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Preservice Teachers' Views of Nature of Science and Their Metaphoric Perceptions of Science and Scientists

Research Article

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ABSTRACT

In this study, a mixed-method approach is used to examine preservice teachers' views of the nature of science (NOS) and their perceptions of science and scientists. Study sample consisted of 72 preservice primary school teachers of the Faculty of Education of a university in the Aegean Region. 10 items selected from the 25 VOSTS-TR items (Turkish version of Views on Science-Technology-Society) and semi-structured interviews were used to determine participants' views of NOS and their perceptions of science and scientists were analyzed using metaphor analysis. Categories developed based on participants' metaphors were compared with their responses to the related VOSTS-TR items. The majority of participants responded to some items (tentativeness of scientific knowledge, values that guide scientists, nature of observations) from a contemporary point of view while about half of them responded some items (professional interaction in the face of competition, scientists' errors in their works, ethics, effect of gender on the process and product of science) from an insufficient point of view. The greater part of the participants generated metaphors that characterize science as a comprehensive, demanding, laborious, or essential process with infinite content and scientists as a diligent, guiding, leading, or research-focused people who put great effort to conduct research and to raise awareness. Moreover, some trends and similarities were observed between participants' NOS views and their metaphoric perceptions. It is believed that this study will pave the way for further research aiming at analyzing participants' NOS views through strategies based on classroom dialogues about metaphors created by students.

Keywords:

nature of science, metaphors, preservice teachers, science education

Introduction

The nature of science (NOS), scientific knowledge, and the relationship between science, technology and society have attracted the attention of researchers since the development of the concept of scientific literacy in the 1950s (Turgut, 2007). Many studies have been conducted on the impact of science education on students' views of the nature of scientific knowledge (Lucas & Roth, 1996; Songer & Linn, 1991), on their

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perceptions of and attitudes towards science and scientists (Buldu, 2006; Finson, Beaver, & Cramond, 1995), and on their future career choices (Rosenthal, 1993). Thus, curriculum development projects and reform initiatives around the world and in Turkey often lay emphasis on NOS in science literacy and on having an understanding of contemporary science (MoNE, 2017; NRC, 2000). Lederman and Zeidler (1987) define NOS as the "values and assumptions inherent to the development of scientific knowledge. For example, an individual's beliefs concerning whether scientific knowledge is amoral, tentative, empirical, a product of human creativity or parsimonious reflect his/her conception of the nature of science" (p. 721).

There are studies investigating students' views of NOS (Fleming, 1987; Kang, Scharmann, & Noh, 2005; Lederman, 1992; Solomon, Scott, & Duveen, 1996) and assessing what format and content the NOS has/should have in curricula (Kaya & Erduran, 2016) and textbooks (Abd-El-Khalick, Waters, & Le, 2008; İrez, 2009; Vesterinen, Aksela, & Lavonen, 2013). According to Kaya and Erduran (2016), most studies show that curricula in general and science courses in particular fail to address the NOS adequately. Therefore, not only students (Doğan & Abd-El-Khalick, 2008; Doğan, 2010; Sadler, Chambers & Zeidler, 2007; Solomon et al., 1996) but also teachers (Abd-El-Khalick & BouJaoude, 1997; Doğan & Abd-El-Khalick, 2008) have incomplete or inadequate knowledge of it.

Teachers have a great influence on students' views of NOS and on their perceptions of science and scientists (Buldu, 2006; Finson et al., 1995; Waters-Adams, 2006). Lederman (1992) attributes students' inadequate knowledge of NOS to the lack of knowledge and skills on the part of teachers. Although there are many studies conducted in Turkey and other countries on teachers' (Aslan & Taşar, 2013; Aslan, Yalçın, & Taşar, 2009; Lederman, 1992; Pomeroy, 1993) and preservice teachers' (Palmquist & Finley, 1997; Tatar, Karakuyu, & Tüysüz, 2011) views of NOS, the majority of those studies focus mainly on science teachers or preservice science teachers.

Students, with their innate sense of curiosity, start to develop scientific thinking and scientific literacy in early childhood period (Lloyd, 2016). Children's perceptions of science and scientists begin to develop in the pre-school period (Güler & Akman, 2006). However, they have to go through a certain process before their perceptions become precise and stereotypical (Lee, 2010). Pre-school and primary school teachers, therefore, play a significant role in helping students develop perceptions of science, scientists and the NOS. Given the fact that pre-school education is not compulsory in Turkey, most of that responsibility falls on the shoulders of primary school teachers (Türkmen, 2008).

Koballa and Crawley (2018) state that students' long term attitudes towards science are shaped by the attitudes of teachers who first introduced science to them. Primary school teachers (primary school teaching graduates) are the ones that introduce science to students in the framework of a science curriculum for the first time at third grade in Turkey. Science teachers (science teaching graduates) teach courses to students from Grade 5 to 8, that is, in secondary school. It is therefore of great significance to determine preservice primary school teachers' views, levels and perceptions of NOS and to develop teacher education curricula accordingly in order to make sure that they are better equipped to teach science to students.

Numerous Likert-type or multiple-choice standardized measurement instruments have been used since the 1960s to determine individuals' NOS views (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). However, those instruments have been criticized on the grounds that they oversimplify or overgeneralize participants' views of NOS (Chen, 2006), that they cause students to perceive and interpret the test items in the same way as researchers do (Aikenhead & Ryan, 1992) and that they lose validity as they reflect the opinions and biases, not of users, but of those who have developed them (Lederman et al., 1998, as cited in Lederman et al. 2002). Because of such criticisms, Aikenhead et al. (1989) developed Views on Science-Technology-Society (VOSTS) to disambiguate whether students' choices really reflect their views of NOS. Based on research on Canadian students, the VOSTS consists of empirically derived multiple-choice items, which are statements reflecting various and justified points of view (Aikenhead et al., 1989).

Lederman et al. (2002) highlighted the forced-choice nature of the VOSTS and emphasized that it would have limitations similar to those of other instruments when applied to non-Canadian and non-Western learners. As a response to these and similar criticisms, researchers have developed different forms of Views of Nature of Science Questionnaire (VNOS), which contain open-ended questions and require follow-up interviews (Abd-El-Khalick, Bell, & Lederman, 1998; Lederman & O'Malley, 1990). As an alternative to the VNOS and similar approaches, some researchers have proposed "Whole Science" (Allchin, 2011) or Family Resemblance Approach (FRA) (Dagher & Erduran, 2016; Irzik & Nola, 2011). In short, many instruments or approaches with different limitations and advantages have been proposed to determine views of NOS. Despite some of its limitations, VOSTS-TR (Turkish version of VOSTS questionnaire) was the measurement tool of choice in this study. VOSTS-TR questionnaire consists 25 items under the categories of the definition of science, influence of society on science and technology, influence of science and technology on society, characteristics of scientists, social construction of scientific knowledge, and nature of scientific knowledge (Doğan-Bora, 2005). Of the 25 items, 10 were used in this study due to their ease of use, time efficiency and appropriateness to the level of participants. Those items were related to the definition of science, characteristics of scientific knowledge and scientists, and factors affecting scientific research and scientists, and therefore, they were concerned mostly with science, scientific knowledge and scientists. Moreover, follow-up interviews were conducted with eight participants from the sample. The aim was to reduce the limitations of the measurement instrument by collecting more data on participants' knowledge and opinions regarding the items and their responses to those items.

Metaphors which are regarded as one of the important data collection tools in qualitative research (Schmitt, 2005), are used to gain insight into students'/preservice teachers' perceptions of science and scientists in some studies (Aktamış & Dönmez, 2016; Şenel & Aslan, 2014). Metaphors refer to the understanding and experiencing of one kind of thing in terms of another" (Lakoff & Johnson, 2010, p. 27). They provide links "between new and extant knowledge" and "language and images (Tobin & Tippins 1996, p. 716) and "the researcher is able to enter into the inner world of the perceptions, understandings, and experiences of the participants" through metaphors (Jensen 2006, p. 41). Metaphors have some limitations as well. For example, they offer a limited perspective on a concept (Demir, 2007) and each individual interprets them only to the extent that they understand them (Thomas & McRobbie 1999). Thomas and McRobbie (1999) emphasize the importance of triangulating metaphorical data with others. Although there are many studies investigating students', teachers' or preservice teachers' metaphorical perceptions of science and/or scientists, none of them compares/supports metaphorical data with others, especially with data on NOS. An important difference of this study is, therefore, the comparison of participants' NOS views (especially, of items related to science and scientists) with their metaphors of science and scientists. In doing so, it is believed that this study will pave the way for further studies aiming at predicting and analyzing students' views of science and NOS through strategies based on classroom dialogues about metaphors created by students.

Although primary school teachers play a key role in the development of students' perceptions of science, the number of studies on preservice primary school teachers is limited (Murcia & Schibeci, 1999; Saraç & Cappellaro, 2015; Tatar et al., 2011). Moreover, there are no studies, to our knowledge, that have employed a mixed method approach and compared preservice primary school teachers' metaphorical perceptions with their NOS views. The aim of this study is, therefore, to investigate preservice primary school teachers' views of NOS and their metaphoric perceptions of science and scientists. This study also aimed to investigate whether there were similarities between participants' metaphoric perceptions and NOS views. In this respect, this study addressed the following research questions: In this respect, this study addressed the following research questions:

1. What are preservice primary school teachers' views of NOS?
2. What kind of metaphors do preservice primary school teachers use to explain the concept of science?
3. What kind of metaphors do preservice primary school teachers use to describe scientists?
4. Are preservice primary school teachers' metaphors of science and scientists any different from their views of NOS?

Method

Research Design

Data were analyzed using an explanatory sequential mixed method design, which involved collecting and analyzing quantitative and qualitative data, and then explaining the former by the latter (Creswell & Plano Clark, 2015, p. 90). In this design, first, quantitative data, which elicit information on the primary question of the research were collected and interpreted, followed by the qualitative phase in which the researcher explains how qualitative results help explain quantitative results (Creswell & Plano Clark 2015, p. 79). Therefore, in this study, first phase involved designing and implementing a quantitative survey while the second phase involved further analysis of the survey items and semi-structured interviews.

Study Group

The study was conducted in the fall semester of the 2016-2017 academic year. The study group comprised 72 second-grade preservice teachers (66 women and 6 men aged 19 to 21 years) of the Primary School Teaching Program. This is a four-year program offered by the Elementary Education Department of Education Faculties. The objective of this program is to provide preservice primary school teachers with scientific knowledge and skills. Students of this program receive different field knowledge, teaching profession knowledge and general culture courses. The study was conducted in the third semester when preservice teachers had already taken science courses but have not yet taken science education/teaching courses and even "Scientific Research Methods" course which included knowledge and skills related to scientific methods and NOS. It is assumed that preservice primary school teachers who have already taken a number of basic science courses should have a general idea of or awareness about scientific knowledge. This study was, therefore, conducted with second-grade students to determine their science-related views before taking courses on NOS. Determining preservice teachers' views before taking those courses is important to compare them with their views after having taken those courses. This study is, therefore, can be regarded as a preliminary study. We believe that implementing this study also before graduation will provide insight into the efficiency of courses.

Instrument and Procedures

VOSTS-TR Questionnaire. The "Views on Science-Technology-Society" (VOSTS) questionnaire developed by (Aikenhead et al., 1989) and adapted to the Turkish language (VOSTS-TR) by Doğan-Bora (2005) was used. Doğan-Bora (2005) adapted 25 items of the VOSTS questionnaire to be applicable to Turkish student populations based on the opinions of four experts. The reliability coefficient of the questionnaire is .72. Ten items were selected out of 25 items based on the opinions of an area expert and the readiness levels of preservice teachers because we assumed that since participants were in their third semester, they would be unlikely to have information about some of the concepts (epistemology of scientific knowledge, biotechnology, scientific models) addressed in the remaining 15 items. Those 10 items address the definition of science, influence of society on scientists and scientific research, characteristics of scientists, social construction of scientific knowledge and nature of scientific knowledge. VOSTS-TR items were classified by Rubba and Harkness (1996) under three categories as "realistic," "has merit" and "naïve," referring to "contemporary point of view," "reasonable point of view" and "insufficient point of view," respectively. Participants' responses were classified according to the scoring scheme developed by Doğan-Bora (2005) based on the opinions of 10 area experts (physics, chemistry, biology and education).

Metaphor Form. Lakoff and Johnson (2010) distinguish metaphors as structural, orientational and ontological. Structural metaphors are used to express a concept in terms of another. In this study, participants were briefly informed about the nature, purpose and use of metaphors. Then, focusing mainly on structural metaphors, participants were asked to create a metaphor about a sample concept as an exercise. Afterwards, participants were distributed a metaphor form consisting of such statements as "science is like………… because…………" and "a scientist is like………… because…………" They were asked to fill it out by concentrating on a single metaphor, and express justification for that metaphor.

Semi-Structured Interview Form. Fraenkel and Wallen (1996) state that semi-structured interviews "consist of a series of questions designed to elicit specific answers on the part of respondents" (p. 447). In this study, semi-structured interviews were conducted with eight volunteer participants recruited using the criterion sampling. This type of sampling includes the all cases meeting some criterion (Marshall & Rossman, 1999, p. 78) to obtain deeper and richer data on survey items. Therefore, participants with many, few and no naïve responses were determined, and those who agreed began to be interviewed. Patton (2002) states that "There are no rules for sample size in qualitative inquiry. Sample size depends on what you want to know, the purpose of the inquiry, … and what can be done with available time and resources" (p. 244). New participants were recruited until data saturation was reached, and data collection was terminated when more data did not add any new information. Therefore, eight participants were interviewed, five of whom had naive responses and the remaining had realistic or has merit responses to especially four items with the highest naive response rates. In this way, responses were obtained at each level for each question from participants. Based on the opinions of an area expert, the interview questions were designed in a way that they focused on the VOSTS-TR items. Parallel to the items in the questionnaire, the interview questions allowed for in-depth analysis of the views held by participants. Each interview lasted 15 to 20 minutes and all interviews were recorded using a voice recorder.

Data Analysis

Each participant was given the VOSTS-TR questionnaire and a metaphor form. Quantitative data were analyzed using descriptive statistics while qualitative data were analyzed using descriptive and content analysis. The stages of "naming and eliminating," "category development" and "ensuring validity and reliability" developed based on literature review (Gültekin, 2013; Saban, 2008) were taken into account in analyzing and interpreting participants' metaphors. In the first stage, participants were asked to focus on a specific metaphor and to provide a valid justification for it. In the second stage, participants' metaphor statements were examined in terms of the common features they have regarding the concepts of science and scientists. Categories were established based on participants' justifications, views and commonalities. In the third stage, research steps were reported in detail, and expert opinion was consulted. According to Patton (2002), investigator triangulation is one of the triangulation types to independently analyze the same qualitative data "to reduce the potential bias that comes from a single person" (p. 560). An expert who had previously conducted studies on metaphors was asked to match the metaphors to the categories to achieve investigator triangulation. Her matching and the researcher's matching were compared using the reliability formula developed by Miles and Huberman (1994). The expert classified five metaphors into a different category, and therefore, their agreement for the categorization (inter-coder reliability) was calculated as .93. The researcher and the expert discussed on the metaphors that were assigned to different categories until they came to an agreement on to which categories those metaphors actually belonged, and then, they finalized the coding.

The selected VOSTS-TR items contained statements regarding the definition of science (Item 1) and personal characteristics of scientists (Item 4). Therefore, participants' metaphors of science and scientists were compared with their views of Items 1 and 4. Most participants' responses to them were "has merit" or "realistic," and therefore, the number of naive responses to all VOSTS-TR items were investigated. The number of naive responses and categories of metaphors for science and scientists were also compared in the study. Moreover, the semi-structured interview data were analyzed using descriptive analysis. Direct quotes were used to provide an accurate and coherent picture of participants' views (Yıldırım & Şimşek, 2011). Interviewees were assigned codes (PST-A to PST-H) for confidentiality.

Findings

Findings Regarding Participants' Views of NOS

Participants' responses to 10 items were examined in five categories. Table 1 shows the rates of "naive," "has merit" and "realistic" responses.

Table 1. Distribution of items and responses in VOSTS-TR Questionnaire

Categories	Subcategories	Item	Distribution of Responses		
			Naïve %	Has Merit %	Realistic %
Definition of Science	Meaning of science	1	5.6	55.5	38.9
Influence of Society	Ethics (religious and ethical views)	2	40.3	30.6	29.1
	Public influence on scientists	3	5.6	27.8	66.6
Characteristics of Scientists	Values that guide scientists	4	13.9	2.8	83.3
	Effect of gender	5	34.7	23.6	41.7
Social Construction of Scientific Knowledge	Professional interaction in the face of competition	6	52.8	44.4	2.8
Nature of Scientific Knowledge	Scientists' errors in their works	7	43.1	47.2	9.7
	Following the steps of scientific method	8	9.7	57.0	33.3
	Nature of observations	9	1.4	19.4	79.2
	Tentativeness of scientific knowledge	10	4.2	4.2	91.6

Findings Regarding VOSTS-TR Items with High Percentages of Naive Responses. Table 1 shows that participants' responses to Items 6 (52.8%), 7 (43.1%), 2 (40.3%) and 5 (34.7%) are substantially naïve. It is interesting that the majority of participants' responses to three (8, 9 and 10) of the four VOSTS-TR items fall into the category of "has merit" or "realistic" while only a small percentage of their responses to Item 7 are "realistic." For this item, 9.7% of participants marked the option that "errors cannot be avoided, therefore, scientists reduce errors by checking each other's results" indicating that only a few participants think that scientists can help each other to correct each other's mistakes. During the interviews, participants generally expressed the view that science would generally advance by detecting and correcting the errors of the past or that errors would lead to new discoveries: "Mistakes attract the attention of scientists and allow science to be developed from different perspectives," (PST-D) "We could not tell right from wrong if it was not for mistakes," (PST-C) "Mistakes generally lead to new discoveries," (PST-A) and "Every mistake allows new information to develop and information to be more accurate." (PST-E)

The previous finding is consistent with that of Item 6 with an option regarding the cooperation of scientists. For this item, very few participants held realistic views of the cooperation of scientists. More than half of the participants (52.8%) held naive views about scientists' ignorance of the ideals of science. They reported that scientists ignore the ideals of science to achieve their outcome-oriented goals (success, financial rewards, etc.). According to this finding, participants think that scientists do not engage in professional interactions and are likely to exhibit unethical behavior in the face of competition or due to result-oriented thinking. Interviewees had similar views of the unethical behavior of scientists: "Scientists are likely to break the rules to reach conclusions for the sake of social status or financial gains," (PST-A) "Scientists are likely to ignore moral values when they focus too much on the end result," (PST-C) and "Some people prefer to be number one or to be able to say 'I am the one who did it." (PST-E).

A high percentage of participants provided naive responses to Item 2. Almost half of the participants (40.3%) held naive views and expressed that religious and ethical views did not affect scientific research. However, 59.7% of participants were of the opinion that religious or ethical views might affect scientific research. During the interviews, they made the following explanations about these views: "No matter how universal science is, everyone has their own beliefs, and religion is one of them. Scientists develop solutions to problems within the boundaries of their own beliefs and cultures. I do not think a Muslim scientist would agree to be frozen and wait to be thawed" (PST-F), "If the society they live in ensures freedom of belief and thought, then scientists can freely express their thoughts and discoveries, contributing to scientific advancement" (PST-G), and "Scientific research requires funding, which is provided by certain groups. Research topics are, therefore, selected to meet the needs of those groups providing the funding" (PST-H).

In fact, most participants expressed their hesitation about Item 2. When they were presented with relevant premises, they stated that both realistic/has merit and naive options made sense to them. For example, one of the participants stated: "On the one hand, I think that each society has its own religious and moral views and that science should not be affected by them because of its universal nature, but, on the other hand, I think that it is only natural for people to be influenced by their own culture when they do research" (PST-C). Another participant, stressing that beliefs may be restrictive for scientists, stated: "The effect of morality and religious beliefs is noticeable. Social beliefs and thoughts are creating a more restrictive environment, which is an obstacle to scientific work and discoveries. Science should be free from religious interference" (PST-A).

Participants who were interviewed also expressed their hesitation with respect to the options of Item 5. One of the participants stated: "The number of female scientists is low because women were not given enough opportunities in the past, but their discoveries should be different since they have different perspectives, values, and nature" (PST-A). Some participants explained their traditional views of Item 5 by stating "Women have different interests, skills and needs than men, and this difference is influential in their discoveries" (PST-E). However, some other participants held more contemporary/reasonable views and stated: "Boys are raised to be more self-reliant, achievement-oriented and autonomous than girls, and discoveries made by men attract more attention. Therefore, discoveries are perceived as unique to men. In fact, there is no gender difference in science. It is individual differences that lead to different discoveries" (PST-F) and "I don't think this has anything to do with gender. It is completely about one's personality, surroundings and thoughts" (PST-G).

Findings Regarding VOSTS-TR Items with Low Percentages of Naive Responses. According to the VOSTS-TR categorization, participants' responses indicate that they have highly (34.7%-52.8%) naive views of the previously mentioned items. However, few participants (1.4%-13.9%) had naive responses to Items 1, 3, 4, 8, 9 and 10. This result indicates that participants seem to have highly reasonable or contemporary views for these items.

Most of the of participants' responses (91.6%) to Item 10 were realistic. The majority of participants are of the opinion that scientific knowledge may change or be reinterpreted. 79.2% of participants' responses to Item 9, which is in the same category as Item 10, were realistic. Almost all participants are of the opinion that scientists may think and experiment differently from one another during scientific work and that they can use different methods but make similar observations.

Another item that participants mostly marked realistic options (83.3%) was Item 4. This item explored such personal characteristics open-mindedness, impartiality, honesty, imagination, etc. that scientists need to have in order to be successful. 38.9% of participants expressed being open-minded, logical, unbiased and objective in their work while 44.4% expressed having some traits such as imagination, intelligence and honesty as the personal characteristics that scientists should possess to be successful.

Most participants provided contemporary/reasonable responses (66.7% realistic and 27.8% has merit) to Item 3. More than half of the participants are of the opinion that family, school and society are important factors contributing to the development of scientific skills, while most of the others suggest that upbringing, children's intelligence, ability and interest in science, and society attaching importance to science play a significant role in encouraging children and providing them with the opportunity to acquire the necessary characteristics to grow up to be tomorrow's scientists. Some of the participants' statements on this theme during the interviews are as follows: “I do not see any reason why someone who has a conscious interest and talent in science and grow up in an environment that is open to exploration and questioning would not make unique discoveries” (PST-B) and “There are more qualified scientists in societies that value science and implement education systems that provide high quality learning opportunities to all students and encourage them” (PST-F).

57% and 55.5% of participants provided “has merit” responses to Items 8 and 1, respectively while 33.3% and 38.9% of participants provided “realistic” responses to Items 8 and 1, respectively, which can be classified as high. The responses indicate that more than half of the participants think that scientists follow the steps of scientific method while 33.3% of participants believe that originality and creativity are as important as scientific method. Majority of participants marked “it ensures valid, clear, logical and accurate results” or "it works well for most scientists" as the options that accounted for why scientists follow the steps of the scientific method. For the definition of science, 38.9% of participants marked the option of “exploring and discovering unknown things about our world and universe,” 22.2% marked the option of “a body of knowledge, such as principles, laws and theories, which explain the world around us” and 27.7% marked the option of “finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution).” Only 5.6% of participants regarded science as just inventing/designing something or an unidentifiable phenomenon.

Findings Regarding Participants’ Metaphors of Science

Participants generated 49 metaphors of science. Of these metaphors, sun, light, space, universe, book, life, biking, ocean, discovery, tree, and journey to the unknown were recurrent. The metaphors that participants suggested were classified under the categories of “unlimited/wide structure," “structural features of the process”, “guide,” "rewarding/facilitating process,” and "process of discovery." The category of unlimited/wide structure includes metaphors (f=21) highlighting the unlimited, continuous, inclusive or rich content of science such as universe, ocean, never-ending energy, and immortality. The category of structural features of the process contains metaphors (f=20) (e.g. biking, long road, flower, and labyrinth) that focus on the qualifications or structural characteristics required by the scientific process (e.g. snowball and basic needs). The category of guide consists of metaphors (f=18) that denote the guiding, leading, instructive and directing characteristics of science such as sun, light, book, guide, and teacher. There are metaphors (e.g. fun, exciting, and constructive) pointing to the positive contributions of science under the category of rewarding/facilitating process (f=7). Metaphors portraying science as a process of invention/discovery (e.g. mysterious forest, book and sea) are under the category of process of discovery (f=6).

Findings Regarding Participants' Metaphors of Scientists

Participants generated 49 metaphors of scientists. Of these metaphors, cook, sun, light, child, astronaut, philosopher, tree, mother, polar star, teacher, and detective were recurrent. The metaphors that participants generated were classified under the categories of "personal characteristics/work habits," "guiding," "rewarding/facilitating" and "indispensable." The category of personal characteristics/work habits includes metaphors (f=39) (e.g. diamond, cook, philosopher, detective, ant, brain and warrior) that characterize scientists as honest and research-focused people who put great effort to conduct research and to raise awareness etc. The category of guiding consists of metaphors (f=16) depicting scientists as guides and leaders such as light, polar star, book, tourist guide, and torch. In the category of rewarding/facilitating are metaphors (f=14) addressing scientists' ability to make innovations and positive contributions such as sugar, tree, key, pomegranate, superhero, and earth. The category of indispensable contains metaphors (f=3) (e.g. earth, sun, and brain) that regard scientists as vital and indispensable.

Findings Regarding the Comparison of Participants' Metaphors and Their Views of NOS

Figure 1 shows that participants with "realistic" and "has merit" responses to Item 1 generated metaphors mostly in the categories of unlimited structure (29.2%), structural features of the process (27.8%), or guide (25%). Those with naive responses likened science to either a rewarding process (4.2%) or to a process leading to discovery (1.4%). The metaphors of participants with realistic/has merit responses and the metaphors of those with naive response to Item 1 concentrated in certain categories. The researcher, therefore, aimed to compare the metaphors of those with few naive responses and of those with many naive responses to all VOSTS-TR items. When the participants' answers to all VOSTS-TR items were examined, the number of items to which participants had naive responses ranged from zero to four. 32% of participants had at most one naive response (referred to as Group 1), 36% had two naive responses (referred to as Group 2) and the remaining 32% had three/four naive responses (referred to as Group 3). Table 2 presents the metaphors created by each group for each category, and some excerpts from their responses.

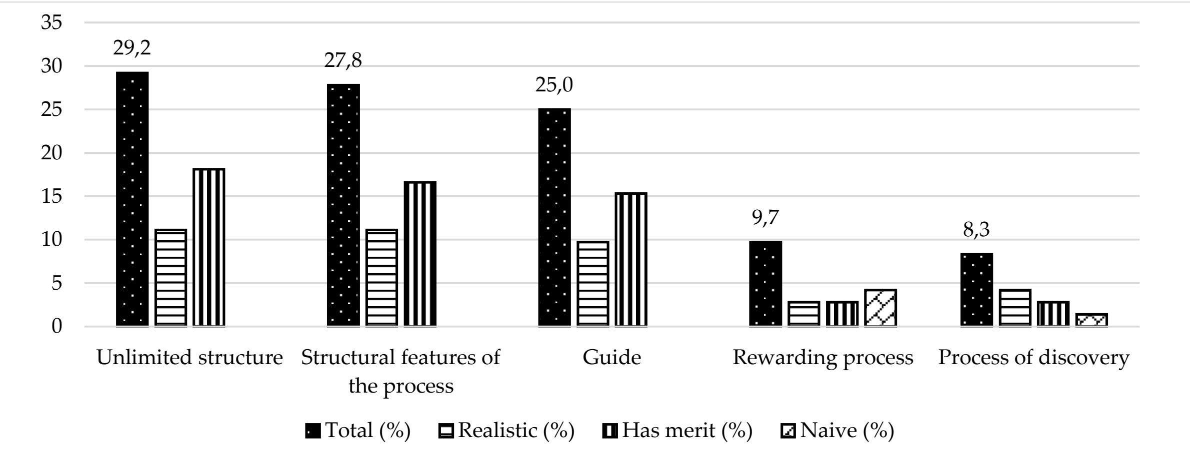

Figure 1. Distributions of participants' metaphors of science and their responses to VOSTS-TR Item 1

Table 2 shows that Group 1 generated 11, 8, and 4 metaphors of science in the categories of unlimited/wide structure, guide, and structural features of the process, respectively, while they generated no metaphors in the categories of rewarding/facilitating process and process of discovery. Group 1 is also the only one that made a statement about the indispensability of science. Groups 2 and 3 generated about the same number of metaphors of science in all categories, with the largest number of metaphors (10 and six respectively) being in the category of structural features of the process. Another notable feature in Table 2 is the difference in interpretation regarding the unlimited/wide structure category between Groups 1 and 3. As the number of naive responses increases, participants' metaphors of science place more emphasis on comprehensiveness/extensiveness than on continuity/eternity.

Table 2. Each groups' number of metaphors (science) and excerpts from their metaphor statements

Categories (Science)	Group 1 (0-1 naive responses) (n=23)		Group 2 (2 naive responses) (n=26)		Group 3 (3-4 naive responses) (n=23)	
	(f)	Sample Statements	(f)	Sample Statements	(f)	Sample Statements
Unlimited/ Wide Structure	11	-it is continuous and renewed -it is a never-ending process	5	-it is everywhere without any limitations -it is constantly renewed	5	-it expands as you learn -it involves lots of facts
Structural Features of the Process	4	-efforts will result in intended outcomes -its necessity should not be discussed	10	-it improves progressively -it needs time, money, and prior knowledge	6	-it is open to innovation -it needs so much effort and hard work
Guide	8	-it acts as a guide to the unknown universe	5	-it always provides information	5	-it guides and illuminates people
Rewarding/ Facilitating Process	0	-	2	-you want to deal with it as long as you have fun	5	-it gives comfort and beauty
Process of Discovery	0	-	4	-new things are constantly discovered	2	-new information is discovered every day

Participants' metaphors of scientists were investigated to compare their responses with the relevant VOSTS-TR item. Figure 2 shows that the percentages of metaphors of scientists generated by participants in the categories of personal characteristics/work habits, guiding, rewarding/facilitating and indispensable are 54.1%, 22.2%, 19.5% and 4.2%, respectively. The comparison of participants' responses to Item 4 and their metaphors of scientists indicate that the majority of them responded Item 4 realistically and generated metaphors for all categories.

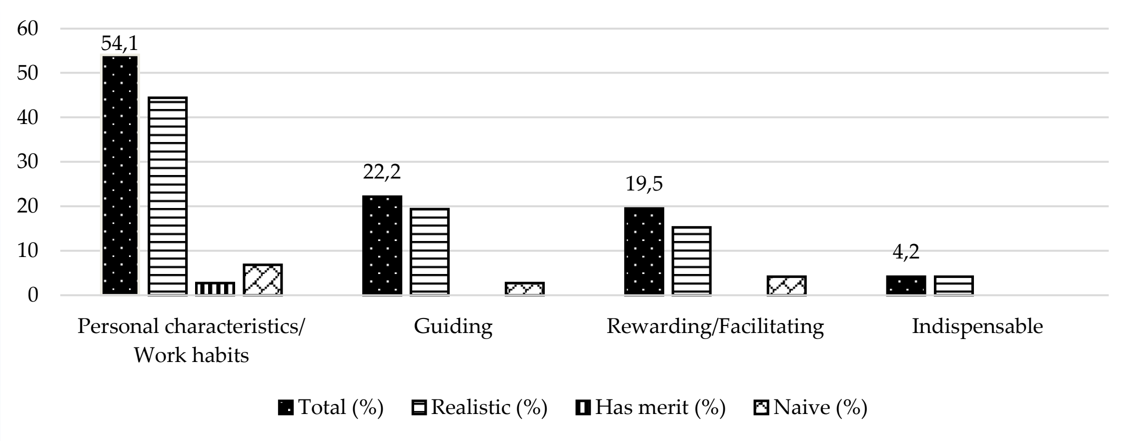

Figure 2. Distributions of participants' metaphors of scientists and their responses to VOSTS-TR Item 4

Table 3 presents the number of metaphors (about scientists) created by each group for each category, and some excerpts from their responses. Group 1 generated more metaphors of scientists in the category of guide than did Groups 2 and 3 while it generated no metaphors in the category of rewarding/facilitating. Group 1 were also the only participants that generated metaphors reflecting the indispensability of scientists. These two findings also emerged in metaphors generated by Group 1 regarding science. This may be due to the fact that participants' perceptions of science and scientists are influenced by or related to each other. The fact that participants who perceive science as an unlimited or cumulative process rather than a useful discovery process also regard scientists as indispensable is compatible with each other.

Table 3. Each groups' number of metaphors (scientist) and excerpts from their metaphor statements

Categories (Scientist)	Group 1 (n=23) (0-1 naive responses)		Group 2 (n=26) (2 naive responses)		Group 3 (n=23) (3-4 naive responses)	
	(f)	Sample Statements	(f)	Sample Statements	(f)	Sample Statements
Personal Characteristics/ Work Habits	13	-always aims to discover new information	12	-discovers beauties with his/her curiosity and desire	14	-seeks science indefatigably and inquisitively -is open to innovations
Guiding	7	-produces accurate information -enlightens people	5	-helps us find our way	4	-guides us -tries something new and tries to teach
Rewarding/ Facilitating	0	-	9	-solves and develops	5	-the one that gives science its flavor
Indispensable	3	-is vital just as brain	0	-	0	-

Though participants in all groups generated about the same number of metaphors regarding the personal characteristics or working habits of scientists, there are differences in the content of metaphors and statements between the groups. The metaphors (mother, astronaut, ant, student, warrior, philosopher, etc.) generated by Group 1 regarding scientists are in the subcategory of "diligent/assiduous" and their statements are mostly about studying, experimenting, researching and exploring especially with emphasis on continuity (13 metaphors). The metaphors generated by Groups 2 and 3 in the subcategory of diligent/assiduous place less emphasis on continuity. Seven participants in Group 2 generated similar metaphors (diver, astronaut, engine, space, cook, etc.) with an emphasis on continuity. Five participants in Group 3 generated metaphors (father, detective, teacher and philosopher) that reflected the characteristics of diligence and assiduousness while only two of them emphasized continuity in their statements. As the number of naive responses increases, participants place less emphasis on continuity (similar with the findings regarding science) but more emphasis on principles (honesty, raising awareness, multidirectional approach, etc.) that scientists should follow or on why and how science is done (shaping, forming, producing information, learning and working meticulously).

Discussion

Discussion Regarding VOSTS-TR Items with High Percentages of Naive Responses

An important finding of the study was that only a few participants' responses to Items 6 (professional interaction in the face of competition) and 7 (scientists' errors in their works) were realistic while the majority of participants' responses to them were naive. This finding can be interpreted as indicating that the majority of participants think that scientists do not cooperate and check on with each other, that they have little confidence in them, and that they violate ethical rules in certain situations. Saraç and Cappellaro (2015) and Türkaslan (2014) also reported similar findings regarding preservice primary school teachers' responses to these items. This might be due to the fact that participants have not met or seen examples of scientists working in harmony and solidarity with each other or showing sensitivity to scientific ethics or that they have been affected by the news on social media of ethical violations.

Another striking finding was that 40.3% and 34.7% of participants provided naive responses to Item 2 (religious and ethical views) and Item 5 (effect of gender), respectively. These were also the items to which participants provided the most conflicting and ambivalent responses during the interviews. Cobern and Loving (2002) conducted a study on preservice elementary teachers using the survey "Thinking about

Science." They reported that participants valued science but did not see it at the top of the epistemological pyramid, that they did not consider science to be more important than religion and that they had some doubts about allowing women and minorities into the world of science. Liu and Lederman (2007) found that preservice teachers were of the opinion that religious and cultural values would not affect scientific studies. Tatar et al. (2011) also reported that preservice primary school teachers thought that scientists should not be affected by social-cultural factors and standards of judgment. The proportion of preservice teachers who were of the opinion that religious and ethical views did not affect scientific research was 26.1% and 24.5% in Türkaslan (2014) and Saraç and Cappellaro (2015), respectively. These percentages are lower than that found in this study. However, 58.2% and 61.8% of participants provided naive responses to Item 5 in the studies of Saraç and Cappellaro (2015) and Türkaslan (2014), respectively. The percentages are higher than that found in this study (34.7%). It can, therefore, be stated that although similar studies on preservice primary school teachers report different percentages of naïve responses to Items 2 and 5, they are considerably high.

The fact that participants, referred to as Group 1, provided only one (if any) naive response to only one of these four items accounts for the high naive response percentage. It is clear that participants have low confidence in scientists exhibiting ethical behavior. It can, however, be derived from the interviews that participants' naive responses to Items 2 and 5 do not necessarily mean that they have insufficient views of these issues. During the interviews, some participants said that they marked the statement "religious or ethical views do not influence scientific research," stating that science cannot progress if some research cannot be conducted due to religious or ethical concerns and if science shifts away from objectivity and scientific data/results are tampered with or ignored. Research shows that religious views have an effect on people's perceptions of NOS (Aflalo, 2018) and even on pedagogical practices of science teachers (Mansour, 2011). Hanley et al. (2014) stated that when students' beliefs are ignored, they are more likely to object to and resist science. Aflalo (2018) has proposed the development of a "dialogue approach" acknowledging the conflict between religion and science, and assuming that the use of scientific arguments and criticism is valid when working on religious issues. The relationship between religion and science is put forward through different approaches, and various pedagogical approaches are proposed in order for people to have a clearer understanding of NOS. There are many factors affecting people's perceptions of NOS in terms of the relationship between religion and science. It is, therefore, necessary to address this issue meticulously (not through responses to only a single item) and to adopt appropriate approaches.

In relation to gender inequality, which has been debated in science education for many years, participants argued, on the one hand, for equality between men and women, while, on the other hand, they stated that discoveries made by men and women would be different because of individual differences and social perceptions. Sinnes (2006, p. 79) has proposed three approaches (gender neutral, female friendly, and gender sensitive) to increase gender equity. According to these approaches, men and women can engage equally in science education, they can produce the same scientific knowledge, or engagement in science education may vary according to biological/social perceptions, or differences among students of the same sex may be as important as (or perhaps more important than) differences between students of the opposite sex. Sinnes (2006) also made some suggestions for curriculum, teaching material and teacher development for each approach. As the contribution of women and men to science can be interpreted from different perspectives, it is important to identify and examine preservice teachers' views in detail and to make necessary arrangements in educational settings accordingly.

Discussion Regarding VOSTS-TR Items with Low Percentages of Naive Responses

Most participants' responses to Item 3 (public influence on scientists), Item 4 (values that guide scientists), Item 9 (nature of observations), and Item 10 (tentativeness of scientific knowledge) were realistic. Some studies (Saraç & Cappellaro, 2015; Türkaslan, 2014) reported similar findings regarding preservice primary school teachers' views of scientific knowledge. Participants in those studies held the view that scientific knowledge may change. On the other hand, some other studies reported that preservice primary school teachers were of the opinion that scientific knowledge is a collection of immutable facts (Craven, Hand, & Prain, 2002; Murcia & Schibeci, 1999; Tatar et al., 2011). Although participants in the studies of Türkaslan (2014) and Saraç and Cappellaro (2015) had higher naive response rates to Items 3, 4 and 9 than those in this study, the majority of participants' responses in both studies were realistic. Overall, these results indicate that the vast majority of preservice primary school teachers have a modern view of some components of NOS, which is a promising finding considering the results of previous studies.

Another interesting finding was the high percentages of "has merit" responses to Item 1 (meaning of science) and Item 8 (following the steps of scientific knowledge). Consistent with the results of this study, a large percentage of participants in other studies provided has merit responses to Items 1 (Saraç & Cappellaro, 2015; Türkaslan, 2014) and 8 (Saraç & Cappellaro, 2015). Different from the results of this study, Türkaslan (2014) reported that the proportion of preservice teachers with naive responses to Item 8 was higher than that of those with has merit responses. The difference in the findings between our study and that study may be due to the fact that participants in the former were second-grade preservice teachers while those in the latter were students at all grade levels.

Participants' high rates of has merit responses to Items 1 and 8 are consistent with the results of their metaphors of science. In their metaphors, participants associate science with such features as rich content, comprehensive, requiring the use of scientific methods, descriptive and problem-solving. It is, therefore, an expected finding that participants would mark the similar has merit options ("which explain the world around us," "to solve problems of interest about the world," "it ensures valid, clear, logical and accurate results") in Items 1 and 8.

Discussion Regarding the Comparison of Participants' Metaphors with Their Views of NOS

A number of studies reported similar findings regarding preservice teachers' metaphors of science and scientists, their repetitive metaphors and categories generated for those metaphors. Similar to the results of this study, Şenel and Aslan (2014) found that preservice teachers frequently generated the metaphors of "light" and "life" for science, and of "light," "sun," "child" and "philosopher" for scientists. The researchers also created in their study the categories of "unlimited/wide structure" for science, and of "indispensable" and "enquirer/explorer" for scientists. Again, similar to this study, Kösem (2017) reported that preservice teachers frequently generated the metaphors of "space" and "life" for science and created the categories of "eternity," "benefit," "guide" and "discovery." Preservice teachers from different departments (music, mathematics, social sciences) who participated in the study of Kıral (2017) also defined scientists as people who produce, invent, explore, reveal knowledge and work for the benefit of humanity.

It is quite clear that metaphors alone are not enough to determine people's views of NOS. Similarly, various measurement instruments consisting of open-ended questions were developed for NOS as a response to the criticism that multiple-choice tests alone would not suffice. This study used multiple-choice VOSTS-TR items, interviews and metaphors together in an attempt to identify the similarities/differences between participants' views of NOS and their metaphors. Although no relational analysis was conducted in this study, there were some differences in the number of metaphors between participants with naive responses to Items 1 and 4 and those with realistic or has merit responses to those items. When the two groups generated a similar number of metaphors in some categories, their explanations about those metaphors differed from each other. For example, the higher the number of naive responses, the lower the number of statements emphasizing the continuity about scientists' working habits. This finding is consistent with the fact that participants with fewer naive responses generated more metaphors of the unlimited and infinite structure of science than did those with a high number of naïve responses. It can, therefore, be stated that participants with a traditional view of

NOS have a tendency to regard scientists as people who produce and form scientific knowledge and make no mistakes while doing so, whereas those with a contemporary views of NOS have a tendency to see scientists as people who constantly work on science as a comprehensive process. It can, therefore, be stated that participants' metaphors and explanations may be used to identify the indicators of contemporary and traditional views of NOS.

Conclusions and Suggestions

The findings of this study and other studies show that preservice teachers hold more contemporary views of some VOSTS-TR items such as tentativeness of scientific knowledge, values that guide scientists, nature of observations, and public influence on scientist while they still approach some other items (influence of religious and ethical views, professional interaction in the face of competition, scientists' errors in their works, ethics, effect of gender on the process and product of science) from a positivist perspective. The items to which participants had mostly naive responses are those concerning ethics in science, which is a highly controversial and oft-discussed issue. Given the fact people's perceptions of ethics in science are influenced by their lives, experiences and religious-moral-cultural-social understandings, some suggestions can be made for researchers, scientists and decision-makers in this regard. First of all, it is crucial to recognize the importance of scientific ethics, and to establish and apply ethical codes/rules. Factors causing people to violate those rules should be investigated, preventive measures should be taken, and scientists should be a role model in this regard. Researchers should determine how and to what extent gender, socio-cultural background and religious understandings influence people's understanding of science. For instance, some researchers emphasize that participants from non-Western cultures have different NOS views compared to their Western counterparts on some aspects (Farland-Smith, 2009; Park, Nielsen, & Woodruff, 2013; Wan, Zhang, & Wei, 2018). Cultural factors should, therefore, be taken into account when shaping or investigating participants' NOS views. In addition, different approaches, methods and techniques should be developed and their effectiveness should be measured to achieve a contemporary level of scientific view. Approaches to improving gender equality or people's (with different religious/ethical views) understanding of NOS should be evaluated in order to adopt one that suits the characteristics of the group that receives training. Taking all these factors into account, the limitations of measurement instruments or approaches that investigate views of NOS should be pointed out.

This study was conducted on 72 second-grade preservice teachers and 10 VOSTS-TR items were used for data collection. Therefore, this study only reflects the participants' views of NOS measured by a certain number of items, thus restricting the generalizability of the results. Further studies should be conducted using different measurement tools on larger sample sizes. Comparing the results of this study with those of further studies using different measurement instruments can yield a more accurate picture of preservice teachers' views of NOS.

This study identified pre-service teachers' preliminary views of NOS prior to their taking science teaching and research methods courses. It is recommended that experimental studies analyze preservice teachers' views of NOS after they take those courses in the senior year to determine whether they still hold naive views or change their views. These results are important as they provide insight into the NOS emphasized in science teaching curricula and into how those curricula are implemented in faculties.

In this study, metaphors were used as a secondary measurement technique. Some trends were found between the categories of metaphors, NOS views and the number of naive responses. There were some differences between the metaphors of participants with realistic/has merit responses and participants with naïve responses to the related NOS items. Moreover, participants having more naïve responses placed more emphasis on comprehensiveness than on continuity in their metaphors of science and they placed more emphasis on principles that guide scientists than continuity in their metaphors of scientists. The lack of a relational analysis in this section is another limitation of this study. However, further studies can explore these trends more deeply and develop dialogue-based strategies through students' metaphors that will enable us to predict/examine their views of NOS more accurately. This can be achieved by teaching preservice teachers how to generate constructive and effective metaphors. Preservice teachers should, therefore, be offered a variety of courses and activities, be provided with the opportunity to develop necessary skills and be encouraged to share and discuss their metaphors with each other.

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