Journal of Science Education

ISSN 0124-5481

Views of Nature of Science of Prospective Teachers from Different Majors

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ARTICLEINFO

Keywords:
Nature of science
consensus view of NOS
science views of prospective teachers
pedagogical training course

ABSTRACT

The purpose of this study was to assess the nature of science (NOS) views of prospective teachers from different majors (sport, engineering, science, health, social sciences, math, and economy) and investigate whether these views were related to their gender and majors. 141 prospective teachers (58 males and 83 females) having pedagogical training course during the 2014-2015 academic year were participated in this study. Teacher candidates were administered a survey covering 18 translated *Views on Science-Technology-Society* items. Participant responses were categorized as "realistic, plausible and naïve" and the frequency variations for these answers were contrasted for gender and majors. The Chi-square ($\square^2$) statistics tests results together with the frequency distributions indicated that prospective teachers from different majors did not hold stable views through the target NOS characteristics and the male participants' views were mostly similar to those of female participants. Moreover, participants' views were not generally related to their majors. Findings of the study were also interpreted by taking into account the critiques to the consensus views of NOS.

1. Introduction

In this section, initially the consensus view on the nature of science (NOS), "which on a basic level states that there are agreed-upon aspects of science that can be taught in K–12 schools" (Bazzul, 2017, p. 66), is handled. Then, it is followed by the critiques to the consensus view, where the researchers nearly agreed that the old view "does not really allow educators to capture the social, historical, cultural, and political contexts of science" (Bazzul, 2017, p. 68). The section is finalized by the studies on NOS views of males and females, and on the views of participants other than science majors.

1.1. The consensus view of NOS

Scientific literacy has been identified as the main goal of science education and understanding NOS is accepted as a crucial component of scientific literacy since the 1960s (Abd-El-Khalick, Bell, & Lederman 1998). According to Lederman (1992) NOS refers to "the epistemology of science, science as a way of knowing, or values and beliefs inherent to the development of scientific knowledge" (p.331).The National Science Education Standards (NRC, 1996) and educational curricula of many countries including Australia, Canada, The United Kingdom and Turkey have advocated a great emphasis on the teaching and learning of NOS. As science education researchers turned their attention to exploring views about NOS, a great body of research indicates that both students and teachers have naive views about NOS (Abd-El-Khalick, Bell, & Lederman 1998; Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2014; Dogan & Abd-El-Khalick, 2008; Dogan, Cakiroglu, Bilican, & Cavus, 2013).

Although the science education community disagree on a specific definition for NOS (Abd-El-Khalick, 2005), there are some agreed upon important aspects of NOS for achieving scientific learning (Abd-El-Khalick et al., 1998; Abd-El-Khalick & Lederman 2000; McComas & Nouri, 2016). Some of the consensus views of NOS as defined by literature are: i) scientific knowledge is tentative, ii) science is based on observations and experiment, iii) scientific knowledge is theory-laden and subjective, iv) scientific laws and theories are very different kinds of scientific knowledge, v) scientific knowledge is based on inferences as well as observations, vi) scientific knowledge requires creativity and imagination, vii) science affects and is affected by the culture in which it is embedded, viii) there is no single 'scientific method' used by all scientists to attain scientific knowledge, ix) serendipity plays a role in science, x) science and technology is not the same thing, and so on (Lederman, 2007; Demirdöğen, 2012). These aspects describe the qualifications of science, scientific knowledge, and scientists. To sum up, in science education, understanding NOS is accepted as a crucial component of scientific literacy which requires not only understand science content but also develop ideas for how science proceeds and how scientists work (Akerson, & Buzzelli, 2007).

In recent years, however, the so called 'consensus view' as a benchmark for NOS understanding is being criticized by researchers for its failure to reflect contemporary scientific practice and for its 'simplified, confusing, misleading and naïve' nature of some individual items that comprise this view (Berkovitz, 2017; Dagher, & Erduran, 2017; Hodson, & Wong, 2017)

Accepted 2 June 2021, Available online 30 July 2021

1.2. Going beyond the consensus view of NOS

Criticisms of traditional NOS definitions have been presented by several prominent educators, in the special issue (Vol. 17, No. 1) of the Canadian Journal of Science, Mathematics and Technology Education. The issue is composed of researchers discussing Hodson and Wong's (2017) review of the consensus view of NOS. The researchers review the leading ideas "concerning the consensus view and offers constructive suggestions about what science is, how it works, and what is relevant when teaching NOS" (Bazzul, 2017, p. 66). The proposals suggested by these scholars is expected to enhance the educational modules and offer students with a much more practical image of science (Berkovitz, 2017).

After a thorough analysis of the old view of NOS, Hodson and Wong (2017) critiqued the old view of NOS to be misrepresenting current scientific practice and comprising very basic, confused, misleading, and philosophically naïve opinions about science. Then, they proposed the following changes to school science curriculum:

.... school science curriculum should pay close attention to the distinctive language of science, the characteristics of scientific inquiry, the role and status of scientific knowledge, the modeling involved in constructing scientific theory, the social and intellectual circumstances of significant scientific achievements, the social dynamics of groups of scientists, the values and conventions that underpin scientific practice, and the ways in which science impacts and is impacted by social contexts (Berkovitz, 2017, p.39).

However, this contemporary view of NOS is also being critiqued for example by Osborne (2017), and Dagher and Erduran (2017) where they see the evaluations of Hodson and Wong (2017) as lacking the traits of serious scholarship.

*1.3.*Research on NOS

There is a great body of research on identifying students' views of NOS in different grade levels, from elementary school level to university level or beyond (Aslan, Yalçın, & Taşar, 2009; Bayir, Cakici, & Ertas, 2014; Doğan & Abd- El- Khalick, 2008; Kang, Scharman & Noh, 2005; Kılıç, Sungur, Çakıroğlu, & Tekkaya, 2005). These studies indicated that regardless of the grade level, few students had adequate views on some agreed upon aspects of NOS. Whilst, in certain aspects of NOS they found statistically significant mean differences between different grade levels (Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2014; Huang, Tsai, &Chang, 2005; Kang, Scharmann, & Noh 2005).

It has been assumed that a teacher's understanding of NOS affects his/her students' conceptions (Lederman, 2007). Therefore, studying teachers' understanding of NOS becomes crucial in science education. Teaching with or about NOS necessarily entails an understanding of the aspects of NOS for both pre-service and in-service teachers (Abd-El-Khalick, 2005). Mesci and Renee'S (2017) showed that many students have naïve views about certain aspects of NOS like tentativeness and subjectivity. If teachers do not have informed NOS views, they cannot help their students understand the science (Capps et al. 2012). Empirical studies showed that both pre-service and in-service teachers do not have adequate NOS understandings as their students (Abd-El-Khalick, Bell, & Lederman, 1998; Dogan & Abd-El-Khalick, 2008; Posnanski, 2010; Wahbeh & Abd-El-Khalick, 2014; Yakmacı, 1998). In his study, Lederman (1992) concluded that teachers do not have an informed understanding of NOS irrespective of the instruments used to assess their understandings. Science education researchers used several instruments for identifying and describing the understanding of NOS including interviews, open-ended tests, Likert type questionnaires, reflection papers, concept maps, drawings, and so on. Among them Views of Nature of Science (VNOS) (Abd-El-Khalick, 1998) in open-ended questionnaire format, Views on Science-Technology-Society (VOSTS) (Aikenhead, Ryan, & Fleming, 1989) in multiple-choice format, and Nature of Science Scale (NOSS) (Kimball, 1968 as cited in Lederman, 2007) in Likert type are the most commonly used instruments for studying NOS understanding.

The results of the past research also showed that academic background variables are not significantly related to teachers' conceptions of NOS (Carey & Stauss, 1970; Lederman, 2007). Carey and Stauss (1970) correlated 35 prospective secondary science teachers' and 221 prospective elementary teachers' scores with some background variables such as high school science courses, college science courses, college grade-point average, and science grade-point average. As a result, no relationship was found between either secondary or elementary school teachers' conceptions of science and any of the academic background variables and it was concluded that none of the academic variables investigated could be used to improve science teachers' conceptions of NOS. In their study Bayir, Cakici, and Ertas (2014) found that the views of the scientists in natural science and in social science were not substantially different. In his study, Kimball (1968 as cited in Lederman, 2007) found that philosophy majors scored higher than either science teachers or professional scientists in NOSS survey. Thus, he concluded that the inclusion of philosophy of science course as part of the undergraduate science major curriculum might improve the situation. In another study with pre-service teachers, Chen (2001) investigated prospective biology, chemistry, earth science, and physics teachers' NOS understanding and the relationship between their understanding and their majors. The results of the study showed that pre-service science teachers from different disciplines varied in their views on NOS. For example, the biology and the chemistry groups both thought that observations are theory-laden; while the physics group believed that observations are theory-independent (only interpretations may be theory laden). More, regarding the objectivity/rationality of scientists, the groups had diverse opinions. Moreover, all groups pointed out the existence o f a universal scientific method.

Specifically, few studies have explored gender differences regarding NOS aspects (Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2014). Concerning the role of gender in NOS, some studies indicate that there are no differences between girls and boys in terms of their NOS understanding (Dogan & Abd-El-Khalick, 2008; Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2014), while other studies identify differences in NOS understanding by gender (Huang, Tsai, & Chang, 2005; Kılıc, Sungur, Cakıroglu, & Tekkaya, 2005; Yenice & Saydam, 2010). In the study of Huang, Tsai, and Chang (2005) males were found to be better in NOS regarding its tentative nature and the importance of social negotiation in scientific studies. While Yenice and Saydam (2010) and Kılıc, Sungur, Cakıroglu, and Tekkaya (2005) found that gender has a significant effect on NOS understanding in favor of girls. In their study, Dogan, and Abd-El-Khalick (2008) assessed NOS understanding of 2,087 high school students and 378 in-service science teachers (physics, chemistry, and biology) in Turkey with the instrument VOSTS. The authors also investigated whether participants' NOS understanding was related to some selected variables including gender, teacher disciplinary background, and type of teacher training program. Both participant teachers' and high school students' views on NOS were said to be not related to their gender. Additionally, teachers' understanding of NOS were found not to be related to their disciplinary background, years of teaching experience, and type of teacher education program (college of education programs, post baccalaureate programs, or teacher education institutes).

Although how NOS held by teachers have been an area of interest to researchers in many countries, there have been limited studies which explored gender and major differences in understanding NOS aspects of pre-service teachers in literature. Apart from STEM subjects, all others include science to some extent. Thus, additional research is needed to know how teachers from different majors form their opinions about NOS, so that teacher education programs can be enhanced to train teachers with more comprehensive views of NOS.

The main aim of the current study, therefore, is to address this gap and to investigate pre-service teachers' views of NOS in relation to gender and their major. With this aim in this study, we examine the following research questions:

1. Do the views of prospective teachers from different majors (sport, engineering, science, health, social sciences, math, and economy) differ by gender?
2. What are the beliefs that teachers from different majors hold about the nature of science?

2.Method

2.1. Participants and Data Collection

Currently, a huge number of teachers are graduating from educational faculties in Turkey. Besides, many graduates from other faculties such as faculty of arts and sciences are also allowed to be teacher since 2010 provided however that they have a certificate after participating to a pedagogical training course (Eraslan & Çakıcı, 2011). Presently, depending on the permission of the Turkish higher education council (YOK) many universities are designing pedagogical training courses for those who want to be a teacher in K-12 schools.

During the 2014-2015 academic year a university from the northern part of Turkey conducted a pedagogical training course for 188 teacher candidates. These were the candidates who graduated from faculties other than education faculty and after the training, most of them were going to be teaching in vocational high schools. Of the 141 applicants from different disciplines were surveyed about their views of several aspects of NOS. The first author was the trainer of the course and the training took one semester. The course was designed to increase teachers' general pedagogical knowledge and pedagogical content knowledge. So, NOS results evaluated in this study are not due to this course.

At the end of the semester the survey was administered via an online assessment tool (Author & Guvercin, 2016; Kaya & Author, 2016). Once the course ended the survey was announced and the volunteer prospective teachers responded it. Meanwhile, teacher candidates were given 5 bonus points for taking the survey.

The participants' demographic details are presented in Table 1. Actually, the participants were from 25 different majors, however, similar majors were grouped, and 7 categories were formed. For example, teacher candidates from biology, chemistry, and physics majors were grouped as *natural sciences* and candidates from food engineering, landscape architecture, and computer engineering were grouped as *engineering*.

2.2. Instrument

The instrument (VOSTS) used to obtain respondents' views about NOS was developed by Aikenhead, Ryan, and Fleming (1989). Originally the VOSTS is a survey that is related to science, technology, and society, and it is composed of 114 items and 8 categories.

Table 1. Teacher candidates who were administered NOS survey by gender and discipline

	N	%		N	%
Gender			**Discipline**		
Men	58	41	Social sciences	21	15
Women	83	59	Mathematics	25	18
Discipline			Economics and business	32	22
Sport	10	7	Natural sciences	17	12
Engineering	14	10	Nursing	22	16

Canadian high school students' written responses and interviews were used to develop VOSTS items and choices. Each item in the inventory allows participants to choose viewpoints on a wide range of topics. A typical VOSTS item from Aikenhead et al. (1989) is as follows:

10111. Defining science is difficult because science is complex and does many things. But MAINLY science is:

Your position, basically: (Please read from A to K, and then choose one.)

A. a study of fields such as biology, chemistry, and physics.

B. a body of knowledge, such as principles, laws, and theories, which explain the world around us (matter, energy, and life).

C. exploring the unknown and discovering new things about our world and universe and how they work.

D. carrying out experiments to solve problems of interest about the world around us.

E. inventing or designing things (for example, artificial hearts, computers, space vehicles).

F. finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution, and improving agriculture).

G. an organization of people (called scientists) who have ideas and techniques for discovering new knowledge.

H. No one can define science

I. I do not understand.

J. I do not know enough about this subject to make a choice.

K. None of these choices fits my basic viewpoint (p.4).

The instrument used in this study included a translation of 18 items (numbers 10111, 20711, 40111, 60211, 90111, 90211, 90311, 90411, 90511, 90521, 90541, 90621, 90651, 90711, 91011, 91012, 91013, and 91111 in Aikenhead et al., 1989) from the original instrument (see Table 2). These items were selected and translated into Turkish by Aslan and Taşar (2013). In determining the items, they have given the priority to the items that represent the topics/concepts that have taken place previously in the literature. To ensure the valid translation they initially used forward-translation (McDermott & Palchanes, 1994) and then "back-translation technique" as suggested by Brislin et al., (1970). Finally, they compared both versions to check accuracy and equivalence. As stated by the authors, in the translation process, two science education experts, three foreign language experts, and two Turkish language experts worked together. After a pilot study with 48 teachers, they applied the VOSTS questionnaire to assess 74 science and technology teachers' views of NOS. All items validated for Turkish by Aslan and Taşar (2013) were used in this study as they are.

2.3. Data Analysis

To determine whether the differences between the groups are statistically significant, the chi-square test for independence was used. The test can be used when one wishes to explore the relationship between two categorical variables from a single population (Glass & Hopkins, 1996; Pallant, 2007). The main aim in a chi-square test is to determine whether there is a statistically significant difference between the expected data and the collected data in one or more categories. It can be used to determine if the variance between the expected and observed values is due to random chance or whether it is an actual variance. Participants were grouped by gender and majors, and their responses to each of the 18 VOSTS items were classified as realistic, plausible, and naïve. Then, chi-square tests were used to calculate whether the rate of realistic, plausible, and naïve responses was statistically different or not. A realistic view shows a suitable and current opinion, a plausible view implies an unrealistic but rational opinion, and finally a naïve view indicates a non-realistic or non-suitable opinion regarding NOS.

3、Result

Participants' responses to each of the 18 "Views on Science-Technology-Society (VOSTS)" items were categorized as naïve, plausible, or realistic. Table 2 was designed to display percentage distributions of these three sets of views for male and female participants. Table 2 suggests that male and female participants' views across the target NOS aspects fluctuate. In other words, the spreading of participants' responses among the "naïve," "plausible," and "realistic" categories were diverse through items. For example, the majority of male (81%) and female (89%) participants held the naïve view that *scientific models are copies of reality* (Item 6). In other words, participants believed that *many scientific models used in research laboratories (such as the model of heat, the neuron, DNA, or the atom) are copies of reality*. In contrast, many males and females held a realistic and consensus view that *scientific knowledge changes*. In this case, it could be seen that many of the male (77%) and female (78%) participants believed that *even when scientific investigations are done correctly, the knowledge that scientists discover from those investigations may change in the future* (Item 8). Additionally, male's and female's views of scientists' discovery of laws were somewhat different from their views of scientists' discovery of hypothesis (Items 15 and 16). In other saying, participants' views regarding *scientists discovery of laws* (27% and 33% respectively for males and females) was more realistic than their views on *scientists' discovery of hypothesis* (2% and 4% for males and females).

In only 2 of 18 items, participant male's views of the target NOS aspects were not the same as those of female participants. For 10th and 18th items the variances between frequency distributions of male and female responses were statistically significant (χ^2=7.11, *df*=2, *p*=.029 and χ^2=8.39, *df*=2, *p*=.015 respectively). These statistically significant differences were related to the relationship between assumptions and the progress of science (item 10), and the understanding of scientists of different fields to each other (item 18). Come to that, a further examination of the item 10 indicates that, while the differences between male and female views were statistically significant their views were mostly naïve. Percentage point values indicate that more females (75%) than males (57%) held naive views in this regard.

A large majority of male and female participants held naïve and/or plausible views of the target NOS aspects. An examination of Table 2 indicates that in the case of seven of the 18 VOSTS items (39%), male and female participants (ranging from 46% to 78%) ascribed to realistic views of the target NOS aspects. For instance, in response to item eight 77% of male and 78% female participants have the realistic and consensus view that *scientific knowledge changes*. Similarly, in seven items the participants held naïve views. For example, in the sixth item 81% of male and 89% of female participants see the *scientific models as copies of reality* (naïve view). In the remaining four items participants mostly held plausible views. For instance, in response to Item 2, 75% of male and 72% of female participants plausibly think that *some communities produce more scientists*. Interestingly, in six items (items 4, 5, 8, 9, 11, and 17) neither male nor female participants selected plausible views. In these items, participants either selected a realistic or naïve view.

Table 3 indicates that except for two items, participants' views of the target NOS aspects were not related to their major. The frequency distributions of participants' responses were significantly different and in relation to the *science is complex and does many things* (item 1: χ^2=22.3, *df*=12, *p*=.034) and the *predictions are never certain* (item 14: χ^2=25.3, *df*=12, *p*=.014).

Table 3 shows that in terms of naïve beliefs none of the participants from the engineering, health, and economy categories have naïve beliefs regarding the complexity of the science (item 1). Similarly, none of the participants from engineering, science, health, social and mathematics categories believe that *some communities produce more scientists*, and none from the engineering category have naïve belief that *predictions are never certain* (item 14). Contrary, all science teacher candidates have the naïve belief that *scientific models are copies of reality* (item 6). This naïve belief has high percentages, changing between 75% and 95%, for other majors as well. Similarly, all majors having percentages changing between 67% and 95% have naïve beliefs that *hypotheses can lead to theories which can lead to laws*. Moreover, in items 16 and 17 all categories have considerable naïve beliefs regarding hypotheses and theories. In some items, in terms of naïve beliefs striking differences appear between categories of participants. For example, while only 13% of the science category believe that *it is difficult for scientists in different fields to understand each other* (item 18), 67% of participants from sports category held this naïve belief. Similarly, while 70% of participants from the sports major have the naïve belief that *errors done by scientists slow the advance of science* (item 13), only 23% of engineering major held this belief.

In terms of plausible beliefs some outstanding variances appear between the categories of participants. As mentioned in the findings concerning male and female participants none of the categories held plausible beliefs in items 4, 5, 8, 9, 11, and 17. Table 3 shows that none of the participants from engineering, science, health, social, and mathematics majors held plausible beliefs that *scientific models are copies of reality* (item 6). Similarly, none of the participants from sports, health, social and mathematics majors have the plausible belief that *scientists classify the nature according to the way nature really is* (item 7), none of them from sports and mathematics majors have a belief that *errors done by scientists slow the advance of science* (item 13) and none from mathematics major has a plausible belief that *scientists discover scientific laws* (item 15). Contrary, all majors have plausible beliefs changing between 50% and 83% regarding the belief that *some communities produce more* *scientists* (item 2) and all majors have plausible beliefs changing between 48% and 76% regarding the belief that *scientists are concerned with the potential effects of their discoveries* (item 3). It is noteworthy to mention that in item 16 (*Scientists discover a hypothesis*) the plausible view of science major (47%) appears to be different from other majors that range between 13% and 22%.

In terms of realistic beliefs categories again vary in percentages. For example, none of the participants from engineering, science, health, and economy majors held realists beliefs regarding the production of the science by different communities (item 2).

Table 2. Percent responses across gender and Chi square statistic

Item	Realistic%		Plausible%		Naive%		Chi square			
	Male	Female	Male	Female	Male	Female	χ^2	df	N	p
1. Science is complex and does many things	33.3	34.6	61.4	60.5	5.3	4.9	.026	2	138	.987
2. Some communities produce more scientists	22.8	27.7	75.4	72.3	1.8	.0	1.81	2	140	.403
3. Scientists are concerned with the potential effects of their discoveries	3.5	2.4	57.9	65.9	38.6	31.7	.936	2	139	.626
4. The best scientists are always very open-minded, logical, unbiased and objective	63.8	67.9	0	0	36.2	32.1	.255	1	139	.614
5. Scientific observations made by competent scientists will usually be different	64.9	71.6	0	0	35.1	28.4	.699	1	138	.403
6. Scientific models are copies of reality	15.8	8.6	3.5	2.5	80.7	88.9	1.86	2	138	.394
7. Scientists classify the nature according to the way nature really is	73.7	64.6	5.3	1.2	21.1	34.1	4.31	2	139	.116
8. Scientific knowledge changes	77.2	78.0	0	0	22.8	22.0	.014	1	139	.905
9. Hypotheses can lead to theories which can lead to laws	16.1	19.5	0	0	83.9	80,5	.266	1	138	.606
10. Assumptions must be true in order for science to progress	19.6	6.2	23.2	18.5	57.1	75.3	7.11	2	137	**.029**
11. Good theories explain observations well, are also simple rather than complex	56.1	67.9	0	0	43.9	32.1	1.98	1	138	.159
12. The best scientists are those who follow the steps of the scientific method	28.6	30.9	30.4	30.9	41.1	38.3	.127	2	137	.939
13. Errors done by scientists slow the advance of science	57.9	51.3	5.3	6.3	36.8	42.5	.593	2	137	.743
14. Predictions are never certain	49.1	46.3	40.4	47.6	10.5	6.1	1.28	2	137	.527
15. Scientists discover scientific laws	27.3	33.3	9.1	7.4	63.6	59.3	.607	2	136	.738
16. Scientists discover an hypothesis	1.8	3.7	19.6	21.0	78.6	75.3	.492	2	137	.782
17. Scientists discover a theory	15.8	21.3	0	0	84.2	78.8	.645	1	137	.422
18. It is difficult for scientists in different fields to understand each other	29.8	37.0	49.1	25.9	21.1	37.0	8.39	2	138	**.015**

Table 3. Percent responses in majors and Chi square statistics

Item	Category	Responses in Majors (#)*							Chi square			
		Sport	Engineering	Science	Health	Social	Math	Economy	χ^2	df	N	p
1. Science is complex and does many things	Realistic	2	5	2	11	7	10	9	22.3	12	133	**.034**
	Plausible	4	9	11	9	12	13	22				
	Naive	2	0	3	0	1	1	0				
2. Some communities produce more scientists	Realistic	3	4	6	4	6	4	7	20.7	12	137	.054
	Plausible	5	9	10	17	15	20	24				
	Naive	2	0	0	0	0	0	1				
3. Scientists are concerned with the potential effects of their discoveries	Realistic	1	0	0	0	2	1	0	12.9	12	133	.378
	Plausible	5	8	11	16	11	12	22				
	Naive	3	5	4	5	6	12	9				
4. The best scientists are always very open-minded, logical, unbiased and objective	Realistic	6	11	14	13	11	20	19	8.8	6	136	,186
	Plausible	0	0	0	0	0	0	0				
	Naive	4	2	3	8	9	4	12				
5. Scientific observations made by competent scientists will usually be different	Realistic	4	8	12	15	16	16	24	4.6	6	136	.592
	Plausible	0	0	0	0	0	0	0				
	Naive	5	4	5	6	4	9	8				
6. Scientific models are copies of reality	Realistic	1	3	0	1	2	6	3	16.5	12	131	.171
	Plausible	1	0	0	0	0	0	2				
	Naive	6	10	15	19	17	18	27				
7. Scientists classify the nature according to the way nature really is	Realistic	7	10	9	13	11	21	24	20.0	12	136	.068
	Plausible	0	2	2	0	0	0	1				
	Naive	2	2	6	8	9	4	5				
8. Scientific knowledge changes	Realistic	5	12	15	17	15	6	26	6.8	6	136	.338
	Plausible	0	0	0	0	0	0	0				
	Naive	4	2	2	3	5	8	6				
9. Hypotheses can lead to theories which can lead to laws	Realistic	3	3	1	1	4	6	8	6.8	6	131	.344
	Plausible	0	0	0	0	0	0	0				
	Naïve	6	11	14	19	15	18	22				

10. Assumptions must be true in order for science to progress	Realistic	3	1	2	4	3	3	1	16.2	12	132	.185
	Plausible	1	5	6	3	6	4	5				
	Naive	5	7	7	13	11	18	25				
11. Good theories explain observations well, are also simple rather than complex	Realistic	4	10	8	15	14	16	21	3.3	6	136	.767
	Plausible	0	0	0	0	0	0	0				
	Naive	4	3	8	7	7	8	11				
12. The best scientists are those who follow the steps of the scientific method	Realistic	3	6	2	7	6	7	9	8.2	12	134	.771
	Plausible	5	4	5	6	9	5	9				
	Naive	2	4	8	8	6	11	12				
13. Errors done by scientists slow the advance of science	Realistic	3	9	9	12	8	19	13	14.5	12	132	.273
	Plausible	0	1	1	2	2	0	2				
	Naive	7	3	7	6	7	6	15				
14. Predictions are never certain	Realistic	0	8	10	10	7	13	17	25.3	12	136	**.014**
	Plausible	5	5	5	11	11	10	13				
	Naive	4	0	1	1	2	1	2				
15. Scientists discover scientific laws	Realistic	2	2	6	6	7	9	11	7.6	12	128	.815
	Plausible	1	2	2	11	2	0	2				
	Naive	5	9	7	4	9	15	16				
16. Scientists discover a hypothesis	Realistic	0	1	0	1	0	1	1	9.8	12	127	.638
	Plausible	1	2	7	3	3	5	7				
	Naive	7	9	8	16	17	17	21				
17. Scientists discover a theory	Realistic	3	4	3	4	5	1	7	5.7	6	132	.459
	Plausible	0	0	0	0	0	0	0				
	Naive	7	9	13	17	14	22	23				
18. It is difficult for scientists in different fields to understand each other	Realistic	1	6	9	6	6	9	9	13.8	12	132	.312
	Plausible	2	4	4	10	6	10	11				
	Naive	6	3	2	5	7	6	10				

* In Table 3, instead of percentages, absolute numbers were used. This was done to avoid confusion. In other words, since all participants did not supplied responses to all items, the number of respondents for each item sometimes does not coincide with the total number of the participants in each category. For example there are 10 teachers in the sport category, but only 8 of them delivered a response to first item.

Table 3 indicates that except for two items, participants' views of the target NOS aspects were not related to their major. The frequency distributions of participants' responses were significantly different and in relation to the *science is complex and does many things* (item 1: χ^2=22.3, *df*=12, *p*=.034) and the *predictions are never certain* (item 14: χ^2=25.3, *df*=12, *p*=.014).

Table 3 shows that in terms of naïve beliefs none of the participants from the engineering, health, and economy categories have naïve beliefs regarding the complexity of the science (item 1). Similarly, none of the participants from engineering, science, health, social and mathematics categories believe that *some communities produce more scientists*, and none from the engineering category have naïve belief that *predictions are never certain* (item 14). Contrary, all science teacher candidates have the naïve belief that *scientific models are copies of reality* (item 6). This naïve belief has high percentages, changing between 75% and 95%, for other majors as well. Similarly, all majors having percentages changing between 67% and 95% have naïve beliefs that *hypotheses can lead to theories which can lead to laws*. Moreover, in items 16 and 17 all categories have considerable naïve beliefs regarding hypotheses and theories. In some items, in terms of naïve beliefs striking differences appear between categories of participants. For example, while only 13% of the science category believe that *it is difficult for scientists in different fields to understand each other* (item 18), 67% of participants from sports category held this naïve belief. Similarly, while 70% of participants from the sports major have the naïve belief that *errors done by scientists slow the advance of science* (item 13), only 23% of engineering major held this belief.

In terms of plausible beliefs some outstanding variances appear between the categories of participants. As mentioned in the findings concerning male and female participants none of the categories held plausible beliefs in items 4, 5, 8, 9, 11, and 17. Table 3 shows that none of the participants from engineering, science, health, social, and mathematics majors held plausible beliefs that *scientific models are copies of reality* (item 6). Similarly, none of the participants from sports, health, social and mathematics majors have the plausible belief that *scientists classify the nature according to the way nature really is* (item 7), none of them from sports and mathematics majors have a belief that *errors done by scientists slow the advance of science* (item 13) and none from mathematics major has a plausible belief that *scientists discover scientific laws* (item 15). Contrary, all majors have plausible beliefs changing between 50% and 83% regarding the belief that *some communities produce more scientists* (item 2) and all majors have plausible beliefs changing between 48% and 76% regarding the belief that *scientists are concerned with the potential effects of their discoveries* (item 3). It is noteworthy to mention that in item 16 (*Scientists discover a hypothesis*) the plausible view of science major (47%) appears to be different from other majors that range between 13% and 22%.

In terms of realistic beliefs categories again vary in percentages. For example, none of the participants from engineering, science, health, and economy majors held realists beliefs regarding the production of the science by different communities (item 2). Similarly, in responding item 6 none of the participants from science major believed scientific models to be copies of reality, none from sports major believed predictions to be certain (item 14) and none from sports, science, and social majors held a realistic view regarding the scientists working on the hypothesis (item 16). Conversely, in responding items 4, 7, 8, and 11 participants from all majors have realistic views having percentages more than 50%. For example, they believe scientific knowledge to be change (item 8) with percentages varying between 56% and 86% and they mostly believe good theories to be complex and explain observations well (item 11) with percentages changing between 50% and 77%. In responding to several items, the alteration of the participants' views fluctuates apparently. For example, while only 11% of sports major have a realistic belief regarding the understanding of scientists in different fields to each other, 60% from the science category have this view (item 18). Similarly, the realistic views of participants on item 1 from science and health majors have percentages of 13% and 55% respectively. Similar alterations between percentages across majors can be seen in items 12, 13, and 17.

To visualize three NOS aspects across items, Figure 1 was constructed. As seen from the figure realistic, plausible, and naïve features of NOS fluctuate through items. For some items, while the percentage of realistic aspects are outstanding, for some other items the plausible and naïve aspects are attracting the attention. For example, in items 1 and 2 participants' percentages of naïve beliefs are 8% and 3%. In other words, participants do not have naïve beliefs regarding to the *science is complex and does many things*, and *some communities produce more scientists*. Similarly, in items 3 and 16 participants' percentages of realistic views are 4% and 3% respectively. In other saying, regarding the *scientists concern with the potential effects of their discoveries* and *scientists discover a hypothesis*, participants mostly have either realistic or plausible views. Likewise, in items 6 and 7 participants held plausible views with percentages of 3% and 4%. Which indicates that, regarding the *scientific models are copies of reality* and *scientists classify the nature according to the way nature really is*, participants mostly have either realistic or naïve beliefs. Contrary, in some items, NOS aspects are remarkable in terms of high percentages. For example, in items 6 and 9 participants' naïve views are 85% and 80%. In other words, related to the *scientific models are copies of reality* and *hypotheses can lead to theories which can lead to laws*, participants held naïve views. Similarly, in items 4 and 8 participants' views are highly realistic (70% and 77% respectively). In other saying, regarding the *best scientists are always very open-minded, logical, unbiased and objective*, and *scientific knowledge changes*, participants mostly held accurate views. Likewise, in responding items 2 and 3 participants held plausible views at percentages of 70% and 63% relatively. Namely, regarding some *communities produce more scientists* and *scientists are concerned with the potential effects of their discoveries*, participants have supplied reasonable views.

4.Discussion and Conclusion

The present study is significant in, at least, three major respects. Firstly, the present results indicate that a great deal of the prospective teachers participated in the present study had naive and plausible views about various NOS aspects (e.g., scientific models are copies of reality, hypothesis can lead to theories which can lead to laws, scientists discover a theory) which is consistent with the previous literature (Abd-El-Khalick, Bell, & Lederman, 1998; Dogan & Abd-El-Khalick, 2008; Wahbeh & Abd-El-Khalick, 2014; Yakmacı, 1998). Seeing the scientific models as the copies of reality is an extraordinary finding that seems to subvert expectations. Thus, we strongly recommend insructors at schools/universities to stress that models represent the reality up to some point.

Secondly, the present results indicate that both male and female prospective teachers participated in the study did not hold consistent views across most of the target NOS aspects which are central to the scientific literacy. The significant gender difference in two of the NOS aspects (item 10 and item 18) indicated that females had more naive NOS understanding than males for these aspects of NOS. These two items were about the relationship between assumptions and the progress of science (item 10), and the understanding of scientists of different fields to each other (item 18). These two items constitute approximately 11% of the given list of 18 test items. So, it is possible for these items to show statistical significance at p=0.05 level by chance.

Yet, in the rest 16 items, there was no statistically significant gender differences exists regarding other aspects of NOS. Previous research has indicated that NOS views were in general not related to gender (Dogan & Abd-El-Khalick, 2008; Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2014), while some specific aspects of NOS (e.g., tentative NOS understanding) are related to gender (Hacıeminoğlu, Ertepınar, Yılmaz-Tüzün & Çakır, 2014; Huang, Tsai, & Chang, 2005; Kılıc, Sungur, Cakıroglu, & Tekkaya, 2005; Yenice & Saydam, 2010) in favor of males or females. The findings of the present study are consistent with the results of those studies in the literature.

Thirdly, regarding the majors of prospective teachers, one might expect to see better NOS views in science or mathematics majors compared to the sport or economy majors. Both the duration and nature of participation in scientific works like laboratory experiences during their teacher education programs in those majors might be responsible for this expectation. However, the Chi-square statistics results indicated that except two of NOS aspects (item 1 and item 14) participants' views of the target NOS aspects were not related to their major. This finding agrees with previous research (Bayir, Cakici, & Ertas, 2014; Carey & Stauss, 1970; Dogan, & Abd-El-Khalick, 2008). In their study, Bayir, Cakici and Ertas (2014) found no substantial difference between the views of scientists in natural (biology, chemistry, and physics disciplines) and social sciences (Turkish linguistics and literature, and history disciplines) about the seven target aspects of NOS. Similarly, Dogan and Abd-El-Khalick (2008) found teachers' conceptions not related to their disciplinary background but related to their graduate degree (BS, MS, PhD) except for three target NOS aspects. These NOS aspects were the theory-driven nature of observations (Item 90111), the relationship between classification schemes and reality (Item 90311), and the role of probabilistic reasoning in scientific investigations (Item 90711).

In order to help students develop appropriate views of NOS, teachers of all grade levels and all disciplines/majors need to have informed views of scientific endeavors. This study indicates that current teacher education programs in Turkey, including those in different types of teacher education programs such as economics and sports as well as more advanced training in the sciences, are not helping prospective teachers enough to develop more accurate understandings about NOS. Therefore, teacher education programs should continue their attempts to promote more adequate conceptions of NOS. Irrespective of the majors of prospective teachers, more emphasis should be given to the teaching and understanding of NOS in their programs. As Lederman (2007) stated, teachers' conceptions of NOS are not automatically and necessarily translated into classroom practice. Therefore, teacher education programs should provide prospective teachers with more opportunities to learn and practice several aspects of NOS. Teachers' ability to teach NOS is crucial as well as their understanding of NOS for having students with the desired understanding of NOS. Thus, teachers need special support, or trainee for teaching NOS. Despite the emphasis of NOS in the new curricula in Turkey and literature emphasizing the importance of NOS instruction, previous research has shown that NOS is rarely addressed in an effective manner by the teachers (Herman, Clough, & Olson, 2017).

NOS is generally included in the curriculum of science (physics, chemistry, and biology), and mostly investigated by science education researchers. In this study, only %12 of the participants are from science. Thus, the basic NOS aspects asked in this study are appropriate to the participants. The newly discussed aspects (Hodson & Wong, 2017) that exceed the consensus view will perhaps be more proper to participants from science majors.

5.Future Studies and Limitation

For future studies of NOS especially in Turkey the next step might be a more fine-grained analysis of the origins, roots, or ideological bases of any such naive views, or of analyzing what leads to adequate views, including the effect of various forms of educational interventions.

Because of its ease of access, in the present study views of NOS of prospective teachers that come from other faculties after their graduation of their bachelors were investigated. In future studies, however, a comparison of views of NOS aspects of prospective teachers who are regular education faculty students and who are from other faculties after their graduation may be recommended. Also, it would be fascinating to follow-up and find out why there is little-to-no gap between the STEM majors and others.

Nevertheless, the results discussed here are limited to the participants and the context within which this research was conducted. While the sample size for gender groups relatively high that of majors maybe hardly large enough to resolve uncertainties based on earlier studies of the majors to NOS understanding. We recommend our results to be interpreted cautiously. Additionally, more research is needed to explore the factors that facilitate and/or hinder NOS understandings. Future research can also focus on investigating the reason why gender and major differences exist in certain aspects of NOS while on certain aspects does not exist.

Nonetheless, the "consensus view" used in our study as a benchmark for NOS understanding is now widely criticized and according to many senior scholars in science education, it no longer reflects the consensus. We suggest the readers to: (i) interpret our results taking into account the critiques to the so called 'consensus views' of NOS, (ii) to start new research on the development of new instruments for NOS assessment, (iii) to focus on including the new aspects of NOS to curriculum development, (iv) and to read the alternative perspectives to the 'consensus view' of NOS from the 2017 issue of Canadian Journal of Science, Mathematics and Technology Education (Vol. 17, No. 1).

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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