



PRE-SERVICE SCIENCE TEACHERS' SUBJECT MATTER KNOWLEDGE OF NATURE OF SCIENCE

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Abstract

In this study aims to determine the status of pre-service science teachers' subject matter knowledge of nature of science (SMK of NOS) and investigate in which contents they are inadequate, if any, and/or they have naive views about the nature of science. 89 pre-service science teachers who are studying in the 4th grade of Science Education Department in Gazi University of Turkey participated in the study. SMK of NOS of the pre-service teachers is determined by the researcher using "Views on The Nature of Science (VONS)" questionnaire which is adapted to Turkish from VOSTS (Views on Science-Technology-Society) questionnaire. In this survey study descriptive model is used. In this regard, the pre-service teachers' responses on the VONS are analyzed based on subject matter experts' encodings. According to the results, pre-service science teachers have enough SMK about some issues such as tentativeness of scientific knowledge, scientific approach for researches and public influence on scientists. However, SMK of NOS of pre-service science teachers is not in a level to develop the students' level of understandings and knowledge of NOS. Pre-service teachers' insufficient SMKs are related to scientific theories, laws and hypothesis also their epistemological status and nature of scientific models.

Keywords: Nature of Science, Pre-service Science Teacher, Subject Matter Knowledge.

INTRODUCTION

In science education, students' are being brought up as scientific literate individuals and it is considered among the most important educational objectives (NRC, 1996; Moss, Abramsand and Robb, 2001; MEB, 2005). Scientific literacy generally refers to one's understanding of the concepts, principles, theories, and processes of science and participation in civic and cultural affairs and economic productivity, and one's awareness of the complex relationships between science, technology, and society (NSTA, 1982; NRC, 1996). In this regard, scientific literacy is linked to the deep understanding of the processes of "scientific inquiry" and "Nature of Science (NOS)" (Abd-El-Khalick and BouJaoude, 1997; Moss, et al., 2001). In this respect, one of the biggest steps for becoming a scientific literate person is that students who have learned science can have contemporary views about NOS. The nature of science can be expressed both in the nature of scientific knowledge and the nature of scientific enterprise (Meichtry, 1992). The nature of science for science educators has defined as composed of the issues concerning philosophy, history,

sociology and psychology of science and as an intersection affecting science teaching and learning (McComas, Clough and Almozroa, 2000: 5). Also, Lederman (1992) has explained the NOS as "the values and assumptions inherent in the development of scientific knowledge".

Many researchers have indicated that teachers, to a very large extent, responsible for the students' knowledge and understanding of NOS. It is put forward that science teachers' beliefs about the NOS influence teachers' perceptions, their teaching practices, students' perceptions (Mellado, 1997; Tsai 2002). Researchers argue that the NOS can be seen cognitive and that the NOS is also a subject matter as the reactions of photosynthesis and pH rather than being seen as an impressive result of the education (Abd-El-Khalick, 2001). Therefore, teachers' comments on NOS, as already being part of their own subject matter knowledge (SMK), and NOS can be seen similar to other contents a teacher can teach and that's why can be thought as a special subject area in which they develop their pedagogical content knowledge (Hanuscin, Lee & Akerson, 2010). In this research, pre-service science teachers' views of NOS are in the context taken as their "Subject Matter Knowledge of Nature of Science (SMK of NOS)". At this point, teachers' SMK of NOS becomes important in terms of their responsibilities of students' gaining the understanding of NOS at a contemporary and adequate level.

Rationale

Previous researches (Lederman 1992; Murcia & Schibeci, 1999; Küçük, 2006; McDonald, 2010) have consistently indicated that students, pre-service and in-service teachers do not possess adequate conceptions of the NOS. If it is thought that teachers' views and SMK of NOS have affected the students' views, knowledge and also their teaching process, it is important that researching teachers' SMK of NOS. In this respect, the present study aims to determine the status of pre-service science teachers' SMK of NOS and investigate in which contents they are inadequate, if any, and/or they have naive views about the NOS.

METHOD

Model of the Study

This survey study is a descriptive research in which qualitative research techniques used. VONS questionnaire is used in research for determining pre-service science teachers' SMK of NOS. VONS includes both structured items and free field for writing knowledge about issues.

Participants

The participants were determined according to purposive sampling method. 89 pre-service science teachers who are studying in the 4th grade of Science Education Department in Gazi University of Turkey participated in the study.

Data Collection Tool

"Views on Nature of Science (VONS)" questionnaire which is adapted to Turkish by Mıhladı (2010) was used in the study. VONS is composed of 21 items, selected from "VOSTS (Views on Science-Technology-Society)" questionnaire which has 114 items and is created by Aikenhead, Ryan and Fleming (1989). In this study, 6 categories selected from VOSTS and also selected 21 items from each categories; Science (1 item); Influence of Society on Science (2 items); Influence of Science on Society (1 item); Characteristics of Scientists (2 items); Social Construction of Scientific

Knowledge (1 item); Nature of Scientific Knowledge (14 items). In the study carried out to test the applicability of VONS questionnaire, three similar answers repeated, after 21 questions, are chosen, only 44 (2.78%), from a total of 1582 replies. In this regard, in researches that VOSTS questionnaire or an adapted version was used, when the rates of the last three items in the literature (e.g., Lieu, 1997 (5.93%); Aslan, 2009 (4.75%)) are compared, it was found out that the pilot application was among the lowest values and for this reason, the VONS questionnaire is quite suitable for research.

Data Analysis

Vazquez-Alonso and Manassero-Mas's (1999) category system is used for analyzing teachers' answers to VNOS. Each statement in a VONS item is categorized by 10 NOS subject experts who assign it to one of the following three categories: *R/Realistic*: The statement expresses an appropriate view. *HM/Has Merit*: While not realistic, the statement expresses a number of legitimate points. *N/Naive*: The statement expresses a view that is inappropriate or not legitimate. After each VONS' item is resolved according to experts' codes, frequency and percentage calculations were made in accordance with the descriptive analysis.

FINDINGS

The findings of the study organized in two parts which are related to VONS' categories. In first part, 7 items which are belongs to first 5 categories of VONS has given in Table 1.

Table 1. Findings of pre-service science teachers' SMK OF NOS on the first 5 categories of VONS

Items	Realistic		Has Merit		Naive	
	f	%	f	%	f	%
01. Defining science	62	69.66	20	22.47	7	7.87
02. Ethics (e.g., influence on research program)	27	30.34	61	68.54	1	1.12
03. Public influence on scientists	67	75.28	20	22.47	2	2.25
04. Social responsibility of scientists	4	4.49	76	85.39	9	10.11
05. Standards/values that guide scientists at work & home	44	49.44	9	10.11	36	40.45
06. Gender effect on the process & product of science	41	46.07	18	20.22	30	33.71
07. Scientific decisions (e.g., disagreements among scientists, consensus making).	51	57.30	16	17.98	22	24.72

As can be seen in Table 1., the most common and enough SMKs of NOS of pre-service science teachers were found about "Social responsibility of scientists (85.39%)", "Public influence on scientists (75.28%)", "Defining science (69.66%)" and "Scientific decisions (57.30%)". Also pre-service science teachers have medium level of SMK about "Social responsibility of scientists (85,39)" and "Ethics (e.g., influence on research program) (%68.54). In this respect, pre-service teachers' SMK of NOS in first 5 categories are enough.

The other category of VONS which is related to pre-service science teachers' "Nature of Scientific Knowledge" has given in Table. 2. This category has 14 items about NOS in VONS.

Table 2. Findings of pre-service science teachers' SMK of NOS on "Nature of Scientific Knowledge" category

Items	Realistic		Has Merit		Naive	
	f	%	f	%	f	%
08. Nature of observations (e.g., theory ladenness, perception bound).	48	53.93	1	1.12	40	44.94
09. Nature of scientific models.	25	28.09	15	16.85	49	55.06
10. Nature of classification schemes	59	66.29	1	1.12	29	32.58
11. Tentativeness of scientific knowledge.	78	87.64	-	-	11	12.36
12. Hypotheses, theories & laws (Scientific ideas develop from <i>hypotheses</i> to <i>laws</i>).	17	19.10	-	-	72	80.90
13. Theories (Good theories are also <i>simple</i> rather than <i>complex</i>)	23	25.84	44	49.44	22	24.72
14. Theories & laws (When developing new theories or laws, scientists need to make certain assumptions)	34	38.20	2	2.25	53	59.55
15. Scientific approach to investigations (scientific method)	33	37.08	30	33.71	26	29.21
16. Scientific approach to investigations (mistakes in scientific studies)	70	78.65	3	3.37	16	17.98
17. Precision & uncertainty in scientific knowledge	65	73.03	20	22.47	4	4.49
18. Epistemological status of laws	19	21.35	8	8.99	62	69.66
19. Epistemological status of hypotheses	22	24.72	18	20.22	49	55.06
20. Epistemological status of theories	25	28.09	-	-	64	71.91
21. Paradigms vs. coherence of concepts across disciplines.	24	26.97	40	44.94	25	28.09

As can be seen in Table 2., pre-service teachers have contemporary views and sufficient SMK on "tentativeness of scientific knowledge (87.64%)", "precision & uncertainty in scientific knowledge (73.03%)", "mistakes in scientific studies (78.65%)" and "nature of classification schemes (66.29%)". However, in this category of VONS, pre-service teachers insufficient SMKs of NOS were found about some issues such as "scientific ideas develop from hypotheses to laws (80.90%)", "epistemological status of theories (%71.91)", "epistemological status of laws (69.66%)" "when developing new theories or laws, scientists need to make certain assumptions (59.55%)" and "nature of scientific models (55.06%)".

DISCUSSION

It is found that the pre-service science teachers in general do not adopt post-positivist views about NOS clearly and also in some issues their naive point of views are more common. In this regard, SMK of NOS of the pre-service science teachers is not in a level to develop the students' level of understanding and knowledge of NOS. In parallel with this research, a lot of researcher (Murcia and Schibeci, 1999; Tsai, 2002; Khishfe, 2008; Aslan, 2009) found that students and also pre-service and in-service science teachers' views and knowledge of NOS are not enough for themselves or improving their student's knowledge of NOS. According to results of this study and some studies (Abd-El-Khalick and BouJaoude, 1997; Abd-El-Khalick and Akerson, 2004) most of pre-service teachers have widely insufficient and naïve SMK about "Scientific ideas develop from hypotheses to laws". We can understand from this naïve knowledge of teachers that these teachers do not know contents of hypotheses, theories and laws. Moreover, parallel to the results, Haidar (1999)

and Aslan (2009) explained that epistemological status of laws, hypothesis, and theories are unknown subjects among teachers.

Also, similar to the results of this research, Haidar (1999) and Doğan (2005) stated that pre-service and in-service teachers have realistic views on some issues such as "precision & uncertainty in scientific knowledge", "Defining science", "Public influence on scientists" and "Nature of classification schemes". These results have indicated that on these NOS issues pre-service and in-service teachers have enough SMK of NOS.

CONCLUSION

When pre-service science teachers' SMK of NOS was analyzed, it was seen that 44.81% represent realistic (contemporary) views, 33.67% represent naive views and 21.52% represent reasonable views. According to the results of the analysis, pre-service science teachers have a certain level of SMK of NOS. However, that level of SMK they have about the NOS does not sufficiently represent a contemporary vision at an adequate level. The common issues in which pre-service teachers have contemporary views and sufficient SMK of NOS, and that can be widely accepted among the teachers can be listed as "Tentativeness of scientific knowledge (87.64%)", "Scientific approach for researches (mistakes in scientific studies) (78.65%)", "Public influence on scientists (75.28%)", "Precision and uncertainty in scientific knowledge (73.03%)". In addition, it is found that pre-service teachers have insufficient SMK about some issues such as "scientific ideas develop from hypotheses to laws (80.90%)", epistemological status of theories (71.91%); laws (69.66%) and hypothesis (55.06%) in very high rates. Besides, it is noteworthy that more than half of the pre-service teachers do not have enough contemporary point of view about "scientists need to make certain assumptions" and "Nature of scientific models".

In this respect, it is thought that firstly pre-service teachers' SMKs should be improved on subject of nature of scientific knowledge. Also in connection with NOS, pre-service science teachers should be educated about philosophy, history, sociology and psychology of science.

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