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PRIMARY SCHOOL TEACHERS' UNDERSTANDING ABOUT SCIENTIFIC INQUIRY

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ABSTRACT

Development of Scientific Inquiry (SI) is one of the major goals of science curriculum. However, understanding about scientific inquiry is very complex as it is often misconstrued that doing experiments and hands on activities automatically promotes scientific inquiry. Review of research indicates that students across all levels have naïve and underdeveloped views about scientific inquiry. Like Nature of science (NOS), lot of studies have been done to probe students' and teachers' understanding about SI and various assessment tools have been evolved to measure the same. VASI questionnaire developed by Lederman et al (2014) is one of the most widely used for a meaningful assessment of SI in learners. As teachers play most important role in developing SI in learners, it is important to know their views and how they incorporate in their classroom discourse. Contrary to the popular view, SI can be promoted in the young learners of primary classes. However, it is possible only if teachers have informed understanding about SI. This paper attempts to find out primary school teachers' understanding about SI specifically in the context of teaching-learning Environmental Studies (EVS). The study is conducted as a part of the in-service teacher professional development program. It is found that majority of teachers have 'mixed' and 'naïve' views about SI

KEYWORDS: *Scientific Inquiry, Nature of science, Environmental Studies*

INTRODUCTION

Scientific inquiry is central to the discourse of science education. Scientific inquiry entails using a variety of science process skills, creativity, and critical thinking to develop scientific knowledge (Lederman et al 2014). The definition of SI is broad and refers to "diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work" (NRC 1996, 2000). Research on Scientific inquiry reveals that thereare three ways in which scientific inquiry can be interpreted-what scientists do, how students learn and a pedagogical approach that teachers use (Minner D.D, Levy A.J 2010). The first aspect addresses conducting investigations using scientific methods, the second aspect concerns with students learning using inquiry approaches, and the third aspect deals with pedagogical approach involving teachers designing activities which support inquiry teaching and extended investigations. The second and third aspects have important implications for science curriculum and pedagogy. Research reveals that Nature of Scientific Inquiry (NOSI views)of the majority of students at all levels are naive and undeveloped (Lederman et al., 2019; Lederman, 2012). In this context, teachers play the most critical role in the process of promoting scientific inquiry and scientific literacy by adopting scientific inquiry in their own classroom discourse. Reforms in the science education suggest that science teachers need to understand the nature of scientific inquiry and its central role in science pedagogy.Research also indicates that scientific inquiry is often misunderstood as doing inquiry activities in the class or engaging in inquiry

activities or investigations develop the understanding about scientific inquiry. It is also found that teachers are not able to use inquiry promoting pedagogy in classrooms due to insufficient understanding about scientific inquiry (Roehring & Luft, 2004, Lederman et al 2012). For this reason, it is important for teachers to understand Nature of Scientific Inquiry (NOSI), which forms the basis of scientific knowledge. Research also indicates that teachers' NOSI views are limiteddue to, not only about the complexity in understanding about inquiry, but also it is often misconstrued with Nature of Science (NOS) (Lederman et al., 2014). It is also challenging to capture and understand various perspectives and views about scientific inquiry due to lack of valid and reliable tools (Lederman et al., 2019). The studies revealthat school students, pre-service and in-service teachers have insufficient and partial views about SI.Teachers,though incorporate teaching of scientific inquiry into various laboratory activities in schools, do not integrate NOSI as the goal of science teaching (Strippel and Sommer (2015). In this context it is important to examine the relation between teachers' views about scientific inquiry and their pedagogical discourse in the classroom.

The present study focuses on exploringprimary school teacher's understanding of Scientific Inquiry (SI). Primary schooling plays a very important role and the starting point in development of inquiry and it is often thought that there is no scope of scientific inquiry in the junior classes. Hence this paper attempts to find out primary school teachers' understanding about Scientific Inquiry in the context of teaching-learning of Environmental studies (EVS).

METHODOLOGY

The present study focussed on understanding of primary school teachers' views and understanding about scientific inquiry. The study was conducted as part of in- service professional development program for teachers teaching Environmental Studies to grades 3 to 5. The sample constitutes 39 teachers of East District of Delhi NCT.The teachers are from diverse academic backgrounds as at the primary level, a teacher has to teach all subjects. However, the impact of factors like gender, experience, academic background on the SI views is beyond the scope of this paper. Profile of the sample is represented in Table 1.

Lederman et al (2014, 2019) identified eight aspects of scientific inquiry. These are "(1) all scientific investigations begin with a question and do not necessarily test a hypothesis; (2) there is no single scientific method; (3) inquiry procedures are guided by a question asked; (4) all scientists performing the same procedures may not get the same results; (5) inquiry procedures can influence results; (6) research conclusions must be consistent with the data collected; (7) scientific data are not the same as scientific evidence; and (8) explanations are developed from a combination of collected data and what is already known". These aspects were used as the framework for development of the views about scientific inquiry (VASI) questionnaire, i.e., an instrument used to assess teachers' understandings about scientific inquiry. The questionnaire was given to the teachers a day prior to the training program. All the eight aspects of VASI questionnaire were represented on a 3-point rating scale, followed by open ended questions for giving their reasons. The responses were analysed using mixed methods approach using the questionnaire data as well as responses in the focus group discussions on these aspects during the training session. The open-ended responses of the teachers were categorised as 'informed', 'Mixed' and 'novice'. Many aspects with examples were addressed in the training session. The rubric used to categorise teachers' responses as 'naïve', 'informed', 'mixed' is represented in Table 2

Table 1: Profile of Sample

Teaching Experience	Less than 5 years-6
	5-10 years- 12
	More than 10 years-21
Gender	Male-11
	Female-28
Academic Qualifications	Post Graduate-13
	Graduate-20
	Any other-06
Academic background	Science-18
	Other streams-21

Table 2: Rubric to Categorise Teachers' Views about SI

Informed View	Mixed View	Naïve View
Complete and consistent with contemporary understanding of SI Able to substantiate with examples. Give reason for their view. Example statements- Scientific inquiry is guided by question Different scientists/students using same procedure can come up with different results. (T9) Interpretation of results involves subjectivity(T11)	Consistent with contemporary understanding but not able to give reason for their view or incomplete and wrong reasoning. Partially consistent view. Example statements- Data and evidence are same(T6) Evidence is subjective whereas data is objective	Inconsistent understanding. Wrong or incoherent reasoning. Example statements-there is only one correct scientific method(T5), If the scientific method is correctly followed, there will no inconsistency in results(T14)

DISCUSSIONS

As mentioned above, the responses were analysed using a 3-point rating scale representing 'Agree', 'Neither Agree nor Disagree' and 'disagree' onstatements representing various aspects of Scientific Inquiry (VASI Questionnaire). The reasons were analysed and coded as 'informed', 'mixed', and 'novice'. This was followed by focus group discussion on each aspect during the professional development session. The follow up discussion focussed on understanding their views, reasons behind these views and addressing these aspects using examples from the curriculum. The following section presents the discussion. Table 3 and Figure 1 present quantitative analysis of the responses on various aspects of SI

The first aspect addressed on teachers' understanding on the role of 'question' in scientific inquiry. Majority of teachers expressed that scientific investigations start with a question and hypothesis testing is an important aspect of scientific investigation. They are of the view that scientific investigation involves answering questions and comparing with the pre-dominant or prelevant view in the science. The majority of teachers have an informed understanding of the role of questions in scientific inquiry. Inquiry must begin with questions. However, some teachers stated that scientific inquiry may begin with daily life observations. In this aspect majority of teachers have informed views and mixed views (Refer Figure 1). The next aspect focussed on scientific method. In this, the majority of teachers are of view that scientific investigations can be carried out with a specific method only. Teachers' understanding that a particular SI can be carried out by a single method is stemming from the belief and classroom practise of giving instructions for the investigation. The over reliance on a single method is also expressed through their opinions that teacher and text books specify the steps of investigation and children need to follow the steps correctly and this is how they can be trained in scientific method. Majority of teachers are also of opinion that investigation and experiment are two different methods in science. The concept of relation between variables was linked to experiments whereas investigations were assumed to be opening ended. In this aspect, majority of teachers have novice views followed by mixed views. Very few teachers have informed views.

The next aspect focussed on "if Inquiry procedures are guided by the question asked". Majority of the teachers agreed with this. During the discussion, many teachers expressed that inquiry cannot take place without a question, and question plays a critical role in choice of method of investigation. However, from their responses, the point of view that question needs to be given by teachers was pre dominant. Majority of them explicitly stated that inquiry needs to be guided by teacher and teacher has to give question and direction to the learners. Though majority of teachers are subscribing to this view, analysis of views expressed reveals that many of them have mixed view. Aspect 4 focussed on influence of subjectivity on results and opinion on the statement that "All scientists performing the same procedures may not get the same results". Majority of teachers disagreed with statement. They expressed that if scientific procedure or investigation is correctly followed, it should yield same results and there is no scope for subjective interpretations. In the follow up discussion, teachers expressed that the difference in the results can be attributed to human errors and external factors rather than difference in inquiry procedures. Aspect 5 focussed on "if Inquiry procedures can influence the results". Results or inferences are influenced by inquiry processes like observation, controlling variables, collecting data, measuring. However, the majority of teachers have expressed disagreement and expressed that the procedures do not affect result as the result or conclusion is independent of the process and person and if the result is not consistent with the expected results, it is indication of adoption of wrong procedure. The next aspect focussed on if research conclusions must be consistent with the data collected. In this also majority of teachers agreed with the statement and are of the opinion that conclusions should be completely based on data collected and if there is any deviation, the procedure should be repeated. However, during discussions, it came into light that majority of teachers are focussing on pre-determined or pre-established results of any experiment. They were referring to verification activities as scientific investigations.

The next aspect was about "Scientific data are not the same as scientific evidence". Majority of teachers could not differentiate between data and evidence. They expressed that data is same as that of scientific evidence. Of the teachers who were able to differentiate between the two, gave justification or explanation that scientific evidence comes from experiments in the laboratory, whereas scientific data comes from published or printed material. Some teachers also expressed that data is tentative and can be changed whereas evidence is final. Few teachers expressed that evidence is subjective and biased but data is quantitative and undisputable as it emerges from lot of research. Regarding the aspect that explanations are developed from a combination of collected data and what is already known, teachers have mixed opinions. Some teachers expressed those explanations should be dependent only on the data collected during the investigation and should not be influenced by already existing understanding whereas others opined that data collected needs to be analysed in the light of previous knowledge in that particular investigation or experiment.

Table 3: Mean Scores of Teachers on Various Aspects of SI

S. No	Scientific Inquiry Aspect	Mean	SD
1	"Scientific investigations all begin with a question, but do not necessarily test a hypothesis"	2.28	0.76
2	"There is no single scientific method"	1.66	0.63
3	"Inquiry procedures are guided by the question asked"	2.46	0.45
4	"All scientists performing the same procedures may not get the same results"	1.76	0.49
5	"Inquiry procedures can influence the results"	1.87	0.89
6	"Research conclusions must be consistent with the data collected"	2.79	0.76
7	"Scientific data are not the same as scientific evidence"	1.94	0.23
8	"Explanations are developed from a combination of collected data and what is already known"	1.95	0.35

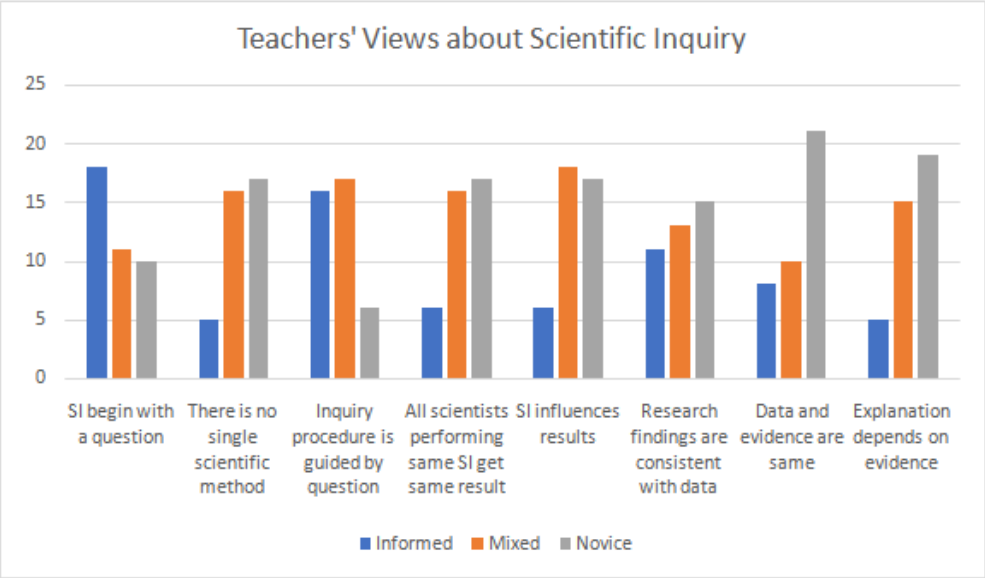

Figure 1: Teachers' about Scientific Inquiry.

Insights Derived from Focus Group Discussion

The in-depth focus group discussion by the researcher as part of the in-service professional development program helped to derive many insights regarding not only about primary teachers' understanding about scientific inquiry but also about the scope of inquiry in the classroom. Following are some of these insights which have far reaching implications on the discourse of environmental studies curriculum transaction.

- Majority of Primary school teachers believe that scientific inquiry involves advanced science experiments and hence cannot be done in the primary classrooms.
- Most of the teachers are of the opinion that there is no scope of any scientific investigations in EVS due to the nature of EVS curriculum.
- Almost all teachers were not able to relate process skill-basedactivities (activities involving process skills like observation, classification, inferencing etc) in primary classes to the scientific investigations or scientific inquiry. They agreed that these process skills are needed for scientific inquiry but were unable to associate or identify elements of scientific inquiry in activities prescribed in the EVS curriculum.
- Most of the teachers also expressed that low student teacher ratio only can facilitate inquiry in classrooms and inquiry teaching is not possible in classrooms of the resource poor schools.
- Teachers were not able to identify various aspects and scope of SI in the prescribed textbooks of E.V.S

CONCLUSIONS AND IMPLICATIONS

The present study explored primary school teachers' understanding and views about Nature of Scientific Inquiry (NOSI). In accordance with other studies done on teachers' views about SI, findings of this study alsoshowed the teachers have naive and mixed views of the NOSI aspects. It is found that teachers are having most informed views in the aspects 1 and 3 i.e.,"Scientific investigation begins with a question" and "inquiry procedures are guided by question". Regarding the aspects of relation between data and evidence, majority of teachers have novice views. In all other aspects, majority of

teachers have mixed views. It is found that most of the teachers are neither able to contextualise SI in the EVS curriculum nor able to identify aspects of SI in various classroom activities. Though teachers are able to express their views on various aspects of SI, they are firmly of the opinion that SI has no place in primary classes. This implicates that both pre service and in -service teacher education programs need to focus on developing an in-depth understanding of the inquiry-basedpedagogy and the development of scientific literacy. Research needs to focus actual development of inquiry in primary classrooms and the ways of strengthening non-laboratory activities to promote scientific inquiry.

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