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Science Teachers' Views on Nature of Scientific Inquiry

Günkut Mesci[a*] & Eda Erdaş-Kartal[a]

a*, Dr., Giresun University, (http://orcid.org/ 0000-0003-0319-5993) * gunkutmesci@gmail.com
b, Dr., Kastamonu University, (http://orcid.org/0000-0002-1568-827X)

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Abstract

The aim of this study is to examine in-service science teachers' views on nature of scientific inquiry and the possible reasons that led to these views. This study was designed as a multi-case study. 22 middle school science teachers who are currently working in various national education schools in Turkey, voluntarily participated in this study. The data were collected online through the open-ended VASI questionnaire and the follow-up semi-structured interviews, and were holistically analyzed with content analysis. According to the analysis, it was seen that the teachers who participated in this study generally had naive and mix views about the nature of scientific inquiry. It has been observed that these opinions of teachers vary depending on their education level, the courses they took in undergraduate and graduate terms, and the quality of education in in-service training. For example, the teachers who continue their master's and doctorate education in science education have quite an informed view. With this study, it is recommended to give importance to scientific inquiry in teacher training programs and in-service courses, and to encourage teachers to pursue graduate education in the field of science education.

Keywords: Nature of scientific inquiry, scientific literacy, middle school science teachers

Fen Bilimleri Öğretmenlerinin Bilimsel Sorgulamanın Doğası Görüşleri

Öz

Bu çalışmanın amacı fen bilgisi öğretmenlerinin bilimsel sorgulamanın doğası ile ilgili görüşlerini ve bu görüşlere neden olan olası sebepleri incelemektir. Bu çalışma çoklu durum çalışması olarak dizayn edilmiştir. Çalışmaya Türkiye'nin farklı şehirlerindeki devlet okullarında çalışan 22 ortaokul fen bilimleri öğretmeni gönüllü olarak katılmıştır. Açık uçlu VASI ölçeği ve onu takip eden yarı yapılandırılmış mülakatlar yoluyla online toplanan veriler, bütünsel olarak içerik analizi ile analiz edilmiştir. Analiz sonuçlarına göre, bu çalışmaya katılan öğretmenlerin genellikle bilimsel sorgulama ile ilgili naif ve geçiş görüşlere sahip oldukları görülmüştür. Bazı temalarda nispeten daha gelişmiş görüşe sahip olan öğretmenler özellikle lisans üstü eğitim almalarına göre önemli ölçüde farklılaşmışlardır. Özellikle fen eğitiminde yüksek lisans ve doktora eğitimine devam eden öğretmenlerin görüşlerinin oldukça gelişmiş olduğu görülmüştür. Öğretmenlerin bu görüşlerinin eğitim seviyelerine, lisans ve lisans üstü donemde aldıkları derslere ve hizmet içi eğitimlerdeki eğitimin kalitesine bağlı olarak değiştiği görülmüştür. Bu çalışma ile birlikte, öğretmen eğitiminde ve hizmet içi kurslarında bilimsel sorgulamaya önem verilmesi ve öğretmenlerin fen eğitimi alanında lisans üstü eğitim almaları için teşvik edilmesi önerilmektedir.

Anahtar kelimeler: Bilimsel sorgulamanın doğası, bilim okuryazarlığı, ortaokul fen bilimleri öğretmenleri

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1 | INTRODUCTION

The most important goal of science education is to raise scientifically literate individuals (AAAS, 1993; National Research Council (NRC), 2011; New Generation Science Standards (NGSS), Lead State, 2013; Ministry of National Education (MoNE), 2018). Scientific literacy is defined as "a combination of science-related skills, attitudes, values, understanding and knowledge, critical thinking, problem-solving and decision-making skills, and maintain a sense of curiosity about the environment and the world" (MoNE, 2005). In other words, scientific literacy is knowing and understanding nature of scientific knowledge and how this knowledge is produced, being aware of how science, technology, and society affect each other, having positive attitudes and value judgments about science and technology, and being able to use this knowledge and awareness in daily life (NRC, 1996). In this sense, nature of science (NOS) and nature of scientific inquiry (NOSI) have been recognized as essential components of science literacy (Lederman, Lederman & Antink, 2013; NGSS, 2014).

SCIENTIFIC INQUIRY AND NATURE OF SCIENCE

Teachers and science educators still come up against various uncertainties regarding the specific characteristics of NOSI and NOS and their integration into existing science teaching and science curriculum (Flick & Lederman, 2006; Park, 2008). The concepts of NOSI and NOS are often used interchangeably (Lederman, 2007; Lederman et al., 2014). Although NOSI and NOS are closely related, the concepts have different structures (Flick & Lederman, 2006; Lederman, 2019). NOSI involves science processes, also refers to combining these processes with scientific knowledge, scientific reasoning, and critical thinking to develop scientific knowledge (Lederman, Antink, & Bartos, 2014). NOSI includes asking questions, planning and applying the research, mathematical thinking, analyzing and interpreting data, and using communication skills effectively in explaining the facts with evidence in the part of sharing and discussing the findings (NRC, 2012; Pedaste et al., 2015). On the other hand, NOS refers to certain characteristics that limit and do not limit the use of scientific knowledge produced as a result of scientific inquiry (Flick & Lederman, 2006). In summary, NOSI is the process in which scientific knowledge is produced, while NOS refers to the basis of the knowledge produced as a result of this process, the epistemology of science, science as a way of knowing, and the values and beliefs inherent in the development of scientific knowledge (Lederman 1992; Lederman, 2006).

Researchers have a common view about the features of NOSI (Lederman et al., 2014; Osborne, Ratcliffe, Collins, Millar, & Duschl, 2013; Schwartz, Lederman, & Lederman, 2008). The characteristics of NOSI that are used as the targeted aspects in this study were listed as (a) all scientific investigations must begin with a question and do not necessarily test a hypothesis; (b) there is no single scientific method or sequence of steps followed in all investigations; (c) inquiry procedures are guided by the question asked; (d) all scientists performing the same procedures may not get the same results; (e) inquiry procedures can influence results; (f) research conclusions must be consistent with the data collected; (g) scientific data are not the same as scientific evidence; (h) explanations are developed from a combination of collected data and what is already known (Lederman et al., 2014; Lederman et al, 2019).

LITERATURE REVIEW AND PROBLEM STATEMENT

Scientific inquiry is seen as two different outputs for students. These are the ability to do scientific processes and to have knowledge about these processes. In international teaching documents, it is stated that scientific inquiry should be emphasized as skill and understanding (NGSS, 2013). It is not possible for students to know the scientific inquiry procedures and to participate in simple inquiry experiences without knowing the NOSI, understanding the epistemology of science, and achieving the objectives that are targeted by scientific inquiry (Doğan, Han-Tosunoğlu, Özer, & Akkan, 2020; Lederman, 2006; Metz, 2004; Wong & Hudson, 2010). Recent studies have, unfortunately, revealed that NOSI views of K12 students of all levels are naive and undeveloped (Anggraeni, Adisendjaja, & Amprasto, 2017; Aydeniz, Baksa & Skinner,

2011; Bell, Blair, Crawford, & Lederman, 2003; Doğan et al., 2020; Leblebicioğlu et al., 2020; Lederman et al., 2019; Lederman, 2012; Lederman, Bartels, Liu, & Jimenez, 2013; Yang, Park, Shin, & Lim, 2017). In this context, teachers are the most critical actors in the process of adopting scientific inquiry in science lessons and developing students' views on the targeted aspects of NOSI (Bostan-Sarıoğlan, 2018). Lack of understanding about scientific inquiry is one of the obstacles for teachers to apply scientific inquiry on their own lessons (Roehring & Luft, 2004). For this reason, it is of great importance for teachers to understand NOSI, which forms the basis of scientific knowledge and guides scientific research, and to carry out scientific inquiry applications (Zion & Mendelovici, 2012).

It has been revealed that teachers' NOSI views are quite limited because of perceiving NOS and NOSI as the same concepts (Lederman et al., 2014), focusing on teachers' inquiry skills rather than their NOSI views, and no sufficient measurement tools to reveal individuals' views of NOSI (Lederman et al., 2019). The studies investigating the individuals' NOSI views are mostly conducted with pre-service teachers, and it has been emphasized that the opinions of the pre-service teachers on NOSI are insufficient (Baykara & Yakar, 2020; Bostan-Saroğlan, 2018; Crawford, Zembal-Saul, Munford, & Friedrichsen, 2005; Haefner & Zembal-Saul, 2004; Mesci, Çavuş-Güngören & Yeşildağ-Hasancebi, 2020; Schwarz, 2009; Şenler, 2017).

When findings of these studies in which in-service teachers' opinions about NOSI are examined, it is seen that the teachers' views of NOSI are insufficient and the studies conducted are quite limited. One of these studies conducted by Lederman and Lederman (2004) included a three-week summer camp focusing on NOS, scientific inquiry, and unified concepts through a series of explicit/reflective activities, reading and discussion, followed by a teacher development program that included monthly workshops throughout the academic year. They found that the participants began the camp with naive views of NOSI especially about the scientific method, and after the trainings and practices, teachers improved their views on NOSI by 85%. In another study, Roehring and Luft (2004) identified the lack of understanding about scientific inquiry as one of these obstacles in their study, where teachers investigated the obstacles in applying scientific inquiry lessons. Lotter, Harwood, and Bonner (2006) examined the concepts and products developed by high school science teachers in a two-week summer camp, which is a part of a long-term professional development program, emphasized that most of the teachers before the camp had insufficient understanding of scientific inquiry and that they improved their understanding after the camp. In their study investigating the effect of an inquiry-based professional development program on teacher' views on NOS, their practices, and student views, Akerson and Hanuscin (2007) revealed that teachers' understanding of scientific inquiry was insufficient at the beginning of the program and they did not include scientific inquiry in their practices. Capps and Ross (2010) examined the effect of a professional development project on teachers. They found that most of the inexperienced teachers' scientific inquiry views were inadequate (naive) compared to experienced teachers (years of service 30 years or more). Dudu (2014) investigated the views of South African high school teachers about NOSI and revealed that teachers have mixed views. Bahbah et al. (2013) investigated the concepts about NOSI of primary and middle school teachers and the effect of participation in the research experience prepared for two different teacher group. They determined that although teachers started the program with sophisticated views, participation in research concepts improved teachers' understanding. Bartos and Lederman (2014) investigated physics teachers' knowledge about NOS and in-class applications on scientific inquiry. They found that there was a limited compatibility between teachers' knowledge structures about NOS and scientific inquiry. It was stated that all the views of four teachers participating in the study about scientific inquiry are at a sufficient level. Strippel and Sommer (2015), in their study investigating how teachers in chemistry classrooms incorporate teaching of scientific inquiry into their laboratory practice, revealed that teachers do not consider teaching NOSI as the main goal, but rather focus on scientific inquiry and developing inquiry skills. Also, they found that the teachers with doctoral degrees realized the role of scientific inquiry, especially the role of questions in scientific research, more than teachers without a doctorate. In their study comparing the views of Chinese and American science teachers on NOS and

NOSI, Wang and Zhao (2016) revealed that Chinese teachers' views on most components of NOSI are at a traditional level, and that American teachers' views are better than Chinese teachers. Adisendjaja, Rustaman, Redjeki and Satori (2017), in their study of science teachers' understanding of scientific inquiry in a professional development program focused on NOS and scientific inquiry, stated that most science teachers had insufficient understanding of scientific inquiry. In their study examining the understanding of science teachers' understanding of NOSI and their use of scientific inquiry in their lesson plans, who participated in a professional development program, Çiğdemoğlu and Köseoğlu (2019) revealed that teachers had insufficient views about scientific inquiry before the program. They reported that teachers' views improved after the program.

Related literature shows that teachers' opinions about NOSI may affect their scientific inquiry practices. In order to implement the scientific inquiry approach that is expected to be adopted in science teaching programs, it is necessary to determine the science teachers' NOSI understanding. It is anticipated that determining the views of science teachers about scientific inquiry might be the basis for the trainings to be planned to eliminate the deficiencies in this subject. As seen the literature given above, there are not enough studies in the national literature investigating the opinions of in-service science teachers on NOSI. It is thought that studies at national level are needed to fill this gap in the literature.

Purpose of the study and research questions

In this study, it is aimed to determine the science teachers' NOSI views and to reveal the factors that cause their views. The following research questions are guided to this study.

1. How do science teachers think about NOSI?
2. What are the factors affecting science teachers' views on NOSI?

2 | Method

This study was a qualitative exploratory case study of science teachers' views about NOSI. Each teacher's views of the aspects of NOSI and underlying reasons of these views were examined which in single-case embedded design (Yin, 1984). A case study is a research strategy in which the researcher thoroughly investigates a program, event, activity, process, or one or more individuals within a bounded time using a variety of data collection procedures (Creswell, 2009).

Participants

22 middle school science teachers (18 females, 4 males; average age: 38), who are currently working in various national education schools in Turkey, participated in this study. Ethical permissions were obtained for the study and teachers voluntarily participated in this study by signing the consent form. All of the teachers had graduated from a 4-year science education department in an education faculty. Some of them (11) are still continuing to do on their master's degree in the different programs like, master in science education, master in curriculum development, or master in measurement and evaluation, while some teachers (4) are continuing to do on their doctoral program in science education (see Table 1). Table 1 also shows the duration of the participants' professional teaching experience, whether that they had taken any NOS course during their bachelor, and whether that they attended any in-service training and any training about NOSI on those in-service training.

Table 1. Participants' Demographics

Participants	Gender	Highest Educational Degree	Professional Experience	NOS course during the bachelor	In-service training/NOSI teaching
ST1	Female	Ph.D. (S.Ed.)	6 years and above	Yes	Attended/Yes
ST2	Female	Master (M.Ed.)	6 years and above	do not remember	Attended /No
ST3	Male	Bachelor	6 years and above	do not remember	Attended /No
ST4	Female	Ph.D. (S.Ed.)	6 years and above	Yes	Attended /Yes
ST5	Female	Master (M.Ed.)	6 years and above	do not remember	Attended /No
ST6	Female	Bachelor	3-6 years	do not remember	Attended /No
ST7	Female	Master (M.Ed.)	6 years and above	do not remember	Attended /No
ST8	Female	Master (M.Ed.)	6 years and above	Yes	Attended /No
ST9	Female	Master (S.Ed.)	6 years and above	Yes	Attended /No
ST10	Female	Ph.D. (S.Ed.)	6 years and above	Yes	Attended /No
ST11	Female	Bachelor	6 years and above	do not remember	Attended /No
ST12	Female	Master (M.Ed.)	6 years and above	Not sure	Attended /No
ST13	Female	Master (S.Ed.)	6 years and above	Yes	Attended /Yes
ST14	Female	Master (S.Ed.)	3-6 years	Yes	Attended /No
ST15	Male	Bachelor	0-3 years	Yes	Attended /No
ST16	Male	Ph.D. (S.Ed.)	3-6 years	Yes	Attended /No
ST17	Female	Master (S.Ed.)	3-6 years	Yes	Attended /No
ST18	Female	Master (S.Ed.)	6 years and above	Yes	Attended /No
ST19	Female	Bachelor	6 years and above	do not remember	Attended /No
ST20	Female	Master (M.Ed.)	6 years and above	Yes	Attended /No
ST21	Female	Bachelor	6 years and above	do not remember	Attended /No
ST22	Male	Bachelor	6 years and above	Not sure	Attended /No

*Ph.D. (S.Ed.) indicates the participant has a Ph.D. degree at science education.

**Master (S.Ed.) indicates the participant has a Master's degree at science education.

***Master (M.Ed.) indicates the participant has a Master's degree at an educational program like, curriculum development or measurement and evaluation.

The teachers' names have been changed with codes in accordance with the principle of confidentiality and no expressions that reflect the true identities of the teachers have been used in any way. In this context, teachers were coded as Science Teacher (ST) and the numbers that follow, like ST1, ST2 etc.

Data collection

The data were collected using The Views About Scientific Inquiry (VASI) questionnaire, which was created by Lederman et al. (2014) and translated into Turkish by Mesci, Çavuş-Güngören & Yeşildağ-Hasancebi (2020). There are seven open-ended questions in the VASI questionnaire in order to reveal participants' NOSI understandings. Due to the pandemic, the data were collected online. The questionnaire was uploaded to google form, and the link shared with the teachers. It took about 20 minutes to filled out by the teachers. The follow-up semi-structured interviews were conducted with each teacher in order to make the answers more understandable and clearer, and to reveal the possible reasons leading to these answers. The online interviews took about 30 minutes for each teacher. While the interview questions vary depending on the individual responses, the typical questions based on the participant's answers were: (1) Can you explain what you mean by saying "_____" in your answer to the question "_____"? Can you give an example to help me understand what you think? (2) Have you considered this kind of issues before? When did you think? (3) What are the things (s) that make you think like that related to this question "....."?

(4) Do you use a similar example in your lessons? (5) Have you taken any lesson or training (in-service or university) related to these issues before? If yes, could you explain the general effect of this on you and your answers?

Data analysis

The teachers' responses to the questionnaire and follow-up interviews were analyzed in a holistic way. The codes and themes, which were identified by Lederman et al., (2014) for analyzing individuals' NOSI views were used during the analysis. A profile had been created for each teacher and their views on the targeted NOSI aspects were classified from naive "-", to mixed "(+)", to increasing level of understanding "+, ++, +++" on a continuum scale (Schwartz et al., 2008) (Figure 1). The teachers' responses were coded as naïve (-) if they have insufficient knowledge or incompatible view about the targeted NOSI aspects. If they have sufficient knowledge about the targeted aspect that is compatible with the literature, they were coded as informed. The informed level ("+", "++", "+++") varies depending on the explanations given appropriate examples with their own sentences. If the teachers' responses show inconsistency within the questionnaire or during the interviews, they were coded as mixed "(+)".

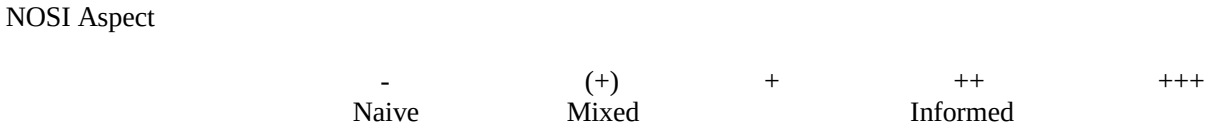

Figure 1. *NOSI Continuum Scale*

Interview data about the reasons that constitute the basis of the teachers' NOSI views were analyzed through content analysis, and codes, themes, and categories were created accordingly. In order to show the effect of teachers' education levels on their NOSI views, the teachers' NOSI views included in each education level were found by proportioning the number of naïve, mixed, and informed ranges in total number of categories.

All data for each participant were analyzed according to the credibility criteria (Başkale, 2016). 20% of all data were analyzed separately by the researchers. Analyses were compared and differences were resolved by further consultation of the data. Then, 40% of the data were again analyzed separately. Results were discussed until 100% consensus was reached. The first author subsequently analyzed the rest of the data.

Research Ethics

After obtaining the necessary ethical permissions for the collection and analysis of the data with the decision of Kastamonu University Social and Humanitarian Research and Publication Ethics Committee, dated 4.05.2020, number 27, the researchers sent a consent form to all potential participant teachers in order to participate in this stud via written script that was used online during the Covid-19 pandemic. The teachers who are interested in the project were asked to read the consent form carefully. After reading the consent form, the teachers who are agreeable to participate in this study, were asked to sign and return the informed consent form to the researcher, who then printed the forms and sealed them in an envelope.

Findings

According to the results of the analysis, it was found that the teachers who participated in the study had generally a naive or mixed understanding regarding the targeted NOSI aspects. The views of each teacher regarding each NOSI aspect are represented in the table below (Table 2). Teachers generally have naive and mixed views in some NOSI aspects, such as, "scientific investigations all begin with a question and do not necessarily test a hypothesis", "inquiry procedures are guided by the question asked", "all scientists performing the same procedures may not get the same results", and "scientific data are not the

same as scientific evidence" (Figure 2). The representative quotations of the teachers' NOSI views are given in Table 3.

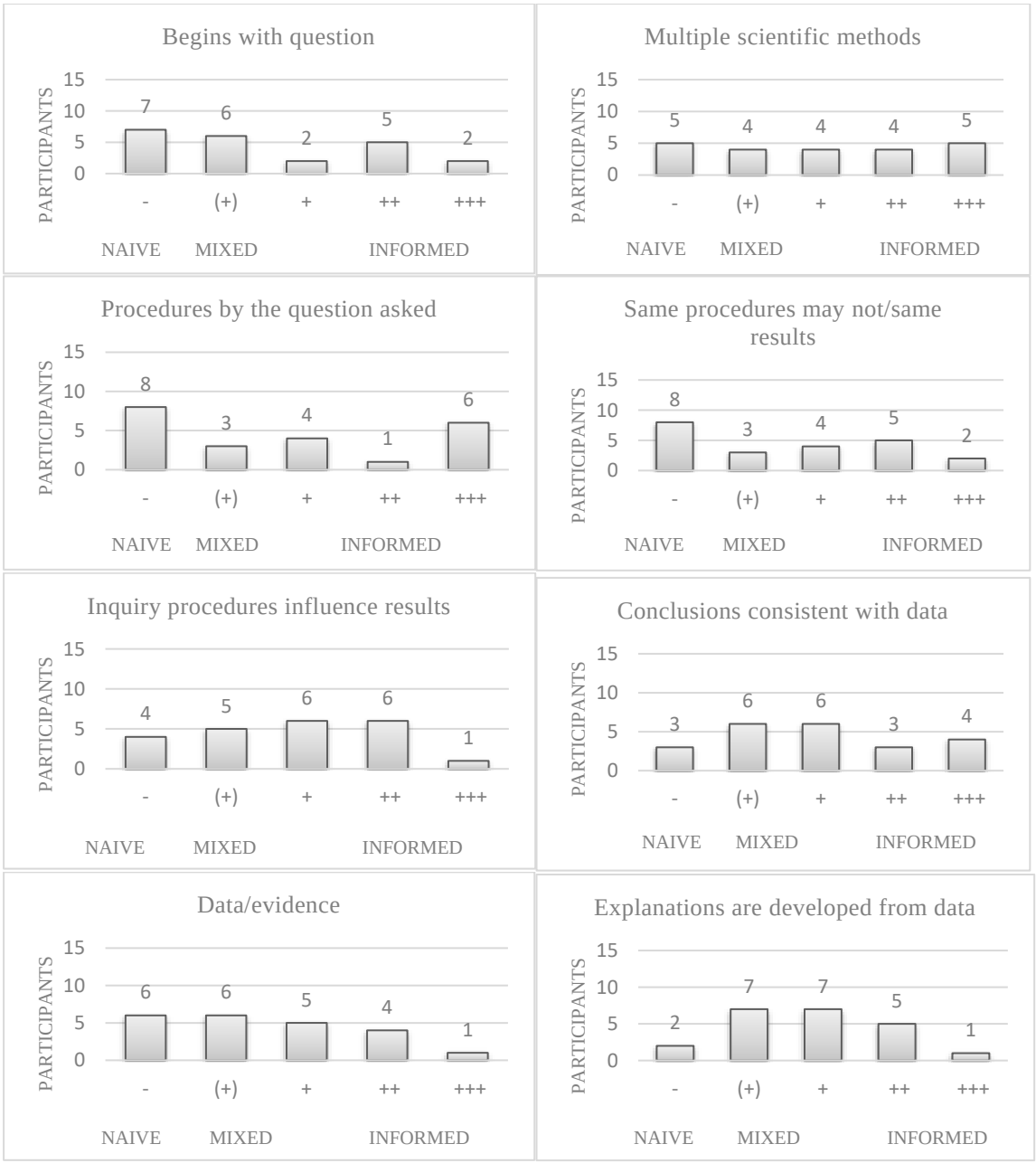

Figure 2. *Views in Relation to Each NOSI Aspect*

Table 2. Alignments of Science Teachers' Views of NOSI with Current Reforms

Participants	Begins with a question	Multiple Scientific Methods	Procedures are guided by the question asked	Same procedures may not get the same results	Inquiry procedures influence results	Conclusions consistent with data collected	Data/evidence	Explanations are developed from data…
ST1	+++	+++	+++	+++	++	+++	+	++
ST2	(+)	-	(+)	+	+	-	++	+
ST3	-	(+)	-	(+)	(+)	++	+	(+)
ST4	+++	+++	+++	+++	+++	+++	+++	+++
ST5	+	+	-	+	+	(+)	-	+
ST6	-	+++	-	-	(+)	-	(+)	(+)
ST7	-	+	+++	-	+	(+)	++	+
ST8	++	-	+++	-	-	+++	(+)	++
ST9	(+)	++	-	(+)	+	(+)	-	+
ST10	++	+++	+++	++	++	+++	++	++
ST11	-	+	-	+	+	+	(+)	(+)
ST12	(+)	-	+	-	-	+	(+)	(+)
ST13	(+)	+++	+++	-	-	(+)	+	(+)
ST14	++	++	-	++	++	+	+	++
ST15	-	-	-	(+)	(+)	-	-	-
ST16	++	++	++	++	++	++	++	+
ST17	+	(+)	-	++	++	(+)	(+)	++
ST18	++	++	+	+	+	++	+	+
ST19	-	(+)	(+)	-	(+)	+	-	+
ST20	(+)	+	+	++	++	+	-	(+)
ST21	-	(+)	(+)	-	(+)	(+)	-	-
ST22	-	+	-	+	+	(+)	-	(+)

"–" indicates naïve views of the targeted NOS aspect, "(+)" indicates mixed or transitional views, "+" indicates the participant's agreement with the current views, "++" indicates the participant's ability to articulate the meaning of the aspect in his/her own words, "+++" indicates the participant's ability to articulate the meaning of the aspect in his/her own words and provide examples

31% of the teachers (n: 7) thought that scientific investigations do not have to start with a question, and that science sometimes existed spontaneously. 27% of teachers (n: 6) gave inconsistent answers. Some teachers believed that a hypothesis had to be tested in science, while others used unstable statements about whether scientific research starts with a question. 40% of the teachers (n: 9) have an informed view on this aspect. Only two of them (these are doctoral graduate teachers) have more informed views and they stated and expressed their opinions with the appropriate examples that a scientific research starts with a question, but it is not necessarily to be tested with a hypothesis (Table 3).

22% of the teachers (n: 5) believed that there is only one scientific method and that all scientists must follow this method. They thought that if it is not followed in the exact order, what is done is not a scientific study. 18% (n: 4) had inconsistent answers and thought that there was only one scientific method, but scientific knowledge could still be produced if this method was not applied. In contrast, 59% (n: 13) stated

that there would be no single scientific method. Teachers, especially those with a more advanced view, argued that there are more than one scientific method and scientists do not have to follow one exact step (Table 3).

Regarding the aspect of "inquiry procedures are guided by the question asked", 36% of the teachers (n: 8) had naïve views, and they could not fully explain the importance of research questions in a scientific study. In general, they believed that the inquiry process was unique and independent of the question in a scientific study (Table 3). 50% of the teachers (n: 11) have advanced opinions on this aspect. In particular, teachers with a more informed view explained the effect of the research question on the research process in a scientific study by giving appropriate examples (Table 3).

36% of the teachers (n: 8) thought that in scientific studies where the same process is followed, the result should be the same because they stated that there is only one truth in science. They thought that if different results are found, there is definitely an error in the inquiry procedure, that error has to be corrected. While 13% of the teachers (n: 3) stated that they were undecided, 50% (n: 11) argued that different results could be obtained even if the same process has been done (Table 3).

Regarding the fact that the inquiry process affects the results in a scientific study, 18% of teachers (n: 4) had naive views and believed that the inquiry process will not affect the results. 22% of the teachers (n: 5) had undecided views, while 59% (n: 13) had informed understandings and thought that the inquiry process might affect the results of the research (Table 3).

Related to the aspect of "conclusions should be consistent with the data collected", 13% of the teachers (n: 3) had a naive view with this aspect. These people interpreted the data according to they have already known, and tried to fabricate the results (Table 3). 60% of the teachers (n: 13) had an informed view about this aspect and underlined that the results should be consistent with the data collected by interpreting the data correctly in the table provided (Table 3).

Table 3. Representative Quotes of Science Teachers' Views of NOSI Aspects

NOSI Aspects	Representative Quotations	
	Naive Views	Informed Views
Begins with a Question	Scientific research does not always start with a question. Scientists often formulate and test a hypothesis for their research to be scientific. (ST6)	A scientific investigation depends on the evidence of a claim based on the data, so a start is required. Thus, scientific research starts with questions because the greatest characteristics of scientists are that they are curious and ask questions. For example, Leeuwenhoek discovered unicellular microorganisms with the question of what I can see if I examine the water in the pond in his garden. (ST1)
Multiple Scientific Methods	In the scientific research, there is only one method and it is clear that the process must be followed so that it can be accepted as a scientific process. The first step is to create a problem, the second step is to make observations, then to collect data as a result of observations, to form a hypothesis in the light of the data, then to make predictions and examine them with experiments. If this order is not followed, the result will be wrong and not scientific. (ST8)	Scientific investigations are carried out with more than one method, for example, a controlled experiment can be done to find out that the potential energy is dependent on height. This is an experimental research. When we look at the theory of evolution, millions of years old fossils have been examined, observed, classified, and made logical inferences. When we look at the theory of relativity, we see that scientific research is done not only with observation and experiment, but also with imagination, creativity and mathematical deductions. (ST4)
Procedures are Guided by the Questions Asked	The path followed by Team B is correct because they have tested the quality of the tire by testing on different roads. (ST11)	If looking at the research question, it is necessary to focus on the quality of the different tires and so keep the road variable constant. Therefore, the research of the team A is consistent with the research question. (ST10)
Same Procedures may not Get the Same Results	If scientists investigate the same question and follow the same methods to collect data, they all get the same results. (Of course, all conditions should be equal. If there are no errors caused by measurement tools or the researcher) Repeatability is important in scientific studies. (ST19)	Even if the methods are the same, No, they do not reach the same result because the inferences vary according to the attitudes and values of the scientist, their perspective, the society they live in, their religious beliefs, and their culture. (ST16)
Inquiry Procedures Influence Results	If scientists investigate the same question and follow different methods to collect data, they all achieve the same results. If the research methods selected are scientific, the results should be the same. (ST13)	They may not achieve the same result. Their conclusion is not only related to whether the method they followed is the same or different because it is important how they evaluate the data, how they make inferences from this data, if they can make the same inferences, they can reach the same result. (ST20)
Conclusion Consistent with Data Collected	Plants grow constantly as they get sunlight because I knew it, plants do photosynthesize. (ST2)	If we interpret it according to the data in the table, as the duration of sunlight that the plant is exposed increased, the growth decreased, then it is increased at a certain point and then the growth stopped, so we can say that there is no relationship between this plant's growth and the sunlight it receives. (ST8)
Data/Evidence	While data is information specific to the observer, evidence is more of the information detected by many observers. Evidence is therefore a stronger concept. I think it is different and the evidence will bring faster results in scientific work. (ST22)	Data is collected and obtained in a study, from the observations or experiences. On the other hand, evidence is the arguments we use to support our claims by interpreting the data. (ST4)
Explanation are Developed from Data and What is Already Known	When scientists explain the results of their research or interpret other studies, they use the truth that everyone accepts. (ST15)	Scientists make their conclusions in accordance with the combination of data that they have and what is already known from existing literature. (St17)

Factors affecting teachers' views on NOSI were categorized into three groups, which are the education level, and the courses taken during the undergraduate and graduate periods, and in-service education. It is a striking factor that the majority of those who have this naive and mixed views about NOSI aspects are the teachers who only have bachelor's degree. It was observed that the education levels of the teachers differed positively especially in favor of the doctoral students who continue on their doctoral program in science education have more advanced views for each NOSI theme. It is seen that among graduate teachers who continue their master's degree in science education had more advanced views than those who continue their master's degree in another education program, like curriculum development or assessment and evaluation. Table 4 shows the relationship between teachers' education levels and NOSI views.

Table 4. The Relationship Between the Teachers' Education Levels and Their NOSI Views

Highest Educational degree		Naive	Mix	Informed
Bachelor		%42	%35	%23
Master	Another Educ. program	%27	%20	%53
	Science Education	%15	%22	%63
Ph.D. in Science Ed.		0	0	%100

Teachers stated that another factor affecting their NOSI views is the courses they have taken, especially during the undergraduate and graduate studies. The pre-service teachers mostly emphasized the effects of courses such as the nature of science and philosophy of science taken during these periods. They stated that they found the opportunity to use the knowledge they have learned in these courses, and that they had the opportunity to use their research in their courses in the school.

"Within the scope of the nature of science course that I took during my Ph.D., we have elaborated on what scientific inquiry is and the themes that make up scientific inquiry. Therefore, it was not difficult for me to answer these questions. For example, before these courses that I had not been taken, I believed that there was only one truth and one method in science. But I understood that this is not like that, and I often underline this to my students, too." (ST4)

"I remember a lesson with these issues during my undergraduate period, but it's been a long time, so I can't remember much. For this reason, I was not so sure when answering the questions." (ST15)

"During my graduate education, I had studies on nature of scientific inquiry and nature of science. My advisor was working on these issues, so I tried to integrate these topics into my lessons so I feel quite enough myself about these issues." (ST1)

Another factor that affects teachers' NOSI view is the participation in in-service training. The importance of scientific inquiry is better understood within the scope of the new science education program, especially for teachers attending in-service trainings or science camps.

"I attended an in-service training last semester. The expert, who carried out the training, frequently spoke about the importance of the scientific inquiry in science education, and stated that the new program was built on it. I can say that many of the answers I have provided have been learned from this in-service training." (ST18)

"I attended a lot of in-service training, but none of these issues were touched on. In fact, when I answered the questions, I realized that I constantly used these concepts in my lessons but I do not really know what they mean. For example, I use the concepts of data and evidence many times in my lessons, but I had difficulty in answering when you asked, I am not sure whether I answered correctly. I wish the in-service trainings would be tightened to learn these basic concepts." (ST22)

4 | Discussion & Conclusion

The purpose of this study was to reveal the science teachers' views about NOSI and the possible reasons that led to these views. In accordance with previous studies (e.g., Baykara, Yakar & Liu, 2018; Bostan-Saroğlan, 2018; Crawford et al., 2005; Doğan, 2017; Haefner & Zembal-Saul, 2004; Karışan, Bilican & Şenler, 2017; Mesci, Çavuş-Güngören & Yeşildağ-Hasancebi, 2020), findings of this study showed the science teachers generally have naive and mixed views of the targeted NOSI aspects. It has been observed that teachers' views were more informed especially in some NOSI themes (e.g. Inquiry procedures influence results) than some other NOSI themes (e.g. scientific investigations begin with a question). Contrary to the studies in the literature (e.g., Lederman and Lederman, 2004), the teachers participated in this study have generally informed views related to multiple scientific methods. Interestingly, it was observed that teachers had a highly informed view on the aspect of "explanation are developed from data and what is already known", which was analyzed in relation to the question asked with the dinosaur skeleton on the VASI questionnaire. Contrary to the findings of Crawford, Capps, Meyer, Patel and Ross (2010) that the views of experienced teachers have more developed views, no data could be found to support their findings in this study. Thus, the teachers' teaching experience did not have a significant effect on their NOSI views in the current study.

The factors affecting teachers' views were generally emerged as the effect of their education level, courses taken during the undergraduate and graduate periods, and in-service training. In particular, the effect of teachers' education levels on their NOSI views, as found in the study of Strippel and Sommer (2015), has been found to be in favor of doctoral teachers while the teachers who have only bachelor's degree have more naive views. As might be expected, it was clearly seen that teachers who had their graduate education in science education also had more advanced NOSI views compared to other educational fields. Therefore, related to NOSI, which is considered to be an important part of science literacy, it is recommended that teachers should begin a graduate program in the field of science education after starting their profession and also NOSI should be given more importance in other graduate programs.

The effect of the courses taken in undergraduate and graduate periods is a rather striking factor affecting teachers' NOSI views. This study showed that the history of science and the NOS courses and the scientific inquiry courses taken in the graduate periods have a significant impact on teachers' views of NOSI. When it is considered that the teachers who only have bachelors' degree, do not remember NOSI much from the related courses, it is recommended that those related courses should be taught more practical and increased an awareness of its' importance. As in the study of Mesci, Çavuş-Güngören & Yeşildağ-Hasancebi (2020), it is necessary to adopt the NOSI features as a science subject and to teach how to integrate them into the science lessons and teach them in the science laboratory courses. It should not be forgotten that it is not possible to teach a subject without fully knowing it or to get the desired efficiency by using it in lessons without knowing a teaching approach (Baykara & Yakar, 2020; Karışan, Bilican, & Şenler, 2017). Thus, it is of great importance for teachers to understand NOSI and to effectively integrate it into their science lessons (Zion & Mendelovici, 2012).

The effect of in-service training on teachers' NOSI views is first seen in this study. It was emphasized how important in-service trainings are especially in learning and teaching of NOSI for in-service teachers. For this reason, it is necessary to give additional seminars and increase the trainings in order to revise in-service trainings and to teach and implement issues such as NOSI, because it is clearly known that the education received during the undergraduate period is not sufficient (e.g., Baykara & Yakar, 2020; Bostan-Saroğlan, 2018; Crawford et al., 2005) and teaching camps for NOS/NOSI are effective (Çiğdemoğlu & Köseoğlu, 2019; Lotter, Harwood & Bonner, 2006). Increasing the number of such studies, particularly focusing on teachers' views on NOSI and its reasons, will expand the national literature and there will be more examples of the importance and application of the NOSI concept. In this respect, it is thought that this study will make a great contribution to national literature. This study is limited by the teachers who

participated in this study. Therefore, it is important to carry out similar studies with larger and different samples.

STATEMENTS OF PUBLICATION ETHICS

The research has no unethical problems and research and publication ethics have been fully observed.

RESEARCHERS' CONTRIBUTION RATE

Authors	Literature Review	Data Collection	Data Analysis	Manuscript writing stages			
				Introduction	Method	Findings	Conclusions
First Author	40%	50%	70%	20%	80%	60%	60%
Second Author	60%	50%	30%	80%	20%	40%	40%

CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

REFERENCES

Adisendjaja, Y. H., Rustaman, N. Y., Redjeki, S., & Satori, D. (2017). Science teachers' understanding of scientific inquiry in teacher professional development. *Journal of Physics: Conference Series*, *812*.

Anggraeni, N., Adisendjaja, Y. H., & Amprasto, A. (2017). Profile of high school students' understanding of scientific inquiry. *Journal of Physics: Conference Series*, *895*, 1-5.

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching*, *44*(5), 653- 680.

American Association for the Advancement of Science [AAAS]. (1993). *Benchmarks for science literacy*. NewYork: Oxford University Press.

Aydeniz, M., Baksa, K., & Skinner, J. (2011). Understanding the impact of an apprenticeship-based scientific research program on high school students' understanding of scientific inquiry. *Journal of Science Education and Technology*, *20*(4), 403-421.

Bahbah, S., Golden, B. W., Roseler, K., Elderle, P., Saka, Y., & Shoutherland, S. A. (2013). The Influence of RET's on elementary and secondary grade teachers' views of scientific inquiry. *International Education Studies*, *6*(1), 117-131.

Bartos, S. A., & Lederman, N. G. (2014). Teachers' knowledge structures for nature of science and scientific inquiry: Conceptions and classroom practice. *Journal of Research in Science Teaching*, *51*(9), 1150-1184.

Baskale, H. (2016). Nitel araştırmalarda geçerlik, güvenirlik ve örneklem büyüklüğünün belirlenmesi [Determination of validity, reliability and sample size in qualitative studies] *Dokuz Eylül Üniversitesi Hemşirelik Fakültesi Elektronik Dergisi (DEUHFED)*, *9*(1), 23-28

Baykara, H., Yakar, Z., Liu, S. Y. (2018). Preservice science teachers' views about scientific inquiry. *European Journal of Education Studies*, *4*(10), 128-143.

Baykara, H., & Yakar, Z. (2020). Preservice science teachers' views about scientific inquiry: The case of Turkey and Taiwan. *Turkish Online Journal of Qualitative Inquiry*, *11*(2), 161-192.

Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it? Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching*, *40*(5), 487-509.

Bostan-Sarıoğlan, A. (2018). Fen bilgisi öğretmen adaylarının öğretim deneyimlerinden sonra bilimsel sorgulama hakkındaki görüşlerinin değerlendirilmesi **[**Assessment of preservice science teachers' views about scientific inquiry after training**]**. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *48*, 136-159.

Crawford, B. A., Capps, D., Meyer, X., Patel, M., & Ross, R. M. (2010, April). Supporting teachers in complex situations: Learning to teach evolution, nature of science, and scientific inquiry. In *American Educational Research Association Annual Meeting*, Denver, Colarado.

Crawford, B. A., Zembal-Saul, C., Munford, D., & Friedrichsen, P. (2005). Confronting prospective teachers' ideas of evolution and scientific inquiry using technology and inquiry-based tasks. *Journal of research in science teaching*, *42*(6), 613-637.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches (3rd ed.). Sage Publications, Inc.

Çiğdemoğlu, C., & Köseoğlu, F. (2019). Improving science teachers' views about scientific inquiry. *Science & Education*, *28*, 439-469.

Dogan, N. (2017). Blending problem based learning and history of science approaches to enhance views about scientific inquiry: New wine in an old bottle. *Journal of Education and Training Studies*, *5*(10), 99-112.

Doğan, N., Han-Tosunoglu, Ç., Özer, F., & Akkan, B. (2020). Ortaokul öğrencilerinin bilimsel sorgulama görüşleri: Cinsiyet, sınıf düzeyi ve okul türü değişkenlerinin incelenmesi **[**Middle school students' understanding of scientific inquiry: an investigation of gender, grade level and school type**]** *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *49*, 162-189.

Dudu, W. T. (2014). Exploring South African high school teachers' conceptions of the nature of scientific inquiry: a case study. *South African Journal of Education*, *34*(1), 1-18.

Flick, L. B., & Lederman, N. G. (2006). *Scientific inquiry and nature of science; Implication for teaching, learning and teacher education.* Dordrecht: Springer.

Haefner, L. A. & Zembal-Saul, C. (2004). Learning by doing? Prospective elementary teachers' developing understandings of scientific inquiry and science and learning. *International Journal of Science Education*, *26* (13), 1653-1674.

Karışan, D., Bilican, K., & Şenler, B. (2017). Bilimsel sorgulama hakkında görüş anketi: Türkçeye uyarlama, geçerlik ve güvenirlik çalışması **[**The adaptation of the views about scientific inquiry questionnaire: a validity and reliability study**]**. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *18*(1), 326-343.

Leblebicioğlu, G., Çapkınoğlu, E., Peten, D. M., & Schwartz, R. S. (2020). Views of nature of scientific inquiry of students in different high schools. *Education & Science/Egitim ve Bilim*, *45*(201), 143-165.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, *29*(4), 311-359.

Lederman, N.G. (2006). Research on nature of science: reflections on the past, anticipations of the future. *Asia-Pasific Forum Science Learning and Teaching*, *7* (1), 1-11

Lederman, J. S. (2007). Development of a valid and reliable protocol for the assessment of early childhood students' conceptions of nature of science and scientific inquiry. *Saarmste Executive*, *446*-450.

Lederman, J. S. (2012). *Development of a valid and reliable protocol for the assessment of early childhood students' conceptions of nature of science and scientific inquiry*. A Paper Presented at the Annual Meeting of the National Association of Research in Science Teaching, Indianapolis, IN.

Lederman, N. G. (2019). Contextualizing the relationship between nature of scientific knowledge and scientific inquiry. *Science & Education*, *28*, 249–267.

Lederman, N. G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science & Education*, *23*(2), 285-302.

Lederman, J. S., Bartels, S. L., Liu, C., & Jimenez, J. (2013). *Teaching nature of science and scientific inquiry to diverse classes of early primary level students*. A Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching (NARST), San Juan, PR, USA.

Lederman, N. G. & Lederman, J.S. (2004). Project ICAN: A professional development project to promote teachers' and students' knowledge of nature of science and scientific enquiry. In *Proceedings of the 11th Annual SAARMSTE Conference*. Cape Town, South Africa.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy. *International Journal of Education in Mathematics, Science and Technology*, *1*(3), 138-147.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching*, *51*(1), 65-83.

Lederman, J.S., Lederman, N.G., Bartels, S., Jimenez, J., Akubo, M., vd. (2019). An international collaborative investigation of beginning seventh grade students' understandings of scientific inquiry: Establishing a baseline. *Journal of Research in Science Teaching*, *56*(4), 486-515.

Lotter, C., Harwood, W. S., & Bonner, J. J. (2006). Overcoming a learning bottleneck: Inquiry professional development for secondary science teachers. *Journal of Science Teacher Education*, *17*(3), 185-216.

Mesci, G., Çavuş-Güngören, S., & Yesildag-Hasancebi, F. (2020). Investigating the development of pre-service science teachers' NOSI views and related teaching practices. *International Journal of Science Education*, *42*(1), 50-69.

Metz, K. E. (2004). Children's understanding of scientific inquiry: Their conceptualization of uncertainty in investigations of their own design. *Cognitionand Instruction*, *22*(2), 219–290.

Ministry of National Education (MoNE) (2005). *Elementary and secondary science curriculum*. Ankara: National Education Press.

Ministry of National Education (MoNE) (2018). *Elementary and secondary science curriculum*. Ankara: National Education Press.

National Research Council [NRC] (1996). *National science education standards*. Washington, DC: National Academic Press.

National Research Council [NRC] (2011). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy Press.

National Research Council [NRC] (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington DC: National Academy Press.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academy Press.

NGSS Lead States (2014). *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.

Osborne, J. (2014). Scientific practices and inquiry in the science classroom. In N. Lederman & S. Abell (Eds.), *The handbook of research on science education*, vol. II (pp. 579–599). New York: Taylor and Frances Group.

Osborne, J. F., Ratcliffe, M., Collins, S., Millar, R., & Duschl, R. (2003). What 'ideas-about- science' should be taught in school science? A Delphi Study of the 'Expert' Community. *Journal of Research in Science Teaching*, *40*(7), 692-720.

Park, J. (2008). Discussions for linking the nature of science (NOS) with scientific inquiry. *Journal of the Korean Association for Science Education*, *28*(7), 749-758.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., et al. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47-61.

Roehrig, G. H., & Luft, J. A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education*, *26*(1), 3-24

Schwartz, R. S., Lederman, N., & Lederman, N. (2008, March). *An instrument to assess views of scientific inquiry: The VOSI Questionnaire*. Paper presented at the international conference of the National Association for Research in Science Teaching. Baltimore, MD.

Schwarz, C. (2009). Developing preservice elementary teachers' knowledge and practices through modeling-centered scientific inquiry. *Science Education*, *93*(4), 720-744.

Şenler, B. (2017). Examination of pre-service science teachers' science teaching self-efficacy beliefs and views about scientific inquiry. *Eğitim Kuram ve Uygulama Araştırmaları Dergisi*, *3*(2), 50-59.

Strippel, C., & Sommer, K. (2015). Teaching nature of scientific inquiry in chemistry: how do German chemistry teachers use labwork to teach NOSI? *International Journal of Science Education*, *37*(18), 2965-2989.

Wong, S., & Hodson, D. (2010). More from the horse's mouth: What scientists say about science as a social practice. *International Journal of Science Education*, *32*(11), 1431-1463.

Yang, I. H., Park, S. W., Shin, J. Y., & Lim, S. M. (2017). Exploring Korean middle school students' view about scientific inquiry. *Eurasia Journal of Mathematics Science and Technology Education*, *13*(7), 3935-3958.

Yin, R. K. (1994). *Case study research: Design and methods. (2nd ed.)* Newbury Park, CA: Sage Publications.

Zion, M., & Mendelovici, R. (2012). Moving from structured to open inquiry: Challenges and limits. *Science Education International*, *23*(4), 383–399.