International Journal of Assessment Tools in Education
2022, Vol. 9, Special Issue, 283–299

https://doi.org/10.21449/ijate.1121814

Published at https://ijate.net/ https://dergipark.org.tr/en/pub/ijate **Research Article**

Learning through teaching: Teaching the nature of scientific inquiry in online outdoor learning environments

Eda Erdas Kartal[1,*], Gunkut Mesci[2]

[1]Kastamonu University, Faculty of Education, Department of Educational Sciences, Kastamonu
[2]Giresun University, Faculty of Education, Department of Science Education, Giresun

ARTICLE HISTORY

Received: May. 26, 2022
Revised: Nov. 1, 2022
Accepted: Nov. 10, 2021

Keywords:
Nature of scientific inquiry,
Outdoor learning,
Teacher training,
Learning through teaching.

Abstract: This study aims to examine the developments of 50 pre-service teachers' NOSI views during a 14-week implementation in the online outdoor learning environment. This is an experimental study that examines each participant's views and changes about NOSI using an open-ended questionnaire (VASI), and follow-up interviews. The data were analyzed by using content analysis. Almost all participants positively improved their views through the explicit/reflective approach and teachers' own experiences by practicing. In this study, the views of pre-service teachers developed more clearly after preparing lesson plans and their teaching practices. This is an indication that NOSI teaching, which does not provide the experience of conveying their learning outcomes to their practices to the participants is limited on its own and that the importance of "learning through teaching" in teachers' in-service and pre-service training on this subject should not be overlooked. Online teacher education in outdoor learning environments might be used in the development of NOSI views of pre-service teachers. We think that it is important to investigate the effect of this training on teacher education. These types of training might create a more economical and sustainable alternative for the development of NOSI views of wider groups of pre-service and in-service teachers.

1. INTRODUCTION

Science and technology are constantly changing and societies are expected to keep up with this rapid change and development. In this regard, raising science-literate individuals who can keep up with the changes has become the primary target of science curricula (American Association for the Advancement of Science (AAAS), 1993; Ministry of National Education (MoNE), 2018; National Research Council (NRC), 2012; Next Generation Science Standards (NGSS), 2013). Different definitions of scientific literacy have been examined and there are three different interpretations of the word "literate". These are literate as learned, literate as competent, and literate as able to function minimally in society (Laugksch, 2000). While interpretations of the concept of literacy move from "informed" to "function in society" from past to present, today, increasing emphasis is placed on scientific literacy qualities to cope with situations encountered in daily life (Laugksch, 2000). Scientific literacy means having scientific knowledge, the nature of scientific knowledge, and how it is produced and using this knowledge to solve problems

*Corresponding Author: Eda Erdas Kartal erdaseda@gmail.com Kastamonu University, Faculty of Education, Department of Educational Sciences, Kastamonu, Türkiye

e-ISSN: 2148-7456 /© IJATE 2022

encountered in daily life. Scientific literacy also requires being aware of how science, technology, and society affect each other and having positive attitudes and value judgments about science and technology (NRC, 2012; Organization for Economic Co-operation and Development (OECD), 2003). Individuals with scientific literacy skills can distinguish science from non-science, use scientific knowledge in problem solving, and think scientifically. They are aware of the role of experiments in science. They know the theories that form the basis of science, how they are achieved and why they are widely accepted. They know the elements of scientific research, the importance of proper inquiry, relying on objective evidence, and deductive reasoning and logical thought processes (Norris & Philips, 2003).

Although scientific literacy includes understanding the content of science, it is much more than that. Students must have an understanding of science subjects as well as the nature of science (NOS) and the nature of scientific inquiry (NOSI) to be scientifically literate (Bartels & Lederman, 2022). As the main component of science literacy, scientific inquiry involves traditional science processes, which refers to combining these processes with scientific knowledge, scientific reasoning, and critical thinking to develop scientific knowledge (Lederman et al., 2014). Scientific inquiry is the whole of systematic research activities carried out by scientists to understand and explain the natural world (Lederman & Lederman, 2012; NRC, 2000). It is important to have scientific inquiry skills, but the fact that students have scientific inquiry skills does not mean that they have knowledge of the NOSI. Teachers usually focus on doing inquiry in schools and assume that students will know how scientific inquiry is done by doing scientific inquiry (Bell et al., 2003). However, students can make scientific inquiries without knowing how and why scientists continue their work (Lederman et al., 2019).

Scientific inquiry should be emphasized as a skill and understanding (NGSS, 2013). Participating in simple inquiry experiences and knowing inquiry procedures without knowing the NOSI is not enough for students to understand the epistemology of science and achieve the objectives that are targeted by scientific inquiry (Lederman, 2006; Wong and Hodson, 2010). The NOSI expresses the characteristics of the scientific inquiry process (Lederman et al., 2014). It is necessary to explain the source of the information we have and why we believe it to teach not only the process of creating scientific knowledge but also the characteristics of this process, that is, to gain an adequate understanding of the features (components of scientific inquiry) (Osborne, 2014; Schwartz, 2004). The aspects of NOSI are defined as follows: (1) All scientific research begins with a question, but it does not always have to test a hypothesis, (2) There is no single, step-by-step scientific method used in all scientific research, (3) Research questions guide the scientific inquiry process, (4) Not all scientists who do the same can achieve the same results, (5) Scientific inquiry procedures can have an impact on the results, (6) There should be consistency between research findings and data collected, (7) Scientific data and scientific evidence are not the same, (8) Combining previously known and collected data develops scientific explanations (Lederman et al., 2014). Researchers and reform documents emphasize the importance of developing students' scientific inquiry skills, as well as their views of the abovementioned features of the scientific inquiry process (Lederman et al., 2019; NGSS, 2013; NRC, 2020).

1.1. Problem Statement

Although it is emphasized in international documents that the foundation of scientific literacy should be established from kindergarten, more importance is given to reading and mathematics in early grades (Aydemir et al., 2017; Bartels & Lederman, 2022). Allocating more time to reading and mathematics in early classes causes science education to remain in the background in these classes. At an early age, children are interrogative and inquisitive by nature. During this period, children's imaginations are also quite strong. The first experiences that children have in this period are extremely important and these experiences form the basis for their future lives (Alisinanoğlu & Özbey, 2011; Çamlıbel Çakmak, 2014). Studies show that children develop an understanding of basic scientific concepts and can use basic scientific process skills at early ages (Opfer & Siegler, 2004). To raise the science-literate individuals of the future, children need to spend this period, in which they learn quickly and the lasting impact of the concepts they learn, productively in terms of science education. Unfortunately, students continue to graduate from high school without science literacy skills due to the lack of time for science teaching in early grades (Roberts & Bybee, 2014). Bartels and Lederman (2022) showed in their research that students' understanding of science, scientists, and how scientists work did not change from the first grade to the fifth grade. The findings of Bartels and Lederman (2022) are a tragic indicator that students fail to make progress in terms of scientific literacy at early grades.

Science teaching, which is recommended from kindergarten onward, should focus not only on science content but also on applications and understanding what science is as a body of knowledge (NRC, 2013). The teaching of NOSI usually begins in middle school, but recent studies have revealed that early graders (kindergarten to K5) also have the capacity to understand some features of scientific inquiry, so it should be started at the earliest age possible (Bartels & Lederman, 2022; Lederman et al., 2019; Tytler & Peterson, 2003). The findings of the limited number of studies conducted with younger children show that these children's views on NOSI are limited (Bartels & Lederman, 2022; Lederman, 2012; Lederman & Bartels, 2018; Lederman et al., 2013; Lederman & Lederman, 2004; Penn et al., 2021).

The attitudes of children toward science and the process of learning science are highly affected by the knowledge, attitudes, and behaviors of the teacher (Yurt, 2015). Thus, teachers are important actors in the process of adopting scientific inquiry in science teaching and developing students' views (Schwartz & Lederman, 2002). Teachers' lack of understanding of scientific inquiry is one of the obstacles to applying it to their lessons (Roehring & Luft, 2004). It is important for teachers to understand NOSI, which guides scientific research and forms the basis of scientific knowledge (Zion & Mendelovici, 2012). Most studies (Baykara & Yakar, 2020; Crawford et al., 2005; Crawford et al., 2010; Dudu, 2014; Karışan et al., 2017; Lederman et al., 2019; Mesci et al., 2020; Mesci & Kartal, 2021; Wang & Zhao, 2016;) have aimed at identifying and developing the views of secondary and high school teachers. The findings of the limited number of studies conducted with early graders' teachers show that these teachers/pre-service teachers have naive views and misconceptions about NOSI (Aydemir et al., 2017; Deniz & Akerson, 2013; Koyunlu-Ünlü, 2020; Perez & Diaz-Moreno, 2022). Considering the limited number of studies aimed at improving NOSI views of pre-service and in-service teachers, there is still a need for dissemination of these studies.

1.2. Theoretical Framework

Science is closely intertwined with real life. Classroom and laboratory environments create some limitations for science teaching about relating science subjects to real life. This may cause difficulties in understanding science subjects. Outdoor learning is of great importance in terms of connecting the theoretical knowledge learned at school with real life and learning the events comparatively. This study was framed by "teaching in an outdoor learning environment", which is a type of teaching carried out by examining an event or phenomenon in its real natural environment, according to a previous plan made for achievements in science teaching (Rickinson et al., 2004). Recent studies have found that outdoor learning environments increase children's motivation to learn (Andiema, 2016) and increase their interest and achievement in science courses (Dori & Tall, 2000), but teachers mostly do not prefer to perform these activities (Tatar & Bağrıyanık, 2012). It is very important for teachers to include outdoor learning environments that affect students' interests, attitudes, and learning levels in the learning-teaching process in their professions (Kubat, 2018). Thus, it is necessary to provide pre-service teachers with experience on how science issues can be handled in outdoor learning environments. Recent studies have suggested that aspects of NOSI should be deemed as science content (i.e., Lederman, 2019; Mesci & Schwartz, 2017; Schwartz et al., 2008). In this context, teaching NOSI experienced by pre-service teachers in outdoor learning environments may be useful in improving views about the components of NOSI.

It is argued that one of the most effective teaching approaches in teaching the nature of scientific inquiry is the explicit/reflective approach (Aydeniz et al., 2011; Bell et al., 2003; Erdas-Kartal et al., 2018; Lederman, 2019; Mesci et al., 2020; Metin-Peten, 2022). For example, in one of these studies, Perez and Diaz-Moreno (2022), in their study where they examined the evolution of NOSI concepts of pre-service primary teachers after they were immersed in a specific teaching module focusing on NOSI, revealed that explicit/reflective approach-based NOSI teaching improved participants' views. Teachers may plan and teach NOSI courses effectively by improving their knowledge and awareness about NOSI (Mesci et al., 2020). Therefore, it should not be forgotten that the training to be offered to the teachers about NOSI should include explicit/reflective instruction on NOSI as well as providing the opportunity to practice. Bringing teachers and pre-service teachers together for such professional development support can be difficult and costly in many cases. To expand such professional development support, the possibilities offered by technology should be evaluated. Being unable to keep up with rapid technological developments is one of the important problems in catching up with the current age, so the use of new technologies in education is encouraged in many countries in the world. It is necessary to benefit from the opportunities offered by rapidly changing technologies in teacher education and in developing teachers' professional standards (Gelişli, 2015). The distance teaching approach, which makes it possible to provide educational services to the masses by using the developed and enriched resources of communication and education technology, is an important option that is suitable for effective and continuous use in pre-service and in-service teachers. One of the distance teacher education training models is web-based education, in other words, online training (Burns, 2011). This model is used in the vast majority of countries where access to Internet is high and technological skills are becoming widespread in school or home settings (Gelişli, 2015). We think it is important to investigate the effect of this training on teacher education. These types of training might create a more economical and sustainable alternative for the development of NOSI views of wider groups of pre-service and in-service teachers.

Based on the above-mentioned literature, this study aimed to develop the NOSI views of pre-service teachers with online training to be given in outdoor learning environments. Online NOSI training in outdoor learning environments is theoretically framed by the learning theory of Reid et al.'s (1989) 5-stage model under the constructivist approach. The first stage of this theory is engagement, which is described as ‘the time during which students acquire information and engage in an experience that provides the basis for, or content of, their ensuing learning’ (Reid et al.,1989). The second stage is exploration, which can be an open-ended process where learners follow their instincts. Transformation is the stage where the knowledge that the learner participates in and discovers can be restructured into a form that allows presentation (the next stage) but, more importantly, into a format from the instructor's point of view. This is usually a lesson plan preparation phase in teacher development programs, which ensures learning objectives. Presenting the transformed knowledge gives the learner time to reflect on the process and content, internalize it, and develop a deeper level of understanding. This section may coincide with the microteaching section in teacher development programs. The transformation and the resulting presentation are not the end of the process. The final stage is a reflection that can take many forms, usually in the form of oral presentations, reflection essays, posters, or creating a newspaper/magazine (Pritchard, 2017). Kolb's (1984) experiential learning model has also emphasized that the most important element in the learning process is the learner's own experiences. According to the experiential learning model, the individual should first engage with a certain concrete experience activity in the teaching process (Brock & Cameron 1999). Then, the individual should observe objectively and carefully in the reflective observation stage and analyze concrete experiences to reach certain judgments (Brock & Cameron, 1999).

1.3. Purpose of the Study

This study aimed to develop the NOSI views of pre-service teachers through online training to be given in outdoor learning environments. In this context, the following questions guided this study:

1.How is the change in the NOSI views of pre-service teachers after the outdoor learning course in online settings?

2.What are the pre-service teachers' views on the impact of the outdoor learning course on their NOSI views?

2. METHOD

A single-group experimental design was used in this study to explore the impact of online NOSI instruction to be given in outdoor learning environments on pre-service teachers' NOSI views (Creswell, 2012).

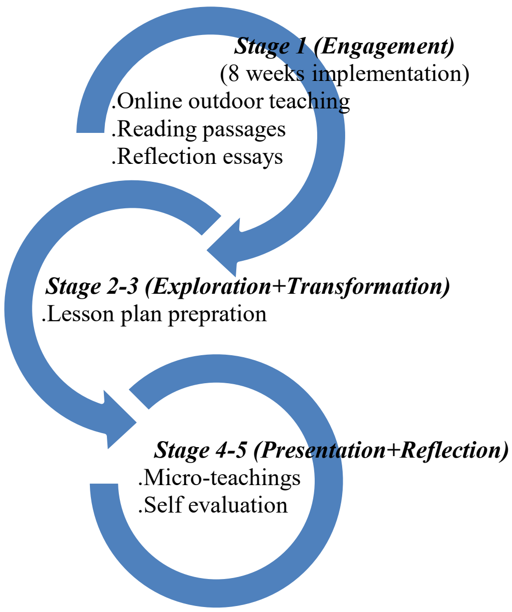
2.1. Participants

The sample of this study consisted of 50 pre-service elementary (25) and preschool (25) teachers who were teaching at a public university in northeastern Turkey. The participants were selected among those who took the undergraduate course, namely, "outdoor learning environments", a common elective undergraduate course for pre-service teachers, and volunteered to participate in the research. None of the participants had taken any course related to NOSI or the nature of science until then.

2.2. Context of the Study and Data Collection

At the beginning of the semester, pre-service teachers were asked to fill out the Views About Nature of Scientific Inquiry (VASI) Questionnaire (Lederman et al., 2014), and follow-up semi-structured interviews were implemented. The context of the study and data collection procedures are summarized in Figure 1 below.

Figure 1. *Context of the study and data collection procedure.*



2.2.1. *Stage 1. (Engagement)*

During the eight weeks of implementation, the researchers made a live video from the places mentioned in Table 1 below and made an interactive presentation for each week (for those who could not attend the live broadcast, it was recorded and uploaded to the system for further watch). Every week, special emphasis was placed on NOSI, and the importance of NOSI aspects within the related socio-scientific issues was discussed explicitly, especially in the selected outdoor places (see Table 1). For example, while discussing fossils belonging to creatures that lived in ancient years, the concepts of scientific data and evidence and their differences were discussed on a science museum tour. After the elucidation of dinosaur bone activity was carried out, the combination of previously known and collected data develops scientific explanations. Another example is that during online visit to the laboratories in the university, it was explicitly discussed what the scientific inquiry is and what features it is built on, the importance of the research question in science, and how it affects the research process. It was clearly expressed that there are different methods in science by interviewing the professors from different fields in both social science and science and emphasized the differences in the methods in their studies. In the online meetings that followed, reading passages were given to the pre-service teachers every week and discussions were made on both these reading passages and the things learned in the outdoor places visited online. In addition, every week, students were asked to write a daily reflection essay about what they had learned on that week. After the 8-week online outdoor teaching focusing on the NOSI, the mid-VASI questionnaire was completed by the pre-service teachers.

Table 1. *First eight weeks of implementation.*

Week	Outdoor Environments	Explanations	NOSI Aspects Intended to Teach	NOSI Generic Activities
1	Seven Mills Nature Park	Investigation of plants and animals in danger of extinction	-Begins with question -Data/Evidence	Tricky track
2	Meteorology Center	Investigation of the cause and effects of global climate change	-The same procedures do not get the same results -Inquiry procedures influence results	Global warming
3	University Laboratories	Interviewing professors from different fields and discussing different methods in science.	-Multiple scientific methods -Conclusions consistent with data	Future scientists
4	Blood Donation Center	Investigation for blood groups and the importance of donating blood	-Conclusions consistent with the data	Where does my genetics come from?
5	Gas and Electricity Generation and Storage Facility	Knowledge about recycling, environmental problems and solutions that may arise as a result of human activities	-Begins with question -Procedures by the question asked -Data/Evidence	My project for environmental problems
6	Hydroelectric Power Plant	Transformation of energy. The benefits and harms of hydroelectric power plants	-Data/Evidence -Conclusions consistent with the data	Argumentation (Is hydroelectric power plant harmful or useful?)
7	Archeology Museum	Having knowledge about fossils and creatures that lived years ago.	-Explanations are developed from the data -Data/Evidence	Dinosaur bones
8	International Airport	Observing the effect of friction force on kinetic energy	-Procedures by the question asked -Conclusions consistent with the data	Airplane runway and aircraft tires

2.2.2. *Stage 2-3. (Exploration + Transformation)*

In the remaining weeks, each pre-service teacher was asked to prepare a lesson plan by associating at least one NOSI aspect with a socio-scientific topic. First, a sample plan was introduced by the researchers, and then the pre-service teachers were asked to prepare their plans.

2.2.3. *Stage 4-5. (Presentation + Reflection)*

After the researchers gave feedback on the plans made, each pre-service teacher had the opportunity to present their plans in the outdoor learning environment of their choice. They video-recorded their presentations and sent them to the researchers. Each student was asked to write a self-evaluation essay in which they evaluated themselves and the whole process after microteaching. In these essays, they were asked to express their strengths and weaknesses and the parts of the process that they had the most difficulty with.

At the end of 14 weeks, the post-VASI questionnaire was completed again, and follow-up interviews were carried out to determine the progress of the pre-service teachers' views of the NOSI. In the final interview, the views of pre-service teachers on the effect of the outdoor learning course on NOSI views were revealed.

2.3. Data Collection Tools

The VASI was developed by Lederman et al. (2014) and adapted into Turkish using the retranslation method by Çavuş-Güngören and Öztürk (2016). The VASI questionnaire is a context-based 7 open-ended questionnaire that explores the views of students in the 6th-grade or above, teachers, and pre-service teachers about the aspects of scientific inquiry targeted by the National Science Education Standards (Lederman et al., 2014). Due to the nature of the questionnaire, participants are challenged to think critically about scientific inquiry and the underlying reasons for their thoughts. It is emphasized that this reasoning should be examined further with follow-up interviews (Lederman et al., 2014). It is preferred that the VASI be given under controlled conditions with no set time limit for completion. VASI responders typically take 30-45 minutes to complete the questionnaire. Participants are encouraged to write as much information as possible on relevant items and to provide illustrative examples to help support their explanations.

2.4. Data Analysis

In its analysis, the VASI Questionnaire developers presented a table, the questions of which corresponded to NOSI aspects (Lederman et al., 2014 p.75). Analyses were made based on this table. In addition, all items on the VASI questionnaire were analyzed holistically to generate a profile of each pre-service teacher's views across the targeted aspects of NOSI. For example, if a participant states that researchers who use different methods in one item can achieve the same or different results people who achieve the same results in another item should have followed the same method, the participant is considered to be in mixed view. It should be emphasized that the answers given to the items in the VASI are not independently scored as correct or incorrect and the participant's view on the relevant aspect of NOSI is classified according to the NOSI continuum scale, taking into account the responses to all items holistically. Using the NOSI views continuum scale, a profile for each participant was developed, describing their views on a continuum from naive "-" to mixed "(+)" to increasing levels of informed "+, ++, +++" (Schwartz et al., 2008). If pre-service teachers had an insufficient view or an incompatible view about the targeted NOSI aspects, their responses were coded as naive (-). The pre-service teachers' responses were coded as informed if they had a sufficient view about the targeted aspect that was compatible with the literature. The informed level "+", "++", and "+++" varies depending on the explanations given appropriate examples with their sentences. The pre-service teachers' responses were coded as mixed "(+)" if their responses showed inconsistency within the questionnaire or during the interviews.

The final interviews were analyzed by using content analysis. The content analysis consisted of coding data, creating categories and themes from codes, and visualizing data (McMillan & Schumacher, 2010). A reasonable amount of data (20%) (Lincoln & Guba, 1985) was reviewed and analyzed by the authors and two leading independent experts. After the analyses were completed, the researchers discussed the analysis findings until 90% agreement was reached. The authors analyzed the remainder of the data based on the commonalities obtained in the inquiry audit.

To increase the consistency of the research, two field experts were consulted about the results of the analysis. To ensure the verifiability of the findings, information about the sample from which the data were collected was presented (Merriam, 2018). The researchers conducting this study have experience and research in teaching NOSI. They also have experience in conducting qualitative research. These increase the verifiability of the findings. To increase the credibility of the findings obtained, the two researchers worked together in the data collection and analysis process. A semi-structured interview form was used to collect in-depth focused data and the data were ensured to reach a saturation point. To ensure the transferability of the research, direct quotations from the participants were made while presenting the findings.

3. FINDINGS

According to the analysis, the pre-service teachers had mostly mixed or naive views regarding the targeted NOSI aspects at the beginning of the study. Pre-service teachers generally had naive views in some NOSI aspects, such as “scientific data are not the same as scientific evidence”, “all scientists performing the same procedures may not get the same results”, “inquiry procedures are guided by the question asked”, and “scientific investigations all begin with a question and do not necessarily test a hypothesis” (see Figure 2). Some of the representative quotes expressed by the pre-service teachers are provided below.

“Scientific research mostly does not start with a question.” (PST12_pre-VASI)

“Data are correct or incorrect results that come from the experiment. However, the evidence is exact information.” (PST41_ pre-VASI Interview)

After the first eight weeks of online NOSI teaching in outdoor learning environments, a positive development was observed in the NOSI views of pre-service teachers, but this development was not at the desired level for all of them (see Figure 2). According to the analysis of mid-VASI responses and interviews, some pre-service teachers were still in the naive and mixed views of some NOSI aspects. The aspects with the highest improvement in the views of pre-service teachers are "there is no single scientific method", "scientists can reach different results even if they follow the same procedures", and "the inquiry procedures affects the research results". Some representative quotations of the pre-service teachers' NOSI views in the middle of the study are provided below.

“There is no one single scientific method. Scientists can follow more than one method. Qualitative and quantitative research methods can be given as examples for different methods.” (PST14_mid-VASI)

“Scientists are people with different experiences, theoretical assumptions, cultures and imaginations, so even if the same methods are followed, different results may emerge.” (PST7_mid-VASI interview)

According to the analysis of pre-service teachers’ post-VASI responses and interviews, after the pre-service teachers prepared lesson plans and follow-up micro teachings, almost all participants dramatically improved their views of the NOSI. The shifting was mostly seen from the mixed view to an increased level of the informed range (see Figure 2).

Figure 2. *Participants' views on NOSI aspects.*

Some of the pre-service teachers still have naive views in only a few NOSI aspects (i.e., “questions guide the research process”, and “explanations consist of collected data and prior knowledge”). Some representative quotations of the pre-service teachers’ informed NOSI views at the end of the study are provided below.

“Data are collected through the observations or experiences. The evidence is an argument that we use to support our claims by interpreting the data.” (PST23_post-VASI interview)

“Scientific research starts with questions. For example, Leeuwenhoek asked himself the question of "What can I see if I examine the pond water in the garden?" and discovered unicellular microorganisms starting from the question". (PST48_post-VASI)

As a result of the analysis of final interviews, teachers thought that some factors might have affected their NOSI views throughout the course. These factors were "online NOSI instruction in outdoor learning environments", "lesson plan preparing + microteachings", "feedback", and "classroom discussions" (see Figure 3).

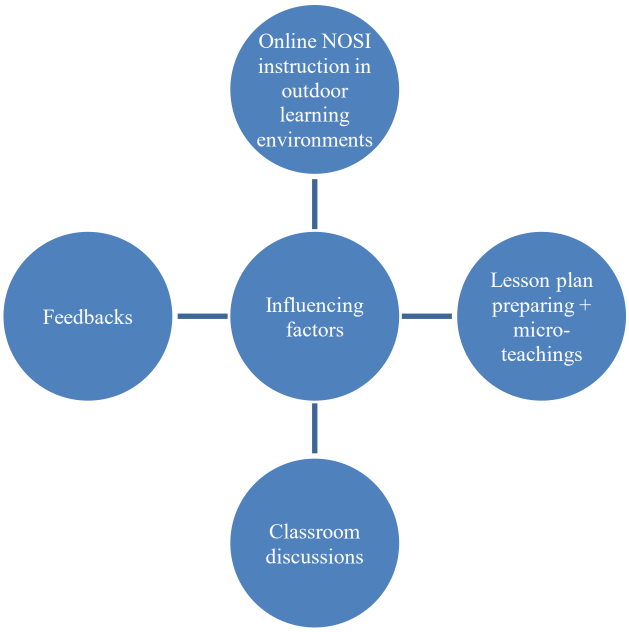
One of the factors stated by the pre-service teachers, which they think is effective, is the effect of online NOSI teaching in open-air learning environments that represents the first eight weeks of the course. In addition to the changes seen in Figure 2, the pre-service teachers also expressed how the first 8-week course affected their NOSI views.

"I think your online instruction in outdoor learning environments was very useful for me to understand the scientific inquiry. Therefore, I did not have much difficulty in preparing my plans." (PST17_Final interview)

"Your instruction on the nature of scientific inquiry by relating it to the contexts we encounter in daily life made it easier for me to understand the aspects." (PST33_Final interview)

"I think, I understood the nature of scientific inquiry better by watching your instructions in the records. I was able to reinforce what I had not fully understood by rewatching." (PST27_Final interview)

Figure 3. *Influencing factors on pre-service teachers’ NOSI views.*



The other factor is the effect of pre-service teachers' lesson plan preparation and teaching practices. The participants explained how the lesson plan preparation and teaching practices affected their NOSI views.

"In fact, these lesson plans and practices have been very useful for me to improve myself and understand the scientific inquiry. I noticed my misconceptions and had a chance to fix them all." (PST47_Final interview)

"I think that preparing lesson plans and follow-up practice improves our views about scientific inquiry. Now, I feel more confidence myself to teach the aspects of nature of the scientific inquiry." (PST7_Final interview)

"While I was preparing my lesson plan, I had the opportunity to review my view about scientific inquiry. I tried to make up for my deficiencies, I think that teaching something is the best way to learn it." (PST13_Final interview)

Another factor stated by the pre-service teachers, which they thought to be effective, was feedback from the instructors. They expressed the importance of feedback on their NOSI views.

"Seeing each other's plans and your feedback helped us to improve ourselves." (PST12_Final interview)

"Thanks to the feedback we received from our teacher in the lesson, we saw our shortcomings, which gave me an idea about how I could do it more appropriately in my last plan." (PST40_Final interview)

"After each lesson plan and teaching practice, I had the opportunity to make up for the deficiencies thanks to the feedback I received from you." (PST15_Final interview)

Last but not least, pre-service teachers thought that their NOSI views might also be influenced by weekly classroom discussions just made after their teaching practices. They expressed as:

"I realized that I did not understand the nature of scientific inquiry at first, or rather, I had difficulty in understanding it. Once I understood the topic, I had a hard time applying it to my plan and activity, but after two exercises and classroom discussions, I thought I understood it better." (PST23_Final interview)

"I thought that I understood it, but when I tried to put it into practice, I realized that I did not quite understand it. After our weekly discussions and the examples I saw, I think I understood the scientific inquiry better." (PST34_Final interview)

4. DISCUSSION and CONCLUSION

The findings indicate that almost all participants improved their views of NOSI in a positive manner through explicit/reflective online outdoor NOSI teaching and teachers' own experience through lesson planning and practice. Explicit reflective teaching is an effective method for developing learners' NOSI views (Lederman, 2019; Mesci et al., 2020; Schwartz and Crawford, 2004). However, the findings of the current study show that when pre-service teachers are provided with the opportunity to prepare a lesson plan and practice after explicit/reflective NOSI instruction, their NOSI views dramatically improve. The findings of this study are valuable, as they show how 'learning through teaching' makes a dramatic change in participants' NOSI views. Explicit/reflective NOSI teaching, which does not provide participants with the experience of transferring what they have learned to their practices, is limited on its own (Mesci et al., 2020). The importance of "teaching experience" in improving pre-service teachers' NOSI views in teacher training programs should not be overlooked. Other studies in the literature also confirm that lesson plan preparation and teaching experience are effective in developing participants' NOSI views (Gess-Newsome, 2002; Lederman and Lederman, 2004; Lederman and Lederman, 2012; Lotter et al., 2009, Mesci et al., 2020).

As Lederman and Lederman (2012) argued, learners more easily adopt what they see from the acts of their peers, rather than what is modeled by professional educators. In the present study, the pre-service teachers not only provided explicit/reflective NOSI instruction and teaching experience but also had the opportunity to see and criticize each other's plans and practices (reflective observations) and received feedback. In parallel with the current study, research shows that reflective discussions and mentors' feedback support the pedagogical development of teachers and pre-service teachers and facilitate the implementation of effective teaching strategies (Melville et al., 2008; Singer, 2005; Yung et al., 2007). Based on the literature (Lederman and Lederman, 2012; Lotter et al., 2009; Mesci et al., 2020), these interactive dialogs and discussions within the group and the feedback received during the process are effective in clearing their current misconceptions about NOSI and improving their naive views.

In the present study, the experiences in outdoor learning environments may also affect the development of pre-service teachers' views. Outdoor learning experiences provide individuals with awareness of the science-society relationship that classroom-based learning environments cannot gain; that is, they provide real contexts from life and offer a more realistic learning experience by practicing (Akgül & Arabacı, 2020; Gürsoy, 2018). Based on the emphasis that different alternative teaching methods should be examined in NOSI teaching (Lederman et al., 2019), the NOSI views of pre-service teachers in outdoor learning environments were developed. The current study shows examples of how to use an explicit/reflective approach to socio-scientific issues in outdoor learning environments. The design of the study may add to the literature and may also be of interest to science educators. In another study, Deniz and Akerson (2013) developed primary school teachers' NOS and NOSI views by integrating explicit reflective teaching with language arts. Mesci et al. (2020) developed pre-service teachers' NOSI views through argumentation-based NOSI teaching in laboratories. These studies may encourage researchers who want to find alternative ways of teaching NOSI in different contexts.

This study is uniquely focused on the changing or unchanging views in outdoor learning environments by using fully online teaching. Developing the views of pre-service teachers related to NOSI with this alternative method (online-outdoor learning) may set an example for NOSI teaching in fully online education. In addition, it is obvious that effective in-service learning activities to be planned in online learning environments can contribute to the professional development of more teachers economically. Although the findings of our study are consistent with other studies in the literature, it should be considered that the findings of this study are limited to the context. Developing teachers' views and teaching skills on NOSI is not easy and takes a long time (Lederman & Lederman, 2012). It is also important to investigate the long-term effects of the results of this study on the participants.

Finally, it is known that early graders' teachers are mostly experts in language teaching (Akerson, 2007) and generally do not have a strong science background (Anderson, 1999). It is essential to provide content and pedagogical knowledge and teaching experience for teaching inquiry-based science to teachers who do not see themselves as science teachers (Lederman & Lederman, 2004). Therefore, these teachers may not be able to teach science effectively without the support of a well-designed professional development even though they are encouraged to teach science (Deniz & Akerson, 2013). Thus, these pre-service and in-service teachers need more opportunities to learn to teach the NOSI than middle and high school science teachers due to their low science background. Non-science major pre-service teachers and researchers who will work with teachers may consider this. Considering the emphasis in international documents on laying the foundations of science literacy from the kindergarten (Lederman & Bartels, 2018), further studies should be conducted to investigate and develop the views of children and teachers who have an indisputable influence on children's learning.

Acknowledgments

A part of this paper was presented at the National Association for Research in Science Teaching (NARST), Vancouver, BC, Canada, March 27-30, 2022.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors. **Ethics Committee Number**: Kastamonu University, 12.10.2020/3-35.

Authorship Contribution Statement

Eda Erdas Kartal: Determining the purpose of the research and the research design; implementing the activities, data collection, and analysis; and writing the introduction, method, and discussion parts of the article. **Gunkut Mesci:** Determining the purpose of the research and the research design; implementing the activities; data collection and analysis; and writing the methods, findings, and discussion parts of the article. Both authors checked the mutually written sections and made necessary revisions.

Orcid

Eda Erdas Kartal https://orcid.org/0000-0002-1568-827X
Gunkut Mesci https://orcid.org/0000-0003-0319-5993

REFERENCES

Akerson, V.L. (Ed.) (2007). *Interdisciplinary language arts and science instruction in elementary classrooms: Applying research to practice*. Erlbaum: NJ.

Akgül, G.D. & Arabacı, S. (2020). Okul dışı öğrenme ortamlarına yönelik fen bilgisi öğretmenlerinin görüşleri [The views of science teachers on the use and application of out of school learning environments]. *Uluslararası Eğitim Araştırmacıları Dergisi, 3*(2), 276-291.

Alisinanoğlu, F. & Özbey, S. (2011). *Okul öncesinde fen eğitimi* [*Preschool science education*]. Maya Akademi.

American Association for the Advancement of Science [AAAS] (1993). *Benchmarks for science literacy: A project 2061 report*. Oxford University Press.

Andersson, B. (1999). Pupils' conceptions of matter and its transformations. *Studies in Science Education, 2*(1), 53-85.

Andiema, N.C. (2016). Effect of child-centered methods on teaching and learning of science activities in preschools in Kenya. *Journal of Education and Practice, 7*(27), 1-9.

Aydemir, S., Ugras, M., Cambay, O., & Kilic, A. (2017). Prospective preschool teachers' views on the nature of science and scientific inquiry. *Üniversitepark Bülten, 6*(2), 74-87. https://doi.org/10.22521/unibulletin.2017.62.6

Aydeniz, M., Baksa, K. & Skinner, J. (2011). Understanding the impact of an apprenticeship-based scientific research program on high school student's understanding of scientific inquiry. *Journal of Science Education and Technology, 20*(4), 403-421. https://doi.org/10.1007/s10956-010-9261-4

Bartels, S., & Lederman, J. (2022). What do elementary students know about science, scientists, and how they do their work?. *International Journal of Science Education, 44*(4), 627-646. https://doi.org/10.1080/09500693.2022.2050487

Baykara, H. & Yakar, Z. (2020). Pre-service science teachers' views about scientific inquiry: The case of Turkey and Taiwan. *Turkish Online Journal of Qualitative Inquiry, 11*(2), 161-192. https://doi.org/10.17569/tojqi.618950

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.

Brock, K.L. & Cameron, B.J. (1999). Enlivening political science courses with Kolb's learning preference model. *Political Science and Politics, 32*(2), 251-256.

Burns, M. (2011). *Distance education for teacher training: modes, models, and methods*. Education Development Center, Inc.

Camlıbel Çakmak, Ö. (2014). *Okul öncesi dönemde fen eğitimi ve öğretmenin rolü* [*Science education and the role of the teacher at the preschool period*]. *In M. Çetin & Ç. Şahin (Eds.), Okul öncesi dönemde fen eğitimi* [*Science education at the preschool period*] (s.29-47). Pegem Akademi.

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.

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. A paper presentation at the American Educational Research Association Annual Meeting-Denver, Colorado.

Creswell, J.W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.). Pearson.

Çavuş Güngören S., & Öztürk E. (2016). *Turkish adaptation of the views about scientific inquiry VASI and examine pre-service mathematics teachers' views about scientific inquiry*. VI. International Congress on Research in Education (ICRE).

Deniz, H. & Akerson, V. (2013). Examining the impact of a professional development program on elementary teachers' views of the nature of science and nature of the scientific inquiry, and science teaching efficacy beliefs. *The Electronic Journal for Research in Science & Mathematics Education, 17*(3), 1-19.

Dori, Y.J., & Tall, R.T. (2000). Formal and informal collaborative projects: engaging in the industry with environmental awareness. *Science Education, 84*(1), 95-113.

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.

Erdas Kartal, E., Cobern, W.W., Dogan, N., Irez, S., Cakmakci, G., & Yalaki, Y. (2018). Improving science teachers' nature of science views through an innovative continuing professional development program. *International Journal of STEM education, 5*(1), 1-10. https://doi.org/10.1186/s40594-018-0125-4

Gelişli, Y. (2015). Practices of distance education for teacher training: History and development. *Journal of Research in Education and Teaching, 3*(1), 313-321.

Gess-Newsome, J. (2002). The use and impact of explicit instruction about the nature of science and science inquiry in an elementary science methods course. *Science & Education, 11*(1), 55-67.

Gürsoy, G. (2018). Fen öğretiminde okul dışı öğrenme ortamları (Outdoor learning environments in science education). *Electronic Turkish Studies, 13*(11), 623 649. http://dx.doi.org/10.7827/TurkishStudies.13225

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. https://doi.org/10.17679/inuefd.307053

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Koyunlu-Ünlü, Z. (2020). Improving pre-service teachers' science process skills and views about scientific inquiry. *Journal of Theoretical Educational Science, 13*(3), 474-489. http://dx.doi.org/10.30831/akukeg.626165

Kubat, U. (2018). Okul dışı öğrenme ortamları hakkında fen bilgisi öğretmen adaylarının görüşleri (Opinions of pre-service science teachers about outdoor education). Mehmet

Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi, 48(1), 111-135. https://doi.org/10.21764/maeuefd.429575

Laugksch, R.C. (2000). Scientific literacy: A conceptual overview. *Science Education, 84*(1), 71-94.

Lederman, J.S. & Lederman, N.G. (2004, April). *Early elementary students' and teacher's understandings of nature of science and scientific inquiry: Lessons learned from project ICAN*. Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching, Vancouver, British Columbia.

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. (2012). *Development of a valid and reliable protocol for the assessment of early childhood students' conceptions of the 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., & Lederman, J. (2012). *Nature of scientific knowledge and scientific inquiry: Building instructional capacity through professional development*. In B.J. Fraser, K. Tobin & C.J. McRobbie (Eds.), Second international handbook of science education (24th ed., pp. 335–359). Springer

Lederman, J.S., Bartels, S.L., Liu, C. & Jimenez, J. (2013). *Teaching the 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., 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., 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. https://doi.org/10.1002/tea.21125

Lederman, N.G. (2019). Contextualizing the relationship between the nature of scientific knowledge and scientific inquiry. *Science & Education, 28*(1), 249 267. https://doi.org/10.1007/s11191-019-00030-8

Lederman, J.S., Lederman, N.G., Bartels, S., Jimenez, J., Akubo, M., et al. (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. https://doi.org/10.1002/tea.21512

Lederman, J.S., & Bartels, S.L. (2018). *Assessing the ultimate goal of science education: Scientific literacy for all*! In S. Kahn (Ed.), Toward inclusion of all learners through science teacher education (pp. 277–285). Brill.

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Sage.

Lotter, C., Singer, J., & Godley, J. (2009). The influence of repeated teaching and reflection on pre-service teachers' views of inquiry and nature of science. *Journal of science teacher education, 20*(6), 553-582. https://doi.org/10.1007/s10972-009-9144-9

McMillan, J.H., & Schumacher, S. (2010). *Education research: Evidence-based inquiry* (7th ed.). Pearson Education, Inc.

Merriam, S.B. (2013). *Nitel araştırma: Desen ve uygulama için bir rehber* (S.Turan, Trans.) [A guide to qualitative research patterns and practice] (Trans. S. Turan). Nobel Press.

National Research Council [NRC] (2000). *Inquiry and the national science education standards*. National Academy Press.

National Research Council [NRC] (2012). *Inquiry and the national science education standards*. National Academic Press.

National Research Council (NRC). (2013). *Monitoring progress toward successful K-12 STEM education: A nation advancing*? National Academies Press.

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

Norris S.P., & Phillips, L.M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*(1), 224-240.

Melville, W., Fazio, X., Bartley, A., & Jones, D. (2008). Experience and reflection: Pre-service science teachers' capacity for teaching inquiry. *Journal of Science Teacher Education, 19*(1), 477-494.

Mesci, G., & Schwartz, R.S. (2017). Changing pre-service science teachers' views of nature of science: Why some conceptions may be more easily altered than others. *Research in Science Education, 47*(2), 329-351. https://doi.org/10.1007/s11165-015-9503-9

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. https://doi.org/10.1080/09500693.2019.1700316

Mesci, G., & Kartal, E.E. (2021). Science teachers' views on the nature of the scientific inquiry. *Bartın University Journal of Faculty of Education, 10*(1), 69-84. https://doi.org/10.14686/buefad.797246

Metin-Peten, D. (2021). Influence of the argument-driven inquiry with explicit-reflective nature of scientific inquiry intervention on pre-service science teachers' understandings of the nature of the scientific inquiry. *International Journal of Science and Mathematics Education, 20*(1), 921-941. https://doi.org/10.1007/s10763-021-10197-8

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

Opfer, J.E., & Siegler, R.S. (2004). Revisiting preschoolers' living things concept: A microgenetic analysis of conceptual change in basic biology. *Cognitive psychology, 49*(4), 301-332.

Organization for Economic Co-operation and Development (OECD) (2003). *The PISA 2003 assessment framework-mathematics, reading, science, and problem-solving knowledge and skills*. OECD Publishing.

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). Taylor and Frances Group.

Penn, M., Ramnarain, U., Kazeni, M., Dhurumraj, T., Mavuru, L., & Ramaila, S. (2021). South African primary school learners' understandings of the nature of scientific inquiry. *Education 3-13, 49*(3), 263-274. https://doi.org/10.1080/03004279.2020.1854956

Pérez, B.C., & Díaz-Moreno, N. (2022). Promoting pre-service primary teachers' development of NOSI through specific immersion and reflection. *EURASIA Journal of Mathematics, Science and Technology Education, 18*(3), 1-16. https://doi.org/10.29333/ejmste/11795

Pritchard, A. (2017). *Ways of learning: Learning theories for the classroom*. Routledge.

Reid, J., Forrestal, P. & Cook, J. (1989). *Small group learning in the classroom: Scarborough (Australia)*. English and Media Centre.

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Choi, M.Y., Sanders, D., & Benefield, P. (2004). *A review of research on outdoor learning*. Field Studies Council.

Roberts, D.A., & Bybee, R.W. (2014). Scientific literacy, science literacy, and science education. *Handbook of Research on Science Education, 2*(1), 545-558.

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.G. (2002). "It's the nature of the beast": The influence of knowledge and intentions on learning and teaching nature of science. *Journal of Research in Science Teaching, 39*(3), 205-236.

Schwartz, R.S. (2004). *Epistemological views in authentic science practices: A cross discipline comparison of scientists' views of nature of science and scientific inquiry* [Unpublished doctoral dissertation]. Oregon State University.

Schwartz, R.S., & Crawford, B.A. (2004). *Authentic scientific inquiry as a context for teaching nature of science: Identifying critical elements for success*. In L. Flick & N.G. Lederman (Eds.), Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education (pp. 331–356). Kluwer Publishing Co.

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.

Singer, J. (2005). *Integrating technology and pedagogy: The ideas, the shift and the targets*. In S. Rhine & M. Bailey (Eds.), Integrated technologies, innovative learning: Insights from the PT3 program (pp. 199–215). International Society for Technology in Education.

Tatar, N., & Bağrıyanik, K.E. (2012). Opinions of Science and Technology Teachers about Outdoor Education. *Ilkogretim Online, 11*(4), 883-896.

Tytler, R., & Peterson, S. (2003). Tracing young children's scientific reasoning. *Research in Science Education, 33*(4), 433-465.

Wang, J. & Zhao, Y. (2016). Comparative research on the understandings of nature of science and scientific inquiry between science teachers from Shanghai and Chicago. *Journal of Baltic Science Education, 15*(1), 97.

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.

Yung, B., Wong, S., Cheng, M., Hui, C., & Hodson, D. (2007). Tracking pre-service teachers' changing conceptions of good science teaching: The role of progressive reflection with the same video. *Research in Science Education, 37*(1), 239–259.

Yurt, Ö. (2015). *Okul öncesi dönemde fen eğitimi [Science education at preschool period]*. In F. Şahin (Ed.), *Her yönüyle okul öncesi eğitim: Okul öncesi dönemde fen eğitimi [Preschool education in all aspects: Science education at preschool period],* (ss.11-20). Hedef CS Yayıncılık ve Mühendislik.

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