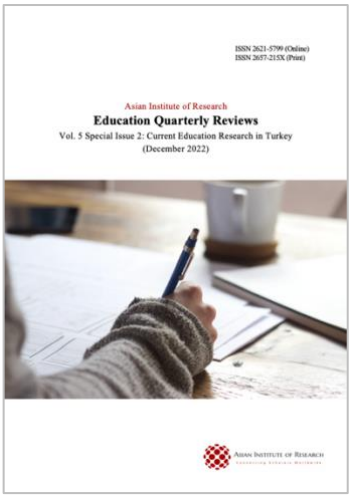

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The Influence of Imagination and Creativity-Based Science Teaching on Turkish Middle School Students' Nature of Science Views*

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Abstract
This study aimed to investigate the influence of teaching materials that can enrich the views of middle school students about the role of imagination and creativity in scientific research. The study was conducted in a village middle school in Rize Turkey. It used a case study method within the scope of the qualitative research approach, seven activities were designed by the researchers toward the imaginative and creative nature of science (NoS). They were applied to the study group by the first researcher for twelve weeks. Data were collected with four open-ended questions and semi-structured interviews as also reflective writings and worksheets during the intervention. The NoS questionnaire and subsequent interviews were administered to participants twice, at the beginning and the end of the teaching. By using qualitative data, pre-post profiles of the students regarding the NoS were created. Each profile was classified using three-stage categories informed, transitional and naïve. It was concluded that students' naive views on the imaginary and creative NoS changed towards transitional and/or informed.

Keywords: Nature of Science, Imagination, Creativity, Science Education

1. Introduction

Learning and teaching science have become one of the most basic conditions of education due to the innovations brought by technology and science (Cinar & Koksal, 2013). New educational policies that emerged in line with the goals and needs of today's societies focus on raising students as individuals with a high level of awareness in the field of science and technology (MoNE, 2005, 2013; Sarac, 2012). American Association for the Advancement of Science (AAAS) gave a broad definition of science literacy in "Science for All Americans" published in 1989 (AAAS, 1993). The concept of science literacy gained importance and started to spread to other fields, especially science education. Today, the vision of "raising scientifically literate individuals" has started to take place in the vision of science education programs implemented both in Turkey and abroad (Nwosu & Ibe, 2014; Yenice et al.,

* This paper was developed from the first researcher's master's thesis and under the supervision of the second researcher.

2015). For example, the vision of the new science teaching curriculum was determined as "training all students as science and technology literate" in Turkey (MoNE, 2013).

The NoS or the nature of scientific knowledge is one of the most important elements of raising scientifically literate individuals (Kucuk, 2006). To develop scientifically literate individuals, they must first understand the NoS correctly (Metin, 2009; Sevim, 2012). There is a strong relationship between students' awareness of the NoS and students' approaches to learning about science and the NoS (Hogan, 2000). Lederman (1992) defined the NoS as "the values and beliefs inherent in scientific knowledge". It includes four important disciplines such as philosophy, history, sociology, and psychology (McComas & Olson, 1998). There is no consensus on a specific definition of the NoS. Despite this, scientists have reached a consensus on what elements of the NoS should be at the center of studies on science education. In this way, some elements related to the NoS that students can achieve at all levels, from pre-school to university level, have been developed (Abd-El Khalick et al., 1998; Bell et al., 2000; Deboer, 2000; Lederman, 1992). One is that scientific knowledge is partly the product of human inference, imagination, and creativity (Abd-El Khalick et al., 1998). The imagination and creative NoS are the most important dimensions of the NoS. Scientific research often involves using logical reasoning and imagination to construct hypotheses and explanations and collecting relevant evidence to make sense of the data collected (AAAS, 1993). Science is mostly a human endeavor, and scientific study is based on fundamental human qualities such as reasoning, understanding, energy, skill, and creativity (NRC, 1996).

The main purpose of science education is to define problems that individuals notice in their close environment, to make observations about them, to make hypotheses, to conduct experiments to test their hypotheses, to analyze the results obtained, and to apply the necessary skills to solve the problem. Science is not only a product but also a process that takes place in every step of an individual's life and includes the creativity component to a large extent (Trnova, 2014). For this reason, children should be raised to have the ability to question the information taught to them and to predict the subject areas that can use this information. This skill can be provided by giving them the awareness of creativity (Akcam, 2007). It is revealed that the students mostly have inadequate views of all the dimensions of the NoS (Deve, 2015; Kucuk, 2006; Sener-Canli, 2018). It has been determined that the research covered more than one dimension of the NoS, but there is no in-depth research on a single dimension. It is thought that examining the dimensions of the NoS, which is one of the most important elements of science teaching, one by one and designing teaching materials accordingly will be beneficial both in terms of providing resources for the relevant field and in terms of students' understanding of the imagination and creative NoS.

The basic goals of science education are to train individuals who have informed views on the nature of scientific knowledge as well as scientific literacy. However, it was revealed that the concepts of science teachers, pre-service teachers, and primary and secondary school students about the NoS are quite "naïve" (Eve & Dunn, 1990; Johnson & Peeples, 1987; King, 1991; Zimmerman, 1991). Moreover, especially primary school students have naïve views about the experimental, imprecise, inferential, creative and imaginative nature of scientific knowledge (Griffiths & Barman, 1995; Kucuk, 2006; Kucuk & Beyaz, 2022). The perception of the NoS by students is important in terms of structuring scientific knowledge correctly in their minds (Sener-Canli, 2018). No consensus has been reached on a common definition of what science is, but some common values and characteristics related to the nature of scientific knowledge have been accepted (Abd-El Khalick et al., 1998). One of them is the imaginative and creative nature of scientific knowledge. It draws attention in the first place that the views of the students about the imaginative and creative NoS are not informed. Studies conducted at the national level also showed that students have naïve views on the imaginative and creative nature of science (Cil, 2010; Deve, 2015; Kucuk, 2006; Sener-Canli, 2018). The critical role played by the imaginative and creative NoS in the production of scientific knowledge is not known by the students. However, it was observed that students could not explain that scientists are individuals with a wide imagination and creativity and that they benefit from these features at every stage of their work (Deve, 2015; Sener-Canli, 2018). It is necessary to examine all dimensions one by one and in-depth and to prepare instructional materials for each dimension. There are not enough teaching materials for the related element of the NoS. In this context, it is believed that the activities produced by integrating each dimension of the nature of science in general, and the imagination and creativity examined in particular, can provide positive outputs in classroom practices. Based on these reasons, in the current study, teaching materials that can enrich

middle school students' views on the role of imagination and creativity in scientific research were designed and their influence was examined.

The research questions of the study are below:

1) What are the students' views on the role of imagination and creativity in scientific research before teaching?
2) How students' views on the role of imagination and creativity in scientific research have changed after the teaching?

2. Method

The study is a case study since students focused on the imaginative and creative NoS and in-depth research has been made using multiple data collection tools (Cepni, 2018). Seven teaching activities were designed to enrich students' views on the role of imagination and creativity in scientific studies based on worksheets (Patan, 2019). They were developed by the explicit-reflective approach. This method has also been used in many national studies (Kucuk, 2006).

2.1. The study group

The study group consisted of a total of fifteen students studying in the 7th grade of a middle school in Rize, a province in the northeast part of Turkey. The average age of the students was 13. Ten of them are girls and five are boys. The school is also an educational institution where students who are transported from the villages by vehicle, as well as students coming from the Eastern and Southeastern Anatolia Regions for board Quran course education.

2.2. The Intervention

In the design process of the activities, the targeted gains for the related element of the NoS were taken into account. In this way, the general gains of the teaching materials were determined as "understanding that scientists benefit from their imagination and creativity in their scientific studies" and "making them comprehend that scientists are individuals with imagination and creative features". In these activities, it was tried to show the reflections on the role of imagination and creativity in scientific studies by going through the scientific studies of scientists in general. The teaching materials allowed students to work individually or in groups, encouraged them to prepare models, and supported the activities with worksheets and homework. Teaching was applied by the first researcher, who is also a science teacher at the same school. The activities were held during the normal course day and mostly in Physical Education and Sports classes. The application of the teaching about the role of imagination and creativity in scientific research was completed in twelve weeks.

For example, the first activity (Which one is in the center? Earth or Sun?) was completed in three phases and 40 minutes. At the beginning of the activity, the students were asked, “What is science?” and “How do scientists work?” By asking questions, they were expected to brainstorm on the subject. First, a worksheet was given to the students regarding the activity, and questions about the universe they lived in (for example, "What do you know about the universe we live in? Do you think the universe we live in has a center?") were asked. Then the sentences "Earth-centered universe" and "Heliocentric universe" were reflected on the board, and they were asked to discuss what these sentences meant with their friends and to draw these two sentences on the activity worksheet visually using their imagination and creativity. Each group was then asked to present their thoughts on these two universe models, together with their drawings, and to present their views on which of these universe models are valid today, along with their reasons. In the second stage of the activity, one colored envelope was given to the groups, and they were asked to identify the life of the scientist, the paradigm on the subject, scientific studies, the difficulties they experienced during the research, and to write the data they obtained in the relevant place on the activity sheet. Each scientist was given seven minutes for life, and after the time expired, each group alternately changed the envelopes. The scientists inside the envelopes are Aristarchus of Samos, Aristotle, Ptolemy, Kepler, Copernicus, and Galileo. In the last stage of the activity groups recorded the scientific life of six scientists, their paradigms

related to the subject, and the data they obtained, the groups were asked to draw a concept map regarding the universe models and to place the scientists in the places in this concept map based on the data they obtained. Now, what is expected from the groups is to gather the scientists who support the geocentric universe model under one group and the scientists who support the heliocentric universe model under the same group. Finally, the views of the students about the change in the universe model were taken. They were asked to explain why the universe model has changed from past to present, what problems scientists have experienced in the historical process, based on the data they recorded, and to refer to the importance of imagination and creativity in the change of scientific knowledge.

2.3. Data Collection

Four questions directly from the "Nature of Science Student Questionnaire" developed by Abd-El-Khalick (1998) and adapted by Khishfe and Abd-El-Khalick (2002) were applied twice, as pre-post tests, to reveal the views of the students in the study group about the role of imagination and creativity in the scientific research process and to determine the changes that occurred after the teaching activities designed by the researchers. Semi-structured interviews and students' reflective writings were also used as data collection tools. The interview questions are:

1. Dinosaurs lived millions of years ago.
    (a) How do scientists know that dinosaurs lived?
    (b) What evidence do scientists use to explain what dinosaurs looked like?
    (c) Do you think scientists are confident about what dinosaurs looked like? What makes scientists confident or skeptical about this topic?
2. What does imagination mean to you? Give an example.
3. What does creativity mean to you? Give an example.
4. Scientists try to find answers to their questions by doing research/experiments. Do you think scientists use their imagination and creativity in their research/experiment? Explain your answer with an example.

2.4. Analysis of Data

The NoS profiles of the students related to the role of imagination and creativity in scientific research were created based on the questionnaire and subsequent interviews with them (Khisfe, 2004; Kucuk, 2006; Kucuk & Beyaz, 2022). To analyze all the data a rubric was created by the researchers and student responses were evaluated according to the rubric (see table 1). The worksheets and reflective writings were examined together and categorized as "naïve", "transitional" and "adequate". While categorizing, was paid attention to whether there were reflections on the role of imagination and creativity in scientific studies in the worksheets and reflective writings. Both the validity of the questionnaire data and the reliability of the obtained profiles were ensured by the two researchers in a panel. This analysis method was also used during the creation of the final profiles of the students after the teaching. Students' views on the role of imagination and creativity in the scientific research process were categorized as naïve, transitional, and informed. Based on the responses by the students to the four questionnaire items, their views on the NoS were explained. To categorize students' views on the role of imagination and creativity in scientific research as "adequate", they were asked to give consistent and correct answers to all questions and present evidence. If the student could not put forward an adequate view of the relevant element of the NoS, he or she was categorized as "naïve". If the student expressed informed views on some items but not all items, they were categorized as "transitional". This categorization method was also used in the studies conducted by Kucuk (2006), Ayvaci (2007), Cil (2010), and also Kucuk and Beyaz (2022).

Table 1: The rubric for the role of imagination and creativity in the scientific research

Informed	Transitional	Naive
- aware that imagination and creativity are personal characteristics of scientists,	- not aware enough that imagination and creativity, which are the personal characteristics of scientists, are	- unaware that imagination and creativity are personal characteristics associated with scientists,

- makes definitions not only for new technology but also for a new knowledge-generation process, - knows that personal characteristics such as imagination and creativity are as important as experimental data and methods in the process of producing scientific knowledge, - knows that personal characteristics such as imagination and creativity are actively used at all stages of the scientific research process and gives appropriate examples.	effective in the scientific research process, - defines only the process of producing new technology, - states that experimental data and methods are often important in the process of producing scientific knowledge, - knows that imagination and creativity are actively used in some stages of scientific research and gives partially appropriate examples.	- makes only classical definitions for the process of producing new technology, - does not know that personal characteristics such as imagination and creativity are as important as experimental data and methods in the process of producing scientific knowledge, - does not know at what stage of the scientific research process personal characteristics such as imagination and creativity are actively used and does not give appropriate examples.

3. Results

The analysis of the data obtained from the research conducted before, during, and after the teaching related to the NoS is below. The first views of the students about the role of imagination and creativity in scientific research are presented below, in table 2.

Table 2: Initial views of students about the role of imagination and creativity in the scientific research

Participant Codes	naive	informed	transitional
E1	X		
K1	X		
E2	X		
K2	X		
E3	X		X
K3	X		
K4	X		
E5	X		
K5			X
E6	X		
K6	X		
K7	X		
K8			X
K9	X		
K10	X		

K: Female E: Male

It is seen from table 2 that there are no students who have "adequate" views. Three of them had "transitional" views about the role of imagination and creativity in the scientific research process and the others had naïve views.

In the first question they stated that scientists knew that dinosaurs lived with the help of fossils:
"Scientists know from fossil remains from past years that dinosaurs lived" [E3]
"They searched and found bones or footprints or bones belonging to the wreckage as a result of research from the past" [K7].

In the second question of that which evidence was used regarding the images of dinosaurs, the role played by the evidence in the creation of dinosaurs was not understood in both the interview and the questionnaire

conducted by them. Three students explained that imagination and creativity are used by scientists to the question "if the dinosaurs could not be observed directly, how could their models have been created?"

"They find dinosaur fossils and then use their imaginations to assemble the pieces"[K5]

"They make models of dinosaurs by imagining"[E3]

In the third question, it was asked whether scientists were sure about what dinosaurs looked like. The students explained that the scientists were sure of the images of dinosaurs and were not in any doubt:

"Dinosaurs are similar to each other and that's why scientists tell the truth [K3]

"Scientists, I think, are sure of the shapes. Because everything science tells us is true [K4]

There is a question in the questionnaire of that "What do imagination and creativity mean to you? Give an example." It was determined that the students could not explain the terms imagination and creativity, and they tried to express imagination and creativity by referring to a certain object or event, not in the sense of producing an idea or knowledge. In this context, it was determined that the students did not have "informed" views on the question:

"It expresses my future"[E5]

"It allows us to be creative"[K4]

"It is the invention we want to make in our minds" [K5]

In the last question of the questionnaire, the students were asked whether scientists use imagination and creativity in scientific research and were asked to give an example. Just one of them stated that imagination has a place in the conclusion of scientists' research and experiments:

"I'm thinking. For example, they make inventions such as telescopes, the telephone, and television with their imagination. For example, Galileo invented the telescope, and Edison invented the light bulb. Scientists make use of their dreams while finding new information and going to the conclusion of their research and experiments"[K5]

Two students stated that scientists use their imagination to produce scientific knowledge, but they could not give an example to support their statement:

"Yes, scientists use their imaginations in their work and come up with new information that no one else has found" [E3]

One week after teaching, the questionnaires and interviews were applied to the students again. Each of the measurement tools was analyzed one by one and the results are presented below.

Table 3: Students' final views on the role of imagination and creativity in the scientific research process

Participant Codes	naive	informed	transitional
E1			X
K1	X		
E2		X	
K2		X	
E3		X	
K3		X	
K4			X
E5	X		
K5		X	
E6		X	

K6	X	
K7		X
K8	X	
K9	X	
K10		X

There were no students who had "informed" views on the role of imagination and creativity in scientific research at the beginning. The number of students who had "informed" views about the role of imagination and creativity in scientific research increased to nine. In particular, the questions given in the questionnaire were "explaining what dinosaurs looked like" and "do scientists use their imagination and creativity in producing scientific knowledge?" It was determined that they also gave more “informed” explanations in their answers to the questions. In the first question asked to them in the questionnaire, "how do scientists know that dinosaurs lived", 13 students explained that they could know this with fossil remains. In the second question, it was mentioned which evidence was used about the images of dinosaurs, and it was seen that the role played by the evidence in the creation of dinosaurs was not understood in the questionnaires and interviews made before teaching. When the question "If dinosaurs cannot be observed directly, how could they have models created, what evidence do scientists use to describe what dinosaurs looked like?" was asked only three students explained that imagination and creativity were used together with fossils to create images of dinosaurs. However, the number of students increased to 13 in the questionnaires and interviews after teaching.

> “They use the bones. They combine these bones by using their imagination” [K2]

> In the question of “Are scientists sure about what dinosaurs looked like?”, 13 students stated that scientists might have doubts and were not sure about the images of dinosaurs. In the questionnaires and interviews conducted after teaching it was determined that they had more "informed" views. “They may not be sure because they haven't seen dinosaurs before”[K7]

Ten students made "informed" explanations about the terms "imagination" and "creativity". Before teaching, they tried to explain the terms creativity and imagination by referring to things and objects rather than referring to a scientific event, so their answers were considered "inadequate”:

> My imagination is to find new ideas and come up with new scientific information. We use it for science. For example, imagination was used while making the atomic models we saw in the lesson. People did not see the atom, but they made its model” [E2]

The last question was about whether scientists use their imagination in producing scientific knowledge. Before teaching, they could not make adequate explanations for this question. It was determined that nine of them understood the role played by the imaginative and creative nature in producing scientific knowledge at the end of teaching.

> Imagination takes place at every stage of scientists’ work. They always make use of their imagination in their scientific research, while revealing new information and inventing. If they don't have dreams, they can't do new and different things. For example, models of atoms have changed constantly. Scientists have worked on the atom at different times, and each scientist has put forward different views. They [Scientists] interpreted the atom differently. Because they use their imagination” [K5]

In this section, the change in students' views on the role of imagination and creativity in scientific research is explained. Daily NoS profiles were produced from the analysis of reflective writings and also worksheets after each activity and are presented below in table 4.

Table 4: The distribution of students' views on the role of imagination and creativity in scientific studies throughout the teaching

Students Codes	Pre-test and Interview	Activity 1 worksheet and reflective writings	Activity 2 worksheet and reflective writings	Activity 3 worksheet and reflective writings	Activity 4 worksheet and reflective writings	Activity 5 worksheet and reflective writings	Activity 6 worksheet and reflective writings	Activity 7 worksheet and reflective writings	Post-test and Interviews
E1	-	-+	-+	+	-+	-+	-+	*	-+
K1	-	-	-+	-	-	-	-+	*	-
E2	-	-+	+	+	-+	+	+	*	+
K2	-	-+	+	+	+	-+	+	-+	+
E3	-+	+	+	+	-+	+	+	*	+
K3	-	+	+	+	+	+	+	+	+
K4	-	-+	-+	+	+	-+	-+	-+	-+
E5	-	-	-+	-	-	-	-	-	-
K5	-+	+	-+	+	+	+	+	+	+
E6	-	+	+	-+	+	-+	+	*	+
K6	-	+	+	+	+	-+	+	*	+
K7	-	-+	+	+	-+	-+	-+	+	-+
K8	-+	+	+	+	+	+	+	+	+
K9	-	+	+	-+	-+	+	+	*	+
K10	-	+	+	+	-+	+	+	*	-+

***(-) naïve; (-+) transitional; (+) informed; (*) not attending the class**

The activities were analyzed by referring to student worksheets, models prepared by students, and student reflective writings.

In the first activity "Dinosaur Map", it was determined that ten students were able to express those scientists have different imaginations.

> In this activity, we saw that scientists are hardworking, imaginative people, and their thoughts and perspectives are not the same [K5]

Eight students also stated that scientists use their imagination and creativity in scientific research.

> We put forward theories about the extinction of dinosaurs using the data we have. We have attributed different meanings to the data in our hands. Because we all have different imaginations. Scientists come up with new theories thanks to their imagination [E6]

Seven students stated that group work reveals different perspectives.

> We split into groups. We placed dinosaurs in different parts of the maps. The different ideas in the group made us come up with a more logical approach [E2].

In the second activity "Atomic Models", ten students explained that imagination and creativity contribute to the emergence of new scientific knowledge.

> Since scientists do not see atoms, they put forward hypotheses. They use their imaginations. [K5]

Three students said that scientific knowledge can change over time.

> We learned that scientists came up with new ideas as time passed. I realized that because everyone's imagination is different, so many views arise. Imagination is important [E5]

Seven students also explained that scientists have different perspectives and gave examples.

> Everyone's thoughts, perspectives, and imaginations are different. This led to the emergence of different models of atoms. Atom is the same, everyone interpreted it differently. Thomson likened the atom to a "raisin cake", and Rutherford likened it to the solar system [K7].

In the third activity “One Light, Multi Color”, nine of the students stated that scientists use their imagination and creativity in their work.

> While Aristotle and Alverniali lived in the same period, they put forward different theories about the formation of rainbows. They progressed their work differently from each other. The most important reason for this is that they have different imaginations [K6].

Five students gave examples from the work of scientists.

> While working on the formation of the rainbow, one scientist used a raindrop and the other used a glass prism and sphere. The experimental tool they both use is very different [E1]

In the fourth activity “Which one is in the center? Earth or Sun?” ten of the students stated that imagination and creativity play a role in the progress of scientific studies.

> I learned that imagination and creativity are different for everyone. This is how scientists work. We learned about the life of scientists [E3].

Seven students also stated that scientists use their imagination and creativity in their scientific studies.

> Our teacher handed us a paper. This paper had questions about astronomy. Then she gave us an envelope with different scientists. Some of these scientists advocated the geocentric model, while others advocated the heliocentric model. Even though we all look at the sky, we see different things. This shows that our imagination is different. [K6]

> All seven students in the activity stated that imagination and creativity helped to reveal different views. For example, some scientists defend the geocentric universe, while others defend the heliocentric universe. In other words, we understand that everyone's thoughts, perspectives, and ideas are different. It comes up with imagination and creativity in different ideas [K2]

In the fifth activity “In the Mystery of Cards," nine students stated that scientists have different imaginations.

> With this activity, I learned that not all of us think the same and that our dreams affect our knowledge [E4]

Seven students also stated that scientists use their imagination and creativity in scientific studies.

> I learned that we need to have a big imagination in every subject, and activity and that we always use our imagination, which is important when we work like scientists [E6].

Seven students also stated that group work reveals different perspectives.

> When our teacher gave us the first envelope in the lesson, we both used our old knowledge and imagined a little while sorting the animals. We thought about which animal we could put where. No group's ranking was the same in the first stage. Because I realized that even though we all look at the same thing, we can say different things. This is because our imaginations are different from each other [K9]

In the sixth activity “The data Beyond the Sky” nine students stated that scientists have different imaginations.

> We saw that scientists have designed different telescopes from the past to the present, starting with Lippershey. Some used lenses, and some used mirrors. Because while making their designs, they make use of the old knowledge and imagination from the past [K5]

Six students also stated that scientists use their imagination and creativity in scientific studies.

> I learned that scientists use their imagination and creativity while working. Lippershey invented the first working telescope, and then Galileo developed the telescope to observe the sky and collect data. For example, Newton used the mirror to make a telescope [E6]

In the seventh activity “The Story of the Light Bulb”, seven students stated that scientists have different imaginations.

> I learned how to work like a scientist by making our light bulbs. We worked as a group using our imagination [K2]

Six students also stated that scientists use their imagination and creativity in scientific studies.

> I learned that scientists have different imaginations and they use them in their studies. For example, Tesla and Edison both made light bulbs and they both have different light bulbs. Tesla designed a pin bulb. Edison did more than 1000 experiments for his light bulb and invented the light bulb with the yarn of the jacket button. Both of them designed different light bulbs with different experiments [K8]

4. Discussion

In this study, we aimed to design seven teaching activities and investigate the influence of them that can enrich the views of middle school students about the role of imagination and creativity in scientific research. There is a need to enrich students' views on the value of imagination and creativity, which are among the personal characteristics of scientists and play a major role in all stages of scientific research (Kucuk, 2006). We created the pre and post-profiles for the imaginative and creative NoS by questionnaire and semi-structured interviews (see Tables 2 and 3). In this way, we examined to what extent the teaching was able to reveal the expected effect on students' views. Table 1 revealed that 12 of the 15 students had "naïve" and three had transitional views on the role of imagination and creativity in scientific research before teaching. This result coincides with many studies conducted in Turkey with the same grade levels (Deve, 2015; Kucuk, 2006). It is striking that students did not know scientists are individuals with high imagination and creativity, actively use their imagination and creativity at every stage of scientific research, and also those individual characteristics are as important as experimental data and research methods as in the other research done by the second researcher in 2006 (Kucuk, 2006).

The profiles of the students about the relevant element of the NoS were reconstructed throughout the teaching (see table 4). The qualitative data obtained from the worksheets and also reflective writings revealed how the profiles developed throughout the teaching. Tables 3 and 4 revealed that the initial "naïve" views developed towards "informed" views. They are aware that imagination and creativity are personal characteristics of scientists, and they defined not only a new technology but also a new knowledge production process, they know that personal characteristics such as imagination and creativity are as important as experimental data and methods in the process of producing scientific knowledge. It was also observed that personal characteristics such as imagination and creativity were actively used in all stages of scientific research with appropriate examples. They learned that imagination was used while making the atomic models. Because scientists use their imagination and creativity when interpreting (inference) the data they obtain at every stage of their scientific studies (McComas, 1996).

The activity outputs evaluated in three categories reflect “informed”, “transitional” and “naïve” views in detail. It is striking that the number of students with "informed" views varies depending on the content of the activities. For example, the activities with the highest frequency of students with "informed” views were "Atom Models/

Journey to the Unknown", "One Light, Many Colors" and "From the Sky". It can be said that the activities in which the topics are included in the formal science curriculum during the teaching semester are contributed to the active participation of the students. In this way, it is clear that NoS activities that integrate the science subject area are more effective in enriching students' views on the role of imagination and creativity in scientific research. Similar results were obtained in other previous studies (Khishfe, 2004; Kucuk, 2016). This means that the context provides the rationale for learning and it links the physical world to scientific ideas in a similar way to practical work (Kazeni, 2012; King & Ritchie, 2012).

The worksheets and reflective writings for each activity revealed that some activities for example "The Mystery of the Cards" and "Which one is in the center? Earth or Sun? made limited contributions to the NoS views. Table 3 shows that the number of students who have "informed" views in these two activities is only seven. The reason is most probably due to students' lack of knowledge about the content. There is a need to establish clear and direct connections between the studies by students and those of scientists, which can reveal the effect of imagination and creativity (Kucuk, 2006). The subject area knowledge of the students is sufficient for these connections to be established.

5. Conclusion

It is very difficult for students to learn that scientific knowledge includes imagination and creativity (Dogan, 2010). Because students generally think that science has a neutral structure and that imagination and creativity are not used in producing scientific knowledge (Lederman, 1992). In the current study, it was determined that nine of the students whose initial views on the imagination and creative nature of science were analyzed as "naïve", made progress toward the "informed" level at the end. In line with these results, it can be argued that although the intervention could not reveal the expected greater impact on all students' views on the role of imagination and creativity in the process of scientific knowledge, it could still be considered successful in terms of the study group, which is quite heterogeneous in many aspects such as religious values, socio-economic structure, and others. There is also a close relationship between the aspects of the NoS, it is concluded that it may be more beneficial to teach each of them together instead of trying to teach them separately. It is in question that students can more easily associate the NoS activities with the related element of the nature of science on topics with higher subject area knowledge.

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References

AAAS (1993). *Science for all Americans*. American Association for the Advancement of Science New York: Oxford University Press.

Abd-El-Khalick, F. (1998). *The influence of the history of science courses on students' conceptions of the nature of science* (Unpublished Ph.D. dissertation). Oregon State University, OR

Abd-El-Khalick, F., Bell, R.L., & Lederman, N.G. (1998). The nature of science and instruction practice: Making the unnatural natural. *Science Education, 82,* 417- 436.

Akcam, M. (2007). *İlköğretim fen bilgisi derslerinde yaratıcı etkinliklerin öğrencilerin tutum ve başarılarına etkisi* [Effects of creative activities on students' attitudes and achievements in primary school science courses] (Unpublished master thesis). Balıkesir University, Balıkesir, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Ayvaci, H.S. (2007). *Bilimin doğasının sınıf öğretmeni adaylarına kütle çekim konusu içerisinde farklı yaklaşımlarla öğretilmesine yönelik bir çalışma* [A study toward teaching the nature of science based on different approaches for classroom teachers in gravity content] (Unpublished Phd thesis). Karadeniz Teknik University, Trabzon, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/)

Bell, R. L., Lederman, N. G., & Abd-El-Khalick, F. (2000). Developing and acting upon one's conception of the nature of science: A follow-up study. *Journal of Research in Science Teaching, 37*(6), 563-581

Cepni, S. (2018). *Araştırma ve proje çalışmalarına giriş*[Introduction to research and project work], (8th ed), Trabzon: Celepler Press.

Cil, E. (2010). *Bilimin doğasının kavramsal değişim pedagojisi ve doğrudan yansıtıcı yaklaşım ile öğretilmesi: Işık ünitesi örneği* [Teaching of the nature of science in conceptual change pedagogy and explicit reflective approach: A case study for Light unit]. (Unpublished Phd thesis). Karadeniz Teknik University, Trabzon, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/)

Cinar, M., & Koksal, N. (2013). Sosyal bilgiler öğretmen adaylarının bilime ve bilimin doğasına yönelik görüşleri. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 9*(2), 43- 57.

Deboer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37*(6), 582-601.

Deve, F. (2015). Bilim *tarihi destekli ışık ünitesinin 7.sınıf öğrencilerinin bilimin doğası anlayışlarına etkisi* [The effect of history of science based Light unit on 7th grade students' nature of science views] (Unpublished master thesis). Recep Tayyip Erdogan University, Rize, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Dogan, M. (2010). *Bilim ve teknoloji tarihi* [History of science and technology] (3. ed.) Ankara: Ani Publication.

Eve, R., & Dunn, D. (1990). Psychic powers, astrology & creationism in the classroom. The American biology teacher. *University of California Press, 52*(1), 10-21.

Griffiths, A.K., & Barman, C. (1995). High school students' views about the nature of science: Results from three countries. *School Science and Mathematics, 95*, 248-255

Hogan, K. (2000). Exploring a process view of students' knowledge about the nature of science. *Science Education, 84*(1), 51–70.

Johnson, R.L., & Peeples, E. E. (1998). The role of scientific understanding in college: Student acceptance of evolution. *University of California Press, 49(*2), 96-98.

Kazeni, M. M. M. (2012) *Comparative effectiveness of context-based and traditional teaching approaches in enhancing learner performance in life sciences.* (Unpublished Ph.D. thesis). University of Pretoria

King, D.T., & Ritchie, S. M. (2012) *Learning science through real-world contexts: The international handbook of science education,* Dordrecht: Springer Press.

Khishfe, R. F. (2004). *Relationship between students' understandings of nature of science and ınstructional context* (Unpublished Ph.D. thesis). Graduate College of The Illinois Institute of Technology. Chicago, Illinois.

Khishfe, R. F., & Abd-El-Khalick, F. (2002). 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), 51-578

King, B. B. (1991). Beginning teachers' knowledge of and attitude toward history and philosophy of science. *Science Education, 75(*1), 135-141.

Kucuk, A. (2016). *Işık konu alanı içinde ve dışında bilimin doğasının öğretiminin 5.sınıf öğrencilerinin bilimin doğasına yönelik anlayışlarına etkisi* [The effect of teaching nature of science in or out of light science content area on 5th grade students' nature of science understandings] (Unpublished master thesis). Recep Tayyip Erdogan University, Rize, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Kucuk, M. (2006). *Bilimin doğasını ilköğretim 7. sınıf öğrencilerine öğretmeye yönelik bir çalışma* [A study toward teaching the nature of science for seventh grade primary students]. (Unpublished Phd thesis). Karadeniz Teknik University, Trabzon, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Kucuk, M., & Beyaz, O. (2022). Explicit-reflective teaching of the nature of science for primary school students. *Base for Electronic Educational Sciences, 3*(2), 12-21. http://bedujournal.com/

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: a review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359.

McComas, W.F. (1996). Ten myths of science: reexamining what we think we know about the nature of science. *School Science And Mathematics, 96*(1), 10.

McComas, W.F., & Olson, J.K. (1998). The nature of science in international science education standards documents. In W. F. Mccomas (ed.), *The nature of science in science education (*pp. 41-70). London: Kluwer Academic Publishers.

Metin, D. (2009). *Yaz bilim kampında uygulanan yönlendirilmiş araştırma ve bilimin doğası etkinliklerinin ilköğretim 6 ve 7.sınıftaki öğrencilerin bilimin doğası hakkındaki düşüncelerine etkisi* [The effectiveness of guided-inguiry and explicit nature of science activities applied at a summer science camp on sixth and seventh grade children?s views of the nature of science] (Unpublished master thesis). Abant Izzet Baysal University, Bolu, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

MoNE (2005). *İlköğretim fen ve teknoloji dersi, 4-8 sınıflar öğretim programı.* Ankara: Milli Eğitim Bakanlığı

MoNE (2013). *Fen bilimleri dersi öğretim programı ve kılavuzu (3., 4., 5., 6., 7. ve 8. sınıflar).* Ankara: Milli Eğitim Bakanlığı

National Research Council [NRC] (1996). *National science education standards.* National Academies Press.

Nwosu, A. A., & Ibe, E. (2014). Gender and scientific literacy levels: Implications for sustainable science and technology education (STE) for the 21st century jobs. *Journal of Education and Practice, 5*(8), 113-118.

Patan, A. (2019). *Ortaokul öğrencilerinin bilimin hayal gücü ve yaratıcı doğasına yönelik görüşlerinin geliştirilmesi* [Development of secondary school students 'views on science and creative nature of science] (Unpublished master thesis). Recep Tayyip Erdogan University, Rize, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Trnova, E. (2014). IBSE and creativity development. *Science Education International, 25*(1), 8-18

Sener-Canli, D. (2018). *Bilimin doğası etkinliklerinin ortaokul 7. sınıf öğrencilerinin görüşlerine etkisi (Kırşehir il örneği)* [Effect of the nature of science activities on 7th grade students' views of science (Kirsehir sample)]. (Unpublished master thesis). Ahi Evran University, Kirsehir, Turkey. https://tez.yok.gov.tr/UlusalTezMerkezi/

Sevim, S. (2012). How to teach the nature of science for student science teachers?. *Turkish Journal of Teacher Education, 1*(2), 61-74. http://tujted.com/

Yenice, N., Ozden, B., & Balci, C. (2015). Fen bilgisi ve sınıf öğretmeni adaylarının bilimin doğasına yönelik görüşlerinin incelenmesi [Examination of views about nature of science of preservice science and elementary school teachers']. *Erzincan University Journal of Education Faculty, 17*(1), 237-281. https://doi.org/10.17556/jef.52022

Zimmerman, M. H. (1991). *Perspectives on the Interpersonal Relationships of Learners in College Learning Communities*. Seattle: Seattle University Press.