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Relationship Between Pre-Service Teachers' Views Of Nature Of Science And Their Study Subjects

Öğretmen Adaylarının Bilimin Doğasına Yönelik Anlayışları İle Öğrenim Gördükleri Alanlar Arasındaki İlişki

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Abstract

The aim of this study was to investigate pre-service science and mathematics teachers' views of the nature of science and to find out any relationships between their views and their study subjects. For this aim the Views on the Nature of Science (VNOS) questionnaire was administered to 220 pre-service science and mathematics teachers from departments of chemistry, physics, biology and mathematics in both Faculty of Education and Faculty of Science. The participants' responses to VNOS questionnaire were analyzed by employing a coding theme based on seven aspects of the nature of science. Chi-Square test was implemented to analyze data to check the relationship between the pre-service teachers' views of NOS and their study subjects. It was found that less than 50% of the participants' views of certain aspects of NOS are considered as "informed," except subjectivity nature of scientific knowledge and role of creativity and imagination in science. A relationship was found between the participants' views of NOS and their study subjects for five out of seven aspects of NOS. Implications for science teacher education and for future studies are discussed.

Keywords: *nature of science; pre-service science and mathematics teachers*

Özet

Bu çalışmanın amacı fen ve matematik öğretmen adaylarının bilimin doğasına yönelik anlayışlarını ve bu anlayışlarla öğrenim gördükleri alanlar arasında bir ilişkinin bulunup bulunmadığını irdelemektir. Buna yönelik olarak, "bilimin doğası anlayışları testi" hem fen hem de eğitim fakültelerinin kimya, fizik, biyoloji ve matematik bölümlerinin son sınıflarında öğrenim gören toplam 220 öğretmen adayına uygulanmıştır. Test sonuçları, bilimin doğasının yedi boyutu dikkate alınarak geliştirilen kodlama sistemine göre betimsel olarak analiz edilmiştir. Öğretmen adaylarının anlayışları ile öğrenim gördükleri alanlar arasındaki ilişkiyi *incelemek için Ki-kare testi kullanılmıştır. Bilimsel bilginin nesnel doğası ve bilimde hayal gücü ve yaratıcılık boyutları hariç, öğretmen adaylarının yalnızca %50'sinden daha azının bilimin doğasının diğer boyutları ile ilgili olarak geçerli anlayışlara sahip oldukları tespit edilmiştir. Ayrıca, bilimin doğasının yedi boyutunun beşinde öğretmen adaylarının anlayışları ve öğrenim gördükleri alanlar arasında bir ilişki bulunduğu da görülmüştür. Çalışmada, fen eğitimi ve daha sonra yapılacak çalışmalara yönelik çeşitli önerilerde bulunulmuştur.*

Anahtar Kelimeler: *bilimin doğası, fen ve matematik öğretmen adayları*

1. Introduction

Science education curriculum or standards of many developed and developing countries have been included nature of science (NOS) as an important aspect of science education (AAAS, 1993; McComas, 2008; MoNE, 2007, 2013; NRC, 1996). There are many reasons for worldwide appreciation of NOS in science education. Breadth and depth of understanding of NOS affect ones' learning of science; how to learn and utilize science in everyday settings (Ryder, Leach, & Driver, 1999). A science teacher, for example, might adopt and spread a more empiricist view of science to his/her students. This might affect how students evaluate and value scientific knowledge.

Driver, Leach, and PhilScot (1996) discussed comprehensively what other noteworthy impacts of learning NOS would have. They argued that in addition to enhancing learning of science content, there are four other crucial effects of the inclusion of the NOS into science education curriculum including utilitarian, democratic, cultural, and moral views. For utilitarian view an understanding of the NOS was necessary for scientific and technological literacy. In modern societies, many scientific enterprises have become a social issue. Thus, individuals with NOS comprehension in society could interpret socio-scientific issues and be actively and consciously involved in decision-making processes which it turns society to more participatory democracy. Appreciation of science as a major element of contemporary culture is another impact of having a sound view of NOS. The last one was a moral view that understanding the NOS was necessary to understand the norms of the scientific community, embodying moral commitments that are of general value in modern societies. In other words, an understanding of NOS might set a base line for universal ethical values in every society.

By referring to the study of Driver et al. (1996), McComas, Almazroa, and Clough (1998) also mentioned similar benefits of understanding the NOS, but they asserted other valuable benefits. They discussed how the NOS enhance learning science by distinguishing learning science content, understanding of science, and interest in science. McComas and his colleagues (1998) noted that an understanding of how science works was essential for "evaluating the strengths and limitations of science, as well as the values of different types of scientific knowledge" (p.12). Thus, individuals keep an open mind for new discoveries and inventions that may conflict with currently – accepted knowledge. It was also argued that "incorporating the nature of science while teaching science content humanized the science and conveys a great adventure rather than memorizing trivial outcomes of the process" (p.13). This was believed to enhance interest in science and eventually resulted in improved learning science outcomes as well as choosing STEM fields as future career (Ainley & Ainley, 2011; Wyss, Heulskamp, & Siebert, 2008)

Nature of science

Although there is currently no general agreement on the definition of the Nature of Science (NOS) among philosophers of science (Alters, 1997), many science educators have indicated that there is an overall consensus in several aspects of the NOS (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; McComas et al., 1998; Murcia & Schibeci, 1999). According to McComas et al. (1998) "the nature of science is a multi-faceted concept that refers to a variety of issues related to the philosophy, sociology, and history of science." In a similar fashion, the NOS was defined as the epistemology of science; science as a way of knowing, or values, beliefs and assumptions inherent to the development of scientific knowledge (Abd-El-Khalick, Bell, & Lederman, 1998; Bell, Lederman, & Abd-El-Khalick, 2000; Lederman, 1992). Six aspects of NOS are argued not controversial and there is a shared wisdom among science educators about these aspects: "scientific knowledge is tentative; empirical; theory-laden; partly the product of human inference, imagination and creativity; and socially and culturally embedded." It is also noted that there is a general agreement among scholars from various study subjects about the difference between the roles of observation and inference in science; laws of nature and scientific theories; and that there is no recipe-like method for doing science (Lederman et al., 2002; McComas et al., 1998).

NOS Research

It has been almost three decades since the scientific literacy movement was emerged as one of the main goals of formal education (NSF, 1983; TRC, 1985). The heart of scientific literacy is a sound understanding of NOS which became an important research topic especially after "Science for All Americans" (AAAS, 1993), "Benchmarks for Scientific Literacy" (AAAS, 1993) reports. Initial studies attempted to investigate primary and secondary school students' beliefs and views of what science is and how science works (Aikenhead, Fleming, & Ryan, 1987; Lederman & Omalley, 1990). Later, research subjects shifted to undergraduate students, pre-service and in-service science and elementary teachers (Brickhouse, 1990; Liang et al., 2009; Macaroglu, Tasar and Cataloglu, 1998; Murcia & Schibeci, 1999; Ryder et al., 1999; Tasar, 2003; Turkmen, 2008) and even graduate students and science faculty (Samarapungavan, Westby, & Bodner, 2006; Schwartz & Lederman, 2008). Along with this process better ways of teaching NOS were developed and employed (Abd-El-Khalick

& Lederman, 2000; Akerson, Hanson, & Cullen, 2007; Gess-Newsome, 2002; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2007; Lin & Chen, 2002; Palmquist & Finley, 1997; Rudge & Howe, 2009). Even though there are numerous studies in this field, most of them have been conducted in developed countries. Relatively limited number of studies examined students and pre-service teachers' views of NOS across study subjects in developing countries; such as Turkey.

Context of the study

Recently, reform movements have taken place in teacher education as well as primary and secondary science education curriculum for the last decade in Turkey. NOS and history of science, for example, were included in high school chemistry and physics curricula (MoNE, 2007, 2013). Similarly, history of science and/or science-technology-society topics have been integrated into teacher education programs as compulsory courses based on the recent movement in the world. Because the main aspects of NOS are knowledge-based, they can be taught and learned (Schwartz, Lederman, & Abd-El-Khalick, 2012; Urhahne, Kremer, & Mayer, 2011). It is also known that a naïve understanding of NOS and positivist beliefs of NOS can be found in all target groups, including pre-service and in-service teachers (Abd-El-Khalick & Lederman, 2000; Abell & Smith, 1994; Dogan, Cakiroglu, Cavus, Bilican, & Arslan, 2011; Kilic, Sungur, Cakıroglu and Tekkaya, 2005; Kucuk, 2008; Liang et al., 2009; Lin & Chen, 2002; Palmquist & Finley, 1997; Ryder et al., 1999). Therefore, further investigation of pre-service teachers' views, beliefs, and understandings of NOS is necessary. Another need has been emerged to further understanding of NOS construction. As pointed out by Schwartz and Lederman (2008) so far studies about NOS have been dealt solely with NOS without focusing on majors relations. If science subjects have some differences related to their nature then it could be assumed that understandings gained from these majors may be different (Ryder et al., 1999). It is recommended to compare pre-service teachers regarding their college study subjects including physics, chemistry, biology, and mathematics (Schwartz & Lederman, 2008). This study aims to address these existing issues in Turkey, after the reforms of the pre-service science and mathematics teacher education programs.

The Purpose of the Study

The purpose of this study was to define views of the nature of science of the senior pre-service biology, chemistry, physics and mathematics teachers who were from both Faculty of Education (FE) and Faculty of Science (FS) and to evaluate whether their views are associated with study subject in which the pre-service teachers participate.

Thus, guiding research questions to the purpose of this study are:

- What are secondary education pre-service science and mathematics teachers' views of NOS?
- Is there a relationship among pre-service science and mathematics teachers' views of NOS and their study subjects?

The Method

This study was planned and conducted in accordance with the qualitative research approach. Qualitative research aims to explore the meanings and relationships in depth. It focuses on the numbers and meanings rather than on quantitative measurements. Different aspects of any phenomena are examined in-depth in qualitative research approach (Miles & Huberman, 1994; Yildirim & Simsek, 2005). In this study, senior pre-service science and mathematics teachers' views about the nature of science were examined.

The Sample

The sample of the study consisted of 220 the senior pre-service science and mathematics teachers who were from departments of biology, physics, chemistry and mathematics at both Faculty of Education (FE) and Faculty of Science (FS). All these candidates were seeking certificate of teaching secondary science and mathematics. The sample was determined in accordance with convenient sampling method, which is one of the non-random sampling methods (Gall, Gall, & Borg, 2003).

Data Collection and Analysis

To examine nature of science understandings of the pre-service science and mathematics teachers in-depth, VNOS-C (Views on the Nature of Science) was used. This questionnaire was first developed by Lederman and O'Malley (1990) and later adapted and used in many studies. The VNOS test is adapted by Abd-El-Khalick et al. (1998) to examine understanding of teachers and students with a qualitative approach more in-depth. Celik (2009) adapted the test for the Turkish language. There are items in the test for examining seven different aspects of the nature of science.

The data were analyzed descriptively, which is one of the methods of qualitative data analysis. In the determination of units for descriptive analysis which are codes, categories and themes, similar studies in the literature are referred (McMillan & Schumacher, 2009; Miles & Huberman, 1994; Yildirim & Simsek, 2005). To ensure the reliability of the data analysis, both authors analyzed 15% of all responses. Over eighty percent agreement was established between two raters. After completing the first order analysis of the responses, second order analysis was done to obtain a general profile for each student regarding seven aspects of NOS. For this analysis, a commonly thematic structure regarding the participants' views of NOS, which includes "informed", "mixed" and "naive" categories, was employed similar to related literature (Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006).

Results

In this section pre-service teachers' views of the nature of science were presented based on seven aspects of the nature of science. In addition, the results of the relation between these views and pre-service teachers' study subjects were presented. Results were extended with the excerpts from the pre-service teachers' views. To cite each excerpt, pre-service teachers' faculties' abbreviation, departments' name and the numeral code assigned for each was used.

The tentative nature of scientific knowledge: According to the results presented in Table 1, it was found that majority of the pre-service science and mathematics teachers have naïve views regarding the tentative nature of science. It is seen that the percentage of pre-service teachers, who have informed views, was very low. It is also seen that the average percentages (9%) of who have informed views is very low. When pre-service teachers are compared based on their faculties, it is seen that the pre-service teachers from FS have a higher rate of naive views. It was also found that the biology pre-service teachers have the lowest percentage of informed views about the tentative nature of scientific knowledge.

It was determined that in the responses, categorized as naïve, there were frequent expressions such as; the scientific knowledge, which has been proven certain, never changes" and Scientific theories changes but scientific laws never change. On the other hand, from the result of qualitative analysis it was found out that few responses include that "all kinds of scientific knowledge are always open to change". An example of the naïve view of the pre-service teachers' responses was presented in the following excerpt:

> *Science is a collection of knowledge accumulated over time. There is certainty in science. It doesn't change depending people. One thing is proven and accepted as truth then studies are done on it. There wasn't chance to do experiments but in scientific fields such as physics, chemistry, and biology. There is a chance to experiment in these fields, but knowledge in these areas is certain (FS Physics. 18)*

Table 1. Pre-service teachers' views of the nature of science

			% Views of Pre-service Teachers									
			FE B	FE C	FEM	FE P		FS B	FS C	FS M	FS P	
Aspects of NOS	Views	N	24	31	36	30	$\bar{X}$	24	17	29	29	$\bar{X}$
Tentative nature of science	I		8	16	19	7	**13**	0	6	7	7	**5**
	M		17	32	28	33	**28**	0	29	17	28	**19**
	N		58	39	47	53	**49**	79	59	59	45	**61**
	B		17	13	6	7	**11**	21	6	17	21	**16**
Experimental nature of science	I		17	35	19	20	**23**	13	29	24	24	**23**
	M		83	52	78	40	**63**	79	47	66	72	**66**
	N		0	0	3	40	**11**	8	0	7	3	**5**
	B		0	13	0	0	**3**	0	24	3	0	**7**
Relationship between scientific law and theory	I		17	23	19	17	**19**	13	41	28	24	**27**
	M		83	48	78	43	**63**	79	47	66	72	**66**
	N		0	13	3	40	**14**	8	6	7	3	**6**
	B		0	16	0	0	**4**	0	6	0	0	**2**
Role of subjectivity in science	I		63	45	47	53	**52**	71	76	62	31	**60**
	M		13	26	8	3	**13**	4	12	3	10	**7**
	N		8	16	3	3	**8**	8	0	14	7	**7**
	B		17	16	42	40	**29**	17	12	21	52	**26**
Role of creativity and imagination	I		96	61	83	87	**82**	79	88	86	97	**88**
	M		0	19	3	0	**6**	4	0	0	0	**1**
	N		0	0	6	10	**4**	4	12	3	0	**5**
	B		4	20	8	3	**9**	13	0	10	3	**7**
Role of social and cultural values in science	I		63	29	47	50	**47**	58	41	35	31	**41**
	M		4	16	3	3	**7**	0	6	3	0	**2**
	N		29	19	47	33	**32**	42	35	55	48	**45**
	B		4	36	3	13	**14**	0	18	7	21	**12**
Experiments in science	I		8	32	17	10	**17**	25	12	34	0	**18**
	M		4	6	6	7	**6**	0	18	0	10	**7**
	N		79	36	67	77	**65**	50	71	62	83	**67**
	B		8	26	11	7	**13**	25	0	3	7	**9**

I: Informed; M: Mixed; N: Naïve; B: Biology; C: Chemistry; M: Mathematics; P: Physics; FE: Faculty of Education FS: Faculty of Science

The experimental nature of science: With regard to the experimental nature of scientific knowledge, the vast majority of pre-service teachers (65%) have mixed views as presented in Table 1. So, it is understood that the pre-service teachers do not have a clear understandings about the experimental nature of scientific knowledge. When compared to other departments, chemistry pre-service teachers from FE have the highest rate of informed views regarding this dimension of the nature of science. While physics pre-service teachers from FE have the lowest understandings in this regard.

It was found that the pre-service teachers generally think that scientific knowledge is solely based on the direct experimental proofs and they rarely show an awareness regarding role of inferences in science. The ideas such as "*Scientific knowledge is just based on the experimental (concrete) evidences*" and "*Scientific knowledge is proved with experimental evidence*" were common among the pre-service teachers. In addition, it was found that a few pre-service teachers thought that there are personal interpretations in areas such as religion and philosophy, but there is no place for these kinds of personnel interpretations in science. An example from pre-service teachers' responses was presented in the following excerpt:

> *Science is done based on experimental and observational activities. Differing from other research areas, there are objective opinions in science and these opinions are proved with experiments or there is an attempt to prove (FE Biology. 21).*

The relationship between scientific theories and laws: As seen in Table 1, almost one fourth of the pre-service teachers' views of theories and laws are informed. On the basis of the departments there was not any noteworthy difference. It is seen that the pre-service teachers from physics department at FE have the highest percentage (40%) of naïve understandings regarding this aspect of NOS.

Naïve statements such as; "Scientific theories are unproven ideas." and "Scientific theories become scientific laws." was found very often in the pre-service teachers' responses. On the other hand, informed statements such as "Scientific theories and laws are different kind of terms" and "Either scientific theories or laws are open to change" were found very rarely in their responses. Following two excerpts from the participants' responses illustrate their views:

> *Scientific theories may change later. But scientific laws never change. For example, it is evident that the law of gravity will not change. However, the theory of evolution is changing every day. It cannot be considered as certain. (FE Chemistry.4)*

> *Scientific theory is a collection of scientific knowledge suggested by some one on a topic. Confirmed the accuracy of scientific theory and, if accepted by everyone it would be scientific law. (FE Matehemtics.12)*

The subjectivity nature of scientific knowledge: According to the results of Table 1 it is seen that the understandings about subjective nature of scientific knowledge were mostly informed. It was found that over 50% of the pre-service teachers from both faculties (52% FE and 60% FS) had informed views about this dimension of NOS. Physics pre-service teachers from FS demonstrated the lowest percentage of informed views. Only 31% of physics pre-service teachers held informed views about the subjective nature of scientific knowledge.

The pre-service teachers, who had informed views, often stated that "*There is subjectivity in science even if it is in part.*" and "*The subjectivity stems from interpretations of people.*" in their answers. One of such answer was presented in the following.

> *Because scientists trained in different cultures and they have different characters, obtained results are interpreted by different scholars differently. Scientists' beliefs, desires and expectations are effective in disagreements. (FE Chemistry. 27)*
>
> *Different imagination could be due to different interpretation of experiments. Because they evaluate parts of a whole from different aspects, achieving such results is very natural. If every brain thinks the same thing science can't progress already. Different ideas are essential for science. (FS Mathematics.12)*

The creativity and imagination in science: Considering the results in Table 1 it is understood that majority of pre-service teachers had informed understandings about the role of creative and imaginative thinking in science. The percentages of who had mixed and naïve understandings in respect of this dimension of the nature of science were very low.

In the answers given to the related question,, it was determined that statements such as; "*Scientists use their original thoughts and imagination to make original studies.*" and "*Scientists use these powers in all stages of their studies.*" were very often. Two of these statements were given below as example answers:

> *"I think they use their original ideas at the every stage, but they use them more in the planning stage. For example, when a researcher makes a chemistry experiment he/she mix several items to see what happen and then try more and more different matters. The sense of wonder pushes scientists to use their imagination." (FE Mathematics. 2)*
>
> *"Scientists are people who are very rich in imagination and the contributions of the imagination in helping them to reach the scientific knowledge are underestimated. Therefore, saying that they only use their imagination and original ideas occasionally in their study would be unfair. I think they have benefited from imagination and original ideas at every stage of their studies. (FS Physics.7)*

The influence of social and cultural values on science: Regarding impact of social and cultural values on science, the number of the pre-service teachers' views categorized as informed and naïve are close to each other. It was determined that averagely 44% of the pre-service teachers had informed and 39% had naive views. Regarding this aspect of NOS, it was found that mathematics pre-service teachers from FS had the highest rate (55%) of naïve understandings and biology pre-service teachers from FE had the highest rate (63%) of informed understandings.

While the pre-service teachers with informed understanding often stated, "*social and cultural values impact the decision of scientists about determining of the research topic*", the pre-service teachers held naïve understanding mainly indicated, "*because scientific knowledge is universal social and cultural values don't impact on science*" in their answers. Two excerpts including these kinds of statements from the answers were presented as example in the following:

> *"Science may or may not be universal. But science is influenced by social and cultural values and reflects them. Doing some studies, which contradict to the social structure of our society, is impossible. For example, in the case of cloning in biology, because social and cultural structure of the society is not ready for these kinds of studies, some studies have been blocked." (FE Mathematics.4)*

> *"Science is universal, because the rhetoric is always the same for all scientists, even if they are on the other side of the world. For example, a law obtained in any science branch such as chemistry and physics is valid everywhere." (FS Mathematics.12)*

The experiment in scientific research: As it can be seen in Table 1, almost two third of the pre-service teachers have naïve understandings regarding role of experiments in scientific research. Approximately 17% of the whole participants express informed views about role of experiments in scientific research. No one in pre-service physics teachers from FS was able to answer the questions with informed view regarding role of experiments in science. In their answers to the related question, expressions such as "*experiment is the only source of scientific knowledge.*" and "e*xperiment is a method referenced in proving scientific theory or hypothesis.*" has been frequently encountered. On the other hand, statements such as "Experiment is a way of investigating relationships between facts in a controlled manner." have not been encountered very often in the responses to VNOS. Sample responses regarding this aspect were presented as follows:

> *"The experiment is a device for proving the accuracy of the collected data about a research topic." (FS Mathmatics.21)*

> *"For developing scientific knowledge experiment is essential. It is also the best way to prove accuracy. It may guide another researches or may even cause new information" (FS Physics.15)*

Relationship between the Participants' NOS views and Study subjects

In this section, relationship between the participants' views of NOS and their study subjects were examined by employing Chi square statistical approach to the data that are presented in previous section.

We sampled 220 pre-service teachers and evaluated whether the participants have similar views of NOS based on their major for certain aspects of NOS. Table 2 presents standardized residuals as well as Chi square scores for the participants' views.

Table 2. Chi square scores for the participants' views of main aspects of NOS across their study subjects.

Aspects of NOS	Views	Study subjects (Std. Residual)								Chi Square	df	p value
		FE B	FS C	FE M	FE P	FS B	FS C	FS M	FS P			
Tentative nature of science	N	0,5	0,1	-0,8	-0,3	2,1	0,1	0,5	-0,3	23,24	14	0,056
	M	-0,6	0,3	0,2	0,8	-2,3	0,3	-0,5	0,7			
	I	-0,1	-0,6	1,7	-0,6	-1,5	-0,6	-0,3	-0,3			
Experimental nature of science	N	-1,4	-1,1	-1,2	5,9	0,0	-1,1	-0,2	-0,9	54,95	14	0,000
	M	0,9	-0,3	0,7	-1,9	0,7	-0,3	0,1	0,3			
	I	-0,7	1,1	-0,5	-0,4	-1,1	1,1	-0,1	0,1			
Relationship between scientific law and theory	N	-1,6	-0,6	-1,5	4,9	-0,4	-0,6	-0,6	-1,2	42,60	14	0,000
	M	1,0	-0,8	0,8	-1,6	0,7	-0,8	0,0	0,3			
	I	-0,6	1,8	-0,3	-0,6	-1,0	1,8	0,3	0,2			
Role of subjectivity in science	N	-0,1	-1,3	-0,9	-0,7	-0,1	-1,3	1,0	0,4	15,99	14	0,314
	M	0,2	0,0	0,1	-0,9	-1,0	0,0	-1,1	0,8			
	I	0,0	0,5	0,3	0,6	0,5	0,5	0,1	-0,5			
Role of creativity and imagination	N	-1,0	1,4	0,4	1,5	0,1	1,4	-0,1	-1,1	39,136	14	0,000
	M	-1,0	-0,8	-0,3	-1,1	0,2	-0,8	-1,0	-1,1			
	I	0,4	-0,1	0,0	-0,1	-0,1	-0,1	0,2	0,5			
Role of social and cultural values in science	N	-1,0	-0,1	0,3	-0,5	-0,2	-0,1	1,1	1,2	26,508	14	0,022
	M	-0,2	0,3	-0,6	-0,3	-1,1	0,3	-0,3	-1,1			
	I	1,0	0,0	-0,1	0,6	0,6	0,0	-1,0	-0,7			
Experiments in science	N	0,6	-0,3	-0,1	0,4	-0,5	-0,3	0,5	0,8	29,258	14	0,010
	M	-0,4	1,7	-0,1	0,0	-1,1	1,7	-1,2	0,8			
	I	-0,9	-0,5	0,2	-0,8	1,7	-0,5	-0.3	-2,1			

I: Informed; M: Mixed; N: Naïve; C: Chemistry; P: Physics; M: Mathematics; B: Biology; FE: Faculty of Education FS: Faculty of Science

As seen in Table 2, a relationship was found between the participants' views of NOS and their study subjects for five out of seven aspects of NOS. The participants' views of the experimental nature of science ($\chi2(14) = 54.959$, $p< .05$); the relationship between theory and natural laws ($\chi2(14) = 42.609$, $p< .05$); role of creativity and imagination in science ($\chi2(14) = 39.136$, $p< .05$); effects of social and cultural values to science ($\chi2(14)=25.508$, $p< .05$); and role of experiments in scientific inquiry ($\chi2(14)=29.258$, $p< .05$) aspects of NOS are found to have significant relationship with their study subjects. This relationship can attribute to a certain predictive variable when the level of standardized residuals is equal or higher than ± 1.96. As can been seen in Table 2, the pre-service physics teachers are considered as the reason of this relationship for two aspects of NOS; tentative and experimental nature of science. For these two aspects, pre-service physics teachers held "naive" views more than rest of the study subjects. The pre-service chemistry teachers in faculty of education (experimental nature of science) and faculty of arts and science (relationship between scientific law and theory) have slightly more informed views when compared to other study subjects.

Relating to two aspects of NOS (role of subjectivity and role of creativity and imagination in science), the pre-service chemistry teachers held mixed views more than other groups and this is considered as the reason for the relationship. For experiments in science aspect, the pre-service chemistry teachers held the most informed views, but the pre-service physics teachers held the least informed views than expected when compared to rest of the majors. Even though no significant relationship was found between views about tentative nature of science and study subjects, numbers of pre-service biology teachers who held naïve views in faculty of science were the least among other majors regarding this aspect of NOS.

Discussions and Conclusions

Even though having contemporary views about nature of science is one of the core component of scientific literacy, it was found that less than 50% of the participants' views of certain aspects of NOS are considered as "informed," except subjectivity nature of scientific knowledge and role of creativity and imagination in science. Finding that the participants' informed views are low is undesirable, but not very surprising as related literature reported similar results (Abd-El-Khalick, 2005; Abd-El-Khalick & Lederman, 2000; Abell & Smith, 1994; Celik & Bayrakceken, 2006; Lederman, 1992; Mellado, 1997; Sarkar & Gomes, 2010; Tasar, 2003). But, the fact that most of the participants' views of subjectivity nature of scientific knowledge are informed seems a little bit interesting because based on conventional wisdom and traditional teaching "scientific knowledge is very objective and universal." However, what surprises us more is that even though around 56% of the participants claimed that scientific knowledge involves subjectivity, 55% of retained naïve ideas about tentative nature of scientific knowledge. This situation is more evident with the pre-service biology teachers who enrolled in faculty of science. As seen in Table 2, no body retains informed view of tentativeness of scientific knowledge whereas more than 70% of the same group asserted subjectivity involvement in scientific knowledge. This is somewhat contradictory because viewing scientific knowledge, as humanly constructed ideas and seeing it as absolute knowledge of reality attainable via scientific inquiry, which is a static perspective, are not logical. Schwartz and Lederman (2008) found that scientists' views of NOS is consistent and attributed this to the participants' ability of demonstrating interconnectedness of all aspects of NOS. Similarly, Samarapungavan, Westby and Bodner (2006) found that there is higher sophistication and consistency about NOS with research expertise. Thus, this evidence suggests that the reason for this kind of contradiction could be lack of a well-constructed view of science where every aspect of science is interconnected which can be accomplished via experience (Treagust, Chittleborough, & Mamiala, 2002). Another reason could be role of the pre-service teachers' formal education. Traditional science teaching conveys a positivist view of science whereas teaching educational science involves a more post-modern view of science. These might cause a duality in mental structure of the pre-service teachers. For biology case, theory of evolution might play a role since most of the Turkish public believes that the theory of evolution was constructed by a human being with ideological mindset and does not really represent reality (Miller, Scott, & Okamoto, 2006). Thus, biology majors might stay between their cultural perception and formal education.

The pre-service chemistry teachers' responses had the most informed views, which can be expected as they have had most laboratory experience when compared to the rest of the group. Interestingly, on the other hand, more pre-service mathematics teachers convey informed views of experimental nature of science than physics and biology majors. Most of the pre-service physics and biology teachers over emphasize "tangible" evidence aspect and "confirmatory" role of experiments, but a few mention inferences made by scientists via contemplation. The pre-service mathematics teachers, however, are more familiar with deductive arguments, so they emphasize inferences emerged from experiments and deductions generated from those inferences. This might be the main reason of why the pre-service mathematics teachers had similar views are or even more informed views than the pre-service physics and biology teachers.

The myths about scientific theories and laws are very common among both public (McComas, 1998) and among pre-service teachers (Tasar, 2003). We also found these myths in the responses of the pre-service teachers. There was much stress on the relationship between scientific theories and laws in the responses but from a naïve perspective. The participants believed that there is a hierarchical order and scientific laws are on top for certainty. Even though some believe scientific theories can change over time, many consider scientific laws as absolute. Interestingly, almost half of the pre-service physics teachers from faculty of education retain this naïve view. Newtonian laws of mechanics based on mass and gravity might have a great impact on these participants because gravitational force is seen for them as "absolute." Likewise, they do not take advance quantum mechanics classes to undermine their Newtonian roots. Related literature similarly suggested that root learning of traditional teaching might be the reason for this and similar naïve views (Dogan et al., 2011; Irez, 2009).

By employing Chi square test, we examine relationship between NOS views and study subjects. Results indicate that NOS views are related to study subjects. Even though there is variation within groups, variation across groups is significant. Differences in views seem to be embedded in study subjects. Especially this is evident for the pre-service physics teachers for experimental nature of science and relationship between scientific laws and theories. This is somewhat contradictory of what Schawartz and Lederman (2008) suggested. They claimed that scientists' views of NOS are consistent across variety of majors. As discussed earlier, scientists or individuals with expertise in the field might have a broader and inter-connected view of NOS. So, they might have a more informed view for almost all aspects of NOS. However, individuals with limited experience in research, but huge course load would have a naive view of NOS. Therefore, pre-service teacher programs as well as professional development programs for science teachers should emphasize different aspects of NOS based on study subjects' specific content. Our results show that more support is needed for pre-service science teachers from all study subjects. However, the pre-service physics teachers are the ones whose traditional education leads them to have more positivist view of NOS. They need extra help and their curriculum should be revised to address these issues.

Lastly, this study can contribute to the field of NOS research in several ways. First, the numbers of pre-service teachers who participated in this study are substantially larger than many previous studies, which provide a greater generalizability. Even though we did not utilize interviews, the VNOS with open-ended written questions provides many insightful data regarding the pre-service teachers' views of NOS.

Second, this work provides an informative comparison among secondary level pre-service science and mathematics teachers who are affiliated in different study subjects. This information will be able to provide better understanding of how to implement NOS to pre-service science teacher education. It can be transferred to in-service teacher training programs as well.

Finally, findings of this study can contribute to recent debate in the field regarding major specific and overarching/common NOS and NOS teaching. The findings revealed that there is a relationship between the participants' views of NOS and their study subjects. In many aspects of NOS the pre-service physics teachers skew negatively and the pre-service chemistry teachers skew positively. This might be an evidence to support the idea of content and context specific NOS should be introduced to every subject of science.

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