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An investigation of nature of science views of science teachers in project schools in Turkey

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Abstract

The aim of the study was to examine nature of science (NOS) views of science teachers in project schools in Turkey. The sub-research questions of the study targeted at the relationships between the teachers' views on NOS in terms of different demographic features of the participant teachers. The participants were composed of convenience sample of 47 science teachers in different project schools in Turkey. Views on the Nature of Science-C questionnaire developed by Lederman, Abd-ElKhalick, Bell and Schwartz (2002), and a demographic data form developed by the researcher were utilized as the data collection tools. The data were collected via Google form application and analyzed via content analysis, one of the qualitative data analysis methods. The findings of the study showed that nature of science views of the participant science teachers were not in line with the contemporary views about nature of science.

Keywords: Nature of science, project school, science teachers, teachers' viewpoints

1. Introduction

In science education, it is an inevitable fact that students should have certain level of nature of science (NOS) understanding. The arguments supporting the necessity of having certain level of NOS understandings agreed on its contribution to improve scientific literacy. For example, Norris and Phillips (2003) examined the definitions of scientific literacy made by many research groups and educational institutions, and they identified the common emphasis in terms of the knowledge, skills and understandings required for scientific literacy. One of these emphases is the NOS understanding. While there have been ongoing discussions both about the content of the NOS understanding that students should have and how it can be developed (Allchin 2011; Duschl and Grandy, 2013; Irzik and Nola 2011; Lederman 2007; Matthews 2012; McComas 1996;

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Niaz 2009; Osborne et al. 2003), researches on the examination of teachers' and students' NOS understanding have been still valuable (Bayır 2016; Demirdöğen, Hanuscin, Uzuntiryaki-Kondakci 2016; Khishfe, 2015; Olson 2018). When the literature focusing science teachers' NOS understanding was examined, it was revealed that most of the researchers investigated primary (Bilican 2017; Stefanidou & Skordoulis 2017; Ozgelen et al. 2013), middle school science (Mesci & Cobern 2020; Özer et al. 2019; Wicaksono, Minarti, & Roshayanti, 2018) and high school science teachers from various disciplines (e.g., physics and chemistry) (Schizas & Psillos 2019; Pavez et al. 2016). Participants of these studies are not substantially different from each other in terms of their education and teaching experience. However, science teachers working at project schools (project school science teachers) differ from these teachers in terms of their teaching experience, which might contribute to their NOS understanding. Project schools are expected to carry out more comprehensive scientific researches/investigations (e.g., international projects) compared to other schools due to their vision and mission. Considering that project school science teachers should take an active role in these scientific studies, it can be said that it is very important to examine these teachers NOS views to examine whether their experience lead to a more adequate NOS understanding. Therefore, the purpose of this study is to examine NOS understanding of projects school science teachers in some cities of Turkey.

1.1. Project Schools in Turkey

In the 2014-2015 academic years, some schools with suitable infrastructure in Turkey were included in the project school by the Ministry of National Education (MoNE). According to the Regulation on Educational Institutions Implementing Special Programs and Projects published in the Official Gazette, dated 1 September 2016, by the MoNE "schools and institutions that were established within the framework of cooperation agreements with domestic or foreign institutions and organizations or other countries that carry out national or international projects, and schools that implement certain educational reforms and programs are designated as project schools" (MoNE-Regulation on Educational Institutions Implementing Special Programs and Projects, 2016). According to the regulation change published in the Official Gazette, dated 6 July 2018, at least one of the criteria must be fulfilled in order for designating a MoNE affiliated school or institution as project school. Some of the criteria are as;

- to stand out in terms of physical infrastructure, equipment and educational-social activities compared to other schools,
- to be a school that implements or is planned to implement a new or different program or project at national or international level,

- to make a protocol with public institutions and organizations, large-scale enterprises or non-governmental organizations on subjects that include specific applications and comprehensive studies in accordance with its field of duty,
- to be a vocational and technical secondary education institution providing education in a branch program belonging to the field.

Teachers are appointed to these project schools for four years utmost unless they fulfill some general criteria such as "having at least four years of teaching experience including the period of candidacy" rather than special conditions. Number of students in class at project schools is maximum 30. Project schools in both middle and high school levels are divided into different program types such as Anatolian High School, Anatolian Imam Hatip High School, Science and Social Sciences High School, and Science High School. If a student's academic success rank in the nationwide central exams coincides with the percentiles of a project school, this student can be admitted to that school. Apart from this, “If necessary, the admission of students to the project schools at middle level can be determined according to the results of the written or oral exams administered by the school administration” (MoNE-Regulation on Educational Institutions Implementing Special Programs and Projects, 2016).

Available official sources providing detailed information about the project schools are limited to the regulations published in the official gazette, the official web pages of some units of the MoNE, and the official web pages of the project schools. Although information about the total number of the project schools and the teachers working in these schools is not available, there is some information in a brochure on the web page of the General Directorate of Religious Education that introduces the program diversity of the schools. (See http://dogm.meb.gov.tr/pdf/Proje_Kitap.pdf). This brochure contains the following information;

“In project schools, students conduct scientific studies, experiments, examine and make observations. They are actively involved in laboratory work. They conduct research on scientists and their inventions and discoveries. They participate in TUBITAK projects…………. science fairs, debates and sportive activities. Each school prepares the annual work schedule for these activities in October and sends it to the General Directorate.”

While both teachers and students are constantly engage with the activities such as laboratory studies and scientific projects in project schools, there might be a reciprocal interaction between the activities engaged and teachers’ NOS understanding. Teachers’ NOS understanding might have an impact on the activities, and the activities might also have an impact on their NOS understanding. For this reason, it is valuable to determine the NOS views of science teachers working in different types of project schools.

In the literature, there have been very few studies on project schools. (e.g., Günday 2019; Kaya, 2019; Kocasaraç & Karataş 2017; Meşeci Giorgetti et al., 2018; Tabancalı & Becerikli, 2019 Zengin & Karaman, 2020). Günday (2019) conducted a theoretical study focusing on the background of the purpose of establishing project schools and provided examples for functioning of project schools. Kaya (2019) interviewed 4 administrators and 18 teachers about the structure and operation of the project schools where they work. Kocasaraç and Karataş (2017) revealed the perceptions of teachers working in Science and Social Sciences High Schools about innovative teacher characteristics. Meşeci Giorgetti and her colleagues (2018) examined the views of project schools' administrators about whether the project schools carry the qualified school characteristics. Tabancalı and Becerikli (2019) examined school administrators' views on talent management. Zengin and Karaman (2020) examined students' reasons for choosing Project Anatolian Imam Hatip High Schools and their vocational tendencies. Based on the available literature on project school and its teachers, teachers' NOS views have not been a concern among science educators, to the best of author's knowledge. Considering the nature of project schools, this study will make significant contributions both to the literature and the future of project schools, which needs new formation to develop, as it examines the NOS views of project schools science teachers.

1.2. Nature of Science in Science Teaching and Learning

What students should learn and how it should be assessed are among important problems in science education since there has been ongoing debated between science educators and philosophers of science. Nevertheless, some science education researchers argue that there are certain NOS aspects that should be taught in the context of school science lessons (e.g., Abd-El-Khalick, Bell and Lederman 1998, Lederman, Abd-el Khalick, Bell, & Schwartz, 2002; Smith & Scharmann 1999, McCommas and Olson 1998, Osborne et al. 2003, Abd-El Khalick, 2013). They advocate that students from kindergarten through college should have a more complex understanding about science, scientific inquiry, scientific method, scientific knowledge, and scientists without differentiating among different disciplines in science (e.g., chemistry and astronomy). This view expects students to understand aspects that are common to various science disciplines and accepted as adequate. These science educators have provided arguments for that advocation. First, the differences of opinion among philosophers of science, sociologists of science, and historians of science about NOS are not important when educational purposes are taken into account (Lederman, 1998). Second, these disagreements about the NOS need not be surprising or alarming, given the multifaceted and complex NOS (Lederman et al., 2002). Third, disagreements about the NOS are difficult and abstract for students from kindergarden through high school and students can easily understand and generalize at an acceptable level about the NOS related to their daily lives (Abd-El-Khalick et al., 1998). The following are the aspects of the NOS that primary and secondary school students can easily understand and considered to be related to their daily lives (Abd-El-Khalick, Bell and Lederman, 1998);

- Scientific knowledge is tentative (subject to change)
- Scientific knowledge is empirically based (based on and/or derived from observations of the natural world)
- Scientific knowledge is subjective (theory-laden)
- Scientific knowledge is partly the product of human inference imagination, and creativity (involves the invention of explanation)
- Scientific knowledge is socially and culturally embedded.
- The distinction between observations and inferences, and the functions of, and relationships between scientific theories and laws.

McComas (1998) called the misconceptions about science as "myths of science" and stated that these myths were most likely due to the inadequacy of teacher education programs in terms of philosophy of science, the inability of these programs to provide teachers with real scientific research experiences, and the shallow handling of the nature of science in textbooks. McComas (1998) emphasized that these myths about science do not represent all of the important issues that teachers should consider when designing their teaching about the NOS, but that these myths can serve as a starting point for evaluating current instructional focuses when developing future curricula. These myths are listed below.

- Hypotheses become theories that in turn become laws.
- Scientific laws and other such ideas are absolute.
- A hypothesis is an educated guess.
- A general and universal scientific method exists.
- Evidence accumulated carefully will result in sure knowledge.
- Science and its methods provide absolute proof.
- Science is procedural more than creative.
- Science and its methods can answer all questions.
- Scientists are particularly objective.
- Experiments are the principal route to scientific knowledge.
- Scientific conclusions are reviewed for accuracy.
- Acceptance of new scientific knowledge is straightforward.
- Science models represent reality.

- Science and technology are identical.
- Science is a solitary pursuit.

Some researchers have tried to create a framework for NOS by referring to the views of scientists. (e.g., Glasson & Bently 2000; Samarapungavan, Westby, & Bodner, 2006; Schwartz & Lederman, 2008; Wong & Hodson, 2009, 2010). For example, Wong and Hodson (2009, 2010) stated that in addition to the contributions of philosophers, sociologists, and historians of science to the views on NOS, scientists working in the field of discovery of science can also play an important role in developing and refining the views of science educators on issues such as the practices of the scientific community, the nature of scientific studies and the purposes behind it, and the relations between science and the society in which it takes place. Thirteen scientists who have worked in different countries such as the UK, New Zealand, China, USA, and Switzerland from various research fields such as traditional astrophysics and rapidly developing molecular biology participated in their studies. A modified version of the VNOS-C questionnaire (Lederman et al. 2002) and associated interviews were used to determine participating scientists' NOS views. As a result of the analysis of the data, views of scientists on science were gathered under the following three main themes and eight categories under them.

- Methods of scientific investigation
  - Variation of scientific investigation
  - Creativity and Imagination versus Objectivity
- The Role and status of scientific knowledge
  - Theory-laden observation and interpretation
  - Laws, theories, and models, and their tentativeness
- Science as a social practice
  - Funding issues – priorities, ethics, and fraud
  - Collaboration and competition
  - Peer review – issues of status, bias, and self-interest

Erduran and Dagher (2014), who adapted the family resemblance approach of Irzık and Nola (2011) to science education, believe that science can be taught in a more holistic way as a cognitive, epistemic and social-institutional system with this approach. Erduran and Dagher (2014) found the components of the social-institutional system suggested by Irzık and Nola (2014) as limited and added three more components to this system, which are social organizations and interactions, political forces, and financial systems.

When all the debates about NOS have been considered, I can conclude that there is no "consensus list of aspects" for the NOS understandings focused in this study or there is no such approach as the NOS consists of the aspects By taking into account the epistemology of science in the project design process and NOS aspects considered as important for scientific literacy (Lederman et al., 2002), the following NOS aspects were examined in this study; Scientific knowledge is tentative, scientific knowledge is based on inferences as well as observations, the theory-laden nature of scientific knowledge, scientific laws and theories are different kinds of knowledge, experiment is not the only way to reach scientific knowledge, science is not only a body of knowledge, but also a way of knowing, the social and cultural embeddedness of scientific knowledge, scientific knowledge is a product of human imagination and creativity.

1.3. Studies on Investigating Teachers' Understanding of the Nature of Science

Among factors such as teachers, textbooks, classroom teaching, and laboratory experiences that affect students' NOS understanding, perhaps the most important is teachers. A curriculum that does not match the teachers' philosophical approach can be ineffective, even if it is well structured (McComas, Clough, & Almazroa, 1998). For this reason, examining the teachers' views on NOS is among the principal studies in the field of education. Lederman (1992) examined studies from the 1950s to 1992 and showed that science teachers' lack of sufficient NOS understanding is a common result of these studies. Studies conducted in many different countries, including Turkey have revealed that pre- and in-service teachers' NOS understanding is not adequate (Bayır 2016; Chen, 2001; Doğan, 2005; Erdoğan, 2004; Gül & Erkol 2016; Liang et al., 2009; Taşar, 2006; Yeşiloğlu, 2014). Among those studies Liang et al.'s research (2009) has important findings for Turkey. A total of 640 pre-service teachers (209 from the United States, 212 from China, and 219 from Turkey) participated in their study. Their views on observations and inferences, theory and laws, tentativeness, social and cultural factors, creativity and imagination, and scientific method were examined. According to the descriptive statistical analysis results, all pre-service teachers had the lowest score on "theory and laws" and the highest score on "the tentative nature of scientific knowledge". ANOVA results showed that there was a significant difference between three different samples in terms of each NOS aspect. It was found that Chinese pre-service teachers had higher scores than American and Turkish ones in five of the six aspects related to the NOS in the Likert-type scale. Also, American pre-service teachers had more informed views than Chinese and Turkish ones about only the aspect of observation and inference, while Turkish pre-service teachers had more traditional views about all six aspects than the pre-service teachers from other nationalities. The results of this study showed that Turkish pre-teachers did not have contemporary NOS understanding in all dimensions in those years, they need more education about the NOS, and more emphasis should be placed on studies that would improve teachers' NOS understanding in Turkey. Hanuscin, Lee, and Akerson (2010) also argued that studies on both improving pre- and in-service teachers' NOS understanding and developing pedagogical content knowledge for NOS in all countries of the world are insufficient.

Over the last decade, studies investigating the NOS views have shifted towards studies developing activities for teaching NOS and investigating the effectiveness of these activities. However, inadequate NOS understanding (Abd-El-Khalick et al., 1998; Schwartz & Lederman, 2002) is one of the factors that impede teachers' successful NOS teaching practices. In order for teachers to use these activities in their classrooms or to be involved in project-based scientific studies, determining and developing their understanding of the NOS seems to be a never-ending and constantly renewing process.

2. Method

The main research question of this study is: What are the views NOS views of project school science teachers in Turkey? However, whether there are relationships between the teachers' NOS views and their demographic data emerged as a sub-question. Qualitative survey was used as a research design. Qualitative surveys typically consist of a series of open-ended questions exploring people's views and opinions (Braun et al., 2020). The use of open-ended items, rather than ticking pre-determined response categories as in quantitative surveys, allows respondents to explicate their own views (Lederman, Wade, & Bell, 1998) with their own language and terminology (Braun et al. 2020).

2.1. Participant characteristics

Data were collected from a convenience sample of 47 science teachers who work in project schools in Turkey. The participants were informed pseudonyms were used to keep their identities confidential. All the participants voluntarily agreed to participate in the study. The further demographic characteristics about the participants were given in Table 1.

2.2. Data Collection and Analysis

Data collection tools included Views of Nature of Science-C (VNOS-C) questionnaire developed by Lederman, Abd-ElKhalick, Bell and Schwartz (2002) and demographic data form. VNOS-C contains 10 open-ended questions about the NOS views of focused in this study.

The data were analyzed by content analysis. Coding was done according to the framework used by Khishfe and Lederman (2006). In this coding framework, participants' NOS views are evaluated in three different categories, which are naive, transitional, and informed. In order to understand how coding is done, it is necessary to introduce the VNOS-C questionnaire first. Each question in the questionnaire can reveal more than one NOS view. If a participant have informed views about a NOS aspect in all related questions the participant's view regarding that aspect was categorized as informed, if not as naïve. If a participant's views about a NOS aspect were informed in some questions but naive in others, it was coded as transitional. Interrater agreement was established for the reliability of data analysis. Another researcher with experience collecting and analyzing data with the VNOS-C independently analyzed a blind random sample (about 25%). When the interpretations were differed between the author and the researcher, they discussed them until the best represented the meaning of the data. The percentage agreement score was 100%.

Table 1.Participants'demographic information

		N	%				N	%
Gender	Female	37	79	**Experience in teaching profession**		1-5 year	11	23
	Male	10	21			6-10 year	7	15
City	Ankara	22	47			11-15 year	9	20
	Antalya	1	2			16-20 year	10	21
	Bolu	1	2			21 years and over	10	21
	Gaziantep	1	2	**Type of Project School**	**High School**	Anatolian High School	13	28
	Hatay	16	34			Anatolian Imam-Hatip High School	1	2
	İstanbul	1	2			Anatolian Imam-Hatip Science and Social Sciences High School	5	11
	İzmir	1	2			Science High School	4	8
	K.Maraş	1	2			Social Sciences High School	1	2
	Kırşehir	1	2			**Middle School**	23	49
	Malatya	2	4	**Graduate Degree**		Junior college	2	4
Specialized content area in teaching	Physics	5	13			B.S.	37	79
	Chemistry	12	25			M.S.	5	11
	Biology	6	11			P.D.	3	6
	Science	24	51	**Learning experience about nature of science**	**Yes**	University education	1	
Teaching experience the project school	1-2 year	28	60			Master education	3	15
	2-3 year	12	25			In-service education	3	
	4 years and over	7	15			**No**	40	85

3. Results

3.1 Project school science teachers' NOS views

Teachers' views on the NOS were analyzed using both deductive and inductive coding. 8 categories emerged as a result of analysis of participants' views. These categories are given below.

- Scientific knowledge is tentative.
- Scientific knowledge is based on inferences as well as observations.
- The theory-laden nature of scientific knowledge.
- Scientific laws and theories are different kinds of knowledge.
- Experiment is not the only way to reach scientific knowledge.
- Science is not only a body of knowledge, but also a way of knowing.
- The social and cultural embeddedness of scientific knowledge
- Scientific knowledge is a product of human imagination and creativity

3.1.1. Scientific knowledge is tentative (tentativeness)

Teachers' understanding of this aspect was derived from the answers to question 4 in VNOS-C, which directly asks whether scientific knowledge tentative, and question 5, which actually focuses on the difference between theory and law. In question 4, only 2 (4%) teachers stated that the theories would not change, which was an indication of their naïve views about tentativeness. One of those two teachers with naïve views stated that theories could have standard deviations, just like the data, but do not change. The other naive teacher believed that theory would not change because it was supported by convincing evidence. All the other participating teachers (n=45) stated, "Theories can change" (96%). However, analysis of 45 teachers' responses to question 5 showed that 20 (45%) of them advocated that theories could change whereas the laws were absolute. Moreover, most of the teachers' views about the reason for tentativeness of scientific knowledge were also naïve since they believed in scientific knowledge can change over time as technology develops or because it is not accepted by everyone. There were no more epistemologically informed views about the reasons, such as the acquisition of new data or the reinterpretation of existing data. As a result, 4% of the teachers were categorized as naive (n=2), 53% as informed (n=25), and 43% as transitional (n=20). The followings are some participants' responses.

The theory may not be accepted by everyone, so it can change. It can change until it becomes law (Participant 9, VNOS-C/4).

Scientific theories change when they are inadequate and not universally accepted (Participant 9, VNOS-C/4, sub-question).

Scientific knowledge is subject to change. Science is constantly changing as it evolves (Participant 19, VNOS-C/4).

3.1.2. Scientific knowledge is based on inferences as well as observations

Teachers' views about this aspect were obtained through the answers given to the 1st, 6th, 7th and 8th questions. Teachers mostly emphasized the importance of conducting observation and experiments for producing scientific knowledge. Moreover, there was almost no emphasis on the importance of inference as much as observation. Most of the teachers answered the question of what science is either as an effort based on observation and experimentation or as a systematic body of knowledge. While 19% (n=9) of the teachers who stated that both observation and inference are essential in science were informed, 72% (n=34) of the teachers were naïve, and 9% (n=4) were transitional. Below are the responses given by the same participant to the 1st, 6th and 8th questions and the examples of naive views.

Science is to conduct research, obtain data, and innovate without being influenced by anything (Participant 36, VNOS-C/1).

Scientists are certain about the structure of the atom by doing a lot of research (Participant 36, VNOS-C/6).

Through the research conducted by the scientists and the different evidences or the experiments they have discovered (Participant 36, VNOS-C/8).

3.1.3. The theory-laden nature of scientific knowledge (theory-ladenness)

The theory-laden nature of scientific knowledge and inquiry is also closely related to the role of observation and inference in science aspect. Therefore, if the findings related to these two aspects are similar to each other it can be accepted as an indicator of their consistency. According to the responses given to the 6th, 7th, and 8th questions, 19% (n=9) of the teachers were informed in terms of theory-ladenness, while 70% (n=33) of them were naïve, and 9% (n=4) were transitional. Only 1 teacher (2%) answered all of these questions, as "I don't know". The teachers emphasized that scientists' experiments and observations might be different, rather than their theories. It could be concluded that teachers prioritize practice rather than mental processes in science. The same participant’s responses, which were coded as informed, given to the 6th, 7th, and 8th questions are presented below.

I'm having trouble teaching this aspect. Students ask how we can talk so certain about things we can't see. I tell the students that some physical events evidence that this is the case, and many topics are not explained in science and that this is the most valid explanation for now (Participant 30, VNOS-C/6).

They act according to previous classifications. They say they've found a new species if it does not match in any species (Participant 30, VNOS-C/7).

Astronomers and volcanologists consider it from their own perspective. Scientists from different disciplines of science evaluate events in the world within the framework of their own expertise (Participant 30, VNOS-C/8).

3.1.4. Scientific laws and theories are different kinds of knowledge

The teachers' understanding of this aspect was obtained through the 5th question. It was revealed that most of the teachers (79%, n=37) had naïve views about this aspect. Only 1 teacher (2%) stated that he did not know the difference between theories and laws, while 19% of the teachers (n=9) were informed. Participants had naive views such as "laws are more absolute than theories, theories turn into laws if they are proven enough". In addition, it was observed that some teachers confuse the law with the phenomenon in question. For instance, they think the Law of Gravity is the way things fall to the ground. Below are some examples of naïve participants' responses.

Scientific theory may be the common thesis of a person or an organization, but unless this thesis is accepted all over the world, it will not be a scientific law (Participant 19, VNOS-C/5).

A theory becomes a law when it reaches the same result over and over again over a long period of time with different methods (Participant 25, VNOS-C/5).

Laws are proven to be true, theories are not (Participant 36, VNOS-C/5).

3.1.5. Experiment is not the only way to reach scientific knowledge

For this category, besides the responses to the 2nd and 3rd questions, the responses to the 6th, 7th, and 8th questions were also coded. Although more than half of teachers (60%, n=28) had informed views about the empirical nature of scientific knowledge teachers' definitions of "experiment" were not adequate with regard to characteristics and examples of real experiments in science. Teachers' experiment definitions included putting theoretical knowledge into practice (13%), making concretize theoretical knowledge (2%), and confirming/proving theory (11%). These definitions have epistemological problems, which were also indicated by others (Kirchner 1992; Yeşiloğlu ve Köseoğlu, 2020).

Does the development of scientific knowledge require experimentation? 89% of the teachers (n=42) said, "yes" to the question and the rest said "no". Among the participants who responded as no, only 3 (6%) had informed views. Others with no response were categorized as naive since their answers were "no experiment is needed for the situations where science can be done with qualitative data". This answer is an indication that teachers believed that only quantitative data can be obtained through experiments. Teachers' naïve views about the vitality of experiments in science were also evidence for their naive understandings about the scientific method. Below are the examples of naive views including the responses to the 2nd and 3rd questions.

We can say that the experiment is a practical replication of a topic/concept that has been learned in theoretical ways utilizing a pre-prepared plan and by taking safety precautions (Participant 14, VNOS-C/2).

Experiment is a trial. It is conducted to reach the reality and to confirm the accuracy of knowledge (Participant 15, VNOS-C/2).

Experiment is not required. Scientific knowledge can also be supported by qualitative data (Participant 4, VNOS-C/3).

An experiment is anything that can be conducted to concretize the research topic. Yes, (experiment) is required. Experiments at CERN are trying to find more precise knowledge about the past and future of the Earth and the Universe (Participant 32, VNOS-C/2 &3).

3.1.6. Science is not only a body of knowledge, but also a way of knowing

Views about this NOS aspect were evidenced firstly through responses for the question of what science is and other all questions in the questionnaire. Since the responses about what science is are very comprehensive, they could not be categorized as naive, informed, and transitional. However, the responses were coded as; science is a systematic/consistent/objective/concrete/provable body of knowledge (30%, n=14), science is conducting experiments and observations (23%, n=11), and science is a quantitative research (4%, n=2). Although other participants (43%, n=20) did not explicitly emphasize that science is also a way of knowing, there were general statements that science is generally a field of evidence-based research. The most interesting result about this aspect was that the two teachers associated science only with quantity, which were evident in the following responses,

Experiments are for quantitative observational data (Participant 11, VNOS-C/2).

…….although scientists achieve quantitative results, they should use their imaginations so that they can come up with ideas that can investigate or predict the future (Participant 11, VNOS-C/10).

3.1.7. The social and cultural embeddedness of scientific knowledge

Teachers' views of this aspect were directly obtained from the 9th question in the questionnaire. Only 2 teachers (4%) responded, "I don't know" to this question. While 1 teacher (2%) was coded as transitional, 30% of them (n=14) were coded as informed and 64% (n=30) as naive. While explaining that science is universal, the examples given by the teachers with naïve views indicated that they see science as the body of knowledge or invention it produces but not as a process. Below are some responses coded as naive;

I think science is universal since we use the same periodic system everywhere (Participant 1, VNOS-C/9).

Science is universal. What is accepted in a region is recognized all around the world. For example, the law of gravitation applies everywhere (Participant 2, VNOS-C/9).

Science is universal. For example, the law of conservation of mass is equally valid all over the world. Or the symbol for sodium is Na everywhere (Participant 11, VNOS-C/9).

The data about this NOS aspect also revealed that some teachers believed that science is universal because it should be objective. A few teachers claimed that the value to science varies from society to society.

3.1.8. Scientific knowledge is a product of human imagination and creativity

Teachers' views of this NOS aspect were directly obtained from the 10th question in the questionnaire. In addition, the responses to the 9th question were also coded. It was determined that the most frequent number of informed views was observed regarding this aspect. Vast majority of teachers (83%, n=39) had informed views whereas 13% (n=6) had naive understandings, and 4% (n=2) were coded as transitional. Examples of naive views are given below.

Imagination and creativity are not used in science. It is necessary to start with precise data. Science should also be clear (Participant 22, VNOS-C/10).

Creativity and imagination are features that should be used in art. Only facts emerge in science (Participant 36, VNOS-C/10).

Some teachers had the following views about where imagination and creativity were used; at every stage of science (n=5), at planning and designing stage (n=12), at hypothesizing stage (n=3), and when there are some limitations (e.g., when experiment cannot be conducted and when data is limited) (n=3).

3.2. Relationships between Teachers' NOS Views and Their Demographic Data

Considering whether there was a relationship between teachers' demographic data and their views on the nature of science, some findings were noteworthy. The demographic data of the teachers, who were informed in at least 4 and at most 2 of the NOS aspects in the study, were examined. Only 2 of the teachers with informed views about at least 4 NOS aspects (n=11) had previously studied the NOS. The most informed one learned about NOS during undergraduate education while the other through professional development program organized by the MONE. However, it was revealed that other teachers (n=5) who had previous learning experience about NOS were informed in only 1 or 2 aspects. Moreover, only 2 of the informed teachers (n=11) had graduate degree (i.e., Ph.D). Other teachers with graduate degree (n=6) had naïve NOS views. These results are significant since teachers with Ph.D degree and earlier NOS learning experiences had naive NOS views. In terms of experience in teaching profession, 2 of the informed teachers had 1-5 years of experience (one of them has Ph.D) and the others (n=9) had at least 11 years of experience. It can be concluded that more experienced teachers have more informed NOS views.

4. Conclusions and Implications

In this study, project school science teachers' NOS views and some relationships between the teachers' NOS views and their demographic data were examined. The findings of the study showed that most of the teachers (N=36, 77%) had naïve NOS views focused in the study. The number of teachers with informed views about at least 4 or more NOS aspect was 11 (23%). The NOS aspects of which majority of the teachers had informed views were as follows; the role of imagination and creativity in science (83%), scientific knowledge has empirical basis (60%), and scientific knowledge is tentative (55%). The NOS aspects of which majority of the teachers had naive views were as follows; the difference between theory and law (79%), scientific knowledge is based on inferences as well as observations (72%), and the theory-laden nature of scientific knowledge (70%). Many studies have found that teachers' understanding of the difference between theory and law is one of the most naïve views (Bridget, Mulvey, Bell, 2016; Mesci and Schwartz 2017; Wheeler et al., 2019).The common point of project school teachers' the most naive NOS views (difference between theory and law, scientific knowledge is based on inferences as well as observations and theory-laden nature of scientific knowledge) may be related to lack of understanding, or neglecting the role of theories and inferences in science.

Project school teachers, who are expected to conduct projects and scientific researches in line with the mission of the school where they work, had generally naive NOS views, which might affect how they carry out these researches. Akerson, Abd-El-Khalick, and Lederman (2000) suggested that teachers' understanding of how science is done is crucial for implementing inquiry projects in their classroom.

In a study by Akerson et al. (2005), nineteen pre-service teachers learned about NOS through the activities implemented with explicit-reflective approach for a semester. The pre-service teachers' views were taken with VNOS-B questionnaire before and after the implementation. The results showed a progress in terms of their NOS understanding. However, in the interviews conducted 5 months after the end of the study, it was determined that some pre-service teachers returned to their previous naïve NOS views. The followings were concluded from this study; explicit-reflective approach is effective for developing pre-service teachers' NOS understanding; It is not enough to teach NOS with only one course, pre-service teachers should be provided with NOS teaching experiences, and the NOS teaching experiences should be integrated to their all professional development careers. The findings of the present study also support these conclusions. Of the 7 teachers who had previously learned about NOS, only two were informed. Although what these teachers learned and how they learned were not known, it can be concluded that the teachers' previous NOS learning experiences are insufficient considering the fact that those teachers did not have adequate NOS understandings. Based on this finding, it is clear that project schools science teachers should be provided with the opportunities where they both learned about NOS and teach NOS (Akerson et al., 2005).

The data obtained in this study were based on project school science teachers' declarative views on the nature of science. In future studies, to obtain more in-depth data, it would be useful to examine teachers' NOS views during authentic scientific practices (e.g., when they carry out a scientific research), namely their knowledge-in action.

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