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Perception about Nature of Science and its Incorporation in Teaching at Secondary Level

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Abstract

The present study was designed to explore the perception of science teachers about nature of Science (NOS) and its incorporation in their teaching. The participants in this study were science teachers teaching at secondary level in Islamabad Model Colleges (IMCs). The frequency of the participants is 120 science teachers, consisting of 60 males and 60 females. The instrument used in the study was the 3-point Likert scale. The statistical tests used were percentage, correlation coefficient and association. The major findings of the study are that the out of five tenets of NOS: tentativeness, empirical, imagination and creativity, subjectivity and theory-laden, and socio-cultural embedded, science teachers appreciate the first three tenets and do not appreciate the rest of two tenets and whatever they perceive, they incorporate as such in their teaching. The recommendations of the study are: the NOS may be considered while constructing the curriculum of science subjects and training courses of science teachers . Moreover ,along with the full continuum of tenets of NOS, the two less appreciated tenets of this study should also be investigated by the researchers of the science education field.

Keywords: nature of science, perception, incorporation, tenets, descriptive research.

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Introduction

Perception may be characterized from physical, physiological, and psychological perspectives. The cognitive dimensions of perception were introduced by Eggen and Kauchak (2001).According to them, perception was qualified as the process through which people attach meaning to experiences. Further they illustrated that when people are exposed to some stimuli in their sensory memories, mental processing continues in accordance with the perception. Perception affects the information that is received by the humans.

Science is a knowledge as well as method. In scientific method ,knowledgeis constructed which explains and predict the phenomenon of real world. (Wilson, 1999). Science educators has identified three structural and functional constituents of science i.e. knowledge, set of methods / processes, and a method to know about physical world .Nature of Science (NOS) is a comprehensive term, described by a set of number of characteristics or tenets(Khalick &Lederman,1998). Among them the following five tenets of NOS were considered for study: science knowledge is reliable as well as tentative, science knowledge is empirical, science knowledge is resulted from human imagination, inference, and creative thinking, science knowledge is subjective and theory-laden, and science is a social activity and culturally embedded.

The above mentioned tenets have been recognized and defined by the researchers of the science education field: tentative (may subject to evolve, as the science knowledge is not to prove, rather it is to falsify);empirical(based on facts);involving human imagination, creativity (putting forward explanations), and inference (distinct from observation), and having strong link with concerned society(Bell&Lederman,2003;Schwartz,Lederman &Crawford,2004;Kang,Scharmann&Noh,2005).

There has been a wide spread theme regarding NOS in science education reforms as an essential aspect of science literacy (American Association for the Advancement of Science (AAAS), 1993; National Research Council (NRC), 1996).Lederman (2007) studied understanding of those teachers who were teaching science regarding NOS. and came up with the following three outcomes: i) science teachers are deficient of ample appreciation of NOS; ii) conception about NOS may be enhanced among science teachers if they integrated either historical aspects of science or they put explicit focus on NOS; and iii) academic background

of science teachers is not appreciably related to appreciation of science teachers concerning NOS.

Akerson, Khalick and Lederman(2000) studied the understanding about NOS among elementary-level science teachers. They concluded that explicit focus on NOS enhanced teachers' conceptions about NOS.

Importance of NOS was also highlighted by Lakin and Wellington(1994) in their study on science teachers .They found that those teachers who are ignorant about NOS could not adopt adequate approaches to address this domains of science. As a result science teaching becomes ineffective .In the views of Luft (2001) and Khalick (2005), role of secondary level science teachers is critical in developing the appreciation of NOS among students .Therefore ,without knowing the perception of science teacher achievement of objectives of science at secondary level is not possible.

Objectives of the Study

This study pivoted aroundthe following two objectives:

- To investigate the perception of the science teachers teaching at secondary level about NOS, i.e. to what extent they appreciate tenets of NOS.
- To find out the relationship of perception of science teachers and their teaching approach, i.e. whether they incorporate NOS in their teaching by sharing tenets of NOS in their classroom.

Methodology

The study was descriptive in nature. Survey questionnaires were used as main tool of the data collection for the study.

Participants

The participants were the science teachers of Islamabad Model Colleges (IMCs) teaching at secondary level.A random sample of 16 IMCs was taken in which there were 8 Islamabad Model Colleges for Boys (IMCBs) and 8 Islamabad Model Colleges for Girls (IMCGs). There were total 120 science teachers: 60 males and 60 females.They teach physics, chemistry and biology at secondary level .

Instrument

To explore appreciation of science teachers and incorporation of NOS in their teaching, following two questionnaires were developed by the researcher :

1. Questionnaire :this questionnaire was developed to explore the perception of science teachers regarding nature of science.
2. Questionnaire: this was developed to find out the teaching approach of science teachers

Both questionnaires were based upon 3-point Likert scale:Disagree (D), Undecided (U), and Agree (A). Each questionnaire consists of five categories of tenets of NOS.Each category further consists of four items pivoted around the same conception regarding that tenet.

Validation and Reliability

The questionnaires were first pilot tested and then sent to a panel of experts of the related field. This procedure helped in improving the validity and reliability of them.

Procedure of Study

Researcher visited IMCsand distributed the questionnaires among science teachers. Later, filled-in questionnaires were collected from a sample of 120 science teachers. Each participant filled two questionnaires: One for appreciation of NOS and the other for incorporation of NOS in their teaching.

Response percentages were calculated for each category of tenets of NOS. The relationship between appreciation and incorporation was determined through correlation coefficient. Further a test for association between gender and appreciation and gender and incorporation was done.

Results

The following five tables have been included that demonstrate the overall findings of the research study.

Table 1

Serial No.	Tenets of NOS	%age

1	Tentative NOS	80
2	Empirical NOS	93
3	Inferential, Imaginative and Creative NOS	81
4	Subjective and Theory based NOS	46
5	Socially and Culturally based NOS	39

Percentages of science teachers' appreciation about each tenet of NOS

Table1demonstratesthe percentages ofappreciation of each tenet of NOS by science teachers. Higher percentages indicate greater understanding of each corresponding tenet of NOS.Science teachers' appreciation towards first three tenets i.e. tentative nature; empirical nature; inferential, imaginative and creative nature of science is high while appreciation towards last two tenetsis low.

Table 2

Percentages of science teachers' incorporation of each tenet of NOS in their teaching

Serial No.	Tenets of NOS	%age
1	Tentative NOS	79
2	Empirical NOS	84
3	Inferential, Imaginative and Creative NOS	72
4	Subjective and Theory based NOS	43
5	Socially and Culturally based NOS	33

Table 2shows the percentages of incorporation of each tenet of NOS by science teachers. Higher percentages indicate greater integration of each corresponding tenet of NOS in their teaching. Science teachers' incorporation of the first three tenets i.e. tentative nature; empirical nature; inferential, imaginative and creative nature of science is high while incorporation towards last two tenets is low.

Table 3

Relationship between Science Teacher's Perception about NOS and its Incorporation in their teaching

Tenet No.	Perception (No. of Science Teachers)	Incorporation (No. of Science Teachers)
1	96	95
2	111	101
3	97	86
4	55	51
5	47	39
r = 0.99		

Table 3highlightsthe perception of science teachers about NOS and its incorporation in their teachingi.e. whether they share whatever they perceive regarding five tenets of NOS in their classroom with the students. The value of correlation coefficient is obtained between perception and incorporation.As the value of coefficient of correlation (=0.99) is near 1 which shows that perception about NOS and its incorporation in teaching are strongly related .

Table 4
Association between gender of Science Teachers and their Perception about NOS

Gender / Perception	Appreciating	Not Appreciating	Undecided	*df*	*α*	χ^2_{tab}	χ^2_{cal}
Male	208	43	49	2	0.05	5.991	1.372
Female	198	42	60				

df = degree of freedom,α= significance level,χ^2_{tab}=tabulated value,χ^2_{cal} = calculated value

Table 4 reveals that is there any association of being male or female and having distinct perception regarding NOS.As The p-value of χ2cal (=1.372) is 0.5036 which is greater than α (α = 0.05), hence gender and perception about NOS has no association .

Table 5
Association between gender of Science Teachers and Incorporation of NOS in their teaching

Gender / Perception	Appreciating	Not Appreciating	Undecided	*df*	*α*	χ^2_{tab}	χ^2_{cal}
Male	189	51	60	2	0.05	5.991	1.280
Female	183	46	71				

df = degree of freedom,α= significance level,χ^2_{tab}=tabulated value, χ^2_{cal} = calculated value

Table 5 discloses that is there any association of being male or female and having distinct incorporation of NOS in their teaching. It is evident from the above table that p-value of $\chi 2cal$ (=1.280) is 0.5273 which is greater than α ($\alpha = 0.05$), therefore it is concluded that there is no association between gender and incorporation.

Results of analysis of data collected from all 120 science teachers about 5 tenets of NOS is as follows. the tentative nature: appreciation (80%), incorporation (79%); the empirical nature: appreciation (93%), incorporation (84%); the inferential, imaginative and creative nature: appreciation (81%), incorporation (72%); the subjective and theory-laden nature: appreciation (46%), incorporation (43%); the socially and culturally-embedded nature: appreciation (39%), incorporation (33%).

Among 60 male science teachers, the tentative nature: appreciation (78%), incorporation (73%); the empirical nature: appreciation (93%), incorporation (83%); the inferential, imaginative and creative nature appreciation (90%), incorporation (80%); the subjective and theory-laden nature: appreciation (45%), incorporation (43%); the socially and culturally-embedded nature: appreciation (40%), incorporation (35%).

Among 60 female science teachers,the tentative nature: appreciation (82%), incorporation (85%); the empirical nature: appreciation (92%), incorporation (85%); the inferential, imaginative and creative nature appreciation (72%), incorporation (63%); the subjective and theory-laden nature: appreciation (47%), incorporation (42%); the socially and culturally-embedded nature: appreciation (38%), incorporation (33%).

A correlation coefficient test was performed, and the result showed a strong relationship between appreciation of NOS and its incorporation in their teaching.Further Chi-Square test of independence was performed with gender and their perception about NOS and Chi-Square test of independence was also performed with gender and incorporation of NOS in their teaching. The results showed that these were statistically independent.Further Chi-Square test revealed that gender and perception of NOS were statistically independent. Similarly, gender and incorporation of NOS in teaching were also statistically independent.

Discussion

Data was analyzed usingSPSS: percentages, correlation coefficient and association statistics is applied on the data. The percentage result show that science teachers have higher percentage of appreciation for first three tenets of NOS and consequently their incorporation of these tenets in their teaching is also higher in percentage. The correlation

coefficient result reveal that appreciation of NOS and incorporation of it in teaching are related with each other.The association result demonstrates that there is no association between gender (being male or female science teacher) and appreciation about NOS.Researchers opined that teachers' understanding and knowledge of NOS affects students understanding and knowledge regarding NOS(Khalick & Lederman, 2000; Khalick, Bell, & Lederman, 1998).

Study of Schwartz and Lederman (2002) is also in line with these results. They investigated the development of understanding about NOS among naive science teachers along with incorporation of their perceptions into classroom practices. The results revealed the depth of NOS appreciation, subject matter understanding, and the perceived association between NOS and science-subject material influenced the teachers' pedagogical ideas of NOS.

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Recommendations

Five tenets of NOS were investigated; the science teachers were not appreciating all the five tenets fully, so it is recommended that NOSshould be integrated as a part of curriculum and training courses.These tenets of NOS may be more emphasized and illustrated in curriculum and trainings so that these might be more appreciated by the science teachers.Among five tenets of NOS, the two less appreciated tenets should be further explored by the researchers of science education field.

There are a number of tenets identified in the research literatures, out of them five tenets were investigated in this study; it is suggested that the other tenets may also be explored like the difference between observation and inference, the distinct natures of theory and law, or the myth that there is only one way to do science so called scientific method, or whether the scientific knowledge is discovered or invented etc.

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APPENDICES

APPENDIX-A

QUESTIONNAIRE OF PERCEPTION ABOUT NATURE OF SCIENCE

Encircle the option; each statement is followed by three choices indicating:

D = Disagree U = Undecided A = Agree

Item No.	Item Statement	Options		
	The Tentative Nature of Science			
1	Scientific knowledge is subject to modification in light of new empirical evidence	D	U	A
2	Scientific knowledge is tentative	D	U	A
3	Change in scientific knowledge is unavoidable as new observations may confront the prevailing theories	,,,,,,,,,,,,,, D	U	A
4	Scientific knowledge is absolute	,,,,,,,,,,,,,, D	U	A
	The Empirical Nature of Science			
1	Scientific knowledge is built and/or derived from observation and experimentation	D	U	A
2	Scientific knowledge entails empirical evidence	D	U	A
3	Scientific knowledge can be established without observation and experimentation	D	U	A
4	Scientific knowledge has empirical nature	D	U	A
	The Inferential, Imaginative and Creative Nature of Science			
1	Scientific knowledge is created from human imagination	D	U	A
2	The creation of scientific knowledge is established by inference	D	U	A
3	Imagination and creativity play important role in the development of scientific knowledge	D	U	A
4	Science does not have inferential, imaginative and creative nature	D	U	A
	The Subjective and Theory-laden Nature of Science			
1	Background knowledge influences how scientist view data	D	U	A
2	Scientific investigations are theory driven	D	U	A
3	Scientists' observations are affected by their exposures and perceptions	D	U	A
4	Scientific conclusions made by a scientist are not dependent on his or her perspectives	D	U	A
	The Socially and Culturally embedded Nature of Science			
1	As a social activity, science inevitably manifests social values and point of views	D	U	A

2	The scientific research is directed by the socio-cultural interests	D	U	A
3	Science is driven by prevailing opinions of the socio-cultural setting	D	U	A
4	Science does not have socio-cultural nature and it transcends cultural limitations and boundaries	D	U	A

APPENDIX-B
QUESTIONNAIRE ABOUT TEACHING APPROACH

Encircle the option; each statement is followed by three choices indicating:
D = Disagree U = Undecided A = Agree

Item No.	Item Statement	Options		
	The Tentative Nature of Science			
1	I incorporate tentative nature of science in my teaching	D	U	A
2	I assert in my classes that scientific knowledge is tentative rather than absolute	D	U	A
3	I elaborate in my classes that scientific knowledge is subject to modification in light of new empirical evidence	D	U	A
4	I seldom integrate tentativeness of scientific knowledge in my lessons	D	U	A
	The Empirical Nature of Science			
1	I incorporate empirical nature of science in my teaching	D	U	A
2	I emphasize in my classes that scientific knowledge is established and/or derived from observation experimentation	D	U	A
3	I assert in my classes that scientific knowledge entails empirical evidence	D	U	A
4	I rarely integrate empirical nature of scientific knowledge in my lessons	D	U	A
	The Inferential, Imaginative and Creative Nature of Science			
1	I incorporate has inferential, imaginative and creative nature of science in my teaching	D	U	A
2	I discuss in my classes that the creation of scientific knowledge is based on inference	D	U	A
3	I emphasize in my classes that imagination and creativity play important role in the development of scientific knowledge	D	U	A
4	I infrequently integrate inferential, imaginative and creative nature of science in my lessons	D	U	A
	The Subjective and Theory-laden Nature of Science			
1	I incorporate subjective and theory-laden nature of science in my teaching	D	U	A
2	I emphasize in my classes that scientists make observations and interpretationsinfluenced and driven by their exposures and perceptions	D	U	A
3	I discuss with my students that science is directed and shaped by the prevalent scientific notions	D	U	A

4	I scarcely integrate subjective and theory-laden nature of scientific knowledge in my lessons	D	U	A
	The Socially and Culturally embedded Nature of Science			
1	I incorporate socio-cultural embedded nature of science in my teaching	D	U	A
2	I discuss in my classes that being a social activity, science inevitably manifests social values and point of views	D	U	A
3	I share with my students that the scientific research is directed by the socio-cultural interests	D	U	A
4	I barely integrate socio-cultural nature of science in my lessons	D	U	A