable it is never absolute or certain and this tentative nature of science never occurs solely from the fact that scientific knowledge is inferential, creative, and socially and culturally embedded. Contrast to this understanding the pre-service teachers have viewed that science is totally meant to be proved. They explained Science as a body of knowledge,

attitude, and temper and it is strictly dependent on the experiments and facts/evidences. According to them science is the study of environment and habits of organism related to realistic world. They also viewed science as the study of facts and figures. These explanations show the Naïve understanding of NOS among pre-service teachers.

On the Inference / theoretical entities in science, the pre-service teachers explained their response as the structure of atom is known by the scientist by performing many experiments and they had seen it under microscope. And finally with trial and error method they finally concluded the structure of atom. This is a Naïve response, more satisfactory view as mentioned by Leaderman (1992) evidence is indirect and relates to things that we do not see directly. We cannot say whether scientist knows what the atom look likes, because it is more of a construct.

Again, about the categorization of species pre-service teachers presented their views as species are the categorization of organisms made by the scientist. Scientist had taken account many factors for this like interbreeding, same habitat, physical structure, habits, etc. this is also not satisfactory reply as explained by Leaderman (1992) species is a human creation. It is a convenient framework for the categorizing things. And with the more advancement it may change like we cannot draw a line between the species and sub-species.

The methods of science, subjective / theory-laden nature of scientific knowledge are also not clear to them they take the experiment as a step wise method, take experiment as the necessity for the development of scientific knowledge and experiments are the tool to prove the theory. These are the misconception of the pre-service teachers. Actually the clearer concept is that experiment cannot prove a theory or a hypothesis. It just discredits or adds validity to them (Leaderman, 1992). Leaderman also explained that the myth of the scientific method is about the stepwise procedure exists, that all scientist follow when they do scientific work. But in reality there is no single scientific method that would guarantee the construction of knowledge. Pre-service teachers have beliefs that there is typical sequence of events. It is true that scientist observe, compare, measure, test, speculate, hypothesize, create ideas and conceptual tools and construct theories and explanations. But there is no single sequence of activities that lead to functional or valid solution.

Regarding scientific knowledge almost all agreed that scientist uses creativity and imagination while doing works in science. Pre-service teachers explained that scientist uses their creativity and imagination while designing the research and data collection and in interpretation also. So, they came under transitional score. In contrast to this in a recent study conducted by Liang et al. (2008), their study showed that most of the pre-service elementary teachers hold naive conceptions on creativity and imagination (%42). The more informed view as explained by Leaderman (1992) is during scientific process logic plays a large role. Creativity and imagination explains why the result was observed. Generating the scientific knowledge involves human imagination, it is contrary to common belief it is not a lifeless, entirely rational and orderly activity. Science involves the invention of explanation and theoretical entities which require a great deal of creativity on the part of scientist.

About the difference between the theory and law, pre-service teachers strongly believe that theory changes and it is a broader concept and laws are universal and narrow. Theory is the result gained by the scientist after experiment and law is proved to be true in every situation. This is a Naïve view, theory does not mean a broader concept it is a concept which has considerable evidence behind it. It is the common observations that go beyond and propose new explanatory models for the world. And law describes the quantitative relationship between phenomenons such as universal attraction between objects (Leaderman, 1992).

On the Socio-cultural embeddedness of scientific knowledge the pre-service teachers responded that science and scientific knowledge is universal. It would not be affected by the social and cultural factors. They have view that science is totally fact based and could not be influenced by cultures and society. Pre-service teachers do not understand that science is a human enterprise. It differs with the person to person from the background of the scientist or the social and cultural aspect of the researcher. There are scopes for the change in the way of presentation of the evidences (Leaderman, 1992).

Result and Discussion

From the present research study it was found out that the pre-service teachers have Naïve understanding about the different aspects of NOS. Only they have some knowledge about the Subjective/ Theory-laden nature of scientific knowledge and Creative/Imaginative nature of scientific knowledge.

There are many studies done before where the same conclusion was seemed by many researcher like Erdođan (2004) ; Aguirre, Haggerty, and Linder (1990); Murcia and Schibeci (1999) their result showed that respondents have a naive and unclear understanding of scientific method-the discovery of truth through observations and also they have poorly developed understanding of scientific theory. There was little awareness of the social context of science and scientists' work in the responses.

In the present study the pre-service teachers explains that experiment is necessary for the science. These are in agreement with the findings of Gürses, Dogar, & Yalçın, (2005); Thye and Kwen (2003) they also found that the participants viewed experiment is necessary for science. Present study found that the pre-service teachers have inadequate understanding on the empirical and tentative nature of science. But, in contrast to the Liu and Lederman (2007) the pre-service teachers of present study have Transitional view regarding the involvement of creativity and imagination in scientific enquiry and they would not show any type of hierarchical relationship between theories and laws. Here also the pre-service teachers fail to understand the affect of social and cultural factor on the scientific processes.

As discussed above, the present study shows a coherence of the findings. This study has similar findings as observed by many researchers in different countries

of the world. This shows that the pre-service teachers have many misconceptions regarding the different aspects of NOS.

Major Findings of the Study

Major findings as revealed in this study on the understanding of the pre-service teachers' on the different aspects of NOS are stated below.

- i) Pre-service teachers have naïve understanding on the aspects of NOS like tentative nature of science, Empirical nature of science, Inference/ theoretical entities in science, Theory & Laws, Socio-cultural embeddedness of scientific knowledge and Methods of science
- ii) Pre-service teachers have transitional understanding on these aspects of NOS; Subjective/ Theory-laden nature of scientific knowledge and Creative/Imaginative nature of scientific knowledge.
- iii) None of the pre-service teacher has the informed understanding on the different aspects of NOS.

Conclusion

NOS is a way of knowing science. Previous studies revealed that the inadequacy in the understanding of NOS is one of the causes of failure of many science teaching courses. The findings of the present study revealed that the pre-service teachers who are prospective teachers, have misconception regarding the aspects of NOS and they do not have proper understanding on the NOS. This demand more focused approach in the teaching learning process of the teacher education program. Because, these pre-service teachers are going to teach the school students after completion of their teacher education program.

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