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A Qualitative Study to Explain Middle School Student's Understandings of Nature of Science

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ABSTRACT

This study was conducted with the aim to explain 7th grade middle school students' nature of science understandings by employing qualitative measuring tools of an interview and a questionnaire. In this context, the participants were 17 7th grade students. In order to explain the participants' nature of science understandings, first a nature of science questionnaire to explain their nature of science was conducted. Following, in depth interviews were conducted with the students. The four facets of the students' nature of science understandings were categorized using three dimensions: informed-transitional-naïve and by constantly comparing the data. The results gathered by the aforementioned analysis indicated that most students' nature of science understandings were weak or varying (78%) and only 22% of the students had adequate understandings. In this respect, it is suggested that the direct-reflective methods should be used instead of indirect ones for students to understand the real nature of science.

Keywords: Science; Nature of Science; Turkish Middle School Students.

INTRODUCTION

One of the main purposes of science education is to educate scientifically literate individuals. Scientifically literate individuals are individuals who are informed about the nature of scientific knowledge and who can effectively use the concepts, principles, theories and laws of science, in other words individuals who are aware of nature of science. In this regard, having adequate views about nature and attributes of science is being considered as one of the important steps towards being scientifically literate (Abd-El-Khalick & Lederman, 2000; Murcia & Schibeci, 1999; Tsai, 1999; Rubba, Homer & Smirt, 1996; McComas, 1996; Ryan & Aikenhead, 1992).

Numerous definitions of nature of science exist. Nature of science has been defined as a way of knowledge acquisition or rigid beliefs and values during knowledge development (Lederman, 1992). In another definition it is explained as what science is and what roles it contains, who the scientists are and what roles do they entail, scientific clues, observations, phenomenon, rules, laws and scientific methods, and understanding how science is executed (Taşar, 2003).

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Getting to understand nature of science is a way of getting to know science. The nature of scientific knowledge and the beliefs about how this knowledge is produced and evaluated affect the ways how students' try to learn science (Hammer, 1994; Hogan, 1999; Roth & Roychoudhury, 2003; Songer & Linn, 1991). Students' views about the nature and the strategies of learning science are developed through their schooling (Sandoval & Morrison, 2003). Therefore, the ways knowledge is presented to students through their schooling affect how they understand and build a relationship with it. If science is presented to students simply as proven facts or holistic truths, correspondingly, students start to memorize these facts and to think that all knowledge is proven though the use of scientific method. On the other hand, if students experience science as an on-going process of conceptual development, an interpretive attempt to decide what meaning the data carries and these meanings as a discourse process between individuals, it can be possible for them to focus more on the concepts and their change.

It is deemed useful to teach nature of science to students in every learning level to some extend as below mentioned angles. In this regard, learning nature of science;

- Can help people to understand science, scientific products and the daily methods of it.
- Can help people to involve in discussions on the problems about science and scientific decision making processes
- Understanding the nature of science can make people to value scientific enterprise which is one of the most effective scientific products of scientific culture and getting to know societal norms.
- Learning nature of science can help to learn science subjects more effectively.

In the literature, existing are many studies that investigate students', teachers', and preservice teachers' understandings of nature of science and that analyze the conceptual changes as a result of different instructional applications (Bell & Matkins, 2003; Brickhouse, Dagher, Letts & Shipman, 2000; Clough, 2003; Clough & Olson, 2001, Demirdöğen et al., 2015; Peters, 2012; Wahbeh, Abd-El-Khalick, 2014). When these studies were analyzed using content analysis it is found that questionnaire type measurement tools were used not to describe but to classify the nature of science understandings of individuals with different learning levels.

Before beginning to treat the students' nature of science understandings, first thing to do is to successfully reveal the identification process of this understanding. Therefore, it is believed that students' nature of science understandings can be better explained by qualitative measurement tools instead of quantitative ones which can be more appropriate to nature of social sciences. This study is planned regarding the reasons discussed up until here.

Nature of Science and Science Teaching

There has been an intense discussion about the elements of nature of science which receives many citations in science education and teaching studies and science education documents that have been received attention from international community. The first chapter of Benchmarks for Scientific Literacy Benchmarks (BFSL) (AAAS, 1993) and the sixth National Science Education Standards (NSES) (NRC, 1996) includes important explanations about what does nature of science mean, why it is important and how it can be taught. Subjects of the literature, especially studies after 1960s, focus on nature of science and scientific research. The results of these studies assert that there is a direct relationship between a person's values and assumptions about acquiring scientific knowledge and their beliefs about the nature of science.

Although there is no consensus about the definition of the nature of science, US education reform documents and prior science education research indicate that the following elements of nature of science can be easily accessed by K-12 science students and are important (Lederman, 1999, p.917):

- Scientific knowledge is tentative (subject to change)
- Scientific knowledge is empirically based (based on and /or derived from observations of the natural world)
- Scientific knowledge is subjective (theory laden)
- Scientific knowledge necessarily involves human inference, imagination, and creativity
- Scientific knowledge necessarily involves a combination of observations and inferences
- Scientific knowledge is socially and culturally embedded.

Another element that is added to these, not being touched upon in the reform documents but is closely related to understanding of observations and inferences, is the functions of scientific theories and laws and relationship between them.

BFSL (AAAS, 1993) and NSES (NRC, 1996) receive more citation when we look at the studies that investigates which above mentioned elements of nature of science are more suitable for middle school students. These documents include the expected elements that are stressed and expected from 6-8 and 5-8 grade students' to gain understanding about the nature of science.

According to BFSL report, teachers and students do not know the real nature of science. In this document, how ideas and concepts about the physical world is changed and developed as well as the role of observation, thinking, experiment, and evidence are comprehensively explained. This process is being accepted as the main element of the science and state how scientific knowledge differs from other knowledge types.

Researchers that prepare the BFSL report, assert that although the fundamental structure of the nature of science is established, the boundaries of it expands in time and grows when it is justified. In other words, natural laws, which are considered logical, exist everywhere in the physical world. Although the belief that the knowledge is considered to be produced by investigating the part of the world, there is a consensus that the only true piece is the time. For instance, it was known that the light particles traveled in the light speed, two physicists found that some "star materials" or cosmic materials travel in different speeds (Govett, 2001). This theory directly contradicts Einstein's theory. Hence, more effort should be spend on the fundamental elements of nature of science-the necessity of the questioning of science; tentativeness of scientific knowledge and the necessity of open-minded reactions to the science.

BFSL advocates the integration of mathematics and technology for the success of scientific enterprise. Although these initiatives have their own features and histories, each one is related to the other and reinforces the other. Many researchers agrees on the idea the scientific work is a mental and a social enterprise. In other words, science is an application of human intelligence towards explaining how world works. It is asserted that when how scientists work, how they reach scientific results and the limitation of these results are known; people would react to scientific claims more logically and would gain better knowledge about the real nature of science (Govett, 2001).

Another dimension of the nature of science is the scientific literacy. In BFSL document, there is a chapter not only on the important advancement in science but also a chapter that includes a historical perspective about the development of science and technology as an accumulation of knowledge throughout years. Science teaching would not be effective if it is taught as simple invention of laws, concepts and theories about knowledge accumulation about the knowledge accumulation about science. In case of behaving this way, it is not possible for science teaching to contribute to students' learning about the relationship between science and technological development.

Teaching nature of science has been considered as an important learning goal for students in every level and mostly towards science lessons. Statements about the nature of science teaching have been included in the Turkish science teaching programs. One of the general goals of the programs are "to establish [students'] understanding of the nature of science and technology, the interplay between science, technology, and society". However, there is no resource that has been provided to teachers and that include concrete examples, whose effectiveness are known and exist in the national literature. In this regard, it could be assumed that the students who participate in the science and technology curriculum activities that include inquiry-based learning activities and encourages students to construct their own knowledge would learn nature of science as a by-product.

When the literature is examined, inquiry-based learning programs, that have a significant place in students' academic achievement and performance, are not effective for students to adequately learn about nature of science (Jungwirth, 1970; McComas, 1996; Moss, Abrams & Robb, 1998; Moss, Abrams & Kull, 1998; Abd-El-Khalick & Lederman, 2000). In this regard, the current study can also reveal how much do the science teaching programs based on constructivist and inquiry based approach; can shape the students' nature of science understandings.

This study was conducted with the aim to explain 7th grade middle school students' understandings of the nature of science by employing qualitative measuring tools of an interview and a questionnaire.

METHODOLOGY

In this study, as the students' nature of science understandings are analyzed qualitatively, the research can be accepted as a qualitative study. Moreover, because the study focuses on the meanings that the participants, who are students, attribute to the different elements of the nature of science, the study is an interpretive one in nature (LeCompte & Preissle, 1993). It is accepted that actions and phenomenon can only be explained by interpretive research, which is one of the qualitative research approaches (McNabb, 2002).

In this approach researchers make interpretations about a phenomenon, by assigning meaning to social events or actions. The reason for choosing this type of research approach is that it enables us to understand people's actions when they execute them in social conditions and circumstances. If a research is built on the assumption that the meaning people attribute to social events is learned directly; it is assumed to be an interpretive research (McNabb, 2002). Therefore, the interpretive research is always context-laden. The reasons for considering the current study as interpretive research are that the researchers focus on the meanings that the students attribute to the elements of nature of science when they examine the concepts of nature of science and the researchers try to reveal these using different research methods. When examining sixth grade students' nature of science concepts Khishfe ve Abd-El-Khalick (2002) indicated the reason that they chose to use interpretive research as "the present study is interpretive in nature and focused on the meanings and participants ascribed to the emphasized aspects of nature of science" (p. 557) . The purpose of this research approach is to produce many explanations and interpretations about human experience.

a) The Study Group

The study group of this research is composed of 17 seventh grade students attending to a middle school 5 km away from Artvin city center. This school is also an educational institution that has students who commute to school as a result of transportation-education implementation. The average age for the students who are in the sample and are examined in this research is 13. 11 of them are female and 6 of them are male. When the prior studies about nature of science are examined, it is found that the students' nature of science understandings is greatly depended on science content and science and academic achievement factors in addition to cognitive and social variables such as logical thinking, qualitative and verbal understanding levels, and gender (Scharmann, 1988a, 1988b). Based on these results, interviews conducted with the teacher, who is the councilor teacher and the science and technology teacher of the class, revealed that the classroom that the study group chosen included students with different science achievement levels, social and personal characteristics, academic achievement and verbal skills.

The characteristics of the students in the study group were reported in Table 1.

Table 1. *The characteristics of the students in the study group*

Pseudonym	Science Achievement	Gender	Age	Socioeconomic Status	Place where the student lives
M1	High	Male	13	High	City center
M2	High	Male	13	High	City center
M3	Medium	Male	13	Medium	Village
M4	Medium	Male	14	Medium	Village
M5	Low	Male	13	Medium	Village
M6	Low	Male	13	Low	Village
F1	High	Female	12	Medium	Village
F2	High	Female	13	High	City center
F3	Medium	Female	15	Medium	City center
F4	Medium	Female	12	Medium	Village
F5	Low	Female	13	Low	Village
F6	Low	Female	12	Medium	Village
F7	Low	Female	12	Medium	Village
F8	Low	Female	13	Low	Village
F9	Low	Female	14	Low	Village
F10	Low	Female	15	Medium	Village
F11	Low	Female	14	Low	Village

M: Male; F: Female

In Table 1, regarding the students' socioeconomic statues an evaluation was done as high, medium and low. In this process, if one of the parents of the student's do not work or the family did not have a constant occupation or income, social status were decided as low; if at least one parent was working and monthly income could be considered as normal the social status were decided as medium; and if the monthly income could be considered as above normal, the social status were decided as high. In this regard, only three of the students were in high socioeconomic status, and the others were considered as low or medium socioeconomic status. From these students, K10 and K11 were not wanted to be sent to school by their parents for couple of reasons.

b) Data Collection Tools

Data was collected using a questionnaire –Nature of Science Student Questionnaire- that included open-ended questions aim to measure the concepts that the students have about the nature of science. After this questionnaire was employed, in-depth semi-structured interviews, which lasted for about 30-45minutes, were conducted to study the questions included in the questionnaires but wanted to be explained more and especially to meet validity and the reliability. During these interviews, a copy of the written questionnaires filled out by the student given and additional questions were asked to students for them to give more detailed answers to their written answer.

The questionnaire that is used to reveal the students' nature of science understanding and had six questions in total was gathered from the literature and used by adapting it to Turkish (Khishfe & Abd-El-Khalick, 2002). For this purpose, the readability of the questionnaire was checked by a linguist. Then, a pilot study was conducted in another 7th grade classroom of a school where the actual study was conducted and comprehensibility of the questions was tested. In this process, some of the sentence structures were adjusted. For instance, during the pilot studies the fourth question in the questionnaire asked students "how do scientists be certain about the way dinosaurs look?" 95% of the students answered the question by indicating that the scientists should be certain about the ways dinosaurs look. The purpose of asking this question was to reveal whether the students understand the tentative, creative and experimental nature of science. Therefore, this question item was changed as "do you think that scientists are certain about the way dinosaurs look? What makes scientists to be certain about the way dinosaurs look?" In this way the questionnaire's final version were developed and it is administered to the students by the teachers that the study was conducted with, in 40 minutes.

The questions in the questionnaires and the reasons for asking each question explained above.

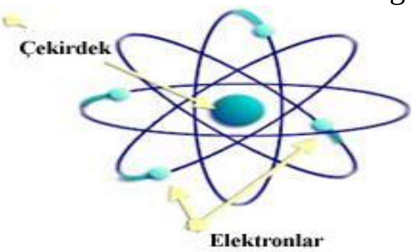
1. Scientists produce scientific knowledge, some of this knowledge is found in your science textbooks.

   (a) Do you think this knowledge may change in the future?

   (b) If your answer is ''yes,'' explain why. If your answer is ''no,'' explain why. Give an example.

With this question, it is aimed to identify students' understanding about the tentative nature of scientific knowledge

2. The diagram below is taken from your science textbook. The diagram shows the atom as having a nucleus in the center with electrons moving around it.



Do you think scientists are certain about the structure of the atom? Why or why not?

With this question, it is aimed to identify students' understandings about the tentative, experiential, inferential, imaginary and creative nature of scientific knowledge.

3. The dinosaurs lived millions of years ago.

   (a)How do scientists know that dinosaurs really existed?

   (b) What evidence did scientists use to tell how dinosaurs look like

   (c) Do you think that the scientists are certain about the way dinosaurs look? What makes scientists to be certain about the way dinosaurs look?

With this question, it is aimed to identify students' understandings about the tentative, inferential, imaginary and creative nature of scientific knowledge.

4. What does the word imagination mean to you? Give an example

5. What does the word creativity mean to you? Give an example

With the 4th and 5th question, it is aimed to identify how the students perceive the terms imagination and creativity

6. Scientists try to find answers to their questions by doing investigations/experiments. Do you think that scientists use their imagination and creativity in their investigations/experiments? Explain your answer with an example.

In this last question, *it is aimed to identify students' understandings about the tentative, inferential, imaginary and creative nature of scientific knowledge.*

After administering the questionnaire used in this study, each questionnaire form was investigated and copied. These copies were given to the students and semi-structured interviews were conducted with them. In this way, the students who had a chance to read the answers given to the questionnaire were asked to support their answers with additional examples or clarify the answers given if needed. Data gathered through these interviews was used as a measurement tool that supports the validity of the questionnaire during the creation of the students' nature of science profiles. For instance, to explain the answer given to the questionnaire item about the ways scientists reach to a model in the science textbook, students were further exposed to questions such as "do you think the scientists saw this shape with their own eyes" or "what kind of investigations they conducted" etc.

c) Data Analysis

The group of 17 students' profiles of the nature of science was created based on the questionnaires and semi-structured interviews conducted with them. In this process, for the analysis of students' nature of science understandings, constant comparative analysis was employed (Strauss & Corbin, 1990). In the literature, it is found that many studies, which aim to detect both students' and teachers' nature of science understandings, employed this method (Khishfe & Abd-El-Khalick, 2002; Khishfe, 2004). Using this method, to clearly produce the participants' profiles on the elements of nature of science understandings were generated based on students' answers given in the questionnaires and interviews. In this process, both interview and questionnaire data were handled together so that the potential problems that might rise during generating students' nature of science profiles were solved. Based on both research data after students' nature of science profiles were generated, a profile was decided through the detailed analysis of data. In this way, both validity and the generated profile's reliability was controlled. In addition to the profiles of nature of science, the students' views about the elements of the nature of science were investigated broadly by using direct quotations from students' answers to the questionnaires and interviews and including frequencies and percentages.

The coding rule for categorizing the participants' views of nature of science was built on the perspective that the students' views have a constant change (Khishfe & Lederman, 2003). The participating students' views of nature of science have been categorized in three ways: naïve, transitional, and informed. Before explaining this analytical framework, we need to mention that multiple elements of nature of science were explained in more than one questionnaire item. The tentative nature of science are explained based on the students' answers given to the item about the change of scientific knowledge, the item about atom, and item about the dinosaurs; the first, second and third items. To categorize the participants' all views about the tentative nature of science as informed, they were asked to provide evidence that they have informed views in their answers given to the all items. If the participant did not provide enough views for the three items about the nature of science, the view held by the student was categorized as weak. If the participant provided some views to some items but not the others, the view held by the student was categorized as transitional. This categorization method was also used in a study conducted by Khishfe (2004).

FINDINGS

In this section, the findings gathered from the questionnaires and interviews conducted to reveal students' nature of science understandings were presented. In this regard, four expected elements- being tentative, experiential, inferential, and imaginary and creativity, which the 5th-8th grade students have about the nature of science constituted their profiles. Additionally, to enhance the discussion that will be done about the students' nature of science understandings, the answers given to the questionnaire and the semi-structured interview were extensively explained by using direct quotations from the students' own statements.

In Table 2, each student is defined by a pseudonym representing each student and their understandings of the four elements of nature of science is categorized by using one of the naïve, transitional, and informed categories.

Table 2. *Categories of the students' elements of nature of science understandings*

Students	Tentative Nature of Science			Difference between Observation and Inference			Experiential Nature of Science			Creative and Imaginary Nature of Science		
	I	N	T	I	N	T	I	N	T	I	N	T
M1		X		X					X	X		
M2		X				X	X				X	
M1		X		X			X				X	
F2	X			X					X			X
M3			X	X			X			X		
M4			X			X		X			X	
F3	X			X			X			X		
F4		X			X			X		X		
M5		X				X		X			X	
F7		X			X			X			X	
F5		X				X		X			X	
F6		X				X			X		X	
F8		X			X				X		X	
F9		X			X			X			X	
F10		X			X			X			X	
F11		X			X				X		X	
M6			X		X			X			X	

I: Informed, N: Naïve, T: Tentative, M: Male, F: Female

Table 3. *Categorical distributions of the student's nature of science understandings*

Participants N:17	Tentative Nature of Science		Difference between Observation and Inference		Experiential Nature of Science		Creative and Imaginary Nature of Science	
	f	%	f	%	f	%	f	%
Informed	2	12	5	29	4	24	4	24
Naïve	11	65	7	41	8	47	12	71
Tentative	4	24	5	29	5	29	1	6

Investigating Table 3, it is found that 22% of the students have informed understanding of the tentative, experiential, imaginary and creative and inferential nature of science; 56% of had naïve understanding of the nature of science for the four elements investigated. Also, 22% of the students' answers which were given to the questionnaire and the interview about the elements investigated of the nature of science, could not be categorized as either "informed" or "naïve". The reason for this is that the students gave inconsistent answers to the questions. The answers of these students were classified during data analysis under "tentative" subheading and were accepted as "they have naïve understanding of the elements of nature of science investigated."

a) Tentative Nature of Science

65% of the participants had naïve understanding of the nature of science. It is found that most students in this group believe that the scientific knowledge is absolute or true and it never changes. When the students' understanding of nature of science about it being tentative was analyzed; two answers that they give in the questions in questionnaire and the semi structured interview. The first one is the first item on the questionnaire about "whether the scientific knowledge on science textbooks will change in the future."

53% of the students answered this question as "scientific knowledge would not change" [because] "*scientists would not put these [information] in the textbooks" [F8].* Another student's answer to the same question was

> Scientific knowledge is true, it is true because [scientists] do research and it is true because they experiment what they found. [F5]

It was found that these students believed the knowledge would not be put in the textbook if the scientist were not certain about the knowledge structure and if the knowledge was not accepted by everybody. One student answered to the question "do you believe the scientific knowledge can be changed" as "*No, [scientific knowledge] doesn't change because it is accepted by everybody [M1].*

The answers 71% of the students investigated gave to the second and third questions in the questionnaires indicate that they believe scientists are "certain" and "confident" about the structure of an atom and dinosaurs explained in the textbooks. Additionally, it has found that most students had inadequate content knowledge about dinosaur subject.

> Scientist researched and saw an atom's structure. [M2]
> Scientists saw an atom through a microscope explicitly. [F5]
> Scientists explicitly prove what dinosaurs looked like by looking at the remaining fossils from them [F6]

Secondly, a few of the students asserted that the scientific knowledge can be changed by adding new knowledge to the existing knowledge. One student explained this situation as

> When scientists conduct experiments they cannot be sure… Their results change when they conduct other experiments because they have more knowledge [F3].

It was found that only 12% of the participants had "informed" understanding of tentative nature of science. Students in this group asserted that scientists are not certain about the ways dinosaurs looked because scientists use imagination and creativity when picturing dinosaurs.

> Scientists are not certain about the ways dinosaurs look, this knowledge is not totally accurate as they make a prediction about them [M1]
> I don't believe in the explanations scientists make about the ways dinosaurs looked because it cannot be totally true as they didn't see dinosaurs [F2]

b) The Difference between Inference and Observation

70% of the participants did not have "informed" understanding about the difference between inference and observation. It is found that the students in this group used "knowing" as a synonym for "seeing". The students believe that for scientist to learn something about a phenomenon they simply need to observe it. 47% of the participants believe that scientists are certain about the structure of an atom because they can see an atom by using a microscope. Three of these students indicated their thoughts as

> [Scientists] know this knowledge about atom that has been spread to everyone, this knowledge is accepted. They saw this shape by using an electron microscope. [F9]
> As the [Scientists] saw this shape, the knowledge about the atom is certainly true. [F7]
> [Scientist] investigated the structure of an atom and saw it by looking through a microscope [M2]

Similarly, it is found that 41% of the participants thought that the scientists saw the dinosaurs with their own eyes and therefore the knowledge about what they look like is certainly true.

> [Scientists] saw dinosaurs by looking [F11]
> [Scientists] preserved dinosaurs for preventing them from extinction [F5]

When the interview data about this questions deeply, it is found that the students did not know about the difference between the way scientists explain the existence of dinosaurs (inference) and the fossil bones that these explanations endure (observation). For instance after the students' answers gathered as when the scientists decide on what dinosaurs look like "they simply gather bones of the skeleton"; the researcher asked the following question additionally: "but how does a scientist know about the color of a dinosaur?. Some of the answers given to this question this question were given below

> [Scientists] know the color of the dinosaurs by conducting some experiments with their bones [E5]
> [Scientists] find the color by conducting more research with the remaining bones of dinosaurs [E4]
> [Scientists] tell the color by looking at the structure in the bone of dinosaurs [F11]

In the interview, 47% of the students had "informed" understanding of the difference between observed (fossil) and the inferred (that they live in the past) on the question about the dinosaurs.

> [Scientists] say that the dinosaurs live in some time by looking at the remains of dinosaurs.[F4]

> [Dinosaurs] have fossils, they have big bones, they know about the height by combining these bones [F2]
> [Scientists] find bones when they do experiments and make calculations with them, through this way they reach some truths about the dinosaurs. [F3]

c) Experimental Nature of Science

47% of the participants have naïve understanding of the experimental nature of science. As stated in the previous section, 47% of the students used seeing synonymously with knowing. These participants could not make any connections between knowledge and evidence. Therefore, they failed to know some claims about some phenomena have several unexplained dimensions and even though the scientists could not observe these directly they can claim these based on the evidence. In the interview it is from the answers given to the question about the dinosaurs indicated that 41% of the students thought that the scientist really saw the dinosaurs with their own eyes and the role of evidence when generating images of dinosaurs were not understood:

> Scientists imagine the way [dinosaurs] look by thinking [F4]
> [Scientists] construct the knowledge about the dinosaurs in their head through their thoughts, it is doubtful that these are correct [M3]

It is found that 24% of the participants had "informed" concepts about the roles that data plays during the creation of scientific knowledge. These students asserted that scientists could generate some accurate images based on the fossil remains even though they cannor actually see the dinosaurs.

> Scientists cannot prove the dinosaurs really exist but they can claim this by using fossils. On the other hand, they produce the style they look through their own thoughts [E3]
> Scientists, not being so certain about it, try to explain what dinosaurs look by the evidence they found and the traces that they left [F3].

d) The Role of Imagination and Creativity In Creating Scientific Knowledge

It is found that 71% of the participants had "naïve" understanding of the imaginary and creative nature of science. Three different tendencies were emerged. First, as mentioned previously, 47% of the students asserted that scientists learn atomic nature of an atom by observing it under a microscope. Second, 41% of the students do not know the description of dinosaurs include creative and imaginary work. These students implied that the scientists certainly saw dinosaurs or their pictures.

If the comparison is made, only 35% of the students indicated that the scientist used imagination and creativity when they explain the structure of matter and the existence of dinosaurs. Still, students were not "informed" explaining the role of experimental evidence when generating this knowledge:

> Scientists use imagination and creativity in their work. For example, they can't see an atom but they say the way it looks by imagining it [F1]
> People can do different things by imagining and generate formulas [F2]

Third, it is found from the answer given to the question which is the last one in the questionnaire and about "whether scientists use imagination and creativity", 18% of the students asserted that science could not include human features such as creativity and imagination as it can lead to wrong conclusions.

> Scientists do not use imagination and creativity in their work. They don't acquire knowledge by thinking, they need to do experiments. On the other hand, they use their creativity but not their imagination [M2]

24% of the participants indicated that scientists use imagination and creativity in their work. However these students used the terms imagination and creativity with the purpose of citing some other activities and element instead of creating knowledge and idea. Fourth and fifth items in the questionnaire were asked for what they meant by these terms and to clarify the thing that they assert. 76% of the students used "imagination" and "creativity" in science synonymously as a person's ability to create a scientific product and an 'nterest'ng talent of doing an experiment:

> Scientists think about "would it be better if I do this" by using imagination and creativity in the work they will do [M3]
> Using these [imagination and creativity], they try to add some more beauty when they do a work. [F5]

DISCUSSION and CONCLUSION

Teaching science and nature of scientific knowledge adequately has become a mutual goal of science educators and science education researchers for a long time (Lederman, 1992). It is known that students who have an informed understanding of the nature of science can learn science content successfully and understand the phenomena that happen around them (Driver, Leach & Millar, 1996). Having adequate knowledge of nature of science help students to appropriate the scientific studies and to comprehend that more studies needed for scientific and technological advancements.

Based on these explanations, we tried to detect middle school students' knowledge about the nature of science in our country. It is concluded that a few studies exist about the subject that explain our country's educational situation. It is found that some studies identified the primary or university level students' while most studies identified the high school level students' nature of science understandings (Deng, Chai, Tsai, Lin, 2014; Oyman, 2002; Çelik & Bayrakçeken, 2004; Kılıç, Sungur, Çakıroğlu & Tekkaya, 2005; Khishfe, 2015a-b). These studies mostly used questionnaires to identify students' concepts regarding their nature of science (Macaroğlu, Taşar & Cataloglu, 1998; Yakmacı-Güzel, 2000). In these studies, it is concluded that almost all of the high school students thought scientific knowledge is whole and complete and believed that the scientific hypotheses and theories are absolute truths. Valuing scientific perspective, accepting science is not in a static but in a dynamic structure and therefore perceive science as a field that he/she can contribute can help students to be more successful in science lessons (Lederman, 1992).

In the current study middle school students' nature of science understandings were identified using nature of science student questionnaire and semi-structured interviews. With the six items in the nature of science questionnaire that determine students' understandings of experimental, tentative, inferential, imaginary and creative nature of science was aimed to be identified. A nature of science questionnaire prepared in this direction was administered to the students. Then, in depth interviews were conducted with the students based on the answers they gave in the questionnaire. In this way a profile was generated for each student regarding four elements of nature of science experimental, tentative, inferential, imaginary and creative. The students' profiles were categorized as "informed, tentative and naïve". This coding was used in a study conducted by Khsihfe (2004).

Based on the data gathered, a couple of students', whose scientific achievements and socioeconomic statuses were different, nature of science understandings (about the investigated elements) were naïve. This result is consistent with the results reached in the studies that evaluate the students' nature of science understandings in the international literature (Bady, 1979; BouJaoude, 1996; Smith, Maclin, Houghton & Hennessey, 2000; Meichtry, 1992). Data in Table 3 indicates that 22% of the students had "informed" understanding of tentative, experimental, inferential, imaginary and creative nature of science. After all, 56% of the students had "naïve" understanding of the elements that are investigated regarding nature of science. If we add a group of students (22%) who had "transitional" nature of science understanding, it is understood that 78% of the students had inadequate nature of science understanding. This result is similar when compared to international literature.

However, the reasons for middle school students' this level of inadequate nature of science understandings should be discussed. In science lessons, the purposes of scientific studies and nature of scientific knowledge should be explained. Teaching both the nature of science and the purposes of scientific studies in an adequate level is important. The lessons on scientific process skill are not sufficient to foster the concepts about the nature of science. Data in the current study supports that the inquiry-based science activities are not sufficient to teach students the nature of science effectively. This result requires finding some different ways to follow instead of using indirect attempts to teach students the nature of science. Herein, there is a need for using direct-reflective nature of science teaching which is successful to teach students sufficient level of nature of science (Rudge and Howe 2009; Akerson et al. 2008; Khishfe and Abd-El-Khalick 2002).

65% of the students have "naïve" understanding of the tentative nature of science. It is found that almost all students who share this thought believed that the scientific knowledge is absolutely true and therefore would never change. They provide their reasoning to this idea as "scientists would not put this knowledge in the textbooks if they are not certain about something." It is concluded from the answers the students gave to the second and third questions that the students believed that the knowledge scientists provide about the atomic structure and dinosaurs' extinction is 100% correct. The way an atom looks and what are atomic models were taught in a lesson prior to the current study. In this case, the participating students' ideas on scientists' knowledge about atomic structure is being absolutely true and believing that the structure of an atom given in the questionnaire 100% correct should be discussed. In this regard, there is a need for explaining the ways scientists reach to this knowledge or conducting activities portraying this. It is important that the teachers make an explanation about the structure of models when presenting students with models. In this way, students can succeed to understand that scientific knowledge is not the 100% true copies of the reality. A study conducted by Khishfe and Abd-El-Khalick (2002) found that 85% of the sixth grade students in their study had "naïve" understanding of tentative nature of science. It can be said that the number of students that had naïve understanding of tentative nature of science was even for the students in the study groups of this study and the current study. It is striking that the students thought the scientific knowledge will be absolutely true and will never change because the knowledge produced by scientists' work is a product of a scientific work. Thus, it can be said the students' knowledge about scientific work and their understanding of scientific process skills can negatively affect the understanding that they construct about the tentative nature of science. Additionally, the "scientific" word in the statement "to characterize something as true it should be scientific", which is stated in many resources, leads individuals to bias.

41% of the participants did not know the difference between observation and inference. Therefore, they adopt naïve understanding of the inferential nature of science and scientific knowledge. The students with naïve understanding about this perceive "knowing and seeing" synonymously. In addition to this, they think that in order to know something scientifically, it needs to be directly observed. It is striking that the students who believe scientists directly observe it when reaching scientific knowledge, state that "atomic structure of an atom is known through direct observation under a microscope" and also the it is known that the "dinosaurs lived once upon a time again through a direct observation". Some students stated their idea about the question regarding dinosaurs in the questionnaire as "scientists decide whether the dinosaurs existed through investigating the fossils." However, they could not answer the question "how scientists know about the ways dinosaurs look" in a way that reveals their sufficient understanding of inferential nature of science. However, it is found that 47% of the students had "informed" understanding of about the identification of the difference between the observed (fossils) and the inferred (they lived previously).

47% of the students had "naïve" understanding of the experimental nature of science. Investigating the students' understanding of the experimental nature of science at the beginning of the study, 47% of the students thought "knowing as seeing" synonymously and this explained in the previous paragraphs. The students in this group failed to make or realize the relationship between data and evidence. As an example, none of the students answered questions about atom and dinosaurs as "scientists use data in other words evidence when they decide on the both types of knowledge." The students in this group insisted on the idea that the scientists can only have knowledge about a subject by seeing in their own eyes. Supporting this, they explained that "scientists would not have any knowledge if they don't see with their own eyes." Everybody experienced how diversely students generate ideas about and make predictions about how events can occur in a setting. Students do not need to be present in these settings to in order to do so. However, when the subject is science and scientific knowledge "scientist should be able to see things in orders to know something about a subject" explanation should be discussed. In this result, it can be said that the students' "naïve" understanding of the experimental nature of science affects their thoughts about the tentative nature of science. In other words, it can be interpreted that the students who adopt scientific knowledge as accurate, complete, and absolute truth; construct scientists in their mind as people who know everything accurately and observe directly. In this regard, there is a need for students to construct images of scientists in order to understand the tentative and experimental nature of science. Students need to abandon their ideas about scientist being people who can success everything and every time and do the right things every time. Students who succeed this or students who are provided with such experiences can abandon the thought "scientists observe things in order to know about them."

At the beginning of the study, 71% of the students had "naïve" understanding of the imaginary and creative nature of science. There are three tendencies of the ideas that the students adopt about this element of the nature of science. First, most student (47%) think that when scientists reached to the model explained in the science textbooks about the structure of an atom, they observe it directly under a strong microscope. Second, most students (41%) do not know identifying the ways dinosaurs look includes creative work. The students in this group believe that scientist look at the pictures of dinosaurs in some way. From the answers given to the last question in the questionnaire, 24% of the students believed that scientists use imagination and creativity and 18% did not believe it. When the 18% of the students' answers, students who did not believe scientists use imagination and creativity, were investigated; it is identified that they had an understanding as "it could lead to wrong results if the scientist use these". Therefore, the students believe that the science would not include the humane features such as imagination and creativity. However, when interpreting the data gathered in every stages of their work, scientists use both their imagination and their creativity (Mccomas, 1996).

The answers given to the 4th and 5th questions by the students (24%) who think that the science includes creative and imaginary elements were analyzed. It was asked students to write what they understand from the concepts imagination and creativity. Based on the analysis of this data, it is found that most students, who believed that the scientific knowledge has imagination and creative features, used these concepts different than the purpose of these questions were being asked. Students used creativity for citing other activities rather than producing knowledge and idea. Imagination and creativity are explained as a tool that nobody knows or designing an interesting experiment. None of the students in this group, give "when deciding what atomic structure is and the ways dinosaurs look like scientists use imagination and creativity" as an example.

This can be interpreted as opportunities were not provided to students where they can use their imaginations and creativities in the previously conducted studies in the science lessons. In addition to this, there is a need for open and direct connections made between the effects of imagination and creativity on studies conducted with students and scientists. Meichtry (1992) asserted that if the connections were not made between the subjects students learn and the methods used and the elements of nature of science, students would not make these connections. If the attention was paid to these in the previous studies, students would answer as creating new knowledge and ideas when explaining these two concepts. To teach these elements of the nature of science sufficiently to students, there is a need for both giving opportunities and presenting personal and occupational features that the scientists have.

SUGGESTIONS

To date, in the science teaching programs prepared in our country, the necessity of nature of science learning has not been discussed in order for students to learn science content and gain positive views towards science. However, there has given a very brief reference to nature of science in the introduction section of the latest science and technology program which has been implemented in the schools as 2005. This program has been defined as an inquiry-based constructivist program. It is known that the inquiry-based learning approaches have an important effect on students use of scientific process skills and therefore to gain sufficient knowledge about scientific work.

However, teaching nature of science is different than teaching how to conduct scientific work. Nature of science concept is not easy as involving in research activities and learning it sufficiently a by-product of these activities (Abd-El-Khalick & Lederman, 2000; Khisfe & Abd-El-Khalick, 2002). For this reason, teachers should spare extra time and intensive effort to teach students nature of science. A more direct-reflective approach should be used to teach sufficient level of nature of science instead of an indirect approach. In other words, science and the nature of scientific knowledge should be approached as "cognitive learning goal" in the science learning programs and should be taught in the scope of different activities respectively (Abd-El-Khalick & Lederman, 2000).

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