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An Analysis from Different Variables of Views of Pre-Service Science Teachers in Turkey on the Nature of Science

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Abstract

It is known that the level of welfare is higher in societies that scientific knowledge is integrated with individuals' lives. In this sense, it is of vital importance to apprehend the nature of science; that is, to understand what scientific knowledge is, what it involves, and how it evolves. Professional competency of science and technology teachers, who have an essential role in teaching the nature of science, is also very important. Considering the fact that pre-service science teachers' will teach science and technology course in future, an analysis of their knowledge and their view on the nature of science becomes significant. For this purpose it was aimed to determine pre-service science teachers' views on the nature of science. Descriptive research methodology was used in this research. Research data was collected through the "Views on Science and Education Questionnaire (VOSE)", which was developed by Chen. The questionnaire was translated into Turkish by researchers, and its reliability and validity tests were conducted. The sample of the study is composed of 237 students, who are 1st, 2nd, 3rd, and 4th year science education students, studying at Giresun and Kırıkkale Universities. The study revealed that views on the nature of science do not change according to the class level, and students have certain insufficiencies to understand the dimensions of nature of science.

Keywords: Nature of science, science teacher, teaching science and technology.

Introduction

Throughout the history, societies have conducted studies in order to take advantage of the scientific applications. As a result, they made an effort to upgrade their standards of living. It is seen that a number of scientists describe science different from each other. Generally, science is defined as sound thinking, researching the truth and knowledge, obtaining systematic information through scientific methods and the process of knowledge construction, and efforts to understand and define the universe[1]. Ertürk analyzed science in two groups, knowledge and method. Both scientific knowledge and the quality of the scientific method can be expressed through the nature of science[2]. Bayrakçeken and Çelik emphasized that it is possible to understand scientific activities and the quality of scientific knowledge from the nature of science. The ways how scientific activities and scientific knowledge were formed, how the needs of society affect science during this formation process, and psychology and environmental conditions of a scientist while he is doing science are all analyzed within the framework of nature of science[3]. In this regard, the concept of science and the media is great importance in the formation of the environment[4].

The Nature of Science and Characteristics of Scientific Knowledge: Today science is perceived within an innovation oriented framework and inaccurate knowledge of science is started to change. Below there are explanations, which were questioned within the scope of this study, of some features of scientific knowledge.

Theory and laws are different from each other: Scientific theory and laws are two different concepts, although it is frequently thought that they have a hierarchical relationship with each other[5]. Theories are explanations that cannot be observed directly, they have different topics, and have too many supporters; on the other hand, laws are descriptions of what exist in nature. Descriptions can include mathematical operations. There is no hierarchical relationship between theory and law. These two concepts are not interchangeable and one is not superior to other[6].

Scientific knowledge is affected by socio-cultural norms*:* A society's values, beliefs, and culture affect the scientific knowledge produced within that society. Scientific knowledge has never developed independent from this framework[7, 8].

Scientific knowledge is subjective: Scientific knowledge is affected by scientist's subjectivity in terms of its origination. Scientist's former knowledge of the topic, his imagination, beliefs, and expectations can be counted among this subjectivity[9]. In other words, while scientific knowledge is subjective at its origination phase, once formed, it becomes objective and it can be experimented, rejected, or supported by others.

Scientific method and scientific knowledge are not accurate: In modern science expressions like proof, accuracy, and truth are not preferred. All scientific knowledge is open to change. It is known that some knowledge that was once accepted as true, are not true anymore[9]. The changing structure of science should be grasped perfectly; hence, it would be avoided to describe and understand it as an inconsistent entity. Scientific knowledge is a dynamic structure, not static.

In our age, understanding science and adapting it into daily life are described as science literacy. Realizing the nature of science is a dimension of science literacy[10]. Ministry of National Education (MoNE) revised the content and extent of 'Science and Technology course' in order to reach the education norms of developed countries. In this sense, it is aimed to enhance the skill of scientific literacy and the knowledge of nature of science among elementary school students[11]. Due to its extent, Science and Technology course is an appropriate course regarding teaching the nature of science. In this regard, science teacher can be the guide to develop students' skills of scientific literacy. For this purpose, competency studies were conducted by the Ministry of National Education towards teachers; and, professional field competencies were determined for each field of teaching. Following items are the professional field competencies of a science teacher. i. Following developments in science and reflecting them to the classroom activities. ii. Admiring being scientific. iii. Promoting students to gain scientific knowledge and the habit of scientific thinking. iv. Providing learning experiences that give students the opportunity to examine research, evaluate, and appreciate the relations between science-technology and society-environment[12].

According to these competencies it can be argued that a science teacher needs to grasp science, scientific thinking, and the relationship between science and society. Palmquist determined that, observing the teaching methods of science teachers revealed that the way how they generally teach science courses depends on their perception of science and the way how they learned it[13]. In this sense, the way how a science teacher internalizes the nature of science is of importance.

Related studies show that primary and secondary school students, higher education students, and in service teachers have unsatisfactory knowledge of the nature of science; also, they have misconceptions concerning the structure of scientific knowledge of modern science, and they still believe in certain scientific mythos[14-20]. Schwartz, Lederman and Crawford conducted an experimental study in order to develop the views on nature of science. They used Authentic Context approach in their study. Before the study, participants were asked to get their opinions regarding the nature of science. It was determined that for most of the participants scientific knowledge is a form of knowledge that is proved, accurate, and unchangeable[21]. In the same study those participants who emphasized the necessity that scientific knowledge should be proved by experiment, supported the principle of seeing is knowing. In their research, Kılıç et al. aimed to change secondary school students' perceptions regarding the nature of science[22]. In the study it was revealed that despite the differences between school types, students' ideas such as scientific knowledge can change and scientists can use their imagination and creativity while producing scientific knowledge, are compatible with the modern science. In addition, it was argued that students have misconceptions like if there are two theories about a topic; it is probable to select the easier information. In a study conducted by Aslan, Yalçın and Taşar, it was aimed to determine science teachers' views on nature of science[23]. Studies showed that teachers have insufficient knowledge of the quality of hypothesis, theory, and laws; and they believe mistakenly that a scientist always has an objective point of view; on the other hand, teachers have the exact information about changeability of scientific knowledge. In their study Morgil et al. aimed to develop science education students' views and beliefs on nature of science, through project based education. Before the application, a scale was developed in order to determine participants' existing misconceptions and mistakes[24]. Accordingly, it was claimed that most of the participants have insufficient knowledge of law and theory, they are unable to explain producing two different hypotheses from one data, and they do not think that scientific knowledge is affected by social values. Miller et al. analyzed undergraduate students, who are studying at two different educations of science, for their views on the nature of science. Within this scope, they determined that students have certain misconceptions, such as different scientists would make the same observation and interpretation on a certain topic; imagination and creativity contradict with science; hence they do not belong to the formation of scientific knowledge; and, scientific theories would never change[25]. In their study Doğan et al., created an in service training program to develop teachers' views on the nature of science. At the beginning of the study they researched teachers' existing views on the nature of science[26]. They revealed that most of the teachers have incorrect epistemological knowledge regarding the facts that hypothesis, theory, and laws are interchangeable scientific knowledge, they have a hierarchical relationship in each other; and, hypotheses and laws are either invention or discovery.

The Purpose of the Study: According to the literature review, concepts and topics regarding the nature of science are understood sufficiently neither by teachers and undergraduate students, nor by the primary and high schools students. In this study it was aimed to determine if undergraduate students of science education have different views on nature of science according to their class levels. Since science education department offers the course the nature of science and history of science for 3rd year students, and students take a number of laboratory and field courses. Eventually, students are expected to grasp certain basic concepts regarding the nature of science throughout their undergraduate education. The scope is to question if students' views on the nature of science change once they take the classes related to research. From this point of view, following sub-problems will be elaborated according to students.

With respect to the class levels of undergraduate students of science education; i. What are their views on the quality of scientific theories? ii. What are their views on the quality of scientific laws? iii. What are their views on the quality of the relationship between science and socio-cultural environment? iv. What are their views on the subjectivity of scientific knowledge? v. What are their views on the quality of the scientific method? vi. What are their views on the changing structure of scientific knowledge?

Material and Methods

Research Model: The survey method, which is one of the descriptive research methodologies, was used in this study. Main reason to select this method is to determine teacher candidates' views on the nature of science. Survey method is a model that is used to reveal current conditions and interpret them[27].

Research Group: The sample of the study is composed of 237 students, who are 1st, 2nd, 3rd, and 4th year science education students, studying at Giresun and Kırıkkale Universities. The research took place during the fall semester of 2011-2012academic year. Table 1 shows participants' distribution according to their classes.

Table-1
Descriptive Statistic Results of the Research Group according to their Class Levels

Level of Class	N
1	59
2	60
3	51
4	67
Total	**237**

Data Collection Tool: Research data was collected through the "Views on Science and Education Questionnaire (VOSE)", which was developed[28] by Chen. Items basis of the scale can be categorized as the following: i. The quality of scientific theories (A, D, E, G, M)., ii. The quality of scientific laws (F, G, M)., ii. The relation of science and socio-cultural environment effects (B)., iii. Subjectivity of scientific knowledge (C, H, N, P), iv. The quality of scientific method (I, J), v. The changing structure of scientific knowledge (K, L)

These six categories, which were examined in the scale regarding the nature of science, were written by 15 item basis. Each item basis was divided into items varied from 2 to 9, and 5 point Likert scale was developed. Items of the scale were examined within the framework of scope validity, and the relationship between each item and upper category was explicated in the light of expert opinions. In this sense, the structure of the scale was untouched. Related scale was translated into Turkish by linguists with reference to the field specialists of science education. Reliability analysis of the scale was examined from the perspective of internal consistency, and the Cronbach's Alpha was 0.79. This coefficient shows that the scale is a highly reliable assessment instrument for the social fields.

Data Evaluation: In data evaluation the value of the VOSE scale, which was prepared as the 5 point Likert scale type, was 0.80. Following values were determined based on the number of points. Accordingly values between 1.00 and 1.79 mean "Strongly Disagree"; 1.80 and 2.59 "Disagree"; 2.60 and 3.39 "Neutral"; 3.40 and 4.19 "Agree"; and 4.20 and 5.00 "Strongly Agree".

Within the framework of the purpose of this study, SPSS 16.0 package program was used for the necessary statistical analysis of data collected regarding the sub-problems. Frequency, percentage, and arithmetical mean, which are methodologies of descriptive analysis, were calculated and findings were interpreted.

Results and Discussion

Students' Views on the Forms of Scientific Knowledge: Pre-service science teachers' views on the forms of scientific knowledge were analyzed according to the class level, table 2 shows the results.

Table 2 shows that in part A, 1st year, 3rd year, and 4th year students selected "Agreed"; while it is seen that 2nd year students did not give a clear answer for that part. It can be understood that students typically know that same fact can be explained by two different theories. In part K it can be seen that 1st year students clustered around the answer "Disagree"; while, 2nd year, 3rd year, and 4th year students clustered around the "Neutral"; and they have unclear information about the structure of scientific knowledge. Due to their epistemological structure, modern science examines scientific theories within the category of invention. In part D, a major part of the students answered "Neutral", without any difference according to the class level. Once related literature is reviewed, the idea that theories can be changed in due course becomes prominent. In the study that Lederman analyzed the ways how teachers understand and apply the nature of science, he claimed that a vast majority of the participants believe that theories, as forms of scientific knowledge, can change in due course[17]. In part F most of the answers are "Agree", and on the contrary of the existing studies in literature, it can be argued that students have true information regarding the epistemology of the scientific laws. At the beginning of their study, Doğan et al. claimed that teachers cannot understand epistemological structure of law, hypothesis, and theory[26]. It is seen that in part G answers were clustered around "Neutral". At that point it is possible to claim that students have unclear knowledge of laws and theories. Likewise, Taşkın, Çobanoğlu and Apaydın addressed that undergraduate students cannot make a distinction between theory and law, and even if they make it they cannot grasp this distinction exactly[19].

Table-2
Descriptive Analysis of the Views on the Sub-Categories of Forms of Scientific Knowledge

Views on various forms of scientific knowledge	Class Level	$\bar{x}$
A. Scientists should accept both theories, when two different theories are developed to explain the same fact	1	3,40
	2	3,36
	3	3,61
	4	3,52
K. Scientific theories (natural selection, atom theory etc) were invented by scientists in nature.	1	2,54
	2	3,19
	3	3,16
	4	3,03
D. Even if the scientific research is conducted accurately, proposed theory can be refuted in future.	1	3,01
	2	3,13
	3	3,28
	4	3,04
F. Scientific laws (law of inertia, etc) were discovered by scientists in nature.	1	3,61
	2	3,48
	3	3,59
	4	3,56
G. Compared to the laws, theories are supported by lesser evidence.	1	2,97
	2	2,92
	3	2,91
	4	2,88

Students' Views on the Fact that Scientist Reflects his Personal Characteristic on Science: Pre-service science teachers' views on the fact that scientist reflects his personal characteristic on science, were analyzed according to the class level, table 3 shows the results.

Table 3 reveals that for part C, a vast majority of 3rd year students answered "Neutral"; while a considerable part of 1st year, 2nd year, and 4th year students answered "Agree". In literature there are other examples of this finding, which support the idea that scientific knowledge is affected by creativity and imagination. In their study about the nature of science Abd-El-Khalick, Bell, and Lederman determined that most of the participants support, imagination and creativity are important for scientific knowledge[15]. In part H, without any difference according to the class level, a vast majority of students clustered around "Disagree", which shows that they were wrong to ignore the importance of personal characteristics in the process of science. In their study Tatar, Karakuyu, and Tüysüz aimed to determine pre-service classroom teachers' scientific knowledge of the nature of science and their misconceptions regarding scientists. According to the study, which is in line with the finding, teacher candidates mentioned that a scientist should be independent from his personal beliefs, feelings, and thoughts while doing scientific research[20].

Table-3
Descriptive Analysis of the Views on the Sub-Categories of the Fact that Scientist Reflects his Personal Characteristic on Science

When scientist does science	Class Level	$\bar{x}$
C. Scientists use their imagination while they do their scientific studies	1	3,42
	2	3,44
	3	3,38
	4	3,44
H. Scientists' observations are affected by their personal beliefs (personal experiences, assumptions, etc); as a result, they may not make similar observations for similar experiments.	1	2,32
	2	2,17
	3	2,35
	4	2,32

Students' View on Scientific Method
Pre-service science teachers' views on scientific methods were analyzed according to the class level, table 4 shows the results.

Table-4
Descriptive Analysis of the Views on the Sub-Categories of Scientific Methods

Views on Scientific Method	Class Level	$\bar{x}$
I. Many scientists follow the universal scientific methods (such as determine a hypothesis, set an experiment, data collection, and draw a conclusion) step by step, while they conduct scientific research.	1	3,64
	2	3,74
	3	3,69
	4	3,64
J. Students should learn the process of scientific method and procedure.	1	3,55
	2	3,57
	3	3,59
	4	3,62

Table 4 reveals that in I and J parts the majority of the students, independent from their class levels, clustered around "Agree". Participants supported the idea that scientific method should be learned which is also accentuated by the study of Doğan et al. within the framework of insufficiencies. In this study participants advocate that scientific methods should certainly be followed, because they are highlighted in text books; and they are valid and logical[26].

Students' Views on the Nature of Science in Science Courses: Pre-service science teachers' views on the nature of science in science courses were analyzed according to the class level, Table 5 shows the results.

Table-5
Descriptive Analysis of the Views on the Sub-Categories of the Nature of Science in Science Courses

The Nature of Science in Science Courses	Class Level	$\bar{x}$
M. Science courses should determine and research the relationship between hypothesis, theory, and laws.	1	3,98
	2	4,05
	3	4,06
	4	4,00
K. Science teachers should expect that students refer to the same findings when they examine the same event.	1	3,12
	2	3,19
	3	3,16
	4	3,03
L. Students should understand that scientific knowledge can change.	1	3,04
	2	2,91
	3	2,92
	4	2,99

Table-6
Descriptive Analysis of the Views on the Sub-Categories of Scientific Research and Social Environment

Interaction between Scientific Research and Social Environment	Class Level	$\bar{x}$
B. Scientific research is affected by the socio-cultural values (daily tendencies, values)	1	2,96
	2	2,86
	3	2,99
	4	3,09
N. From the perspective of science education, scientists are not affected by socio-cultural norms.	1	3,30
	2	3,32
	3	3,44
	4	3,30
P. From the perspective of nature of science, scientists are not affected by socio-cultural norms.	1	3,21
	2	3,32
	3	3,37
	4	3,30

Analyzing table 5 it can be seen that students clustered around "Agree", and they are independent from their class levels. It is seen that for the K and L parts, the large part of the students are neutral. The reason why teacher candidates cannot form an opinion may stem from the fact that they internalized scientific knowledge wrongfully. Certain studies in literature support the idea. In a study Tatar, Karakuyu, and Tüysüz determined that classroom teachers describe scientific knowledge as a total of proved, uncriticizable, and accurate knowledge[20]. Akerson, Abd-El-Khalick, and Lederman applied activity based courses in order to teach the nature of science. They found out that before the application participants have limited knowledge of some dimensions of the nature of science[18]. In this sense, they mentioned that most of the undergraduate students as well as graduated students do not accept the changeability of scientific knowledge.

It can also be understood from the findings in table 5 that students understood changeability of scientific knowledge of the nature of science, yet this changeability should not be taught in science courses. It is possible that arguments, such as the motive that scientific knowledge is changeable decreases students' attention to learn science, makes it hard for them to accept science, and there are some basic knowledge in science; may lead them to the indistinctness about instructing the changeability of knowledge (within the framework of science education) to the elementary school students.

Students' Views on Scientific Research and Social Environment: Pre-service science teachers' views on scientific research and social environment were analyzed according to the class level and the results were shown in table 6.

Table 6 reveals that regarding the fact that scientific research is affected by socio-cultural values, most of the students, apart from their class levels, are neutral. According to the analysis of part N, it 3rd year students disagree that science education is affected by social values. For the same part, it is determined that 1st year, 2nd year, and 4th year students were neutral. From the perspective of nature of science, in part P, which addresses the interaction between science and social environment, most of the students clustered around "Neutral". The reason may be the misconceptions about the nature of science. Identification of biological diversity and agricultural wastes is important to evaluate in a good way[29,30]. Studies in literature support these findings. In a study Macaroğlu, Taşar, and Çataloğlu analyzed pre-service teachers' level of understanding concerning the nature of science[16]. With respect to the analysis it was determined that participants "Somewhat Agree" with the interaction between scientific knowledge and society. The development of science and technology will contribute to the development of the environment[31]. According to a research by Miller et al., before the application participants argued that science includes universal facts, for this reason it would not be affected by society and cultural environment[25].

Conclusion

In this study it was aimed to determine if students' views on the nature of science differ according to their class levels. According to the findings, it was revealed that class levels do not cause major changes in students' views on the nature of science. Also, the research findings point that a considerable part of the students have wrong or unsatisfactory knowledge of the dimensions of nature of science. For instance, it can be seen that students do not have sufficient knowledge of the structure of scientific knowledge and they do not understand clearly the laws and theories (table 2). Analyzing the results about these findings it was figured that, Doğan et al. concluded that teachers

cannot understand exactly the structures of law, hypothesis, and theories[26]; while in their study Taşkın, Çobanoğlu, and Apaydın found that students do not have knowledge of theory and law[19].

It was observed that students have sufficient knowledge of the interaction between scientific knowledge and creativity and imagination; and scientific laws are discovered (table 3). It is also showed that in a study by Tatar, Karakuyu, and Tüysüz similar results were obtained[20].

Furthermore, it is seen that students have insufficient knowledge of the quality of theories, changeability of scientific knowledge, interaction between the scientist and social environment, creativity in scientific method, and subjectivity of scientific knowledge (tables 4, 5, and 6). According to the research results, it was revealed that results are similar to the research findings[16,18,25]. From this perspective it can be argued that during their undergraduate education, students do not learn sufficient knowledge of modern science in the related courses that refer to the nature of science. From this point following items can be suggested concerning teaching the nature of science: i. Clear- thought provoking scientific argumentation, and clear-thought provoking examination research strategies, which are prominent and found to be effective in our day, can be suggested for science and technology courses while teaching the nature of science[32]. In this regard, the questioning of the information is important[33]. ii. In science and technology courses the nature of science should be elaborated in depth and "Nature of Science (NS)" attainments should be formed. iii. In order to determine the actualization of attainments about the nature of science, assessment instruments should be prepared and teachers should be taught how to uses these inventories. iv. Teachers should be supported to get training about the nature of science.

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