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ARTICLE

Changes in Students' Views about Nature of Scientific Inquiry at a Science Camp

G. Leblebicioglu[1] · D. Metin[2] · E. Capkinoglu[3] · P. S. Cetin[1] · E. Eroglu Dogan[1] · R. Schwartz[4]

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Abstract Although nature of science (NOS) and nature of scientific inquiry (NOSI) are related to each other, they are differentiated as NOS is being more related to the product of scientific inquiry (SI) which is scientific knowledge whereas NOSI is more related to the process of SI (Schwartz et al. 2008). Lederman et al. (*Journal of Research in Science Teaching*, *51*, 65–8, 2014) determined eight NOSI aspects for K-16 context. In this study, a science camp was conducted to teach scientific inquiry (SI) and NOSI to 24 6th and 7th graders (16 girls and 8 boys). The core of the program was guided inquiry in nature. The children working in small groups under guidance of science advisors conducted four guided-inquiries in the nature in morning sessions on nearby plants, animals, water, and soil. NOSI aspects were made explicit during and at the end of each inquiry session. Views about scientific inquiry (VASI) (Lederman et al. *Journal of Research in Science Teaching*, *51*, 65–8, 2014) questionnaire was applied as pre- and post-test. The results of the study showed that children developed in all eight NOSI aspects, but higher developments were observed in "scientific investigations all begin with a question" and "there is no single scientific method," and "explanations are developed from data and what is already known" aspects. It was concluded that the science camp program was effective in teaching NOSI.

Keywords Science camp · Scientific inquiry · Views about scientific inquiry (VASI)

✉ G. Leblebicioglu
gulsen@ibu.edu.tr; gulsenbagcikilic@yahoo.com

[1] School of Education, Department of Mathematics and Science Education, Abant Izzet Baysal University, Bolu, Turkey

[2] School of Education, Department of Mathematics and Science Education, Bozok University, Yozgat, Turkey

[3] Bolu, Turkey

[4] College of Education and Human Development, Department of Middle and Secondary Education, Georgia State University, Atlanta, GA, US

1 Introduction

Students' views of nature of science (NOS) has been a great concern for science educators for years, and research has focused on understanding these views and how to effectively change them to be aligned with currently accepted descriptions of NOS (e.g., Lederman 1992; McComas 1998; Khishfe and Abd-El-Khalick 2002; Lederman 2007). Although NOS and nature of scientific inquiry (NOSI) are related to each other, they are differentiated as NOS being more related to the product of scientific inquiry, which is scientific knowledge; whereas NOSI is more related to the process of scientific inquiry (Schwartz et al. 2008, 2012; Lederman et al. 2014). NOSI aspects that are accessible and relevant for students were described by Schwartz et al. (2008) to include six aspects; scientific questions guide research, multiple methods of research, multiple purposes of research, justification of scientific knowledge, distinctions between data and evidence, and community of practice. Then, Lederman et al. (2014) developed a new instrument; views about scientific inquiry (VASI), that targets some similar but some additional NOSI aspects. The VASI is designed and validated to assess respondents' views of NOSI aspects closely aligned with the Next Generation Science Standards (Achieve 2013). There are eight aspects of NOSI targeted on the VASI (Lederman et al. 2014): "scientific investigations all begin with a question and do not necessarily test a hypothesis." "there is no single set of steps followed in all investigations (no single scientific method)," "inquiry procedures are guided by the question asked," "all scientists performing the same procedures may not get the same results," "inquiry procedures can influence results," "research conclusions must be consistent with the data collected," "scientific data are not the same as scientific evidence," and "explanations are developed from a combination of collected data and what is already known."

The argument for why NOSI is important for learners to understand is similar to the argument for NOS. That is, learners may be able to conduct a scientific investigation, but in order to evaluate the validity of scientific claims and understand how scientific knowledge is generated, people must understand the nature of the practices that are involved in developing and accepting scientific knowledge (Schwartz et al. 2012). For example, understanding NOSI includes understanding the role of scientifically oriented questions in science. A meaningful understanding of this aspect necessitates a critical eye towards "scientifically oriented," which helps the person distinguish between questions that can be explored through scientific practices and those that cannot. Crawford (2014) includes NOSI in her description of what learners should come to know through inquiry practices. In her review, she summarizes arguments supporting the inclusion of inquiry to include: (1) Inquiry aligns with how people learn science. (2) There is a national need for inquirers and engineers. (3) Inquiry is a means to understanding how science is done. (4) Inquiry is a means to develop in young people an interest in science. (5) Inquiry is an important means to understanding that science itself is changing. (6) Inquiry addresses the need for citizens to be able to make decisions related to controversial societal problems. These benefits are associated with learning through inquiry, learning inquiry skills, and learning *about* inquiry (NOSI). Osborne (2014) takes the argument further to raise important and fundamental distinctions between inquiry as done by scientists and inquiry as recommended (or possible) by science education. He states that, "*Any science education that offers students only a conceptual understanding of science without explaining how we know what we know or why we believe what we do leaves students without any knowledge for the epistemic basis of belief*" (p. 580). To understand the epistemology of science (what science is and how we come to know it), one must understand the NOS and NOSI.

There is a growing body of literature describing different methodologies to develop students' understandings of NOSI aspects (see reviews by Crawford 2014 and Osborne 2014). A recent study provided a validation of the VASI instrument and described how it is useful for tracking changes in learners' views (Lederman et al. 2014). It was a study of explicit-reflective instruction of eight NOSI aspects over a period of 7 months by three teachers. Another study involved a science camp with a group of Taiwanese students (Antink-Meyer et al. 2016). This study aimed at introducing NOSI in student inquiries. The study presented in the current paper is also a science camp application to teach NOSI aspects through student inquiries in nature. The main objective of the study was to investigate the effectiveness of this science camp on developing the students' views of NOSI. The study was informed by research in science camps and NOSI research.

2 Background

2.1 Inquiry

Schwartz et al. (2008) defined scientific inquiry as: "*the characteristics of the processes through which scientific knowledge is developed, including the conventions of development, acceptance, and utility of scientific knowledge*" (pp. 3). Both Osborne (2014) and Crawford (2014) provide thorough descriptions and review of the literature related to science as inquiry. With respect to inquiry in science education, Crawford states:

> *In answering scientific questions posted by the teacher or her students, and with the expert guidance of the teacher, the student makes sense of observations, the text in a book, images on a computer screen, or the data gathered during an investigation. A student figures out something for her- or himself and connects this with scientific views. In an inquiry classroom, students engage in generating and evaluating scientific explanations of the natural world as they participate in scientific practices and discussion. At the heart of inquiry is the learner grappling with data and using evidence and logic to make sense of some event or phenomenon in a social, collaborative environment (Achieve 2013; NRC, 1996, 2000) (Crawford 2014, p. 517).*

This description emphasizes the engagement of the learner in scientific practices and scientific thinking.

Crawford (2014) further defined learning *about* scientific inquiry as "both the 'doing' of inquiry (practices) and learning *about* the 'nature of scientific inquiry' as content" (p. 517). We use these descriptions in the current study, with the main focus being on engaging students in the practices of inquiry for the purpose of learning *about* NOSI.

For this study, inquiry is considered a method of teaching science concepts in many schools in many countries such as the US, England, and Turkey. The Ministry of National Education in Turkey suggested inquiry in elementary and secondary science and technology curriculum in 2004 (MNE 2004), and science curriculum in 2014 (MNE 2014). Inquiry was differentiated into three types of as structured inquiry, guided inquiry, and open inquiry. These levels were also proposed by Schwab over 50 years ago (1960). Guided inquiry has less structure than structured inquiry as students are provided a scientific question to explore. Students are guided by the teacher throughout their inquiry, but the students hold primary responsibility for investigation design and conduct. Guided inquiry could also be considered as level 2 inquiry according to Settlage and Southerland (2007), because, a source of the question is given by the teacher, but all other steps of the inquiry are carried by the students. Guided inquiry was applied in this study because we aimed at completing student inquiries in 4 h. Fully open inquiry would typically last longer as students hold responsibility for generating a viable scientific question as well as design and conduct. In open inquiry, students are afforded opportunities to try and redo as necessary in order to generate a viable question and design (Sadeh and Zion 2009). For the current camp experience, we preferred to have guides who were science advisors and monitored students' inquiry process. They also discussed NOSI aspects whenever appropriate during the inquiry. A science advisor was assigned to each group of four students. In this way, all groups were guided as necessary (with questions and suggestions) so that they made progress throughout the session. The students had some difficulties during the first session with designing appropriate investigations for their questions. As the week went on and students gained experience, they came to understand what was expected from them and conducted their inquiries better and with more autonomy. In this respect, this study was designed to provide the students experiences with the whole inquiry process, from their own research question, designing and applying their inquiry, and answering their research question based on their data under the guidance of a science advisor. They assumed ownership of their research as they experienced all parts of an inquiry. The science advisors were science educators who have knowledgeable about NOSI, and they pointed out and discussed NOSI aspects in context throughout their inquiry.

2.2 NOSI Research

The concept of NOSI has been around for decades, but under different names and definitions. The notion of "knowledge about inquiry" was evident in the National Science Education Standards (NRC 1996) and associated documents (NRC 2000). In these US reform recommendations, "inquiry" held multiple definitions (Crawford 2014), which lead to multiple interpretations of what inquiry *is* and what students should *be able to do* and *know about* inquiry. It was from these documents (and others) that the term "nature of scientific inquiry" arose with some frequency in the literature (Schwartz 2004; Lederman 2007). More research emerged on inquiry as scientific skills, inquiry as a body of knowledge (NOSI), and inquiry as pedagogy for learning other science content (see review by Crawford 2014). Nonetheless, the concept of NOSI (or what learners should understand *about* inquiry) was often conflated with NOS as well as inquiry skills (Lederman 2007). Schwartz (2004) purposely delineated a distinction for a study of scientists' views of NOS and views of NOSI. This view was further supported by Neumann et al. (2011) used a Rasch-based analysis approach and determined NOS and NOSI to be distinct concepts. Some scholars still purport an overarching concept of NOS to include skills, the nature of scientific knowledge, and the nature of scientific inquiry (e.g., Allchin 2011; Irzik and Nola 2011); while others maintain an overlapping yet distinct conceptual framework for NOS, NOSI, and inquiry skills (or scientific practices) (e.g., Lederman and Lederman 2014; Lederman et al. 2014; Neumann et al. 2011; Schwartz et al. 2012). For the current study, we base the intervention, data collection, and analysis on this latter framework of NOSI as distinct from, yet related to, NOS.

In order to investigate students' views of NOSI, the views of scientific inquiry (VOSI) questionnaire (Schwartz et al. 2008) was previously used. Schwartz (2004) applied VNOS-Sci and VOSI-Sci to scientists working in different disciplines and analyzed their views about NOS and NOSI. Whereas there was no noted relationship between NOS views and science discipline (Schwartz and Lederman 2008), Schwartz found that scientists' views about NOSI may differ depending on their investigative approach. Chemists and some biologists who relied on experimental designs were more likely to propose hypothesis testing; whereas theoretical physicians, geologists, and astronomers recognized that not all scientific investigations involve hypothesis testing. Some biologists and chemists emphasized statistics for justification of scientific knowledge. Whereas, the theoretical physicists, geologists, and astronomers in the study emphasized that scientific knowledge was justified if similar studies result in similar findings (Schwartz 2004). In another study, Aydeniz et al. (2011) examined high school students who worked in scientific laboratories and analyzed the changes in their view about NOS and NOSI. They found that students learned the process of inquiry, but did not learn hidden aspects of NOSI. They suggested making NOSI aspects explicit.

A study by Senler (2015) compares Turkish and American students' NOSI views by using the VOSI-E questionnaire. VOSI-E emerges students' views on four aspects of scientific inquiry: "all investigations begin with a question," "there is no single scientific method," "scientists collect empirical data to answer their questions," and "data and prior knowledge are used to answer questions." The results revealed a significant difference in students' views of scientific inquiry between the countries. The US sample demonstrated more contemporary views on the aspects of "all investigations begin with a question," "scientists collect empirical data to answer their questions," and "data and prior knowledge are used to answer questions" while the Turkish sample demonstrated more contemporary views on the aspect of "there is no single scientific method." A more recent international study exploring NOSI views using the VASI instrument (Lederman et al. 2014) is currently being conducted, with results suggesting similarities across the 19 countries involved in the study of grade 7 students' views about scientific inquiry (Lederman et al. 2017). This study indicates the children across the globe tend to lack informed views of NOSI.

Scientific inquiry has also been used as a pedagogical approach for teaching NOS in apprenticeship studies in which students took part in ongoing research in science laboratories for a pre-planned time. Without explicit teaching of NOS, student experiences in these laboratories and interaction with scientists did not develop students' NOS understanding (Moss et al. 1998; Barab and Hay 2001; Moss et al. 2001; Bell et al. 2003). On the other hand, when explicit NOS teaching was integrated into science research experiences, more development in NOS understanding was reported (Schwartz et al. 2004; Burgin and Sadler 2016). In Schwartz et al. (2004), group seminars were useful for introducing students to NOS aspects, and prompt students to make connections with science research experiences. Lederman and Lederman (2014) also suggested helping learners make connections from research experiences to NOSI aspects. Apprenticeship models for teaching about NOS and NOSI have possible limitations such as timeframe of the experience (a few days to several months), the ownership of the research, and role of the scientist mentor (Sadler et al. 2010). In other words, students may not experience the whole inquiry process from asking questions, designing an investigation to conclusion, and answering the research question. The research was not owned by the students, and scientists would not discuss issues related to NOSI aspects with the students. Thus, students tend to have fewer opportunities to reflect on relevant NOS and NOSI aspects.

These studies raise awareness of the need to address NOSI explicitly in science instruction. Again, the position regarding NOSI is similar to recommendations for NOS instruction: explicit/reflective learning experiences are recommended for helping learners to develop desired conceptions of NOSI (Lederman et al. 2014). Osborne claims that if epistemic goals are not explicitly targeted during inquiry activities, learners only develop knowledge of the content (2014). Reflection plays a critical role. Osborne states,

> "*its [scientific inquiry] function should enable the student to experience the intellectual engagement and satisfaction that science can offer. Perhaps, more importantly, it will help to build a deeper functional understanding of science that is required by the scientifically literate individual.* ***To achieve the latter goal, it is important that there is a reflection on practice with clearly defined goals for the procedural and epistemic knowledge such practice seeks to build***" (p. 581). [bold emphasis added]

By explicit and reflective we do not mean direct, or didactic, instruction where declarative statements are made about NOSI. Rather, explicit/reflective learning experiences mean NOSI aspects are purposely taught in conjunction with other science subject matter through providing inquiry-based experiences (activities, investigations, historical stories, etc.) and intentionally helping draw learners' attention to relevant NOSI aspects through discussion and reflective questioning (Lederman and Lederman 2014).

2.3 Science Camp Research

Science camps are common in many countries such as Canada, the US, and many European countries. Some of them are also being organized around a European Union project (Lindner and Kubat 2014). Science camps are also becoming popular in Turkey by funding of the Science and Society Department of the Scientific and Technological Research Foundation of Turkey. The science camp presented in this paper was supported by this department. The department supports science camp projects which are conducted at different sites throughout the country.

Some science camps are applied as university outreach programs in which students work side by side with scientists at university laboratories. Such programs have been shown to have a positive impact on students' understanding of NOS and scientific inquiry when NOS is explicitly addressed (Schwartz et al. 2004; Kimbrough 1995), increase interests in science, and open avenues for possible career opportunities in science. (Fields 2009; Knox et al. 2003; Gibson and Chase 2002; Atwater et al. 1999; Helm et al. 1999; Richmond and Kurth 1999; Bleicher 1996). Students also develop confidence in sophisticated laboratory skills and increase their performance in advanced science courses (Knox et al. 2003). These positive effects can last for years, as is evident in the Markowitz (2003) study.

Some other science camps are applied independently for a special group of students. Liu and Lederman (2002) conducted a science camp with gifted middle school students coming from Taiwan to a university in the US. Although the researchers in that study applied explicit NOS and inquiry experiences in the science camp, they did not find any change in students' understanding of NOS from pre- to post-test, as the students had already done well at the pre-test. Ceiling effects and a short period of instruction were two possible reasons suggested by the researchers for the absence of change from pre- to post-test. With a similar group of Taiwanese students, Antink-Meyer and colleagues (Antink-Meyer et al. 2016) conducted a recent science camp that aimed to introduce NOSI in the context of student inquiries. The Taiwanese students came to a university in the US for the science camp for 2 weeks. The program consisted of two inquiry activities, and some other science sessions and tour to science centers. NOSI aspects were made explicit in some of the sessions through discussion and guided reflection. They applied the Views About Scientific Inquiry (VASI) questionnaire (Lederman et al. 2014) as pre- and post-test. Their results demonstrated modest developments in five of eight NOSI aspects (scientific investigations beginning with a question, the multiple methods of science, the role of questions in guiding procedures, the distinction between data and evidence, and the combination of data and what is already known in the development of explanations). The results of their study also showed that Taiwanese students have less naïve views on some NOSI aspects (as compared to other studies), and there are misconceptions specific to them.

The researchers in the present study conducted two previous science camps similar to the science camp presented here. The previous camps applied the VOSI-S questionnaire as pre-test, post-test, and retention test (Leblebicioglu et al. 2017). The aim of the science camp program was to teach scientific inquiry and aspects of NOSI by applications in nature (authentic inquiry) and by making NOSI aspects explicit in the context of students' inquiries. The results were compared to determine how effective the science camp program was with respect to developing participants' conceptions of NOSI. The science camp program was found to be effective in introducing three of six aspects: questions guide the research, multiple methods of research, difference between data, and evidence in both science camps (Leblebicioglu et al. 2017). While the VOSI instrument was effective to target some aspects, clarity of some items and consistency of data were problematic for the Turkish participants. We believe that science camps deserve more research attention to assess their effectiveness in introducing NOSI. The students are highly motivated to learn in a science camp and searching nature adds relevance and authenticity to the experience. In addition, students apply inquiry at their level of sophistication and experience the whole inquiry process. If NOSI aspects are made explicit throughout inquiry and they reflect their understanding of NOSI aspects, we believe that science camps could be effective in introducing NOSI. With this belief, we designed a science camp and applied it to introduce NOSI throughout students' four inquiries at the nature site. Instruction included debriefing and making NOSI aspects explicit at the end of each inquiry process. We wanted to search the camp's effectiveness in developing campers' NOSI views. Thus, the research question guiding our study is: *How do students' views of NOSI change after participating in a science camp in which students conduct guided inquiry in nature and experience explicit-reflective teaching of NOSI?*

2.4 Rationale for the Study

Science camps are popular, but their effectiveness should be investigated because they take a considerable effort, time, and money. This study reports the effectiveness of a nature science camp that includes student inquiries about nature and making NOSI aspects explicit. In addition, this study presents teaching NOSI at a science camp which is an informal learning context. Scientific inquiry and NOSI were generally taught in schools. This study informs science educators about different ways of teaching NOSI through guided inquiry in an outdoor, natural setting.

Although this study is a science camp, it would contribute validation of VASI questionnaire in different cultures. New instruments should be tried with different samples and in different applications to determine how valid it is. Data from a different culture would inform developers and users of VASI about its validity in different cultures.

Another fact is that NOS is a highly researched area in science education, but NOSI, as defined in this study, has been studied much less (Lederman et al. 2014). This study and similar studies can attract NOS researchers' attention to NOSI. Students' views about NOSI should also be studied, since core of science education in schools in Turkey and the US is scientific inquiry and implicit scientific inquiry applications do not develop NOSI aspects (Lederman et al. 2014). Thus, more science education researchers would enroll in this line of research and explore students' views of NOSI. Such research would also inform teachers about NOSI aspects and their explicit instruction throughout scientific inquiry and increase the possibility of applying similar instruction in their scientific inquiry applications in schools.

In summary, teaching NOSI at a science camp, applying a new instrument to follow students' views of NOSI, and having data from a different culture, constitute the original contribution of this study to NOSI research.

3 Method

The study was a qualitative case study (Merriam 1998) of a science camp, conducted in July, 2014 in Turkey. Case study is an in depth study of a case. The case in this study is one science camp conducted with 24 students. There were 16 girls and 8 boys. All participants were 6th and 7th graders. They had science classes (4 h per week) starting from 4th grade. Their participation in the science camp was voluntary.

3.1 The Science Camp Program

The core of the science camp program (Table 1) consisted of guided inquiry in nature. The students conducted four guided-inquiry activities related to nature. Each inquiry activity lasted about 4 h in morning sessions and involved nearby soil, water, plants, and animals. They worked in research groups of four students. Each group was guided by a science advisor who is a university science educator such as graduate assistant or assistant professors.

In each inquiry session, each group asked a research question about the subject of the inquiry, designed their inquiry, and collected samples or first-hand data at the site. Then, they analyzed and interpreted their data and answered their research question. In this way, they participated in scientific practices that were relevant and interesting to them; they investigated nature through their curiosity, applying scientific practices, and constructing knowledge based on their data. A few of the research questions searched in inquiry sessions were:

- Are the buoyancy of various samples of water (lake water, tap water, salty water) different?
- What are similarities and differences between river, lake, and underground water?
- Is there a relationship between stalk and number of leaves?
- What are differences between a dragonfly and butterfly?
- Are the length of oak tree leaves at different heights (altitudes) the same or different?

One group's process working on the last question is explained in detail in the following section.

Plant Inquiry Session The context provided for the students was *plants*. The students brainstormed what they would want to investigate about the plants nearby the camping area. For example, a group formulated their research question as "Are the length of oak tree leaves at different heights the same or different?" Heights in this case meant altitude. They decided on their method to be observation and determined different areas for data collection, starting from the entrance of the forest, 500 m, and 1 km up the hill. They collected 20 leaves from oak trees

Table 1 Science camp program

Hours	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day
Morning session (9 am-1 pm)		What is science? Pre-test (Draw-a-Scientist Test (DAST) and VASI questionnaire application. Water machine activity to introduce science	Nature walk (observations at many stations such as trees, plants, and ants.	Soil inquiry (deciding a question about soil around, designing and conducting their inquiry in the nature with their science advisor)	Water inquiry (deciding a question about the water around, designing and conducting their inquiry in the nature with their science advisor)	Plant inquiry (deciding a question about plants around, designing and conducting their inquiry in the nature with their science advisor)	Animal inquiry (deciding a question about animals around, designing and conducting their inquiry in the nature with their science advisor)	Post-test (Draw-a-Scientist Test (DAST) and VASI questionnaire application.)
Afternoon session (3 pm–7 pm)	Coming to the camp	Mathematics in the nature (Fibonacci numbers, golden spiral)	Science, nature and art (face mask, marbling art, Leonardo da Vinci and Beethoven, four seasons symphony)	Creative painting (painting a T-shirt)	Ecosystems around the camp (visiting lake, puddle, stream, forest and teaching ecology)	Environmental pollution (chemicals at home, chemical pollution in the environment)	Poster preparation (preparing a poster about one of their inquiries)	Poster presentation to parents and certification
Evening sessions (8 pm–11 pm)	Welcome party	Evaluating the day getting rest	Evaluating the day getting rest	Evaluating the day getting rest	Evaluating the day getting rest	Evaluating the day space observation (observing the moon and constellations)	Evaluating the day and week party	

at each site and returned to the camp. They measured the length of each leaf and calculated the average length of the leaves collected from each site. They concluded that the length of leaves increases with height (altitude) of where the tree is growing. Their science advisor also asked them how they made this conclusion from their data. They were asked to show evidence for their conclusion, and the evidence needed to arise from their data. They also provided a possible explanation for why the length of leaves changes, combining their knowledge with the evidence. The following excerpts are an example of how NOSI aspects were made explicit during their inquiry.

(After the group decided their question…)

Science advisor: ***All scientific investigations begin with a question. You were given the topic of plants in the area to consider. Then you decided your specific question based on what you were curious about. Now, you can begin your scientific investigation. You will choose your appropriate method for your question now. Think about what you should do to answer this question. Should you do an experiment or observation?***
Student1: Our question is about length of leaves, so measuring is enough. There is no need for experimenting.
Student2: Measuring is observation. We will observe leaves without affecting them.

Science advisor: All right you will make observations of leaves by measuring their length. Ok, you decided on your method. Now you will design your procedure. This means deciding how you are going to do your observations? ***During your inquiry you always keep your question in your mind and decide your method according to the question. Look at your question now. Your question says different heights, so can measurements taken at only one site to answer this question?***

Up to this point, the science advisor drew explicit attention to the NOSI aspects of "all scientific investigations begin with a question," "there is no single set of steps followed in all investigations," and "procedures are guided by the question asked" in the bolded sections. The conservation continues as the following:

Student2: No, there will be more.

Science advisor: Yes, but how many?

Student3: Five

Science advisor: Five sites at different heights would take too much time, we do not have much time. Any other suggestion? [Here is an example of how the advisor guided the inquiry to fit within the allotted time.]
Student4: Let's make it three.

Science advisor: Three would be enough. If it is not you would add one more site later. ***You can develop your procedure if you need, but don't deviate from the question.*** *Ok. You will have three stations, but where will these three stations be? At what heights?*
Student1: One site would be at the beginning of the forest.

Student2: The second site should be really at far away up in the hill then.

Science advisor: Ok. How far?

Student1: 100 m

Science advisor: This may not be enough to see a change. Again, you need to be able to get enough data to answer your question.
Student4: 500 m

Science advisor: That's better. Your procedure is growing. First site will be at the beginning of the forest, second site will be 500 m up to the hill. The third one will be where then?
Student3: 500 m after the second station.

Science advisor: Good. Write down these on your notebooks. ***Now, let's look at your question again. What should you do at these three stations to answer your question?***
Student1: We should measure the length of oak tree leaves.

Science advisor: Yes, but you will have new decisions here. Can you measure the length of all the oak tree leaves or should you narrow down your sample?
Student3: We should narrow down.

The students decided to choose 20 oak tree leaves randomly from each site.

In this exchange, the science advisor made NOSI explicit by targeting "procedure is guided by the question asked" by asking students to review their procedure in light of the question and stating that they can develop their procedure. The conversation continues as:

Science advisor: ***Now let's summarize your procedure and check if you can answer your question by applying this procedure.*** *Your question was "Are the length of oak tree leaves at different heights the same or different? You will have three stations: at the beginning, 500 m, and 1000m high up to the hill. You will collect 20 leaves from each site randomly and return to the camp site. You will measure the length of leaves from each site and compare them.* ***Then, you will provide data. What is data here?***
Student2: Data are our measurements. The numbers.

Science advisor: ***Yes, data are your measurements which are numbers here. Are data always numbers?***

Student2: No, data would be in words too if we say this leaf is short, this leaf is long.

Science advisor: ***Yes, data are our observations. We sometimes say our observations in words, or some other times we make measurement and turn our observations into numbers. Here is the question: can you answer your question by the data you will have by applying your procedure?***
Student4: I think so. We will get three averages and compare them and see if the lengths of oak tree leaves at three sites are the same or different.
Science advisor: Do you agree with your friend?

Student1, 2, 3: Yes.

Science advisor: ***Now, let's summarize what you have done. You begin with a question about lengths of oak tree leaves at different sites. You decided on your methodology to be observation. You designed your procedure with your question in your mind. You thought about your data and you think you can answer your question with the data obtained from your procedure. Then, let's go and collect data.***

The science advisor emphasized the aspect of "procedures are guided by the question asked" and talked about data which then related to evidence they would need to answer their question. The science advisor made NOSI explicit one more time by summarizing their process. It is impossible to give all conversations in this inquiry. But, these aspects would provide a sense of understanding how NOSI was made explicit throughout students' inquiry processes.

After each group completed their inquiry, they presented their process and results to other groups. The first author monitored the presentations and drew further explicit attention to NOSI. She highlighted that students asked different questions, applied different methodologies according to their questions, collected data, and concluded based on their data. She also emphasized that scientists work in this way. There were also many occasions to talk about difference in groups' interpretations and their communication throughout their research.

Since the camp should also involve fun and recreational activities, there were art sessions, and games in the afternoon sessions. There was a break (2 pm–3 pm) for the students rest or play freely with their friends.

3.2 The Instrument

For use in this study, the VASI questionnaire was translated into Turkish, back translated to English, and the new English version was checked against the original

English version to ensure reliability of the translation. The VASI questionnaire (Lederman et al. 2014) was applied as pre- and post-test. The VASI questionnaire consists of seven open-ended questions to probe students' ideas about the eight aforementioned NOSI aspects (Lederman et al. 2014). The VASI was applied at a room in exam conditions. Students individually filled out the questionnaire in approximately 20 min. To validate written responses, five students were randomly selected for interviews about their questionnaire responses. The students were interviewed individually just after they completed their questionnaire. The interviews lasted approximately 20 min.

3.3 Data Collection and Analysis

Data were coded according to explanations in Lederman et al. (2014). The students' responses to different questions were analyzed in light of eight aspects of NOSI. The students' responses were coded into four categories: no response, naive, mixed, and informed. Interview data were used whenever the researchers had difficulty in understanding a questionnaire response. Naive view presents responses which did not indicate an understanding of a particular NOSI aspect. Informed view presents responses which indicate comprehensive understanding of an aspect. Mixed view included responses which have some merit, but not as qualified as informed responses or there is some inconsistency in the responses. Because there was not a direct question for some aspects and students would discuss an issue under a different question, holistic analysis of responses was conducted as suggested by Lederman et al. (2014). The coding scheme for the study is presented in Table 2.

In order to maintain the reliability of the coding process, two researchers coded two questionnaires together to negotiate what type of data will be coded into each category. Then, two researchers coded five questionnaires independently and coding agreement was 82.5% which was high enough for sustaining reliability of the coding process. Then, the first researcher coded the rest of the data.

4 Results

The results from the pre- and post-test are presented in Table 3. The names of the students are pseudonyms.

4.1 Scientific Investigations All Begin with a Question and Do Not Necessarily Test a Hypothesis

The naive view for this aspect is the idea of scientific research starts with a hypothesis; if it does not, then it is not scientific. There were only five students with a naive view at the beginning of the science camp, but only one of them indicated hypothesis testing in his response. The other four students did not accept the idea that science starts with a question, but they explained their reasoning as "*no*, *sometimes we choose the subject of the research*' *(Mesut*, *pre-)* or "*no*, *subject of every scientific investigation is different. Sometimes questions could be nonscientific*" *(Hasan, pre-)*. Hypothesis testing is not taught in middle schools in

Table 2 Coding scheme of VASI responses

VASI aspects	Questions	Naive	Mixed	Informed
1. Scientific investigations all begin with a question but do not necessarily test a hypothesis	1a, 1b, 2.	"I agree with no, because they do not always need to have a question."	"Yes, scientific research starts with a question, because if we want to search a subject, we need to have a question."	"Yes, scientific research starts with a question, because there are millions of things to be searched in a subject. If we ask a question about a subject we search what we wonder and stay on task throughout the research."
2. There is no single set and sequence of steps followed in all scientific investigations	1b, 1c	"because you have to have the scientific method: purpose, hypothesis, procedure.. ."	"Yes, for example everyone does research with a different procedure."	"Yes it would be experiment and observation. In experiment we affect the thing we search and reach a conclusion. But, in observation we investigate the thing we searched without affecting and reach a conclusion.
3. Inquiry procedures are guided by the question asked	5	"Team B's procedure is better because they test problematic brand of tire on three different types of roads to find out which type of road exploded the tire."	"Team A's procedure is better because we test the tires first and we use the best on our cars. If we test only one tire, it would be bad and get flat when we use on our cars."	"Team A's procedure is better because team B were searching something that was outside of the research question."
4. All scientists performing the same procedures may not get the same conclusions	3a	"Yes they would because they are asking the same question and doing the same thing"	"No, even the question and procedure are the same, their resources would be different."	"they would reach the same conclusion or not. Everybody's thinking, knowledge and senses are not the same."
5. Inquiry procedures can influence the conclusions	3b	"Yes because if you have the same question it must lead to the same answer no matter what the procedures are."	"No, they could not, because their data will not be complete. If one of them collects some data, other one would not get the same data."	"they most probably reach different conclusions, because procedures are also different here in addition to personal differences."
6. Research conclusions must be consistent with the data collected	6	"There is no relation between sunlight and plant growth, because every plant is different."	"Plants grow taller with more sunlight, because I believe this conclusion is right for me. If you observe plants, they rotate toward sun"	"Plants grow taller with less sunlight because table shows like that and it was said that according to the table at the beginning of the question. My knowledge was the opposite."
7. Scientific data are not the same as scientific evidence	4	"They are the same because you collect both."	"Data and evidence are different. Data is collecting things from the environment. Evidence is experiments done based on data."	"Data and evidence are different. For example, in a scientific research we find evidence from data for our conclusion."

Table 2 (continued)

VASI aspects	Questions	Naive	Mixed	Informed
8. Explanations are developed from a combination of collected data and what is already known	7	"Because it is bigger."	"First skeleton, because researchers work on these better and fixed the pieces more appropriately."	"First skeleton. I think they use prior knowledge, data from different sources, and logic. In second skeleton, big body could not stand on small legs."

Table 3 Number of students categorized as holding naive, transitional, and informed views

N = 24	Begins with a question		Multiple methods		Same procedures may not get the same results		Procedures influence results	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No response	1	0	1	0	1	0	1	0
Naive	5	1	0	0	13	4	9	3
Mixed	14	2	23	1	3	3	10	5
Informed	4	21	0	23	7	17	4	16
N = 24	Procedures are guided by the question asked		Data are not the same as evidence		Explanations are developed from data and what is already known		Conclusions consistent with data collected	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No response	2	1	0	0	0	0	0	0
Naive	3	3	2	0	8	0	0	1
Mixed	12	7	22	7	15	6	17	10
Informed	7	13	0	17	1	18	7	13

Turkey. Thus, Turkish students participating in this study would not likely think of hypothesis generation or testing.

Most of the students started the camp with a mixed view on this aspect. Almost half of the students generated mixed views which mean that they accept that science involves a question, but could not appropriately explain why.

Yes, because we find the answer of the question at the end of scientific research. (Zeliha, pre-)

Yes, if you will do a research about a bird, you should ask a question about the bird. (Seza, pre-)

Although these students sensed that scientific investigations start with a question, their explanations did not indicate the role of question in guiding every part of a scientific research. Positively, such informed views flourished at the post-test.

At the post-test, almost all the students (21) accepted the idea of scientific research starts with a question and could explain their reason more appropriately. For example:

If we do not have a question, we cannot know which method we would choose and could not collect data. (Hasan, post-)

I agree with the student who says yes. For example, you will search animals. You need to have a question to collect data. It would be that what are the differences between mother and baby animals? (Seda, post-)

There was an emphasis in the camp that the students needed to start with a clear research question. They then designed their procedure, collected data, answered the research question with evidence, and presented their process of inquiry to other groups in four inquiry sessions in the science camp program. It is understandable that most of them could clearly articulate the role of questions in guiding scientific research.

4.2 There Is No Single Set of Steps Followed in All Investigations (There Is No Single Scientific Method)

Similar to the first aspect, most of the participants held a mixed view on this aspect at the beginning of the science camp. Similar to explanation for the previous aspect, the reason for not having naive view in Turkish students may be related to neither hypothesis testing nor a strict scientific method being explicitly taught in the schools. While almost all of the students were readily open to the idea of accepting multiple methods of investigation, they could not distinguish these methods as having different formats such as observational and experimental, as required for an informed view. Rather, these students usually explained procedural differences in an investigation by material difference, subject differences, and source differences. Actually, they were more familiar with searching ready knowledge from different sources such as books, the Internet, etc. as it is evident in the following quote:

(a) *I accept (it scientific), because investigating animals are scientific.*
(b) *Yes, (I accept it as an experiment), because it is a scientific research.*
(c) *Yes, there would be more than one method of scientific investigation. Suppose that the subject of two investigations is birds.*

1. *Investigation: S/he would go to a forest and observe birds there.*
2. *Investigation: S/he would read about birds on the Internet or books. (Duru, pre-)*

Duru's response implies that scientific experiments can be conducted in multiple ways. She was familiar with gaining knowledge through observations as well as from searching different resources. This was characteristic of a mixed view in this study. Even though they accepted the bird investigation as an experiment, their view of experiment is general, indicating any type of investigation involving observations is an experiment.

At the end of the camp, all but one participant accepted that there are multiple methods of research and clearly explained that these methods include observational studies and experiments. Overall, this was the best developed NOSI aspect in the science camp. Two investigative methods were emphasized during the science camp: observational studies and experiments. The questions being explored by the students did not lend themselves for meaningful correlational studies, and so this approach was not emphasized with the students. They did observatory investigations at the inquiry sessions about surrounding plants and animals, but some of the groups did experiments in their inquiries about surrounding water and soil. For every inquiry investigation, they discussed with their science advisor if they should conduct an observational study or experiment for answering their research question. Thus, they came to understand distinctions between observation and experiment and could explain each of them. Duru, on the post-test, stated:

(a) *Yes, because it starts with a question and conclude based on data.*
(b) *No, I do not accept (it as an experiment), because s/he made observation. S/he observed birds and investigated.*
(c) *Yes, for sure (there would be more than one method of investigation). For example, one can investigate soil by experiment, other one can investigate by observation. Experiment: adding water to soil and change its color. Observation: one can examine soil only, s/he does not add anything to the soil. (Duru, post-)*

Duru differentiated experiment and observation by adding something to the matter under study. Another similar response comes from Mesut;

> *Yes, there are two methods. One is observation, the other one is experiment. Experiment: In order to find which one of water, lake water, and underground water dissolves more sugar, we do experiment by adding sugar to each water sample. Observation: If we look at the purity of two water samples, it would be observation. (Mesut, post-)*

4.3 All Scientists Performing the Same Procedures May Not Get the Same Results

The data with respect to this aspect mainly comes from a direct question asking "*if different scientists working independently works on the same research question and apply the same procedure*, *would they get the same conclusion*." The results suggest students have difficulty understanding how scientists performing the same procedure may think differently and come to varying conclusions. Almost half of the students' (13) responses to this question indicated a naive view, which was that scientists would get the same conclusion if they follow the same procedure. Gurbuz was one of those;

To me, they reach (the same conclusion), because of the same methods, they would reach the same knowledge. (Gurbuz, pre-)

There were three mixed views, stating that they could not reach the same conclusion, but could explain the reason simply as using different sources or different materials.

No, because they search from different sources. (Alican, pre-)

Seven students with informed views indicated that scientists could reach different conclusions since they think differently, concentrate on different parts of the data, or have different prior knowledge.

(They) could not reach (the same conclusion), because their thinking is different. Although their methods are the same, they would not reach the same conclusion. (Nil, pre-)
No, they have different brain structure. Although their data are the same, their conclusion could not be the same, because everyone is different. (Pelin, pre-)

Nil's and Pelin's responses indicated that scientists bring different resources to investigations, including ways of thinking.

At the end of the science camp, more students understood this aspect, with 17 of them expressing informed explanations. Their informed views were also more sophisticated. For example, Nil not only stated the difference in thinking as a reason for different conclusions, but also differences in their prior knowledge and differences in their senses as it was evident in the following quote;

They reach the same conclusion or not, because every person's thinking, knowledge, and senses are not the same. (Nil, post-)
No, because their brain structure was different, people also use their prior knowledge, that's why their conclusion would be different. (Pelin, post-)
No, they could not (reach the same conclusion), because their education is different, their thinking is different, their interests are different. (Ata, post-)

There were only four students left with a naive view at the end of the camp experience. At the camp, the students experienced the difference in their thinking while working on the same research question and applying the same procedure in their small groups. They had to share their ideas and negotiate. This experience and associated discussions may have helped them understand this hidden feature of scientific research.

4.4 Inquiry Procedures Can Influence Results

The VASI question that targets this aspect is: "*if different scientists working independently work on the same research question and apply different procedure, would they get the same conclusion?*" It may have been easier for students to think that scientists would reach different results when they perform different procedures, as more students proposed that scientists would reach different conclusions since their experiments were different. Different claims due to different procedures is somewhat informed, but most of the students were not able to explain that even though different scientists asked the same question, the claims could differ based on the procedure. Thus, these students were categorized as having mixed views. Irem stated:

No, because they collect data with different methodology. (Irem, pre-)

Such responses stating only difference in methodology as a reason for their decision was coded as mixed, not as informed, because they did not elaborate beyond what was already stated in the question. Such students just repeated the question. An informed view was represented by more detail than just stating they follow different methodologies. An exemplary informed view is provided by Ata who connects different methods with additional differences in the investigation:

No, because different methods bring different factors along with them. (Ata, pre-)

In this response, Ata went one step further and explained what would differ if methods differ rather than repeating information already stated within the question. There were only four informed views at the pre-test. At the end of the science camp, more than half (16) provided an informed response, in addition to five mixed views. Examples for informed views on the post-test are the followings:

No, because data would be different if the methods are different. Conclusions would be different if data are different. That's why they reach different conclusions. (Ozlem, post-)
It is less probable for them to reach the same conclusion, mostly they reach different conclusions, because other than personal differences, there are different methods here. (Nil, post-)

Only three students remained with naive views, thinking that scientists reach the same conclusion since they were searching the same question and there is only one right answer for a question no matter how you search it. Such responses indicate an absolutist view where there is one question/one answer in science, regardless of method:

Yes, they reach the same conclusion although they collect data by observation or experiment. (Beyza, post-)

4.5 Inquiry Procedures Are Guided by the Question Asked

Data for this aspect were mainly provided by a contextual question in which two research teams (A and B) ask the question "Are different brands of tires more likely to get a flat?" The teams' respective investigations are described and then the respondent is asked to determine which team's experimental procedure is better for the research question. Team A's experimental procedure matches the research question since they tested various types of tires' performances on one type of road surfaces; whereas Team B tested one tire brand on three types of road surfaces.

At the beginning of the camp, there were only three naive responses which did not consider the research question in their decision. Beril was one of those students:

Team B, because, if a tire which was the same brand with the flat tire was tested on three different types of roads, its performance on different roads would be determined. (Beril, pre-)

Beril did not recognize the conflict between the research question and Team B's procedure. She established a different logical argument, but was not the answer to the research question under consideration.

Most of the students (12 mixed, 7 informed) decided on that Team A's procedure is better, but students with mixed views could not mention the reason as Team A's experiment matches the research question.

Team A, because they test more than one brand (of tires), but Team B test only one brand (of tires). (Ali, pre-).

Ali decided on Team A's procedure being better than Team B's procedure by using general sense, not the research question.

Only seven students provided the informed view which indicates Team A's procedure is better because it matches the question or Team B's experiment could not answer the research question:

Team A's procedure is better, because the question says different brands of tires. (Nil, pre-)

Team A, because the question do not say different roads, it says different brands of tires. In other words, they should research brands of tires, not roads. (Pelin, pre-)

At the end of the science camp, more students realized that inquiry procedures should be designed according to the research question at hand. Although most of them decided on Team A's procedure (7 transitional, 13 informed), 13 of them clearly stated that Team A's experiment would better answer the research question. Ali was an example of those students whose views evolved from mixed to informed:

Team A, because experiment should be in accordance with the question and they use different brands (of tires), because the question says different brands (of tires). (Ali, post-)

4.6 Scientific Data Are Not the Same as Scientific Evidence

There were only two naive responses at the beginning of the science camp stating that data and evidence are the same, as it was evident in the following quote:

The same, because data are the clues (knowledge) collected. Evidence is knowledge (clues) collected. (Irem, pre-)
To me, they are the same. For example, suppose that you do a research on fossils. You found a fossil. This fossil is the evidence of how many years past after it died. At the same time, this fossil was a datum when you collect during research. (Ozlem, pre-)

Irem's explanation for why data and evidence are the same was not easy to understand, but it was coded as naive, because she clearly stated that they were the same. We thought that she had difficulty in explaining her reason; she was confused and could not clear up her mind to provide an understandable explanation.

On the other hand, Ozlem's answer was a good one for explaining why she thought data and evidence are the same. She provided an example for that a datum (a fossil) would also be evidence for some research questions such as what the age of the fossil is. Despite this rationale, she was coded as naive, because of her statement of data and evidence were the same was a specific example which she used to generalize to the broader question about data and evidence. There is no mention of evidence being produced or determined based on the research question or data analysis.

Almost all of the students (22 mixed, 0 informed) stated that data and evidence were different, but could not provide an acceptable rationale;

They were different. Data are collected knowledge or things. Evidence is convincing others by showing collected things. (Irem, pre-)

Different. My breathing was the evidence that I live. ¾ of earth's surface was covered by water is a datum. (Beyza, pre-)

At the post-test, all of them stated that data and evidence were different, with 17 being able to explain data and evidence more appropriately, such as;

Data and evidence are different. Data are the knowledge that we get during research. Evidence is the knowledge that we get by comparing data with each other and we use this knowledge to support our claim. For example, if we research the relation between birds' food and type of their beak, data are the knowledge we get by observing them. If we claim that birds' beaks differ according to their food, we compare our data and compare the differences and this would form our evidence. (Ozlem, post)

Ozlem initially held a naive view, but she provided the most informed view at post-test. Even though most of the students' explanations evolved by the end of the science camp, it may be difficult for the students to clearly differentiate data and evidence, although one senses that they are different. At the end of each inquiry session, groups presented their inquiry starting with their research question and following with their methodology, data they collected and their answer based on data. The science advisor monitoring this part of the session took notes on a white board and especially asked each group how they answer their question and require them to show evidence in the data they collected for their answer to their research question. This consistent emphasis likely helped them better differentiate data from evidence.

4.7 Explanations Are Developed from a Combination of Collected Data and What Is Already Known

The data mainly comes from a contextual question which presents pictures of two dinosaur skeletons and asked the respondent to describe at least two reasons why they think most of the scientists agree that the animal in *skeleton 1* has the best positioning of the bones. Then, the following subquestions ask them to explain what types of information scientists use to explain their conclusions; and when scientists do any investigation, what type of information they use to explain their conclusions.

At the beginning of the science camp, eight students presented a naive view indicating that scientists examined dinosaur bones and simply organize them. They did not indicate that scientists also use information from other areas, other living organisms or their logic. Duru was one of these students:

a. Describe at least two reasons why you think most of the scientists agree that the animal in *skeleton 1* had the best positioning of the bones?

   Because skeleton 1 is straight and dinosaurs stand like that.

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?

   The structure of bones of many dinosaurs is like that. They sometimes show evidence if they have any.

c. When scientists do any investigation, what type of information do they use to explain their conclusions?

   They would have evidence about the event. They show their research. (Duru, pre-).

Duru's explanations concentrated only on dinosaurs' bones or evidence they get from these bones. Her response was somewhat circular in that she says the positioning is correct because "dinosaurs stand like that." She did not indicate any other source.

Fifteen students provided mixed views which have merit because they state something else in addition to bones, but their explanations did not indicate that scientists use their prior knowledge.

a. Describe at least two reasons why you think most of the scientists agree that the animal in *skeleton 1* had the best positioning of the bones?

   Such dinosaurs' hands are smaller than their feet.

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?

   They search the history of this dinosaur and show its pictures.

c. When scientists do any investigation, what type of information do they use to explain their conclusions?

   They reach the history of the research or other research studies conducted. (Zeliha, pre-).

Zeliha indicated that scientists use other research studies in her response, but she still does not demonstrate knowledge that scientists use logic (aka. structure and function) and information from current knowledge to reconstruct the fossil organisms.

By the end of the science camp, none reported a naïve response. Most of the students (18) indicated that scientists use data and their prior knowledge in reaching a conclusion. Alican demonstrated a more informed view:

a. Describe at least two reasons why you think most of the scientists agree that the animal in *skeleton 1* had the best positioning of the bones?

   Because, skeleton 1 is more similar to human and its feet can carry its body.

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?

   They use knowledge of being similar to human and other prior knowledge.

c. When scientists do any investigation, what type of information do they use to explain their conclusions?

   They use prior knowledge and their logic. (Alican, post-).

There were six students with mixed views at the end of the science camp. Melek's response would be an example of such responses.

a. Describe at least two reasons why you think most of the scientists agree that the animal in *skeleton 1* had the best positioning of the bones?

   Because, hands are behind in skeleton 2 and thus it cannot walk. It is also seen on the picture that it walks on his hands and its feet stands at an upper position in the air.

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?

   When I wrote dinosaurs on the Internet, there were similar pictures of dinosaur fossils.

c. When scientists do any investigation, what type of information do they use to explain their conclusions?

   Many scientists meet and make a decision. (Melek, post-).

Melek indicated other dinosaur pictures in her response and logic in reasoning that skeleton 2 cannot walk on its feet, because they are small and do not touch the bottom. However, the overall response suggests a mixed view that is not completely committed to scientists using available data and current knowledge.

4.8 Research Conclusions Must Be Consistent with the Data Collected

The data mainly come from a contextual question which presents a table including conflicting data about plant growth and amount of sunlight the plant gets. According to the data on the table, the plant grew more as it gets less sunlight. Three conclusions are presented at the end of the question, and respondents are asked to determine which conclusion they agree with and why.

Even at the pre-test, there were no naive views, and all of the students reached the conclusion supported by the data in the table given in the question (17 mixed, 7 informed view), but only seven of them clearly stated that they chose the conclusion because of the data in the table, despite being contrary to intuitive knowledge about plant growth. Students with informed views (7) clearly stated that plants grow taller with less sunlight, because the trend in the data from the table demonstrates more growth with less minutes of sunlight. Alican was one of these students:

> *Plants grow taller with less sunlight, because this conclusion was appropriate for the data on the table. No, (the data on the table were not the data I expected), because I knew that plants could not grow without sunlight. (Alican, pre-)*
> *Plants grow taller with less sunlight, because table shows like that. No, (the data on the table were not the data I expected) plants need sunlight. They make their food from sunlight and soil. (Guler, pre)*

Students with mixed views made the same conclusion, but could not explain clearly how they made this conclusion based on the data on the table. Two exemplary quotes are as follows;

> *Plants grow taller with less sunlight, because plants grow when they get less sunlight. Yes, data were as I expected. (Musa, pre-)*
> *Plants grow taller with less sunlight, because it is logical for me. I remember like that from my science class. No, data were not as I expected, but I did not grow a plant before. (Melis, pre-)*

At the end, again almost all of them concluded based on data in the table, but more students (13) explained their reasoning according to the table. There was only one naive response at the post-test indicating that she decided according to her prior knowledge without considering the data on the table.

> *Plants grow taller with more sunlight. Because if you look at plants, they turn toward sunlight and I think that this conclusion is right for me. (Ilke, post-)*

Interestingly, Ilke provided an informed view at pre-test as it is shown in the following quote:

> *Plants grow taller with less sunlight, because it was like that according to the table. But, to me, plants grow after they get sunlight. (Ilke, pre-)*

Ilke knew that she should conclude based on the data at pre-test, but decided on trusting on her prior knowledge at the post-test.

5 Discussion

This science camp introduced middle school campers to eight NOSI aspects through engagement in scientific inquiries in nature and making NOSI aspects explicit by discussing them in the context of the inquiries during and just after the presentation of each groups' investigation results. The program was found to be most effective in developing three aspects: "scientific investigations begin with a question," "there are multiple methods of investigations," and "explanations are developed from data and what is already known." Most of the students (21 (87%), 23 (96%), and 18 (75%), respectively) demonstrated informed views at the end of the science camp. It should be noted that most of the students started the science camp with mixed views on these aspects and were able to change their views through the camp experience.

The science camp program positively impacted students' views of three other NOSI aspects: "same procedures may not get the same results," "procedures influence results." and "data are not the same as evidence." More than half of the students (17 (71%), 16 (67%), 17 (71%), respectively) demonstrated informed views at the end of the science camp. Although more students started the science camp with naive conceptions regarding "same procedures may not get the same results" and "procedures influence results" aspects, most of them expressed informed views on these aspects. Naive views on these aspects were opposite of the informed view. The situation was different for "data are not the same as evidence" aspect. Almost all of the students (22) held mixed views at the beginning of the science camp, and 17 of them developed informed views.

On the other hand, the science camp program seemed to be less effective in developing ideas around "procedures are guided by the question asked" and "conclusions are consistent with data collected" aspects. The students started the camp with mostly mixed and informed views on these aspects; naive views were rare. At the end of the science camp, 13 students (55%) expressed informed views and seven students held mixed views in NOSI aspect of "procedures are guided by the question asked." Regarding "conclusions are consistent with data collected" aspect, 13 (55%) students demonstrated informed views and 10 students held mixed views. The reason for less development in the informed views could be due to the intuitive nature of the question (students are expecting plants to grow with more sunlight) and so may not examine the data table with the intent of answering the research question. Additionally, because several students chose the correct option on the multiple choice but did not provide a valid rationale for their choice, there may be a barrier simply due to the unfamiliar structure of the question. It may be that these Turkish students are accustomed to multiple choice tests in the schools which do not require written responses for their choice.

Another point is that the students in this study started mostly with mixed views on most of the NOSI aspects. Some NOSI aspects that have been shown to be challenging for learners (i.e., "multiple scientific methods" (naïve view: one scientific method that involves hypothesis testing) did not fall into the naïve category as substantially as other studies have shown (i.e., Lederman et al. 2014). This result may be due to this aspect not being explicitly taught in Turkish schools. Some other NOSI aspects may be reached by logical consideration of the situation in the question. For example, it was asked in the question why one team's experiment is better than the other. In the research question, it is stated as "are different brands of tires more likely to get a flat." It is logical to work on various tires rather than one tire brand. In the other question, showing plant growth being more with less sunlight, if one only considers the data, it is logical to interpret the data as the plant develops better with less sunlight, because data on the table show that. It is logical to interpret the data according to data in the table, even though the result is counter-intuitive. What we are not ensured of in this case is if the respondent has the research question and any expected answer in mind when interpreting the data. Such logical consequences lead to mixed views. For these reasons, naive views may have appeared less and mixed views more likely. Then, through the camp experience, these mixed views were able to develop into informed views. Nonetheless, interviews associated with written responses would help to tease out reasons and limitations of written ideas provided by these middle school students.

The results of this study are similar to prior reports of how students understand inquiry (see reviews in Crawford 2014, and Osborne 2014). Without explicit intervention, middle grades' students are challenged to understand the role of questions in science, that evidence is the product of data analysis and provides support for claims, that claims are based on available data as well as prior knowledge and understanding of the natural world, among others. This study provides further support that explicit/reflective instructional attention, in the context of student-lead investigations, can improve student understandings of NOSI aspects.

Notably, however, this study used a specific framework for "knowledge about inquiry" that is based on current recommendations for what students should understand about the nature of how scientific knowledge is developed and accepted (Lederman et al. 2014). The NOSI framework used in this study lead to our use of the VASI instrument. Since the VASI questionnaire was developed recently (2014), there are not many reports in the literature to compare with the results of this study. Two similar studies were reported in Lederman et al. (2014) and a science camp study by a similar team (Antink-Meyer et al. 2016). In Lederman et al. (2014), they did inquiry activities with eight graders for 7 months and applied the VASI as pre- and post-test. Antink-Meyer et al. (2016) conducted a 2-week summer science camp in a US university with Taiwanese gifted students and applied the VASI as pre- and post-test. In this discussion, we make loose and general comparisons of results across these three studies, recognizing the differences in sample sizes, programs, and sample choice. For the science camp samples, children chose to participate in science activities. In the larger Lederman et al. (2014) study, the sample comprised children in schools. The science camp samples may be biased in one way or another regarding NOSI conceptions. We make quite lose and general comparisons, recognizing the limitations based on distinctions among the respondents and contexts of these studies.

Comparison of three studies indicated that Turkish students in our science camp and Taiwanese students in Antink-Meyer et al. (2016) science camp demonstrated less naive views than American students in Lederman et al. (2014) study on four of eight NOSI aspects which were "multiple methods of scientific research," "inquiry procedures are guided by the question asked," "scientific data are not the same as scientific evidence" "explanations are developed from a combination of collected data and what is already known." The students mostly started with mixed views on these aspects. Naive views in American students in "scientific inquiry starts with a question" aspect is higher than Taiwanese students in Antink-Meyer et al. (2016) science camp and much higher than Turkish students in this study.

Like NOS aspects, some NOSI aspects may be more difficult to understand than others (Mesci and Schwartz 2016). For example, "all scientists performing the same procedures may not get the same results" contradicts with our everyday reasoning which tends us thinking that if we do the same thing, we get the same results. Most naive responses at the beginning of this study were with this NOSI aspect and naive responses were also high in Lederman et al. (2014) study. In the Antink-Meyer et al. (2016) science camp, almost half of the students (9) started the camp with a mixed view on this aspect, but they did not demonstrate as much positive shift. Perhaps this aspect presents unique epistemological challenges to learners that should be explored further.

On the contrary, the NOSI aspect that "research conclusions must be consistent with the data collected" was the most positive one at the beginning of all three studies. Participants' views developed further after the interventions. Because, if one thinks logically on the data in the table, s/he makes appropriate conclusion based on the data although it conflicts with her/his expectation. It seems that students were already accustomed to making conclusions according to a given data set. Thus, they do not have difficulty with accepting the idea that conclusions should be in accordance with data although it contradicts with their prior knowledge. Again, the difference in sample sizes and choice to participate in a science camp vs. being in a broader population of school science may offer some explanation for differences across the three studies. We might also consider cultural differences in how students understand NOSI aspects, especially with respect to what is emphasized in school science in various contexts. Cross-cultural studies with comparable sample sizes should be conducted to enlighten these differences. Such a global collaborative study is underway that promises to shed light on how students in the middle grades understand these NOSI aspects (Lederman et al. 2017). Nonetheless, direct comparisons of results across different countries is inappropriate, given the aforementioned unique features of the educational contexts.

Another related study conducted by Senler (2015) compares Turkish and American students in their views of scientific inquiry, using VOSI-E questionnaire instead of VASI. VOSI-E emerges students' views on four aspects of scientific inquiry which are "all investigations begin with a question," "there is no single scientific method," "scientists collect empirical data to answer their questions," and "data and prior knowledge are used to answer questions". The results revealed that there is a significant difference in students' views of scientific inquiry between the countries. The US sample demonstrated more contemporary views on the aspects of "all investigations begin with a question," "scientists collect empirical data to answer their questions," and "data and prior knowledge are used to answer questions" while Turkish sample demonstrated more contemporary views on the aspect of "there is no single scientific method." Although her study was conducted with a bigger sample size and applied as a one-time measurement, results could be compared with our pre-test results. The NOSI aspect of "all investigations begin with a question" was not known by 88% of the students in their study. But, in this study, most of the students (18 (informed or mixed) out of 24) agreed that all investigations start with a question. This contradictory result could be explained by difference in questionnaires. A question in VASI, after stating the idea of all investigations start with a question, one student was stated as saying yes and the other one saying no. At the end of the question, it was asked that which student they agree with and why. The NOSI aspect clearly stated in the question and students tended more to provide positive responses. Although they agreed with the students saying yes, only four of them could explain their reason well. For this reason, there were 14 mixed and only 4 informed views in this study. This question may superficially lead to the students demonstrating more informed views. But, in the VOSI questionnaire, there was not a direct question for this aspect. Students' ideas about this aspect are required to emerge from first and second questions asking generally what is science, how scientists do their work, how they decide what to study, and what factors affect their study. Respondents do not always mention questions in their statements. The team conducting this study applied VOSI questionnaire twice and observed that students wrote general statements about science but they did not think about scientific process and wrote about it. Thus, these questions do not emerge students' ideas on this aspect consistently. It was discussed that Lederman et al. (2014) study and these two questions were excluded by them in converting VOSI questionnaire to VASI questionnaire.

In another VOSI aspect of "there is no single scientific method,", Senler's (2015) results are in accordance with our results. It was the only aspect that Turkish students presented more contemporary views than the students in the USA. In this study, almost all of the students agree that there would be more than one method of research and these results were also higher than the results reported in Lederman et al. (2014) study. This might be explained by differences in school learning. The main question for this aspect in VOSI and VASI was the same; bird observation research and question about if this study is scientific, an experiment, and last sub-question asking directly as if there would be more than one method of scientific investigations. Turkish students in this study and in Senler (2015) study were found to have more contemporary views than their counterparts in the US. But, hypothesis testing and experimental design were taught in the schools in the US where as they are not taught in Turkish middle schools. Thus, Turkish students may find it more to accept there would be more than one method of scientific investigations. These comparisons are speculation at this time, and more focused research to explore potential cultural distinctions is necessary.

6 Conclusion

The aim of the science camp program was to introduce NOSI aspects through scientific inquiry in nature and making NOSI aspects explicit in the context of inquiry. Based on our research findings, it was concluded that the science camp program was effective for introducing six of eight NOSI aspects which were "scientific investigations begin with a question," "multiple methods of scientific research," "same procedures may not get the same results," "procedures influence results," "scientific data are not the same as scientific evidence," "explanations are developed from a combination of collected data and what is already known.". There were also developments in students' views in "inquiry procedures are guided by the question asked" and "conclusions should be consistent with data collected" aspects, but less than the previous aspects.

The duration of science camps is short, but campers experienced an intensive program and had the advantage of high motivation of voluntary participation and informal, relaxed, and friendly atmosphere. Most of the science camps reported in the literature were conducted in university campuses or in schools, but this science camp was residential and conducted at a natural site. In many science camps, inquiry activities are conducted with ready-made materials, or students work as a part of research team in science laboratories. In this science camp, four guided inquiries were conducted in nature, allowing students to make decisions about their procedures and findings along the way. These features added authenticity and ownership to the campers' inquiry experiences. They were guided to make connections between their inquiries and NOSI. Such concentrated and purposeful attempts supported their understanding of NOSI in context and resulted in positive results in a short time. Retention of short camp learning was a concern, but we could not conduct the same questionnaires after the science camp this year. Our previous science camp studies with retention data showed that science camp learnings of some NOSI aspects such as questions guide scientific research, there are multiple methods of research, and difference between data and evidence were retained after 2 months (Leblebicioglu et al. 2017).

Cross-cultural studies with comparable sample sizes and parallel research design should be conducted to enlighten possible differences. Data from different cultures would inform developers and users of VASI about its validity in these cultures. Such studies would also inform researchers of potential language-based validity issues associated with translating and interpreting certain terms.

This study has some implications for the Turkish Ministry of Education. In Turkish science education curriculum, scientific inquiry was suggested as a main method of science teaching (MNE, 2014). There is some NOS emphasis in the curriculum, but not sufficiently detailed to inform science teachers about NOS. On the other hand, there is no emphasis on NOSI. Since as it is known from NOS research, implicit scientific inquiry applications do not develop adequate NOSI conceptions, future science education curriculum should have heavy emphasis and detailed information about explicit instruction of NOS and NOSI aspects in scientific inquiry applications. This study would inform that it is possible to make NOSI aspects explicit in students' inquiries that lead to enhanced conceptions.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest in this article.

References

Achieve (2013) *Next generation science standards*. Retrieved from https://www.achieve.org/nextgeneration-science-standards.

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education., 95*(3), 518–542.

Antink-Meyer, A., Bartos, A. S., Lederman, J., & Lederman, N. G. (2016). Using science camps to develop understandings about scientific inquiry-Taiwanese students in a U.S. summer science camp. *International Journal of Science and Mathematics Education, 14*, 29–53.

Atwater, M. M., Colson, J., & Simpson, R. D. (1999). Influences of a university summer residential program on high school students' commitment to the sciences and higher education. *Journal of Women and Minorities in Science and Engineering, 5*, 1555.173.

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*, 403–421.

Barab, S. A., & Hay, K. E. (2001). Doing science at the elbows of experts: issues related to the science apprenticeship camp. *Journal of Research in Science Teaching, 38*, 70–102.

Bell, R., Blair, M., Crawford, B., & Lederman, N. (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*, 487–509.

Bleicher, R. (1996). High school students learning science in university research laboratories. *Journal of Research in Science Teaching, 33*, 1115–1133.

Burgin, S. R., & Sadler, T. D. (2016). Learning nature of science concepts through a research apprenticeship program: a comparative study of three approaches. *Journal of Research in Science Teaching, 53*(1), 31–59.

Crawford, B. (2014). From inquiry to scientific practices in the science classroom. In N. Lederman & S. Abell (Eds.), *Handbook of research on science education, vol. II* (pp. 515–544). New York: Taylor and Francis Group.

Fields, D. A. (2009). What do students gain from a week at science camp? Youth perceptions and the design of an immersive research-oriented astronomy camp. *International Journal of Science Education, 31*(2), 151–171.

Gibson, H., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education, 86*, 693–705.

Helm, E., Parker, J., & Russell, M. (1999). Education and career paths of LSU's summer science program students from 1985 to 1997. *Academic Medicine, 74*, 336–337.

Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science for science education. *Science & Education, 20*(7–8), 591–607.

Khishfe, R., & Abd-El-Khalick, F. (2002). The influence of explicit and reflective versus implicit inquiry oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching, 39*(7), 551–578.

Kimbrough, D. (1995). Project design factors that affect student perceptions of success of a science research project. *Journal of Research in Science Teaching, 32*, 157–175.

Knox, K. L., Moynihan, J. A., & Markowitz, D. G. (2003). Evaluation of short-term impact of a high school summer science program on students' perceived knowledge and skills. *Journal of Science Education and Technology, 12*(4), 471–478.

Leblebicioglu, G., Abik, N. M., Capkinoglu, E., Metin, D., Eroglu Dogan, E., Cetin, P. S., & Schwartz, R. (2017). Science camps for introducing nature of scientific inquiry through student inquiries in nature: two applications with retention study. *Research in Science Education*. https://doi.org/10.1007/s11165-017-9652-0.

Lederman, N. G. (1992). Students' and teachers conception of the nature of science: a review of the research. *Journal of Research in Science Teaching, 29*, 331–359.

Lederman, N. G. (2007). Nature of science: past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education, vol. I* (pp. 831–879). London: Lawrence Erlbaum Associates.

Lederman, N., & Lederman, J. (2014). Research on teaching and learning of nature of science. In N. Lederman & S. Abell (Eds.), *Handbook of research on science education, vol II* (pp. 600–620). New York: Taylor and Francis Group.

Lederman, J., Lederman, N., 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, N., Lederman J., Akubo, M., Barlow, B. J., Bartels, S., Blanquet, E., Blonder, R. EL-Deghaidy, H., Dogan, O. K., Gomez, D. S. Gyllenpalm, J., Al-Lal, S. H., Han-Tosunoglu, C., Huang, X., Kremer, K., Lavonen, J., Liu, C., Liu, E., Liu, S. Y., Mamlok, R., McDonald, C. V., Neumann, I., Pan, Y. Pavez, J. J., Schwartz, R. (2017) Admin symposium: International collaborative investigation of beginning seventh grade students' understandings of scientific inquiry, presented at National Association of Research Science Teaching (NARST), April, 22-25, 2017, San Antonio, TX, U.S.

Lindner, N., & Kubat, C. (2014). Science camps in Europe – collaboration with companies and school. *Implications and Results on Scientific Literacy Science Education International, 25*(1), 79–85.

Liu, S. Y., & Lederman, N. G. (2002). Taiwanese gifted students' views of nature of science. *School Science and Mathematics, 102*(3), 114–123.

Markowitz, D. G. (2003). Evaluation of the long-term impact of a university high school summer science program on students' interest and perceived abilities in science. *Journal of Science Education and Technology, 13*, 3,395–3,407.

McComas, W. F. (Ed.). (1998). *The nature of science in science education: rationales and strategies*. Netherlands: Kluwer Academic Publishers.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey Bass Publishers.

Mesci, G., & Schwartz, R. (2016). Changing preservice teachers' conceptions of nature of science: why some conceptions may be more easily altered. *Research in Science Education, 47*(2), 329–351.

Ministry of National Education (MNE). (2004). *Elementary and secondary science and technology curriculum*. Ankara: Ministry of National Education.

Ministry of National Education (MNE). (2014). *Elementary and secondary science curriculum*. Ankara: Ministry of National Education.

Moss, D. M., Abrams, E. D., & Kull, J. A. (1998). Can we be scientists, too? Secondary students' perceptions of scientific research from a project-based classroom. *Journal of Science Education and Technology, 7*, 149–161.

Moss, D. M., Abrams, E. D., & Robb, J. (2001). Examining student conceptions of the nature of science. *International Journal of Science Education, 8*, 771–790.

National Research Council (NRC) (1996). *National science education standards*. Washington: National Academy Press.

National Research Council (NRC) (2000). *Inquiry and the national science education standards: a guide for teaching and learning*. Washington: National Academy Press.

Neumann, I., Neumann, K., & Nehm, R. (2011). Evaluating instrument quality in science education: Rasch-based analyses of a nature of science test. *International journal of science education., 33*(10), 1373–1405.

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.

Richmond, G., & Kurth, L. (1999). Moving from outside to inside: high school students' use of apprenticeships as vehicles for entering the culture and practice of science. *Journal of Research in Science Teaching, 36*, 677–697.

Sadeh, I., & Zion, M. (2009). The development of dynamic inquiry performances within an open inquiry setting: a comparison to guided inquiry setting. *Journal of Research in Science Teaching, 46*(10), 1137–1160.

Sadler, T. D., Burgin, S., McKinney, L., & Ponjuan, L. (2010). Learning science through research apprenticeships: a critical review of the literature. *Journal of Research in ScienceTeaching, 47*(3), 235–256.

Schwartz, R. (2004). Scientists' epistemological views of science: a cross-discipline comparison of scientists' views of nature of science and scientific inquriy. Unpublished doctoral dissertation. Oregon State Univeristy.

Schwartz, R. S., & Lederman, N. G. (2008). What scientists say: scientists' views of nature of science and relation to science context. *International Journal of Science Education, 30*, 727–771.

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing view of nature of science in an authentic context: an explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), 610–645.

Schwartz, R. S., Lederman, N. G., & Lederman, J. S. (2008). An instrument to assess views of scientific inquiry: the VOSI questionnaire, *National Association for Research in Science Teaching*, March 30–April 2, 2008. Baltimore, U.S.

Schwartz, R., Lederman, N., & Abd-El-Khalick, F. (2012). A series of misrepresentations: a response to Allchin's whole approach to assessing nature of science understandings. *Science Education, 96*(4), 685–692.

Senler, B. (2015). Middle school students' views of scientific inquiry: an international comparative study. *Science Education International, 26*(2), 166–179.

Settlage, J., & Southerland, S. A. (2007). *Teaching science to every child: using culture as a starting point*. New York: Taylor & Francis.