"BOX" ACTIVITIES ABOUT TEACHING THE NATURE OF SCIENCE FOR 7th GRADE MIDDLE SCHOOL STUDENTS

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Abstract

Teaching with the nature of science activities is essential in a science course considering the characteristics of the nature of science. The aim of this research was to design alternative activities that can guide teachers to teach the nature of science in a better way, and 7th grade middle school students to develop their views on the nature of science. In this research, four different activities of "The mystery candle in the box", "Following the trail", "The mystery in the box", and "Colorful lights" were developed at the middle school level. The developed activities were evaluated by 2 field experts, and necessary arrangements were made according to their statements. Criteria for choosing activities are that whether they are appropriate for the middle school level and for teachers use comfortably, for a use in the duration of the course and for the science curriculum. With the developed activities, middle school students were asked to focus on the difference between observation and inference, the role of scientists' imagination and creativity in the creation of scientific knowledge, and tentativeness of scientific knowledge.
Keywords: *box activity examples, nature of* science, *5E model.*

Introduction

Understanding the nature of science is important in structuring scientific knowledge. Despite the fact that the nature of science is defined in many different forms, it has been evaluated by Lederman and Ziedler (1987) as values and assumptions that lead to the development of scientific knowledge. According to this understanding of the nature of science; a) either scientific knowledge can change over time or be renewable, b) it can be developed basing on creative thinking and depending on objectivity, c) it can reflect the influences of the society that has been created in, and d) it finally let us explain natural phenomena with theoretical or factual formation. (Abd-El-Khalick, Bell & Lederman, 1998, Altındağ, Şahin & Saka, 2012; Avinç, Ağgül, Bayrakçeken, Canpolat & Çelik, 2008; Bell, Abd-El-Khalick, Lederman, McComas & Matthews 2001; Bilen, 2012; Erdoğan & Köseoğlu, 2015; Khishfe ve Abd-El-Khalick, 2002; Köseoğlu, Tümay & Budak, 2008; Lederman, 1992; Tümay & Köseoğlu, 2010). This understanding was also on the basis of today's educational reform movements. The goal of all change movements to create a better scientific literacy and a better understanding of knowledge in education is to better incorporate the nature of science into science education (Avinç at al, 2008; Bilen, 2012; Köseoğlu, 2008; Polat & Taşar, 2013).

It has emerged as a result of many researches that both students and teachers do not have enough understanding about the nature of science (Köksal & Şahin, 2014; Köseoğlu at al., 2008; Lederman, 1992; Tümay & Köseoğlu, 2010).

In this context, there has been an effort focusing on motivating students understand and learn the nature of science better by the examples of developed activities. With recent changes in the Turkish education system, the concept of "the nature of science" has been introduced in science curricula, there still are difficulties been experienced about integrating it into every unit taught in science (Doğan & Özcan, 2010; Erdoğan & Köseoğlu, 2015).

Lederman and Abd-El Khalick (1998) have tried to develop activities for teaching the Nature of Science. They classified those activities into four groups. One of these sections consists of black box activities as (1) The hypothesis box, (2) The tube, (3) The cans, (4) The water-making machine and (5) The cubes. They also said that teachers could improve themselves on using the 5 activities comfortably and apply them in any other subject. Black Box Activities aim to provide students similar experiences with scientists. In those activities, students try to understand the natural phenomena and how they work. Students make observations, collect data, find inferences, and suggest hypotheses to explain the data. Then, they make predictions based on these hypotheses, and develop ways to test them (There is no need to limit these paths to controlled experiments). Based on the results from those tests, they decide whether the hypotheses are appropriate.

Adapted black box activities can be used for leading students to understand the dimensions of the nature of science by conveying appropriate concepts such as:

1. The difference between observation and inference,
2. Scientific knowledge is part of human inference, imagination and creativity,
3. Scientific knowledge is based on experiments,
4. The diversity of scientific knowledge,
5. Scientific models (Atom, Genes) are theoretically explaining natural phenomena.

(Lederman & Abd-El Khalick, 1998)

In addition, these activities provide students the opportunity of practicing several process skills such as,

1. Observation and data collection,
2. Inference, hypothesis formation and testing of these hypotheses,
3. Creating models.

Besides, Lederman and Abd-El Khalick (1998) emphasize that instead of applying sample activities strictly the same, teachers can modify them considering your class conditions, students' memorandum and appropriate time consuming. For using those activities in appropriate teaching strategies, among the alternative teaching methods the 5E model containing 5 stages which was developed by Bybee and Landes (1990) came forward.

The 5E model is based on student-centered activities that stimulate students' curiosity for exploration and construct their understanding of scientific concepts and associate them with other concepts (Ergin, 2009; Fer, 2014; Locatelli & Arroio, 2014; Özsevgeç, 2006).

The stages of 5E model are listed as engage, explain, explore, elaborate and evaluate: (Fer, 2014; Maciejowska & Odrowąż, 2017; Metin, 2007; Metin & Özmen, 2009; Nas, Çoruhlu & Çepni, 2009)

At the stage of Engage, teacher finds out students' preliminary information and misconceptions. To increase attention and motivation among students, teacher asks questions and engages them with activities. S**tudents in the stage of Explore,** generate ideas by questioning, discover alternative ways for solutions, and produce hypotheses. Teacher directs the students to work together through group work. **At the stage of Explain,** students are given the opportunity to explain their findings. In addition, teacher gives explanations to students to correct the missing and wrong information. **At the Elaborate stage,** students are allowed to associate their new knowledge with different fields. **At the Evaluation stage,** students are assessed in what level new concepts and new skills are learned. Teacher monitors students at this stage and asks open-ended questions to them.

The fundamental aim of this research is to help teachers to better teach the nature of science by increasing the number of alternative activities for middle school students. In order to reach the purpose of improving students' understanding of the nature of science, four activities were designed implying the characteristics of the nature of science. Promoting those activities to other teachers also is in the focus of this work.

Methodological Approach

We are interested, in particular, in knowing what “the nature of science” box activities are that can be applied in the 7th grade science course, and how "the nature of science" box activities that are designed for 7th grade science course will be applied to model 5E? And also, we intended to design and develop such activities for teachers’ use in-class.

Four different activities related to the Nature of Science were designed by researchers, and then those activities were evaluated by 2 experts from education field, and necessary arrangements were made in lights of their suggestions. These events include; mystery candle in the box, pursuit of trace (pressure-surface relation), mystery in the box (related to friction force), and colored lights activity (reflection and absorption of light). During the process of preparing the activities, materials and models were chosen by the teachers to be able to find it easily. For usage after application of the activity, box activity worksheets were adapted from Doğan, Çakıroğlu, Bilican, and Güngören’s work (2014). They mainly used activities by choosing from original work of Lederman and Abd-El Khalick (1998).

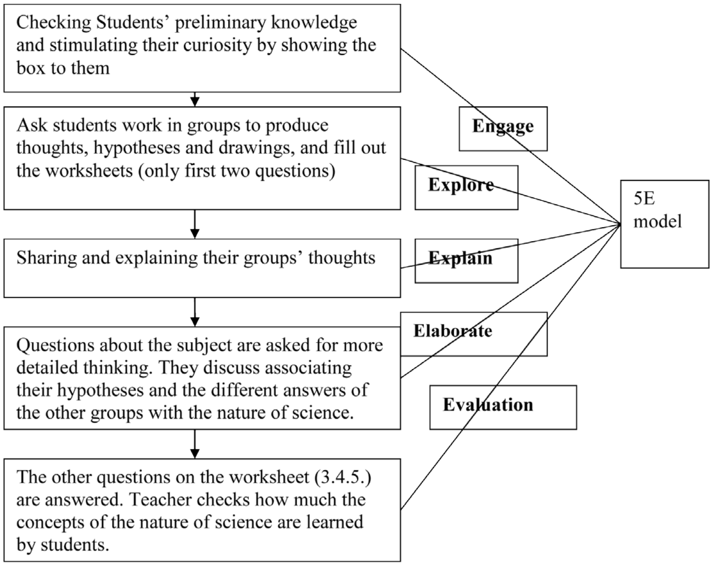

Figure 1: Steps for the process of activity application.

Designing Activities

"The Mystery Candle in Box", "Following the Trail", "Mystery in Box" and "Colorful Lights" are the designed activities for nature of science by the researcher which are based on original work named as black box activities of Lederman and Abd-El Khalick (1998). Designed activities are applied to students by using 5E model (Figure 1).

The activities are presented as below (and also shown in Table 1).

Application of the Activities

Activity 1: Mysterious Candle in the Box

Materials:

2 pieces of candle, 1 piece of water glass, 1 piece of small styrofoam foam, 1 bottle of cold water, and for the box; 1 piece of 18 x 18 cm plywood, 4 pieces of 18x 14 cm plywood (14 cm same size for cup and candle), 1 piece of white glue,1 piece of acrylic paint

Engage; Students should be able to know melting and freezing phenomena and reach melting-freezing points in advance and give examples. These topics are reminded and then the activity starts.

The mechanism shown in Figure 1 is prepared in advance and brought to class so that it can be seen by every student. Students are divided into random groups of 3-4 people. The candle in the box is burnt. The students observe the candle flame from below the eye level, but they cannot see inside the box. Observation continues for a while. Students observe that the candle in the box does not melt, or disappear, or shrink. Ask students what might happen in the Box.

Figure 2: Outside the box.

Explore; Students fill out the worksheet to draw their ideas about what might happen in the box and to make an explanation of what process might happen in the box.

Explain; They make an explanation of the idea of the activity with their drawings in front of the class. Teacher draws attention to the different ideas and answers of the students to emphasize the place of imagination and creativity in the production of scientific knowledge.

Elaborate; Students are asked to compare their group with the other group models. Teacher asks them if their ideas have changed. The argument is focused around whether scientific information can be changed with new data, interpretations and insights. Inside of the box is shown to all groups after completing their drawings. Students observe that candle is placed in a glass of water inside the box (Figure 3 and 4).

Figure 3: Inside the box.

Figure 4: Inside the glass.

Then;
• Why does not the candle melt in the water?
• Will the candle never melt?
• Will this activity give the same results for other liquids?

Evaluate; Questions are asked to stimulate students' thinking about the topic. Teacher points out the similarities of the activity and scientists' works.

They are asked to respond to other questions on the worksheets. Students' knowledge about the characteristics of the nature of science which are tentativeness of scientific knowledge, the difference between observation and inference, part of the inference, imagination, and creativity of humans, and based on experiments are controlled.

Activity 2: Following the Trail

Materials:

2 pieces of bottles**,** 1 piece of tray pan**,** 1/2 kg flour, and for the box; 1 piece of 17 x 11 cm plywood, 2 pieces of 15 x 11 cm plywood (adjusted to 15 cm bottle size), 2 pieces of 17 x 15 cm plywood (adjusted to 15 cm bottle size), 1 piece of white glue, 1 piece of acrylic paint

Engage; In order to apply this activity, students need to be able to know and give examples about what pressure is and how the pressure of solid depends on. Before the activity begins these topics should be recognized by students

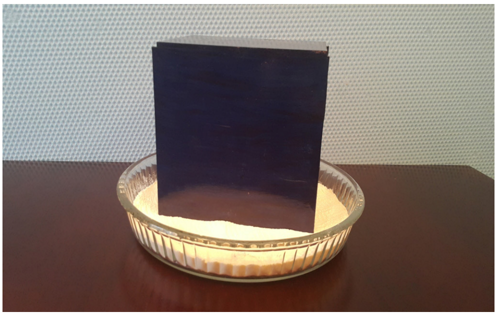

Figure 5: Outside the box.

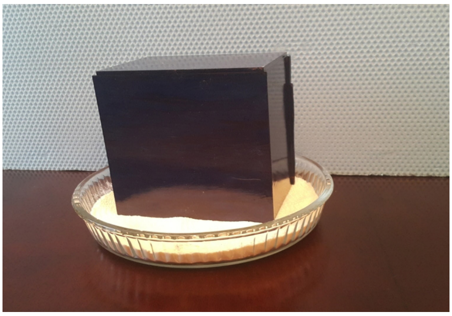

Figure 6: Outside the box.

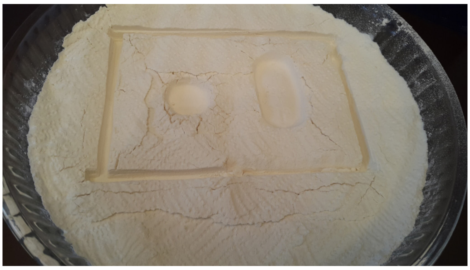

Figure 7: Traces on the flour.

Students are divided into random groups of 3-4 people. The setting in the above Figure is prepared and brought to class. In reverse position, the box is pressed onto a container with full of flour (Figure 5-7). The students observe the traces left on the container belonging to the materials. They notice two traces on the flour, one with small and deep trace, and the other one with bigger and not deeper trace.

Explore; After they are told that both of these marks belong to the same material, students write down their answers and make drawings to explain about what might be in the box.

Explain; Students share their drawings and explanations with the whole class. With this activity, the importance of imagination and creativity as characteristics of the nature of science is emphasized.

Elaborate; Students compare their own models with other groups' models. Then, teacher asks them whether their ideas have changed. Teacher leads an argument about whether the scientific knowledge can be changed or not by means of the new information and interpretation. Students are asked to discuss what aspects of their activity resemble to their scientists' work. At the end, teacher show students inside of the box (Figures 8 and 9).

Figure 8: Inside the Box.

Figure 9: Inside the Box.

Evaluate; The students answer the other questions given on the worksheet. Their answers are checked to see how much they have learned the concepts of the nature of science. Especially, teacher mentions about tentativeness, observation and inference, imagination and creativity, and being empirical of scientific knowledge.

Activity 3: Mystery in the Box

Materials:

1 piece of coin, 1 piece of button, and for the box; 4 pieces of 20 x 14 cm plywood, 2 pieces of 20 x 20 cm plywood, 1 piece of 14 x 25 cm plywood (for slides in), 1 piece of sandpaper, 1 piece of plywood, 1 piece of acrylic paint

Engage; Students should be able to predict and give examples of the frictional force and its inhibitory effect in various environments. The activity starts with reconsideration of these topics.

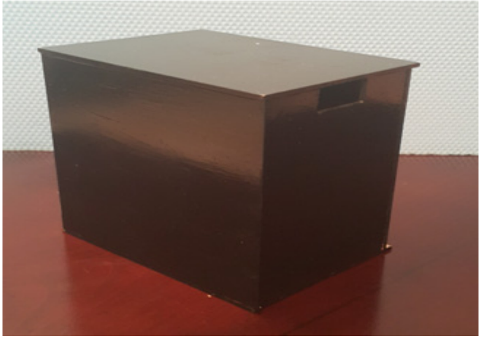

Figure 10: Outside the Box.

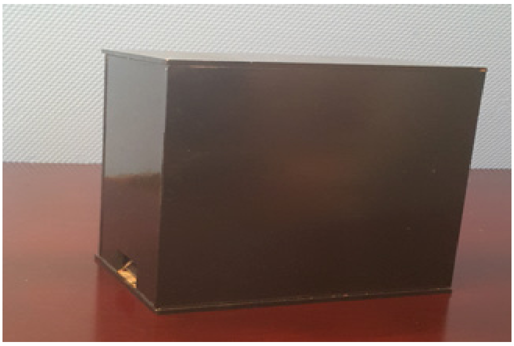

Figure 11: Outside the Box.

The settings in Figures 10 and 11 are prepared and brought to class and placed at a place where each student can see. Students are divided into random groups of 3-4 people. The box has two holes, one above and one below. First, items like coins or buttons are left from the upper holes in the box and come out of the lower hole. Then, the box is turned upside down that turns out the bottom hole to the top, the top hole to the bottom. The same items are moved from the top. Students observe that one side of the box has a lower rate of movement than the other. Ask students what might happen in the Box.

Explore; Students are asked to fill out the worksheets and write down their own ideas about what might happen in the box, and they make a drawing to show how the process might work in the box.

Explain; Once students complete their drawings and explanations, they share their ideas with the whole class. By emphasizing the different answers of the students, the importance of imagination and creativity in the production of scientific knowledge is discussed.

Elaborate; They are asked to compare their own drawings with other groups. Ask whether their ideas have ever changed. Tentativeness of scientific knowledge is emphasized. Students are shown inside the box (Figures 12-15). They observe that there is a two-sided board of sanding paper on one side and smooth surface on the other side in the box replaceable. The path on the board has two stripes on both sides for making the coin or bottom go steadily. Encourage the students talk about in what aspects their activity is similar to scientific works.

Figure 12: Inside the Mystery Box.

Figure 13: Inside the Mystery Box.

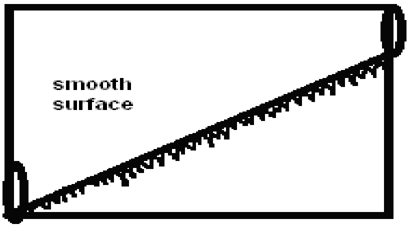

Figure14: Box in first position.

Figure15: Box in reverse position (upside down).

Evaluate; Students answer other questions on the worksheet. Their answers are checked to see how much they have learned the concepts of the nature of science. Teacher mentions about tentativeness, observation and inference, imagination, and creativity, and being empirical based of scientific knowledge.

Activity 4: Colorful Lights

Materials:

3 pieces of CD, 1 piece of hand light, for the box; 1 piece of 18 x 18 cm plywood, 4 pieces of 18x14 cm plywood, 1 piece of white glue, 1 piece of acrylic paint

Engage; Students should be able to know that the light can be absorbed by the matter as a result of interaction between light and the matter. They could also give examples about the white light is sum of all light colors. The activity starts with reconsideration of these topics.

Figure 16: Outside the Box.

The setting in Figure 16 is prepared and brought to class and placed at a place where each student can see. Students are divided into random groups of 3-4 people. At a suitable dark environment, the hand light is placed to the top of the box. Students observe the reflected lights coming out of the box without seeing inside. Students will be asked what might happen in the box and how colorful lights reflected through the box.

Explore; Students fill out the worksheets. They make drawings and explain their opinions on what might happen in the box.

Explain; Once students complete their drawings, they share their ideas and drawings with the rest of the class. Teacher emphasizes that any different answers given by students show the importance of imagination and creativity in the production of scientific knowledge.

Elaborate; Students are asked what they think after they see the drawings and ideas of other groups. They compare their own explanations with other groups'. Teacher asks whether their ideas have changed. Students discuss in what way this activity and scientific work resembles. Finally, teacher shows inside the box (Figure 17). Students notice that CDs in the box cause the white light separated into other colors.

Figure 17: Inside the Box.

Evaluate; Students answer the other questions on the worksheet. Their answers are checked to see how much they have learned the concepts of the nature of science. Students' knowledge about the characteristics of the nature of science which are tentativeness of scientific knowledge, the difference between observation and inference, part of the inference, imagination, and creativity of humans, and based on experiments are controlled.

Results and Suggestions

Designing alternative activities for teaching science will help the 7th grade students to develop their views on the nature of science and to develop better ways to teach the nature of science. The designed activities in this research emphasize the characteristics of the nature of science. These characteristics are: tentativeness of scientific knowledge, the role of imagination and creativity in the production of scientific knowledge, the subjectivity of scientific knowledge, the difference between observation and inference, the influence of social and cultural values on scientific knowledge, and depending on scientific data.

The developed nature of science activities in lights of the 5E model are used for 7th grade students. The names of these activities are "Mysterious Candle in the Box", "Following the Trails", "Mystery in the Box" and "Colorful Lights". During the design of the box activities, the major concern was to the selection of topics from the science curriculum and to the arrangement of these activities in accordance with model 5E. When these developed activities are applied, it is considered that the understanding of the nature of science existing in the students will be improved. It is believed that it would be beneficial to use them by science teachers. During the implementation of the activities, creating an environment in which students can express themselves freely and actively taking part in all activities will stimulate their learning process. Teachers should pay attention about mentioning characteristics of the nature of science after each activity. In addition, all 5E stages should be followed sequentially and without skipping.

These designed activities are examples for the future research efforts conducting on the development of opinions on the nature of science. Exemplary activities can be adapted to different class levels other than 7th grade science course by making minor modifications as suggested by Lederman and Abd-El Khalick (1998).

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Appendixes

Table 1. Box activity profiles.

Activities	Mysterious Candle in the Box	Following the Trail	Mysterious in the Box	Colorful Lights
Grade	5th.6th.7th.8th.	7th.8th.	6th.7th.8th.	7th.8th.
Pre-knowledge	Students should be able to know melting and freezing phenomena and reach melting-freezing points in advance and give examples.	Students should be able to know and give examples about what pressure is and how the pressure of solid depends on.	Students should be able to predict and give examples of the frictional force and its inhibitory effect in various environments.	Students should be able to know white light is the sum of all other colors.
Materials for activities	2 pieces of candle 1 piece of water glass 1 piece of small styrofoam foam 1 bottle of cold water For the box, 1 piece of 18 x 18 cm plywood 4 pieces of 18x 14 cm plywood (14 cm same size for cup and candle) 1 piece of white glue 1 piece of acrylic paint	2 pieces of bottles 1 piece of tray pan Half kg flour For the box, 1 piece of 17 x 11 cm plywood 2 pieces of 15 x 11 cm plywood (adjusted to 15 cm bottle size) 2 pieces of 17 x 15 cm plywood 1 piece of white glue 1 piece of acrylic paint	1 piece of coin 1 piece of button For the box, 4 pieces of 20 x 14 cm plywood, 2 pieces of 20 x 20 cm plywood, 1 piece of 14 x 25 cm plywood (for slides in) 1 piece of sandpaper 1 piece of plywood 1 piece of acrylic paint	3 pieces of CD 1 piece of hand light For the box, 1 piece of x 18 cm plywood 4 pieces of 18x14 cm plywood 1 piece of white glue 1 piece of acrylic paint

Things to consider before the activity	Before students arrive in the classroom, teacher places the box to a location in which students can only see the flame of the candle but nothing else. Glass is filled with water.	It can be prepared by putting flour into a container.	In order to prevent the students seeing inside the box from above and below holes of the box, place the box in where students can only see coins or buttons are left and the other two sides of the box.	Hold the box in position that students cannot see inside the box but can only see lights coming out.
Model construction	Groups of 3-4	Groups of 3-4	Groups of 3-4	Groups of 3-4
Setup	See Figure 2.3.4.	See Figure 5.6.7.8.9.	See Figure 10.11.12.13. 14.15.	See Figure 16.17.

BOX ACTIVITIES WORKSHEET

1. What might be in the box and draw it in the box below.

2. Write down an explanation about how it works.

3.Do you think that imagination and creativity are important components for production of scientific knowledge?

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4. How do scientists explain an event that they can observe but do not know its details?

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5. Did your ideas change after you saw the drawings of other groups? Do you think that scientists' ideas can change in the light of new data, new perspectives and interpretations?

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