Education and Science tedmem

Vol 40 (2015) No 177 1-18

Development of Elementary 6th and 7th Grade Students' Views about Scientific Model and Modeling throughout a Summer Science Camp *

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Abstract

In this qualitative study, the influence of a ten-day science camp on elementary students' views about scientific model and modeling was investigated. Twenty-four 6th and 7th grade students participated to the study. The general aim of the science camp was to introduce Nature of Science (NOS). One of the special aims of the science camp was to introduce scientific model and modeling as an aspect of NOS. Students' views about scientific model and modeling were investigated by Views of the Nature of Science Version D (VNOS D) question "what is the scientific model?" and open-ended probe questions in the interviews before and after the science camp. Qualitative data were analyzed by using interpretive analysis. Codes and themes acquired by students' views before and after the science camp were compared and interpreted to determine the change in the students' views. According to the results of the study, it can be said that students didn't know what scientific model was before the camp. However, after the science camp, as a result of activities which aimed at introducing scientific model and modeling, they were able to conceptualize that scientific model is a kind of scientific knowledge and were able to define scientific model by stating that scientific model is based on data and thus they are the product of scientific research and experiments.

Keywords

Scientific model
Modeling
Elementary 6th and 7th grade students

Article Info

Received: 08.10.2011
Accepted: 12.03.2014
Online Published: 02.15.2015

DOI: 10.15390/EB.2015.1507

Introduction

In general, science is human beings' efforts to make sense of the nature and the life in it. Understanding today's world which has been shaped by science in different ways, grasping what science is and thinking and acting scientifically is only possible through raising individuals who possess scientific literacy. Nature of science (NOS) or nature of scientific knowledge is the most important dimension of scientific literacy. The fact that the importance and place of science of nature-based approaches in science education are better comprehended in recent years has helped shape an approach in which historical, philosophical and sociological properties of science are discussed in science education. The foundation of this approach involves appropriate use of scientific processes utilized in the generation of scientific knowledge and discussions related to the philosophical bases

* This study was conducted within the context of project named Three in One: Nature, Science, and Children Summer Science Camp supported by The Scientific and Technological Research Council of Turkey, Project Number: 108B016

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during the operations of these processes. Scientific model and modeling process are one of the most suitable tools that can be used to provide students with scientific understanding that has been reshaped. Various researchers have reported that scientific model and modeling are integral parts of scientific thinking process that are often emphasized in science education programs and of modern teaching of science (Gilbert and Boulter, 1998; Harrison and Treagust, 2000; Treagust, Chittleborough and Mamiala, 2002; Coll, France and Taylor, 2005).

Gilbert and Boulter (2000) define the scientific model as the representation of an idea, an object, a process or a system. Modeling process is defined by Harrison and Treagust (1996) as the activities to comprehend the world and to transfer the concepts created about the world. Similarly, Dagher (1994) and Treagust (1993) have reported that scientific model and modeling are crucial both in the research process and in disseminating scientific knowledge. As specified by Gilbert (1993); in addition to being the products of scientific ideas and the main dissemination tools to share those ideas, models are also the tools for scientific method and teaching-learning.

Since modeling process has a parallel progress to scientific knowledge formation, it serves as research in which data are generated by scientists by using scientific processes and explained through analysis. While studying the complex phenomena such as atoms, DNA and the inner structures of the earth, scientists generally make use of models to better describe their findings and thoughts. Models generated by scientists have paved the way for other scientists as in the case of atom (Justi and Gilbert, 2000) and contributed to the progress of science by enabling the generation of different models. When it is remembered that science progresses by forming theories in order to explain and make sense of various observations, the crucial role of scientific models in explaining and sense making will become more apparent. Justi and Gilbert (2000) state that models act like a bridge between the events experienced by scientists and the theories they have formed to explain these events. Treagust et. al (2002) report that models are practically the sole methods to be used to explain abstract scientific theories.

Scientific theories can be regarded as the mental models created in the light of scientific data by the scientists whose ideas they represent. In this sense, it is not possible to tell, explain and reflect the mental models that represent our ideas, thoughts and perceptions or to perceive others' mental model as it really is. Therefore, we need different mediating models in order to transfer the mental models from our brains. Gobert and Buckley (2000) defined four different models that include mental models as well: mental model, expressed model, consensus model and teaching model. While Gobert and Buckley (2000) define the mental model as the personal and internal representation of the target system, they describe the expressed model as the external representations generated from one's mental models and that can be expressed by oral and written means, by action or with the help of different materials. They explain the social reorganization of scientific knowledge through consensus model. Consensus model is a model developed and tested by scientists and it was a model that was agreed on. The last model, the teaching model, is defined as the model developed and utilized by teachers and program developers to facilitate the comprehension of the target system.

Mental models can be defined as the structures formed in one's mind about an event, concept or process. Therefore; Grosslight, Unger, Jay and Smith (1991) and Coll, France and Taylor (2005) state that studying students' mental models will provide crucial information for science educators and teachers about conceptual change and development in students. Hence, utilizing model and modeling process in science education is crucial both to reflect and express mental models generated by students and to teach the consensus models. Harrison and Treagust (2000) and Treagust et. al. (2002) report that models are compatible with the constructivist learning theory and they are suitable tools to be used in the process of structuring knowledge. However, effective use of these tools requires active participation of students in the process. Grosslight et. al. (1991) and Treagust et. al. (2002) indicate that students should be provided with environments in which they can practice modeling on a problem to understand how models are formed and the purpose of their use so that they can regard models as a research tool and an opportunity. Van Driel and Verloop (1999) emphasize active participation of students and specify that the nature of the models should be discussed explicitly during the process. In fact, the real purpose of programs which utilize scientific models and active modeling process is to contribute to student ideas about science and scientific knowledge. Students who generate ideas about the historical and philosophical changes of scientific models by time after having grasped them and share scientists' experiences in the generation of scientific knowledge by actively participating in the modeling process will have a more comprehensive scientific understanding. Hence, it is necessary to study and develop student views about the scientific model in general.

In one of the pioneering studies on student views about the scientific model, Grosslight et. al. (1991) made interviews with 7th and 11th grade students about models and their use in science and compared the findings with the expert views related to models. The views obtained in the interviews were categorized under three different themes. Based on the findings, students had realist perspectives in general and thought of models as the physical and visual copies of reality. Almost all students were found to think of models as concrete samples of objects such as an actual building or a plane, but scaled differently. Students expressed the purpose of using models as informing about realities and facilitating the sharing of knowledge. 7th and 1tth grade students who were found to have misconceptions about scientific models stated that various models could be formed about an object only to reflect different characteristics of the object in question. This finding shows that students did not comprehend the fact that different models could be generated with varying theoretical perspectives about an event, case or a process.

In the following years, studies that examined the level of comprehension about content by way of scientific models and that discussed models were designed with various age groups using different content such as weight-density (Smith, Snir and Grosslight, 1992), atom-molecule (Harrison and Treagust, 1996), elbow-movement (Penner, Giles, Lehrer and Schauble, 1997) and states of the matter (Saari and Viiri, 2003).

In their study that examined the views of 8th, 9th and 10th graders on atom models and modeling by using atom and molecule content, Harrison and Treagust (1996) utilized the classification system developed by Grosslight et. al. (1991). According to this classification, while more than half of the students were found to be at the first level in which direct and many similarities between the model and the modeled target existed and in which differentiations between the model and the reality were not possible, the other half was at the second level in which differences were started to be observed between the model and the reality. However, different from the findings obtained by Grossligth et. al. (1991), it was observed that students in these age groups could think of the models as both concrete and abstract.

But using data from previous studies (Treagust, Chittleborough and Mamiala, 2001; Grosslight et.al. 1991), Treagust et.al. (2002) developed a 27-item questionnaire to measure student perceptions about scientific model. Questionnaire items are collected under five categories: multiple representations, exact replicas, explanatory tools, how scientific models are used and the changing nature of scientific models. Based on the findings of this study conducted with two hundred twenty eight 8th, 9th and 10th graders, about half of the students believed that scientific models were exact replicas of the reality. The majority of the students believed that models were used to introduce objects physically and visually and about half of the students were not aware of the role scientific models played in generating scientific theories and ideas.

Saari and Viiri's (2003) study utilized the states of the matter unit to develop 7th graders' views on models and modeling. Prior to the study, researchers identified student views on scientific models and developed a three-week lesson plan about what they needed to learn about scientific models based on these findings. Additionally, 9th grader from another school who learned physics and chemistry for three years were selected as the control group. According to pre-interview data obtained from students before the study showed students believed that only the objects that could be seen could be modeled, that the models were artificial objects and that they were copies of the reality.

Students also emphasized the perfect similarity between the model and the modeled object. Student views were collected under three different themes in the light of the interview and questionnaire conducted subsequently. Based on the findings, almost all the students were found to be at Level A prior to the study in which they believed models should be accurate and exact as fully as possible, but after the study more than half of the students improved to Level C in which students reflected that models could represent known or unknown things and models could be used to generate ideas about the modeled object. More than half of the control group students who were not directly taught about scientific models were found to be at Level A which reflected the belief that models should be accurate and exact and only 16% were found to have sufficient scientific model perception.

Another study that allows comparison with the current study was undertaken by Schwarz and White (2005). Schwarz and White (2005) designed a physics teaching program based on models in which students could learn about the nature of models and participate in the modeling process. The teaching program provided students with opportunities to model their own theories on force and movement in computer environment. The main goal of the teaching program was to allow students grasp the nature of scientific models, the modeling process, the assessment process of the models and the purpose of scientific models. Prior and subsequent to the implementation in which students conducted their own research projects, students were tested on modeling and interviews were undertaken. It was seen that after the implementation students were able to explain abstract models and comprehended that models were representations with prediction and explanation capacity. Also, many students understood that models could be used for many purposes such as research, testing theories and predicting events.

In their study on 1702 6th, 8th and 10th grade Korean students, Kang, Scharmann and Noh (2005) identified student views on NOS with the help of a multiple choice test which included questions about the purpose of science, definitions of scientific theories, nature of scientific models, changeability of theories and the origin of theories. According to research findings, about half of the students regarded models as structures proven via experiments and a substantial number of students were found to possess realist epistemology which regarded models as exact replicas of the reality.

Research results included in international literature present that students do not have appropriate views on the nature of scientific models; on the contrary, students have misconceptions related to models. In general students believe that models are the exact replicas of reality and that one-on-one correlation should exist between the modeled event, object or situation and the model in terms of shape, size and structure. Also, students are not aware that abstract models can exist in addition to concrete models and that the real purpose of models is to direct scientific studies, test the generated theories and predict the events via models.

In Turkey, studies that emphasize the role and importance of models and modeling in science education have increased in recent years. However, these studies were conducted with teachers and teacher candidates (Güneş, Bağcı and Gülçiçek, 2004a; Berber and Güzel, 2009). Güneş, Bağcı and Gülçiçek (2004b) studied Faculty of Education science and mathematics instructors' views on scientific models and modeling via open-ended questions and found that instructors have insufficient knowledge on models and modeling and have difficulties when they provide examples of models.

In their study which categorized models based on related literature, Ünal and Ergin (2006) emphasized the role of models in science education and provided examples related to the use of models in environments which utilized constructivist learning approach.

Doğan Bora (2005) identified the views of 10th graders and their teachers on NOS with the help of Views on Science-Technology-Society (VOSTS) questionnaire. This research which examined various characteristics related to NOS explored the views of teachers and students on scientific model as well. According to study results, more than half of the teachers and students have insufficient perspectives about the nature of scientific models and regard them as realities proven by many studies.

In recent years, Oğuz (2007) designed a study that intended to develop 7th graders' comprehension and thinking through model generation method. The study was conducted with 9 voluntary female students as an extracurricular activity. In this after school activity, students observed the physical properties of insects and designed experiments about insects' reactions to external factors such as humidity and light. Students became aware of their own mental models by reflecting their models which were generated as a result of observations and experiments in their reports. The researcher stated that model generation and development process positively contributed to student perception.

It is clear that although studies on scientific models and modeling have increased in recent years, they are still insufficient. Studies that allow students to develop their own models in the framework of research are needed which will contribute to the comprehension of the nature of scientific models via discussions of the properties of scientific models. It is also required to examine student views on the scientific model in general instead of studying their views on specific issues. The current study examined how science camps, which included activities to specifically inform students about scientific models and modeling in addition to activities that focused on introducing NOS, affected 6th and 7th graders' views on scientific models and modeling.

Method

This study was conducted in the framework of a science summer camp project funded by STRCT (The Scientific and Technological Research Council of Turkey) Science and Society Department. General purpose of the science camp project is to introduce students with the nature with a method composed of reflective guided-inquiry and explicit-reflective activities. The main structure of the science camp consists of NOS activities aimed to introduce the aspects of NOS and research projects that are conducted by students with science mentors. The current study intended to examine how customized activities in the science camp program that aimed to present scientific models and modeling affected student views on scientific models and modeling.

Participants

24 students who finished 6th and 7th grades attended the science camp. 13 of the students were males while 11 were females. The number of students who finished 6th grade and 7th grades were 13 and 11 respectively. The participants were identified as a result of interviews with voluntary students from 10 different schools and science teachers were also consulted during the selection. Science teachers were asked to suggest students who were interested in research and the nature. Parents of the identified students were consulted for their approval in their children's participation to Summer Science Camp. The project team was composed of three science educators from the university and four post-graduate students.

Implementation

A program that would let students learn about the process of science, NOS and the relationship of science with other fields through fun activities in nature was developed by the researchers to introduce the nature to students with a method combined of reflective guided-inquiry and explicit-reflective activities. Guided inquiry that aimed to have students learn how to do science and explicit-reflective approach activities with clear messages at the end were used as the two fundamental methods in the science camp program. The camp period of ten days allowed the students to follow the intensive program composed of various activities intended to introduce science. Various guided research implementations (Let's examine the oscillation in the pendulum, How can we make the best rocket? and four-day research in nature with the guidance of the science mentors) and various activities geared to introduce NOS (Black box, The real fossils, real science, Young woman or old woman?, The hole picture, Tricky tracks, Mystery cubes (Lederman and Abd-El-Khalick, 1998) were undertaken in the framework of the intensive program. Most of these activities emphasize more than one property included in NOS. However, very few of these activities present scientific models, a fundamental dimension of science, through concrete examples in a manner that primary school students can comprehend. Therefore, activities towards introducing scientific models and modeling based on concrete examples and current scientific topics were developed and implemented. These activities were The Invisible Bottom of the Puddle, Path to Information via Earthquake Data and Global Warming activities (see also Metin, 2009). Another goal in these activities was to emphasize the fact that scientific models are based on data and to experience the modeling process. It was intended to have students learn the modeling process by doing and therefore better comprehend the scientific model with the help of these activities in which actual data were used. Prior to the activities geared to introduce the properties of scientific models and the modeling process, discussion environments were created to have students express their prior information about scientific models. Students were asked about the models they knew about and were asked to express their opinions about atom, DNA and earth models which were often used at school. Subsequent to this step, they were shown various examples of models from STRCT Popular Science Books and were told that they would be doing various modeling activities throughout the camp.

Water machine black box activity (Lederman and Abd-El-Khalick, 1998) was utilized first in introducing the scientific model and the modeling process. Since the students could not observe the mechanism inside the box, the aim here was to develop a model to explain an observed situation whose details were not known. Cubes with inscribed numbers on five sides with one obscure side were distributed to groups of four in Mystery Cubes (Lederman and Abd-El-Khalick, 1998) activity. Students were asked to make mathematical patterns with the available data and to predict the unknown number with the help of these patterns. A puddle was prepared in which the indentations and protrusions were not visible due to murkiness of the water in the Invisible Bottom of the Puddle activity. This activity intended to have students model the puddle floor by drawing a 3-D graphic in a graphic program after taking depth measurements from various points they identified themselves.

The effort spent on generating explanations through the generation of data about situations that cannot be directly observed is the common characteristic of these three activities. Examples from scientists' work were provided during the activities to make the process more meaningful. For instance, the puddle prepared for the activity was likened to Lake Abant and the fact that scientists studying Abant modeled the lake floor with similar methods by collecting data from large bodies of water. In Path to Knowledge via Earthquake Data activity, students were provided with earthquake data over 7 and higher recorded in different locations of the country since the year 1200. This activity intended to model the earthquake by marking the actual data on a map. By presenting the earthquake map of Turkey, students were made aware that the region they modeled corresponded to the first-degree seismic zone. It was stated that scientists also marked the experienced earthquakes just like they did and created the earthquake map which was a model. It was mentioned that this map could be used to predict which region experienced the highest number of earthquakes and which regions would have more earthquakes. Students were given graphics composed of actual temperature data during the Global Warming activity. The activity intended to have students understand and interpret these graphics and the changes in them and have them discuss how scientists cloud predict temperature changes for 2050 and subsequent years by using these graphics. Two contents along with their actual data that students often heard in their daily lives were used in Path to Information via Earthquake Data and Global Warming activities. Use of actual data and learning that scientists made future predictions by utilizing these data provided opportunities to emphasize both the importance of science-society relationship and the role of models in science.

Activities included in science camp program were implemented in line with explicit-reflective approach. Discussion opportunities were provided so that students could grasp the NOS aspects that the activity focused on and students were given time to express their own views. Also, the NOS aspect that was meant to be emphasized was explicitly reflected at the end of each activity. Reflective-guided inquiry sessions and NOS activities were implemented by the researchers.

Data Collection

Views of the Nature of Science Version D (VNOS-D) developed by Lederman and Khishfe (2002) was implemented before and after the science camp in order to determine the effect of the science camp - aimed to introduce science to students with its different dimensions- on students' views on NOS. Following this implementation, semi-structured interviews were given with the help of in-depth questions based on questionnaire items to better comprehend student views. VNOS-D questionnaire is composed of 7 open-ended items that aim to reveal student views on scientific knowledge being based on data, the nature of scientific models, the changeability of scientific information, differences between observation and deduction in the generation of scientific knowledge, the subjective quality of scientific knowledge and the role of imagination and creativity in the generation of scientific knowledge.

One of the questionnaire questions that aim to reveal student views on the scientific model asks directly what the scientific model is. Following student answers to the questionnaire, semi-structured interviews composed of in-depth questions about the purpose and function of scientific model, process of scientific model generation and its properties were undertaken. Hence, student perceptions about scientific model before and after science camp were investigated with the help of the views expressed especially via the semi-structured interviews.

Data Analysis

Interpretive research technique, one of the qualitative techniques, was applied in this study (LeCompte and Preissle, 1993). In this technique a coding schema manifested and shaped during data analysis process by participant views was utilized instead of a pre-determined coding schema. Meanings attributed to scientific models and modeling by the students and the change in these meanings throughout the science camp underlie this study. Student views on the scientific model were coded under categories generated about scientific model and modeling. Data in each category were examined over and over again and were classified according to similarities and differences. When similarities were observed between classes, sub categories were generated. In short, data were first coded in categories and then coding and classification was applied in each category through induction. Two researchers cooperated in the study during data analysis process to ensure reliability. The first researcher coded student views under the categories established during the process. The two researchers got together periodically to carry out many stages from providing code titles to generating themes and established consensus via discussions about the stages.

In general, in VNOS D questionnaire, data are collectively approached in the literature and coded either as "unsophisticated/naive" or "sophisticated/informed". In the current study, more comprehensive and inductive analysis about student views on scientific models was conducted by analyzing related question of the VNOS D questionnaire. It is believed that this type of analysis which presents student views in more detail will contribute to the type of analysis in literature based on the coding schema composed of two or three categories by assigning individuals. In this manner, it was possible to interpret student views without distancing the interpretations from original student views.

Results

Student views on scientific models and modeling are provided in this section in the light of the data. Student names were changed to ensure confidentiality. Student views on the definition, purpose and characteristics of scientific model and examples of scientific models provided pre and post science camp by students are presented in the same table for ease of comparison.

Answers by students prior to science camp related to what scientific model was were collected in four main categories as the definition of scientific model, characteristics of the scientific model, purpose of the scientific model and examples of scientific models.

Starting with the definition of scientific model, students were found to represent many different views on this topic. Table 1 presents student views on the definition of scientific model before and after science camp.

Table 1. Students' Defination of Scientific Model at the Beginning and at the End of the Science Camp

At the beginning of the science camp	At the end of the science camp
Visual Impression (9)	Visuals (10)
Figure (7)	*Graphic (5)*
Presentation (3)	*Drawing (4)*
Mock-up (1)	*Schema (1)*
Related to Science (9)	Construction of Unseen Realities (10)
Related to science (3)	Investigation on Unknowns (2)
Based on knowledge (2)	Designing of Ideas (1)
Tools based on science (2)	
Done with scientific tools (2)	
Proof of Science (1)	
Superior to science (1)	
Explanation of science (1)	
Don't Know or Not Avaliable (7)	
Intellectual Dimension (6)	
Proven (3)	
İdeas (2)	
Scientific ideas produced by imagination (1)	
Design (1)	
Related to Investigation (3)	
Result of Investigation (2)	
Examination (2)	
Model of Investigation (1)	
Product (3)	
Product based on result of investigation (2)	
Technological Tools (1)	

Before science camp, about half of the students stated that scientific model was related to science. Examination of answers by students who believed that scientific model was related to science showed that these answers did not define scientific model and that the word "science" was only used as a word. Therefore, it was seen from the answers that explanations by students had no scientific content. Two related quotes were as follows;

> *I have no information (about it) but it must be related to science. Scientific model is something formed by interlocking science. (Giray)*
>
> *In my opinion, it is a model made by scientific tools. (Buket)*

The number of students who stated that scientific model was a visual mock-up or a figure was substantial. In particular, students expressed that scientific model was a visual figure. A limited number of students expressed that scientific model was a product. For instance, one of the basic definitions of scientific model was as follow;

It is a figure that best explains a selected topic visually (Yonca)

More sophisticated definition before science camp was provided below;

When we undertake a study on science, the product created based on our experiments or the product of experiments may be called the scientific model (Gülden)

Before the science camp, a limited number of students expressed that scientific model was obtained as a result of research and it had an intellectual dimension.

Just like science, scientific model may be the results of research. I mean, the model of the research or its real structure (Buket)

When we say model, I think of design, first putting ideas forward and then designing it and realizing it (Çağla)

Almost a quarter of the students reported that they did not know or heard about scientific model prior to science camp. Some students gave explanations using the examples they knew since they did not know about the scientific model.

Student views on scientific model following their experiences gained at the science camp were coded similar to the coding used for views prior to science camp to allow the opportunity for comparison. Students were found to explain the scientific model with more scientific expressions at the end of the science camp compared to the answers they provided before the science camp. It was observed that students mentioned which skills were used while forming a scientific model and therefore expressed the scientific model formation process.

The biggest change observed in students compared to their pre-science camp statements was related to their comprehension of the importance of data in forming scientific models and two third of the students expressed that scientific model was based on obtained data. The majority of students indicated that scientific models were based on research, that scientific models were obtained as a result of experiments, observations, measurements and predictions and that imagination and creativity were used while forming models. According to students, other skills to be used while forming models were identified as interpretation and use of prior information. Two related quotes were as follows;

In my opinion, scientific model consists of data. Just like the path to knowledge via data activity, it is modeling via arranging data. Of course, when I heard of scientific models for the first time, I used to think of something with three dimensions, with width, length and mass. But after this camp, I understood that each result arrived via data is a scientific model. We played games during nature games; we made observations, collected data and put them on paper as graphics. It was also a scientific model. It was the cycle of nature during nature games and we modeled it (Ömer)

Scientific model are models formed by individuals as a result of research, experiments and use of imagination and creativity. For instance, we formed a scientific model during the black box activity. We did not know what was inside the box. Scientists cannot have all the data while forming models. For instance they do not know how the inner layers of the sun are. But they form it as a result of the data they obtain. They do not have the chance to open it up and see. I mean they model it with the help of the data they have. As I said, they do research, they make experiments, and they make many experiments to learn about the layers of the Sun and the Earth. They do research using various sources. As a result, they use their data and their imagination and creativity and interpretation to form a model (Buket)

Some students mentioned the intellectual skills used during scientific model formation at the end of the science camp. The skill that was observed by students and often mentioned throughout the science camp was the modeling of things whose inner structures cannot be seen such as the atom, the center of the Erath and the inner structures of the Sun. A limited number of students similarly stated that unknown can be studied with the help of scientific models. Related quote was as follow;

> *In my opinion, scientific model is the research about something unseen by collecting data. Scientists form models about the things they do not know by collecting data and by using their imagination (Murat)*

As was the case prior to science camp, students used expressions after the science camp as to the visual structure of the models while defining the scientific model. However, the difference was in the use of words such as graphics, drawings or schema instead of the words of figure and visual mock-up that were used before the science camp.

About the characteristics of the scientific model, almost one fourth of the students stated that the scientific model was similar to reality and some students expressed that scientific models were minimized or maximized models of reality. Table 2 presents the student ideas on the characteristics of scientific model before and after science camp.

Table 2. Students' Views on Characteristics of Scientific Model at the Beginning and at the End of the Science Camp

At the beginning of the science camp	At the end of the science camp
Copy of the reality (7)	Based on data (17)
Minimized or maximized forms of reality (3)	*Based on data collected (17)*
Beneficial (1)	*Based on investigations (12)*
Made of different materials (1)	*Constructed by doing measurement (11)*
Symbols (1)	Constructed by making prediction (9)
Visual ipmression (2)	Constructed by imagination (9)
Equal to reality (1)	Not equal to reality (6)
	Not absolute, is tentative (6)
	Based on prior knowledge (3)
	Based on interpretations (2)
	Can be constructed by using computer (2)
	Subjective (2)
	Influenced by the characterisics of scientists (2)
	Minimized or maximized forms of reality (1)
	Equal to reality (1)

Contrary to the misconception cited in literature, majority of students were found to be aware of the fact that scientific models were not copies of the reality at the beginning of the science camp.

> *Of course they are not the exact replicas. They are of similar shapes. The sun has a different shape but we draw it as a circle. We draw it like a ball; its model is also circular. The sides of the sun are a bit disorderly but we cannot draw it all (Zeynep)*

As can be inferred from the examples provided below, one student each respectively stated that scientific model could be the exact replica of the reality; that scientific models were symbolic expressions and that scientific models could be made of different materials.

> *Q: For instance, how did the scientists create the atom model? Can you draw me the atom model? (student draws) How come they were sure of the model?*
> *A: They may have looked at it through a microscope.*
> *Q: In your opinion, does the atom really look like this?*
> *A: My thoughts exactly, because it was looked and seen (Murat)*

Scientific model may be the creation of a human being, an entity, a living substance or an inanimate substance with various substances by minimizing or maximizing it and examining it (Arda)

Following the experiences during the science camp, students used similar expressions related to the characteristics of the scientific model but there were also some differences. In addition to emphasizing the fact that scientific models were not the exact replicas of reality, students applied what they learned about characteristics of science throughout the camp on scientific model and expressed that scientific model was open to change and it was affected by the creativity and other various characteristics of scientists. Related quotes were provided below;

> *Scientific model… we examined the puddle. We collected data and entered them in the computer. We obtained our graphic form there. We created some things based on this with the data. This can be a model for instance. I mean we generated that; it may not be totally correct, totally accurate but as our data increase, it comes close to accurate. We try to form a scientific model about the topic by using the data we have. However our model may change when the data change (Yonca)*

> *Scientific model includes benefiting from the data, doing experiments, studying in-depth and investigating. If the scientist has a comprehensive imagination, scientific model may be different. His/her interpretations, the city he/she lives in may be effective for instance. Sometimes scientists may not reach a consensus. This may affect the scientific model as well (Aslı)*

A limited number of students provided answers that could express the purpose of the scientific model at the beginning of the science camp. Table 3 presents student views on the purpose of the scientific model before and after the science camp.

Table 3. Students' Views on Purpose of Scientific Model at the Beginning and at the End of the Science Camp

At the beginning of the science camp	At the end of the science camp
To explain better (3)	To comprehend and explain better (7)
To learn better (2)	To inform about scientific knowledge (3)
To introduce ideas to the World (2)	To provide benefit to individuals (2)
To convince individuals (2)	To increase conclusiveness of scientific knowledge (2)
To inform (1)	To reveal unknown realities (1)
To make investigation (1)	To provide opportunities to make better investigation and observation (1)
To examine better (1)	

Students expressed that scientific models were generated to better comprehend and learn about things, that individuals may be convinced more easily with the help of models and studies could be presented to the world with more success. Two related quotes were as follows;

> *Scientific models are based on visual expressions that are more beneficial than reading (about them) and they ensure that we learn better. For instance, there*

is a cell model. Like they explain the topics and all but when they draw the shape, it is not the same at all. You see the reality when you examine it under the microscope but when you make its model, it is more explanatory (Yonca)

Scientists make the thoughts into models to convince others to that thought. For instance some people may not believe (in it). But scientists must have examined (it) and made experiments, surely. He makes a model and shows others how it is made. Then people may believe more easily (Aslı)

Examination of the statements about the purpose of scientific model at the end of the science camp presents some changes in student views, albeit small. More students expressed that scientific models facilitated comprehension and explanation. Some students indicated that scientific models provided information about science, benefited humanity and increased the conclusiveness/provability of an idea.

Scientific models may be formed to better comprehend and explain them to the others. Because some people do not understand without seeing any models (Zeynep)

In my opinion, scientific models should provide information about science. For instance, the things we formed about the inside of the box in the black box activity were scientific models for me. Because we approached the contents just like scientists would. In my opinion, scientific model should give information (Fuat)

More than half of the students provided examples of scientific models prior to science camp. Table 4 presents the scientific model samples provided by students before and after science camp.

Table 4. Students' Examples of Scientific Model at the Beginning and at the End of the Science Camp

At the beginning of the science camp	At the end of the science camp
Models in Science Lesson (12)	Examples experienced in Science Camp (16)
Technological Tools (4)	*Black Box (9)*
Dinosaurs (2)	*Water Station (8)*
	Nature Games (5)
	Eartquake Activity (4)
	Fossils Activity (3)
	Global Warming Activity (1)
	Cube Activity(1)
	Models in Science Lesson (9)
	Technological Tools (2)

Generally scientific model samples provided by students were focused on the earth, atom and cell models. Limited number of students gave the example of dinosaur studies and some students were found to believe that technological tools such as telephone telescope, light bulb and computers were scientific models.

When examples provided for scientific models were examined at the end of the science camp, it was observed that more students gave examples and the majority of examples provided by students were related to the activities in the camp.

Especially the black box, the puddle, the game we played yerterday…we formed scientific models in all of those. We used the data, we made tables, drew graphics, formed a model (Giray)

Water station… We formed a model by benefiting the data and the results (Aslı)

Examination of student views on scientific models before the science camp shows that one fourth of the students stated that they did not know about the scientific model. Use of statements about the scientific model used expressions such as "may be, I guess it is, I am not sure but..." by students shows that they did not have established views on the issue. The majority of students equivocated and expressed that scientific model was related to science, that it was done by using scientific tools and that it explained science. However, these expressions were not sufficient to explain their views on what scientific model was. Also, the majority of students believed that scientific model was only a visual material.

It was observed that student views on scientific models became clearer after their experience in the science camp. At the end of the science camp, students realized that just like a scientific study, a scientific model was based on data, was a process of research and therefore was obtained as a result of experiments, observations, measurements, predictions and interpretations. Students also came to realize that things we could not observe by opening them such as atom, the center of the Earth and the inner structures of the sun were modeled. They expressed that scientific models were not exact replicas of the reality and that scientific models could change just like the other types of scientific knowledge. Compared to experiences prior to science camp, rather positive developments were observed in students. While student statements included expressions of probability at the beginning of the science camp that implied lack of clarity in student views, these expressions were gone at the end of the camp and replaced by scientific model definitions which students contributed their experiences in.

Since students experienced modeling in many activities during the science camp, they reflected it in their statements and explained the scientific models in a manner to include modeling process as well. Simple expressions such as "scientific models are related to science" and "scientific models are only products" were observed in scientific model definitions of students before the science camp. Following the science camp participation these statements were replaced by more detailed scientific expressions that included the facts that scientific models were a type of scientific knowledge, that they were developed based on data and that they could change when data did.

Discussion

When students were asked what scientific model was before the science camp, some of them stated that they did not know it while some students used expressions that indicated lack of knowledge such as "may be, I guess it is, I am not sure but…". By using equivocation, the majority of students expressed that scientific model was related to science, that it was done by using scientific tools and that it explained science. However, it was not possible to obtain student views about scientific model from these statements. Also, the majority of students were found to think that scientific model was only a visual material. None of the students participating in this study were aware of the fact that scientific models were abstract ideas that could direct scientific research. It was observed that students did not know the scientific model prior to science camp. Other results in the literature also point to the fact that students at different levels and even teachers did not have sufficient knowledge about the scientific model (Grosslight, Unger, Jay and Smith, 1991; Harrison and Treagust, 1996; Treagust et al., 2002; Kang, Scharmann and Noh, 2005; Doğan Bora, 2005).

However, on the positive side, almost half of the students were aware of the fact that scientific models were not the minimized or maximized copies of reality before the science camp. Studies in the literature about student views on scientific models generally indicate that students regard the scientific model as small scale copy of the reality and they have misconceptions in this regard (Grosslight, Unger, Jay, and Smith, 1991; Kang, Scharmann and Noh, 2005; Doğan Bora, 2005). In the current study, only one student expressed that scientific model is the exact replica of reality. Therefore, it was observed that students did not have misconceptions in this regard before the science camp. It is though that the current finding as opposed to previous findings in the literature may have been resulted largely from lack of complete knowledge about the scientific model. Students did not have negative or positive views about scientific models prior to the science camp. Hence, it was normal for students not to have misconceptions about a topic that they did not really know much about.

It is noticeable that student views on scientific models were similar to those used in defining science in another study (Metin and Leblebicioğlu, 2011). While students stated that science was conducted by using scientific processes such as data collection, research, experiments, observations, predictions and interpretation when they defined science, they also mentioned that these types of scientific process were applied when they defined scientific process. These data prove that students now regard scientific model as scientific knowledge as well. Students have gotten closer to the idea that scientific models are a type of scientific knowledge obtained as a result of scientific investigations by collecting data.

Students also realized that things that could not be opened to examine and to see the inner contents such as atom, the center of the Earth and the inner structures of the Sun were modeled. As they did before the science camp, students mentioned that scientific models were not the exact replicas of reality. It was observed that students became to possess more sufficient views at the end of the science camp. Various activities were implemented during the science camp geared to introduce NOS. Special efforts were provided to introduce students with scientific model and scientific modeling as well. In addition to the Black Box and Cube activity, which were inspired by the literature, additional activities developed by the researchers such as the Invisible Bottom of the Puddle, Path to Knowledge via Earthquake Data and Global Warming were specifically designed to introduce students with scientific model and scientific modeling. During these activities, students modeled using actual data and content they could easily comprehend and observe in their daily lives such as puddles, earthquakes and global warming. They obtained their own data in the black box and puddle activities by taking measurements and modeled the operation of the mechanism in the box and the bottom of the puddle which they could not visually observe. In the other activities they attempted to model how these events changed according to years by using the data on earthquakes and global warming and tried to make predictions for the future by using these models. Therefore, the impact of these activities was observed in student views on scientific modeling following the science camp. During these activities, students were provided with opportunities to collect data first hand, form their own models and to discuss their ideas. Gilbert (2004) who emphasized scientific models and modeling was the basis for authentic science education also stated that the best way to develop student views on the nature of scientific models was to provide them with environments in which they could undertake various types of modeling actively and at first hand.

Another note of importance related to the activities to introduce scientific models implemented during the science camp was the emphasis on the fact that even the invisible things can be modeled and that they could not be the copies of the reality. Students collected data about things that were not directly observable during Black Box and Puddle activities and tried to model them. This experience may have given the students the idea that invisible things can also be modeled. In earthquake and global warming activities, students attempted to model events whose impact were either directly or indirectly experienced. Here, it was ensured that students were made aware of the fact that models were used to test hypotheses, to direct research and to allow scientists make predictions with the help of better observations. Hence, students mentioned that scientific models were formed to better comprehend and relay events, to provide information about things and to have opportunities for quality investigations and observations.

As discussed before, since they also perceived the importance of data in science during the science camp, students started to become aware of the facts that scientific knowledge was based on experiments and data and that scientific knowledge could change when new data was obtained. Students expressed that models, which were different types of scientific knowledge, were based on data and that scientific models were open to change. The fact that students perceived scientific models were open to change as well as scientific knowledge showed that students managed to internalize these characteristics and generalized them to all scientific knowledge. Consistent result regarding tentativeness of scientific knowledge was provided by Metin and Leblebicioğlu (2012). Another indicator that showed internalization of experiences by students during science camp was related to the efforts to define scientific models by giving examples of experiences and by explaining the processes instead of using routine definitions such as "scientific model is…." as they did before the science camp.

The students who did not have much information about scientific models at the beginning of the camp were able to state at the end of the camp that scientific models could be developed based on data and that they could change according to changes in data. The characteristics students learned during camp such as scientific knowledge was based on data and that it was tentative were observed in their discussions of scientific models; an indicator of ability to transfer what they learned about the characteristics of scientific knowledge to scientific models. Hence, students came close to the point in which they could grasp that scientific models were a type of knowledge and carried the characteristics of scientific knowledge. Implementation of modeling activities at camp via collecting data and modeling based on this data may have showed students that modeling process was similar to the process of scientific knowledge construction and supported the development of ideas cited above. It was observed that students who provided explanations on the experimental nature of science based on data (Metin and Leblebicioğlu, 2011) explained the scientific model in the same way. It was concluded that comprehending the nature of science as data based provided a good basis to grasp scientific models as well.

The purpose of this study was to contribute to student views on science and scientific knowledge by using scientific models and modeling process and to have students comprehend that scientific models and modeling were fundamental to science. Students who participated in the science camp learned on the one hand how scientific models were formed by taking part in the modeling process and on the other hand they started to obtain a more comprehensive grasp of science by comprehending the role of models in the progress of science and in the development of scientific ideas. In this manner, students started to grasp the epistemological dimensions of scientific models and the nature of scientific models. Matthews (2007) who emphasized that models were both pedagogical fields to be used in the teaching of science and epistemological fields that could be consulted in understanding science stated that understanding the epistemological dimensions of scientific models formed one of the foundations of science philosophy and that learning about NOS could not be undertaken independent of learning the functions of scientific models in history of science and its epistemological importance. Similarly, Schwarz and White (2005) emphasized that science education shaped around scientific models would develop understanding of NOS as well as letting students comprehend the topic in depth.

Conclusion and Implications

This study examined how 6th and 7th graders' experiences in a 10-day science camp affected their views on scientific model and modeling. According to research results, NOS activities which used explicit-reflective approach and the method composed of reflective guided-inquiry implemented at the camp were effective in introducing 6th and 7th grade students to scientific model and modeling. Qualitative analysis and comparison of the data obtained from VNOS-D questionnaire and semi-structured interviews given at the beginning and at the end of the camp indicated positive developments in student views in terms of scientific models and modeling.

Prior to science camp, the majority of the students provided answers that pointed to the fact that they did not know scientific modeling and defined scientific modeling as something related to science and something that could be done by using scientific tools. Also, the majority of students believed that scientific models were only visual materials. Therefore, it can be claimed that students did not know the scientific model prior to science camp.

It was observed that student views on scientific model started to change and develop as a result of the experiences in the science camp. It was found at the end of the camp that students realized scientific models were also based on data just like scientific research, that they involved research process and that they were obtained as a result of experiments, observations, measurements, predictions and interpretations.

Based on these findings, it can be inferred that the experiences in the science camp developed 6th and 7th graders' views on scientific models and modeling. Results of the current study also point to the fact that active student participation is crucial in learning process of the scientific model and modeling. Throughout the research and in all activities related to introducing the scientific model and modeling, students formed their own models by either generating their data or using the existing data about the current events and actively participated in the process. Therefore, based on the findings of the current study, it can be suggested that providing students with environments in which they can internalize the process is crucial when they are introduced to scientific models and modeling. An educational environment in which students can make their own models or discuss the existing models by analyzing them will provide them with important opportunities to comprehend the varying characteristics of scientific models and to discuss these models through actual examples. Hence, it is suggested to teach scientific models and modeling process with the help of the modeling activities implemented in this research.

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