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Improving Science Process Skills in Science and Technology Course Activities Using the Inquiry Method *

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Abstract

The vision of science and technology curriculum is to raise students as science literate individuals. In this curriculum the importance of science literate individuals having scientific process skills and using the inquiry method as a teaching method during lessons are frequently emphasized. However, when the level of incorporation of this method in the books which are the main resources for the courses is examined, it is seen that the experiments in the books tended to be at the structured inquiry level and therefore, can make students acquire limited basic skills. In this study designed to make prospective classroom teachers realize what new experiments they can develop by adopting a critical look at the experiments in textbooks, the prospective teachers developed experiments at different levels of inquiry, identified the science process skills which can be developed using these experiments, and expressed the understanding they developed with this practice. The prospective teachers who identified the number of science process skills students can acquire thanks to the experiments they developed at the structured, guided and open inquiry levels realized that the higher the openness level of the inquiry applied, the higher number of skills students can develop. This research utilized case study which is one of qualitative research designs. The content analysis was applied to the data obtained from the prospective teachers' views. Under the theme of understanding the applications the categories of "perspectives on experiments" and perspectives on methods" were created. As a result of this research, conducting the experiments included in the course books at different levels of inquiry, the prospective teachers realized the skills that can be developed in students, the relation of these experiments with the daily life, and the fact that conducting experiments can increase students' interest in the course. Moreover, thanks to these activities, the prospective teachers adopted the inquiry approach and they developed self-confidence in applying this approach.

Keywords

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Introduction

Recent studies in education draw attention to the increasing importance of making students acquire such skills as problem solving, critical and creative thinking, active learning and adapting these skills to solve daily life problems. With a view to making students acquire these skills, the vision of the science and technology curriculum, which has been gradually introduced in the academic year 2005-2006 in our country, has been identified as making all students science and technology literate, regardless of their individual differences. A science literate person, defined as the one who comprehend the nature of science and scientific knowledge, and basic science concepts, rules, laws and theories and use them properly, is supposed to make use of science process skills in solving problems or making decisions. (Ministry of National Education [MEB], 2005; MEB, 2013a).

Science process skills which improve students' sense of responsibility, make them active in the learning environment and promote permanence of learning are defined as skills which facilitate learning (Çepni, 2005), which develop knowledge of research procedures and methods, and which should be acquired for scientific research or problem solving (Harlen, 1999). The science process skills that are identified as 11 skills by the American Association for the Advancement of Science (AAAS, 1998) and 14 skills in the science and technology curriculum are generally classified into two groups as basic skills and experimental skills. Given the hierarchical ordering from easy to hard, observing, classifying, measuring, communicating, inferring, predicting, and recording data are basic skills while controlling variables, collecting data, formulating hypothesis, conducting experiments, processing data, formulating models, and doing inferences are experimental skills (Padilla, Okey, & Garrard, 1984).The basic problem in making students acquire science process skills, as identified according to grade levels, is to decide which teaching methods to implement. Teacher-centered traditional teaching methods such as explanation, dictation and laboratory activities for verification cannot be sufficient in improving student's science and technology literacy (MEB, 2005) and therefore, it is clear that it will not be possible by using the traditional teaching methods to raise individuals who are capable of investigating, questioning, thinking critically and having advanced problem solving and decision making skills. In this context, traditional teaching methods fall short of improving the science process skills of students

An examination of the methods which may be used as alternative to the traditional teaching methods reveals the inquiry-based teaching method as one of the most appropriate methods because it directly pertains to the main goal of the science and technology curriculum and it involves practical science. Accordingly, the inquiry method to be applied in the lessons should basically include the following steps: deciding and asking questions, searching for information, designing investigations, carrying out investigations, analyzing data and making conclusions, creating artifacts, and sharing and communicating findings (Wu &Hsieh, 2006). In this process, the education environment should be so arranged as to help students learn science and how to be involved in science and provide them with opportunities to improve their critical thinking, problem solving and science process skills.

Although it is advisable as an inquiry experience for a science student to formulate his/her own questions and ponder on the solution to his/her questions, there are different levels of inquiry based on appropriateness for students in asking and answering questions in classroom applications (Windschitl, 2002). In their study, Schwab (1962) and Herron (1971) coded inquiry levels as "given" or "not given (open)" for the criteria "problem, method and result" as in Table 1, based on the laboratory activities (cited in Buck, Bretz and Towns, 2008).

Table1. Levels of Openness in the Inquiry-based Laboratory Teaching

	Problem	Ways and Means	Answers
Level 0 (Verification)	Given	Given	Given
Level 1 (Structured inquiry)	Given	Given	Open
Level 2 (Guided inquiry)	Given	Open	Open
Level 3 (Open inquiry)	Open	Open	Open

Buck and his colleagues (2008) developed another rubric for assessing the inquiry levels with additional detail. The characteristics of this rubric came from two sources: "the terminology used in laboratory manuals to organize components of a lab" and "the key elements in a laboratory activity." In this study, they identified five levels of inquiry and six characteristics for inquiry-based undergraduate activities. These levels and characteristics are presented in Table 2.

Table 2. A Rubric to Characterize Inquiry in the Undergraduate Laboratory

Characteristic	**Level 0: Verification**	**Level ½: Structured Inquiry**	**Level 1: Guided Inquiry**	**Level 2: Open Inquiry**	**Level 3: Authentic Inquiry**
Problem	Provided	Provided	Provided	Provided	Not Provided
Background	Provided	Provided	Provided	Provided	Not Provided
Process/Design	Provided	Provided	Provided	Not Provided	Not Provided
Results analysis	Provided	Provided	Not Provided	Not Provided	Not Provided
Results communication	Provided	Not Provided	Not Provided	Not Provided	Not Provided
Conclusions	Provided	Not Provided	Not Provided	Not Provided	Not Provided

The biggest problems encountered in the implementation of the inquiry methods in the classroom pertain to the perceptions of teachers and prospective teachers about laboratory activities. While the importance of laboratory activities is acknowledged by all educators, the purpose of these activities tends to be largely ignored and implementations generally do not serve this purpose (Reid & Shah, 2007). When laboratory activities given in the course books and, in particular, the classroom practice, are examined, it is found out that they do not go beyond proving the information learned through the instruction provided, and they serve only to help students improve their manual dexterity (Akben & Köseoğlu 2010; Dana, 2001). However, the research indicates that the most basic purpose of a laboratory activity is to help students acquire experience about the studies conducted by scientists (Arslan, Bekiroğlu, Süzük & Gürel, 2014; Hofstein & Lunetta, 1982; Tatar, Korkmaz & Ören, 2007) and improve their scientific reasoning and comprehension skills (Shepardson, 1997). Therefore, the activities to be implemented in the classroom should be based on inquiry and, these activities should be aimed at not only making students acquire scientific concepts, but also improving their high-level reasoning skills and science process skills. Consequently, teachers are supposed to correctly identify student outcomes in planning laboratory activities, and develop and implement inquiry-based laboratory activities at different openness levels according to the student levels. This expectation brings to the fore the importance of teacher education once again.

National Research Council (NCR, 1996) drew attention the need for educating teachers so that they can use inquiry in education and learning, and the teacher education program that started to be implemented in our country in the academic year 2006-2007 emphasized the significance of making students understand the inquiry approach as well as integrating this approach with the classroom practices. Accordingly, it is clear that if prospective teachers are given the opportunity to perform and make improvement on the inquiry-based practices which they will carry out together with their students in the future, the teacher education programs will be more beneficial, and, in this way, prospective teachers will be able to correctly understand inquiry and distinguish between the inquiry-based and traditional laboratory activities (Bhattacharyya, 2003; Clifford, 1997).

This information clearly shows the importance of using the inquiry approach and applying laboratory activities based on this approach in order to teach students scientific process skills. In this case, teachers are expected to teach process skills to their students by conducting laboratory activities based on the inquiry approach. When the inquiry-based laboratory activities' levels become more open, students will have more opportunities for their participation and gain more process skills. Thus, teachers should include higher order level activities rather than including activities that are in the validation level. However, the examination of activities taking place in the textbooks of science and technology courses (MEB, 2013; MEB, 2008a; MEB, 2008b) shows that these activities are seen to be low in the level of openness and they can teach a limited number of process skills and (Yıldız-Fevzioğlu, Tatar, 2012). In this case, the duty of the teachers is changing and applying activities in the textbooks as higher-level activities. In order to perform this transformation, teachers must have the necessary knowledge and experience. The examined research on the acquisition of these experiences to teachers or teacher candidates shows that studies mainly focused on measuring the effects of using inquiry-based laboratory activities and science process skills, as teaching methods, on participants' gained skills (Duru, Demir, Önen, Benzer 2011; Aydoğdu, Ergin 2008; Bozkurt, 2012). Based on the explanations given above, there is a need of a study in which teacher candidates can gain skills to question the activities, provided in textbooks, according to higher order thinking levels, to recognize that they can teach process skills through these activities, and to reflect these experiences into their professional lives. In this context, this study aims to make prospective teachers identify the science process skills in some experiments given in the course books and acquire hands-on experiences in developing these skills by using inquiry approaches at different levels of openness.

To this end, the answers to the following research questions were sought:

1. Which science process skills can be developed by the prospective teachers using inquiry-based experiments at various levels of openness?
2. What perceptions are developed by the prospective teachers who have designed inquiry-based experiments at different levels of openness?

Method

In this study, firstly the science process skills which can be taught using the experiments in the course books and the inquiry-based laboratory activities at different openness levels developed by prospective teachers were identified. Then, the numbers of the skills which can be taught according to openness levels were compared. The qualitative research method was used to identify the understandings prospective teachers had developed.

Participants

The participants of the study are composed of 30 prospective classroom teachers (7 male and 23 female) who have attended the Primary Education Undergraduate Program in the Department of Primary Education at Ankara University in the academic year 2010-2011 and who have enrolled in the Science and Technology Laboratory Practices II course. Only four of the prospective teachers who participated in the study took part in a limited number of verification experiments where only instructions were applied in their previous educational processes before taking this course, but they did not undertake any inquiry-based laboratory activities. Furthermore, none of the prospective teachers was given any theoretical information about the inquiry approach or attended any related practical exercise before this course. Therefore, the participants' inquiry approach and their knowledge, based on different levels of openness laboratory activities, are limited to what they have learned in this course.

Data Collection

In this study, a case study design, as one of the qualitative research designs, was used. In this process, firstly, theoretical information related to the science process skills, inquiry approach, and laboratory activities with different levels of openness based on this approach have been given to teacher candidates. After these explanations, for a total of 2 hours per week for 3 weeks, the teacher candidates were expected to have first-hand experiences through their own applications in classrooms. For this purpose, elected two sample experiments, validation and planned inquiry, were given to the candidates. Teacher candidates were asked to practice these experiments according to the guidelines. At the end of this application, teacher candidates identified in which level of inquiry these experiments took places and scientific process skills that can be gained by these experiences. They also compared process skills that can be obtained via experiments based on validations and planned inquiries. This application lasted 2 hours and at the end of these experiments the candidates were asked to plan experiments according to the open inquiry level and write a report about it. They were also asked to identify which scientific process skills can be taught if those experiments were performed in this level. The following week, open inquiry level experiments and aimed process skills that were planned by teacher candidates were discussed in the classroom. In this process, teacher candidates’ mistakes and misinformation were corrected. After the 5-week long study, five experiments were picked from the science and technology course books for the 4th and 5th grades in primary education in order to give opportunities for teacher candidates gaining experiences and skills on developing and applying experiments in books. Care was taken to make sure that these experiments relate to different science fields such physics, chemistry and biology. For the study to be conducted, the prospective teachers were asked to form groups of two, and in this way, 15 groups were formed. Each group was assigned with only two of five experiments to ensure that six different groups could work on each experiment. The distribution of experiments by groups is given in Table 3.

Table 3. Distribution of Experiments by Groups

Group No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Experiment No	1-2	3-4	5-1	2-3	4-5	1-2	3-4	5-1	2-3	4-5	1-2	3-4	5-1	2-3	4-5

Each group was first asked to determine which science process skills would be developed by students if the experiments are conducted as instructed in the course books of science and technology curriculum, and to mark them on the table given in Annex 1. For the next class, the prospective teachers were asked to develop these experiments using the inquiry approach at different openness levels, prepare a report and specify the openness level of the experiments they developed, and mark the science process skills which can be acquired on the table. At the next class, to review and re-evaluate the experiments conducted, the experiments numbered 1, 3 and 5 were selected in consultation with the prospective teachers for application in the classroom (Annex 2). Different level examples developed by teacher candidates and those experiments given in textbooks in line with planned inquiry levels were applied in the classroom. Their levels of openness and the process skills which can be taught were reviewed by the whole class. At the end of every experiment, the contributions of the experiments in the course books and the developed experiments to the students' questioning, critical thinking and problem solving skills were discussed and compared at the classroom. Through this 7 course hours long application teacher candidates have been also carried out research and inquiry processes and understood how the inquiry method that can be used for the activities of science and technology course textbooks to improve the scientific process skills. Teacher candidates increased their understandings via participating in these applications, developing experiments, and determining the scientific process skills. The findings obtained were finally organized by the researcher into a table to include the skills acquired through the experiments given in the course books and the skills acquired with the developed experiments.

The responses given to the open-ended questions asked with a view to determining which understandings the prospective teachers had developed at the end of the practice were used as a qualitative data source. For qualitative analysis, the voice recordings of the semi-structured interviews conducted with three prospective teachers were also evaluated.

Analysis of Data

In analyzing the data, firstly the openness levels of the experiments developed by the prospective teachers were determined, and the possible number of experiments can be developed at each level were calculated for each experiment. At the next stage, for a numerical comparison of the skills that can be taught by experiments at different inquiry levels, the science process skills that can be improved with three different levels of the experiments in the course books and conducted in the classroom were recorded into tables. Thus, by examining every table obtained for three separate experiments, the relations between the openness levels of experiments and the skills that can be developed were easily discussed.

For the evaluation of the responses given for the qualitative analysis of the study, content analysis was conducted. In the content analysis which is performed through inductive analysis to find out the concepts behind the data as well as the relations between these concepts (Miles and Huberman, 1994; Yıldırım and Şimşek, 2005), the prospective teachers were first given the open-ended questionnaires and they were asked to answer the questions in the questionnaires. In order to conduct interviews, three teacher candidates were identified according to their level of academic achievements as successful, moderately successful, and less successful. Then, the interviews held with these teacher candidates were recorded using a voice recorder. Coding was performed according to the concepts derived from the written and voice records. First, the most repeated concepts were determined and the codes were created accordingly. Then concepts of the codes were examined to understand in which context they were used. Based on this investigation thematic codes were created. To ensure the internal consistency of thematic coding, a meaningful set of data was created.

For the reliability of the study, the data were evaluated also by another expert other than the researcher. The reliability formula, proposed by Miles and Huberman, was used to test the reliability of the study.

Reliability = Agreements / (Agreements + Disagreements)

The reliability coefficient for the theme was calculated to be 0.72. The reliability of the data analysis was verified as interrater agreement was higher than 70%.

Results

The openness levels of the experiments which were developed by the prospective teachers were first determined using the data obtained from the study. As seen in Table 4, out of 30 experiments which were developed based on the 5 experiments in the course books, 9 were at the structured inquiry level, 8 were at the guided inquiry level, and 12 were at the open inquiry level. The prospective teachers were capable of easily developing open inquiry experiments about basic science topics such as mixtures and opacity of materials while they preferred to develop structured inquiry experiments about the topics which may involve misconceptions such as heat and temperature.

Table 4. The Openness Levels of the Experiments Developed by the Prospective Teachers

Experiments	Levels of Inquiry-Based Experiments		
	Structured	Guided	Open
1. Does the mass of matter change when it is heated?	2	2	2
2. Can I classify living things?	1	2	3
3. Let us stop the light	2	1	3
4. Equal heat - different temperature	4	1	1
5. Let us sort out the mixed materials		2	4

3 selected experiments were carried out by the prospective teachers in the classroom so that they can realize how experiments about the same topic, but at a different level can be developed and they can discuss and correctly assess the science process skills which can be improved using these experiments. The first experiment selected was the experiment titled "Does the mass of matter change when it is heated?" from the section "Change of matter due to heat," from the chapter "Let us learn about matter" from the 4th grade science and technology course book. The purpose of this selection was to prevent students from having misconceptions falsely assuming that the mass of matter will increase upon receiving heat. Based on this experiment, the prospective teachers developed two experiments for each of structured, guided and open levels. Three sample experiments from different levels and the science process skills which can be developed using them are given below.

Sample 1: *At the Structured Inquiry Level*

Tools and Materials: Two beakers, a glass of water, a glass of olive oil, the precision scales, a thermometer, and a spirit stove

Instructions for the Experiment:

1. Measure and record the masses of empty beakers.
2. Pour water into one of the beakers and olive oil to the other, and measure and record their masses.
3. Calculate the mass of water and olive oil by subtracting the mass of empty breakers from the masses of water and olive oil.
4. Heat the olive oil inside the beaker up to 60°C and re-measure its mass.
5. Heat the water up to 80°C and re-measure its mass.

Results of the Experiment:

- Did the masses of water and olive oil change after heating?
- If the heat had any mass, would the masses of water and olive oil change?
- Discuss the effects of your heating water and olive oil to different temperatures on the result.
- What would be the result if you conducted the experiment using other materials?

Sample 2: *At the Guided Inquiry Level*

Tools and Materials: Two beakers, a glass of milk, a glass of water, the precision scales, a thermometer, two spirit stoves (for each group)

Instructions for the Experiment:

1. First, I tell the following story to the students:
"Ayşe wanted to heat up some milk when she returned home from the school. She poured milk into a pot and started to heat it up on the stove. Then, she heard the phone ringing and went to the sitting room and answered the call. As she was talking on the phone, she remembered the milk and rushed to the kitchen. She saw that the milk had risen and spilled over. At that moment, she remembered the science topic of matter they had learned at the science lessons. 'Did the milk rise and overflow because its mass increased upon heating?' she asked herself."

2. After telling this story to the students, I put them into groups and give the experiment tools and materials to the groups.

3. I tell the students to find the masses of water and milk by measuring first the empty beakers and then the beakers with water and milk and subtracting the two.

4. I make them heat them up to a certain temperature and then measure their masses.

Results of the Experiment: I ask one student I pick up as the group spokesperson to explain to the class to what temperature they heated the water and milk and what was the result of their experiment. I ask whether using different temperatures had any effect on the result. I also ask, "What would happen if we used something else instead of water and milk?" If there is any error in the way the experiment was conducted or in its results, then I ask other students' opinions before I explain how they can correct them.

Sample 3: *At the Open Inquiry Level*

Tools and Materials: Beakers, water, juice, oil, the precision scales, a thermometer, a spirit stove, a trivet

Overview: Matter is defined and it is noted that matter has a mass.

Instructions for the Experiment:

1. The students were asked whether a heated material's mass changes or not and discussion is held about the answer to this question. Then, we say "Today, we will conduct an experiment to find an answer."
2. The students are grouped and told to write down an experiment using the tools and materials provided in order to find out whether the mass of heated matter changes.
3. Then, they are told to explain the experiment they have designed to their classmates and the teacher and conduct it.
4. The results are recorded and one student from the group is told to read them aloud in the classroom.

Results of the Experiment: A whole class discussion is held about the results. If there are any points not mentioned by the students, I mention them myself for enabling the students to get to the correct answer.

The science process skills identified by the prospective teachers in the experiments were revised at the end of the exercise and presented in Table 5. Considering the total number of skills for each inquiry level, the skills that can be taught increases from 8 to 12 as we proceed from the structured inquiry to the open inquiry. However, through the experiment in the course book, only six science process skills can be taught.

Table 5. Science Process Skills that can be Developed Through "Does the Mass of Matter Change When it is Heated?" Experiments.

Science Process Skills	***Skills that can be taught through the experiment in the course book***	***Skills that can be taught through the first experiment developed***		
		Structured	**Guided**	**Open**
Observing	X	X	X	X
Comparing - classifying	---	X	X	X
Inferring	X	X	X	X
Guessing	---	X	X	X
Predicting	---	---	---	---
Setting the variables	---	---	---	X
Designing an experiment	---	---	---	X
Recognizing and using experiment tools and materials	X	X	X	X
Measuring	X	X	X	X
Collecting information and data	X	X	X	X
Recording the data	---	---	X	X
Processing the data and formulating models	---	---	---	---
Interpreting and making conclusions	X	X	X	X
Presenting	---	---	X	X
TOTAL	6	8	10	12

The second experiment selected is "What happens when light is blocked?" from the Chapter "Light and sound" from the 5th grade course book, and the purpose of this experiment is to make the students achieve the outcome 2.1. (Students classify various materials as transparent, semitransparent or non-transparent (opaque) depending on their light-transmitting characteristics). When the experiment in the course book was examined, it was seen that the experiment would be insufficient to make students achieve this outcome. With this in mind, the prospective teachers were asked to assess this experiment and develop their own experiment taking into consideration the capacity of the experiment in the course book to make students achieve this outcome. As this experiment would be redesigned both in terms of content and inquiry level, this experiment was selected in consultation with the prospective teachers as the second experiments to be conducted in the classroom. Since there were two structured inquiry level, one guided inquiry level and three open inquiry level redesigned experiments, one experiment from each level was selected and the science process skills which can be taught using them are given below.

Sample 4: *At the Structured Inquiry Level*

Tools and Materials: A flashlight or table lamp, and materials that can be found in a classroom (a transparent folder cover or plastic folder, paper, books, pencil boxes, rulers, nylon bags, etc.)

Instructions for the Experiment:

1. A dark environment is created in the classroom by closing the curtains (if there are no curtains the windows are covered using newspapers and adhesive tape).
2. The flashlight or table lamp is given to the students and they are asked to place various objects in front of the light. Then, they are told to check whether the objects let the light through or not.
3. They are asked to experiment it with other objects in the classroom as well.

Results of the Experiment:

- Make a list and classify the objects according to whether they let the light through or not.
- Keeping in mind that the materials that let the light through are called transparent, those that let only some of the light through are called translucent (semi-transparent), and those that do not let the light through are called opaque materials, make a list of the objects according to whether they are transparent, translucent, or opaque.

Sample 5: *At the Guided Inquiry Level*

Introduction: I first ask the students first why a shadow occurs. I try to elicit that there needs to be some light and an opaque object for shadow to occur. Then, I ask them whether everything that is put in front of the light causes a shadow to occur.

Overview: I give information about how materials are classified as opaque, translucent, and transparent.

Instructions for the Experiment: First of all, I ask the students to predict how the shadows of some of the objects in the classroom might be, and I try to elicit their answers. "Is it a separate page of a notebook or a whole notebook which causes much shadow? What kind of shadow does a pencil box cause? Does the window of the class cause a shadow to occur in the classroom? Can we clearly see outside through the frosted glass in our house?" By asking these questions, I try to have the students think how not all materials let the light through in the same way, how some of them let the light through clearly, some let the light through very little, whereas some do not let it at all. Later, I put them into groups and hand them the table I have already prepared, asking them to write the names of some objects in the table and fill in the prediction part. Then, I give them the flashlight or candle that I bring into the classroom and ask the students to light them. (In case they might burn themselves, I light the candle myself). I ask them to place the objects they have chosen in their predictions and to look at the shadow. This time they are asked to fill in the observation part of the table.

Results of the Experiment: I ask them to tell their classmates the objects they used, as well as explain the differences between their predictions and observations

Objects	Prediction			Observation		
	Transparent	Semitransparent	Opaque	Transparent	Semitransparent	Opaque
………						
………						
………						

Sample 6: *At the Open Inquiry Level*

Instructions for the Experiment: I first ask the students: "Do you play shadow play on the wall at home?" Then, I ask them: "Can you play it in the light?"

"How does a shadow occur when a light is obscured with various objects?" I ask. Later on in the classroom, I ask them to write an experiment plan thinking how they can experiment it in the classroom in groups of 3 or 5. I wander around the classroom in order to correct them through my questions if they misunderstand or do a mistake. Then, I ask them to submit the results they get through experimenting in an orderly table and share the results with their classmates. After they have completed their tables, I explain that the objects that cause a full shadow do not let the light through, i.e. they are opaque; those that let some of the light through are semi-transparent, and those that let all the light through are transparent.

Results of the Experiment: Each group is asked to tell about the experiments they have done. I ask them how they classify materials.

Table 6. Science Process Skills that can be Developed through "What happens when light is blocked?" Experiments

Science Process Skills	*Skills that can be taught through the experiment in the coursebook*	*Skills that can be taught through the second experiment developed*		
		Structured	**Guided**	**Open**
Observing	X	X	X	X
Comparing - classifying	X	X	X	X
Inferring	---	---	---	X
Guessing	---	---	X	---
Predicting	---	---	---	---
Setting the variables	---	---	X	X
Designing an experiment	---	---	---	X
Knowing and using experiment tools and materials	X	X	X	X
Measuring	---	---	---	---
Collecting information and data	X	X	X	X
Recording the data	---	X	X	X
Processing the data and formulating models	---	---	---	X
Interpreting and making conclusions	X	---	X	X
Presenting	---	---	X	X
TOTAL	5	5	9	11

Science process skills to be developed through the implementation of the experiment "What happens when light is blocked?" at structured, guided and open inquiry levels are given in Table 6. Considering the total number of skills for each inquiry level, the skills that could be taught increases from five to 11 as we proceed from structured inquiry towards open inquiry. Whereas, through the experiment in the course book, only four science process skills could be taught.

The last experiment selected for the implementation was the experiment titled "Can mixtures be separated?" from the chapter "Let us learn about matter" from the 4th grade science and technology course book. This experiment aims to make the students achieve outcomes 7.1, 7.2, and 7.3 of the chapter in question, thereby making the students comprehend various separation methods such as filtering, evaporating and separating with a magnet. The prospective teachers were told that they may incorporate into their experiments the outcomes 7.5 and 7.6 (separation by floating) as well. This experiment was picked for the third practice in the classroom in order to find out how the prospective teachers redesigned this experiment so as to incorporate new outcomes and use different inquiry levels.

Since there were two structured inquiry level and four open inquiry level experiments developed by the prospective teachers, one experiment for the guided inquiry level and two experiments for the open inquiry level were selected and the science process skills which can be taught using them are given below.

Sample 7: *At the Guided Inquiry Level*

Tools and Materials: A piece of loosely woven cloth (gauze, etc.), a magnet, iron powder, sand, gravel, salt, sugar, lentils, pasta drain, water, a spirit stove, a trivet, beakers, scraps of paper

Instructions for the Experiment:Before the experiment, I show the students pictures of salad, mixed nuts, and pasta with cheese. I ask them to tell me how they separate something they do not like out of salad. Then, I ask whether they add cheese or parsley into pasta. I ask what they do if they do not like parsley. I mix sand, gravel, iron powder, salt and lentils and hand it to some students. I ask them how they can separate all these, asking them to do the experiment and give me a written report. I put iron powder, sugar, gravel and scraps of paper in water and I give the mixture to some other students in the class, asking them to do the same.

Results of the Experiment: I ask them to tell their classmates how they have separated the mixtures I havegiven to them.

Sample 8: *At the Open Inquiry Level*

Tools-Materials: Thumbtacks, paper clips, erasers, coins, sand, small pieces of stone, salt, water, a spirit stove, a magnet, a strainer, dry leaves, cologne, a trivet

Instructions for the Experiment: We want the entire experiment to be completed by the students so we tell them a story beforehand. Here is the story.

The other day, while I was going to school, a student passed by me running. While running hurriedly, the student dropped his pencil box and most of the things in the pencil box fell out. The paper clips, thumbtacks, erasers, coins, pens that fell out jumbled together sand, pieces of crushed stone and dry leaves. The student put everything back into his pencil box in a hurry because he had to arrive at the school in a short time. Everything in the pencil box (the paper clips, thumbtacks, erasers, coins, pens, pieces of crushed stone and dry leaves) were jumbled.

Having told the story, I ask them "How can we separate all the objects jumbled in the pencil box?" I ask them to experiment the same event using the materials I give them in order to find the easiest way.

After they complete their experiments, I ask them again. "All these objects were solid. What happens if solids mix with liquids? How, then, can we separate them? Or, what happens is liquids are mixed together? How could they be separated?" Once again, I ask them, using the materials given to them, to mix solids with water, as well as mix cologne with water and find out how to separate the components in these mixtures through experimenting. Once they complete their experiments, I ask them "Tell your classmates what you have done".

Results of the Experiment: I ask them what ways they have tried to separate the mixtures and what other ways we would use.

Sample 9: *At the Open Inquiry Level*

Tools and Materials: Sawdust, iron powder, rice, lentils, wheat, needles, paper clips, small pieces of paper, a plastic spoon or fork, salt, sugar, water, a strainer, five spirit stoves, five trivets, five beakers, five magnets.

Instructions for the Experiment: First, I decide how many student groups I will form for this experiment. If there will be, say, five groups, then I prepare five different mixtures in five small bags.

1. The first bag includes iron powder, small pieces of paper, rice, wheat and salt.

2. The second bag includes sawdust, lentils, wheat, needles, plastic spoon or fork, sugar.
3. The third bag includes iron powder, needles, rice, lentils, small pieces of paper, sugar.
4. The fourth bag includes sawdust, needles, paper clips, wheat, rice, salt, plastic spoon or fork.
5. The fifth bag includes sawdust, iron powder, rice, lentils, wheat, needles, small pieces of paper, and sugar.

During the class, I ask the students to form 5 groups and I give a bag to each group. I ask them to decide together with their group mates what they need to do in order to separate the mixtures in the bag and write a report about it. Once they decide what to do, I ask them to carry out their experiment using any of the objects and materials placed on my table, namely water, strainer, alcohol stove, trivet, beaker, and magnet. (I light up the alcohol stoves). I ask them to write down what they do and the results.

Results of the Experiment: Each group, in turns, is asked to tell what their materials are, how they have carried out the experiment, and what the results of the experiment are. After the groups present what they have done, I start a class discussion by asking what other means could be used to separate the components of mixtures.

Table 7. Science Process Skills that can be Developed Through "Can mixtures be separated?" Experiments

Science Process Skills	***Skills that can be taught through the experiment in the course book***	***Skills that can be taught through the third experiment developed***		
		Structured	**Guided**	**Open**
Observing	X	X	X	X
Comparing - classifying	X	X	X	X
Inferring	---	X	X	X
Guessing	---	---	X	X
Predicting	---	---	---	---
Setting the variables	---	---	---	---
Designing an experiment	---	X	X	X
Knowing and using experiment tools and materials	X	X	X	X
Measuring	---	---	---	---
Collecting information and data	---	X	X	X
Recording the data	---	---	X	X
Processing the data and formulating models	---	---	---	---
Interpreting and making conclusions	X	X	X	X
Presenting	---	---	X	X
TOTAL	4	7	10	10

An examination of the experiments designed for the experiment "Can mixtures be separated?" given in Table 7 and implemented at the classroom reveals that seven skills can be taught using the experiment at the guided inquiry level while 10 skills can be taught using the first and second open inquiry level experiments. However, in comparison, only four skills can be taught using the experiment in the textbook.

Teacher Candidates Developed Perceptions Due to Applications

The qualitative analysis method was used to find an answer to the second question of the study by obtaining the views of the prospective teachers concerning the study. The written documents containing the answers the prospective teachers gave to the open-ended questions and the records of the interviews held were examined to identify common codes. From common concepts among the codes, thematic coding was identified and the understandings developed through the study were determined. The thematic codes determined and the codes are as Table 8.

Table 8. Coding Steps in Qualitative Data Analysis

Theme	*Thematic codes*	*Codes*
Perceptions developed through the study	Experiment-related perceptions	Comprehending the skills that are developed by the experiments Realizing that experiments increase the interest in the course Realizing that experiments are related to daily life
	Method-related perceptions	Comprehending the method Increasing self-confidence in implementing the method

There are three codes under the thematic code titled "***Experiment-related perceptions***" identified through examining the qualitative analysis data. The statements of the prospective teachers revealing their views regarding the experiments are presented below in order of the code.

Comprehending the skills that are developed by the experiments

As is noted above, the aim of this study is to teach prospective teachers how they can improve the students' science process skills through experiments in order to help them become science literate individuals. Therefore, it is utterly importance that the prospective teachers realize which skills they will teach through these experiments. While the prospective teachers talked about science process skills to be taught in their statements, they drew attention to another feature that is as important as these skills. They mentioned that the skills of solving problems encountered in the daily life and decision making that are should be developed in a science literate individual could also be developed through these.

> *"Inquiry-based laboratory activities can be utilized to develop any science process skills in students. Students can formulate a problem (specify problems faced in daily life and try to solve them), carry out problem-based experiments, plan these experiments, use experimental tools and materials, as well as observe, examine the results, write an experiment report, and share these with classmates."*

> *"Through providing my students with higher level activities, I can have them acquire a lot of science process skills such as observing the objects and phenomena around, as well as grouping, making and recording measurements, and deducing conclusions. Also, by having my students design experiments and reach conclusions by themselves through open inquiry experiments, I can help them develop skills in solving problems in daily life."*

> *"Inquiry based laboratory activities help students develop critical thinking skills, implement science process skills and comprehend science better. These activities also help students develop skills to conduct experiments, comprehend science concepts and the scientific method better. This provides them not only with the skills in science but also with skills in other fields. They will be able to associate what they have learned to other situations."*

> *"We can have our students acquire the additional skills of making observations, classifying, inferring, identifying variables, designing experiments, using experimental materials, conducting experiments, making measurements, collecting and recording data, making inferences, and making presentations only if we implement the experiments in the book both at verification level and at open level rather than implement them only at verification level. Naturally, it is not possible to teach all of these skills in one experiment only. It is indeed the existence, or lack thereof, of these skills which determine the nature of research."*

Prospective teachers that are convinced that their students will develop science process skills through experiments expressed student-centeredness of this method as well.

"Experiments designed with guidance from the teacher in a student-centered fashion provide the students with opportunities to develop themselves and use their science process skills. This process facilitates self-development on behalf of the student. They start to develop their self-confidence and creativity at such young ages."

"Through these activities, we have witnessed that the students are able to obtain the knowledge themselves. It was through experimenting that the student could develop inquiry, creative thinking and higher level science process skills instead of memorizing. Is it loading the student with a lot of information? Or is it enabling them to obtain the knowledge by themselves? Which one is more important?"

Realizing that experiments increase the interest in the course

Comparing these activities with those in their own educational experiences, prospective teachers realized that experimenting is indeed enjoyable and also it leads to more permanent learning.

"I would like to start with an example from my own life. What my science teacher did was only to demonstrate the experiments. Then, the teacher lectured the theme of the day. We weren't given any opportunity to conduct any experiment; so I slowly took a dislike to science experiments. I never wanted to hear the word "experiment". However, the activities we have done proved me that experimenting is not as difficult as it was told, but rather it is simple and fun. My curiosity grew more eager and what I have learned became more permanent."

"I think I will pay attention to implement this method in all experiments in the future. I think both the students and I will have much more pleasure in experimenting."

"In this course, I have realized that laboratory activities are not boring; on the contrary, they are fun. It is now more important for me considering my ability to conduct experiments in addition to the qualities gained through scientific process skills."

Having realized how fun experiments are and how they can contribute to increasing the course motivation, the prospective teachers also became aware that these experiments could help them develop science literate individuals and expressed their opinions as follows:

"Activities done in various forms might help increase students' creativity. Students' interest in science lessons will increase, their problem-solving skills will be developed, and they will learn by doing rather than by rote learning. Thus, they will gain many science process skills."

"Students both gain many skills and also lessons become fun. These experiments resemble the old boring ones in no way because the student is always active, watching, writing, and measuring."

"It was very interesting to have the experiments conducted in different ways. I learned by doing, by experimenting. I comprehended the stages of science inquiry and scientific process skills better. What I have learned lasts. Question marks in my mind are gone. I have really seen that experimenting is great fun and an effective teaching tool."

"I always thought experimenting in science courses is both difficult and takes much time. I believed experimenting would not be efficient due to the time it takes. All in all, we had gone through a traditional way of education. Yet, upon seeing different stages of experimenting, I recognized that it is not very difficult and how it motivates students. The lessons become much more enjoyable when this method is followed in preparing and presenting the course. Students learn better through experiments they conduct themselves. They reach conclusions. And these become their own ideas. They start using experimental tools and materials more aptly. I would also like to implement it. I will also let my students experiment and observe, reach accurate results, develop science process skills and feel the pleasure in the self-confidence these will help them build. I will let them like science class; not fear it; not have prejudices against it."

Realizing that experiments are related to daily life

That prospective teachers used examples from daily life have led them recognize that experimental subjects are actually taken from daily life. The views stated by these prospective teachers regarding this awareness are as follows:

> *"Students can notice a problem through activities carried out at different levels of inquiry, thus designing experiments and implement them. When the experiments were made in this way, students can associate what they learn with everyday life. For instance, once Ayşe boiled some milk over. Students might also associate science experiments with such experiences."*

> *"Through activities at different levels, students can associate experiments with life. There were also such cases in the experiments that we have done. One student dropped his pencil box and jumbled his belongings and leaves together. Another one boiled the milk over while heating it at home. As a result of such experiments, students will also realize that science lessons are very much intertwined with daily life."*

> *"Asking questions to the students before the experiment rather than directly doing the experiment, as well as giving several real life examples would help arouse students' interest in the subject. Students internalize the experiments they conduct, adding something of their own each time. Therefore, they realize the experiments they conduct are indeed the same as the subjects they come across in daily life."*

The second thematic code "***perceptions about method***" comprises the two sub-codes of "comprehending the method" and "gaining self-confidence in implementing the method". Their opinions regarding these codes are as follows:

Comprehending the method

The prospective teachers stated that they had understood the method in a thorough and permanent way.

> *"We indeed subconsciously comprehend the phases of inquiry through these activities while making us think which level goes with which experiment. Through each activity, we learn inquiry better."*

> *"We did not know this method exactly while we designed experiments. We tried to implement the method in the experiments and then we realized understood the method we implemented better... In this way, we found a concrete way how the method. This helped the method we learned stay in our minds."*

Another prospective teacher who believes that he has learned the method exactly and permanently also indicated that he comprehended the levels of inquiry, as well.

> *"This work was very helpful in our understanding of the levels of the inquiry method. Because we implemented it ourselves. Learning by doing and experiencing led to permanent learning in our case."*

Other prospective teachers who share the same thoughts expressed that they understood the method by applying it themselves.

> *"In this course, we also learned the levels of inquiry through implementing the method of inquiry. It was not the levels only what were taught in the course. We were given experiments and we were asked to prepare it at various levels. Therefore, during our work, we investigated by ourselves, we reviewed the levels of the method and the science process skills. In other words, we also used this method while preparing the experiments and learned it properly."*

> *"If I had learned it without implementing these different levels, I would probably not implement it in my professional career. In moving from the abstract to the concrete, my involvement in developing these activities proved very helpful. If a teacher had explained to me the characteristics*

of these levels, I would only memorize them and I wouldn't know how to implement them. Therefore, I wouldn't be able to show them to my student through practice... We cannot properly visualize the concepts if they are not taught in a practical manner. But as I implemented it, I realized that it was not very complicated."

The prospective teachers noted that thank to the exercise, they could digest the steps of the method and drew attention to the difference between learning through hands-on practices and through traditional methods.

"As a matter of fact, I already know the steps of inquiry method, and, thanks to the exercise, I have comprehended it thoroughly. If I had learned all this only by hearing from my teachers, I would probably forget about them in a short time. But as I participated directly in the process, I managed to comprehend this scientific method thoroughly. This is a lasting learning, and I will use it in my professional career."

"...If the inquiry methods at different levels had been explained to me as purely theoretical knowledge, and if we hadn't performed this exercise, we would continue to carry out the experiments given in the textbooks. (We would conclude, 'This was taught to us in this way; so it should be taught in that way.')"

Increasing self-confidence in implementing the method

Following the exercise, the prospective teachers' concerns were replaced with self-confidence. The prospective teachers expressed how they acquired self-confidence in designing and implementing experiments, by saying:

"After this exercise, I feel more self-confident about planning an experiment about any subject and I feel myself sufficiently conscious to do this."

"We have now gained self-confidence enough to design and implement experiments independently."

"These experiments have changed my views. Previously, I wouldn't think I can conduct any experiment. But now I believe I can perform them with my students."

"I believe I can improve on what I learn at university and pass them on to my students with this confidence..."

"It helped us to boost our self-confidence and showed us that it is not a challenge to conduct experiments. We reached the conclusion that other experiments can be easily conducted."

The prospective teachers gained confidence in designing experiments and implementing them and they also noted that it was fun to get involved in such an exercise.

"I believe I can easily employ the experiment designing and implementing techniques I learned at this course while I teach my own students. It was fun to participate in the lesson. I am sure my students will also find it pleasant."

"I gained very much confidence. It will be pleasure to implement them as it was pleasure to learn them. If every teacher could implement them, then we would be able to raise many knowledgeable people. At least, I believe I can do it."

Moreover, the fact that the prospective teacher believes that this method should be implemented by every teacher is significant in that it draws attention to the importance of the method.

Discussion, Conclusion and Suggestions

In this study which aimed to make prospective classroom teachers acquire hands-on experiences in developing experiments at different inquiry levels and in identifying the science process skills which can be taught with these experiments, the levels of the experiments developed by the prospective teachers, the science process skills which can be improved using these experiments and the understandings the prospective teachers developed with this practice were determined. Before carrying out the exercise with the prospective teachers, an examination was conducted and it was found out that despite the fact that the importance of making students acquire the science process skills is emphatically underlined in the science and technology curriculum, all of the experiments given in the 4th and 5th grade science and technology course books tend to specify the experiment's purpose and how to carry it out and guide the student with the questions asked in the result section, and it is very unlikely for students to acquire many skills if these experiments are carried out as such. This finding is in harmony with the results of Yıldız-Feyzioğlu and Tatar’ study (2012) in which they investigated the science process skills at the 6th, 7th and 8th grade science and technology course books, and it is clear that the textbooks will not be sufficient to make students acquire these skills. Moreover, in another study which involved the final year students at the primary school teaching department, Şimşek (2010) found that the prospective teachers had difficulties in identifying the science process skills in the 4th and 5th grade course books and they were not very successful. Given the fact that the prospective teachers face problems in identifying science process skills and the experiments given in the course books are incapable of making students attain these skills properly, it is essential that the prospective teachers should comprehend these skills and are able to design experiments with which more skills can be taught.

In a number of studies, it was found out that one of the most appropriate methods for making both primary school students and prospective teachers acquire science process skills and improve their skills in a meaningful manner is the inquiry method (Akben, 2011; Bahadır, 2007; Budak, 2008; Tatar, 2006). Therefore, the prospective teachers were not directly told that they would develop skills or experiments at certain levels; instead, the inquiry approach was applied and they were asked to design experiments on their own. Each of the 15 two-member groups was asked to identify the science process skills which can be developed using two experiments on different topics selected from the 4th and 5th grade course books and compare them with the skills which would be developed if they had developed those experiments at different inquiry levels. Of the experiments designed by the prospective teachers, nine were at the structured inquiry level while eight and 13 were respectively at the guided inquiry and open inquiry levels. The fact that four experiments developed at the open inquiry level were from the topic "Let us sort out the mixed materials" and three open inquiry experiments were developed for each of the experiments "Can I classify living things?" and "Let us stop the light" implies that the prospective teachers have confidence in themselves about basic science topics and they believe they can guide students by just giving them the problem and offer them proper guidance concerning the method and result parts of the experiment. The open inquiry level was least used concerning the experiment "Equal heat - different temperature" and of the six experiments designed four were at the structured inquiry level. As to this experiment, the prospective teachers were not able to propose much improvement over the tools and materials or method given in the textbook; instead, they preferred to carry out the experiment process by themselves by giving the research questions, method and guiding questions to the students. This was probably because the prospective teachers themselves did not have sufficient conceptual knowledge about this topic. This inference is in harmony with the Aydoğdu's (1999) conclusion that lack of theoretical knowledge decreases the likelihood of success in laboratory activities.

The prospective teachers did not face any trouble in identifying the openness levels of the experiments they had developed and they took into consideration the openness levels, formulated in extra detail by Buck, Bretz, and Towns (2008) in identifying these levels. The prospective teachers found this rubric more self-explanatory since the result section comprises the analysis, association, and presentation steps and the structured inquiry differs from the guided inquiry in respect of whether analysis of results is given or not. This finding implies that this rubric, originally developed for laboratory activities for the undergraduate students of the chemistry department, also applies to the experiments designed for primary school. Moreover, at the primary school level, it is impossible to conduct an experiment without providing the problems and theoretical knowledge, only open inquiry, not authentic inquiry, can be applied at this level.

The prospective teachers who identified the skills they could develop with the experiments they developed based on the science process skills included in the primary school 4th and 5th grade science and technology curriculum were generally successful in correctly determining these skills. Given the skills that can be taught based on the increasing levels of openness of the experiments, the prospective teachers realized that the more skills they can teach as they move from structured inquiry to open inquiry in the sample experiments selected. Moreover, the findings from this study comply with the conclusion that basic science process skills can be taught during the first stage of primary education while integrated science process skills can be given at the second stage of primary education (Yıldız-Feyzioğlu and Tatar, 2012). Indeed, it is obvious that using the experiments designed by the prospective teachers, the integrated science process skills such as designing experiments, collecting and interpreting data, and inferring can be taught as well.

When the qualitative analysis data were evaluated to find out the understandings the prospective teachers developed through the exercise, it was observed that they had significant acquisitions both concerning the experiments and the method. When the codes pertaining to these understandings as noted by the prospective teachers are classified, two code categories as "understandings pertaining to experiments" and "understandings pertaining to the method" were created. The most remarkable findings from the views in the first category is that as they were listing the skills which could be developed using the experiments, the prospective teachers referred not only to the science process skills, but also to the skills which are supposed to be found in science literate individuals such as critical thinking and problem solving. This indicates that the exercise's goal of "raising science literate people, i.e., the individuals who can use and improve their science process skills, by using the inquiry approach in training students and teachers" has been achieved as regards the training of students. Similarly, as voiced under the first code category, the view that the experiments are not unrelated to life, but contain topics from daily life and that lessons will be more pleasant with such practices points to major benefits from the exercise. It can be assumed that this positive attitude the prospective teachers have developed will be projected to their professional careers in future, helping their students develop positive attitudes as well.

The second code category created in the qualitative analysis is about the understandings pertaining to the method. When the codes under this category are examined, it is observed that the prospective teachers have comprehended the method and acquire the self-confidence with which to employ this method in their professional careers. The prospective teachers noted that they have learned how to develop experiments at the different levels of inquiry approach with the same approach and through hands-on experience, and they asserted that they have comprehended the method and acquired lasting knowledge about the method. The prospective teachers who have bolstered their self-confidence in developing and implementing experiments thanks to this experience expressed that they will use this approach and every teacher should employ it. The prospective teachers’ views do not agree with Kırıkkaya's (2009) findings with science teachers who said they would experience difficulty in implementing their acquisitions about the science process skills although they found them to be realizable. This difference of opinion between the science teachers who participated in Kırıkkaya's study (2009) and the prospective teachers of the current study may be due to the experiences the prospective teachers gained during the exercise. When teachers realize that they don't have to conduct the experiments according to the instructions given the textbooks and they have knowledge and self-confidence to design different experiments at different levels of inquiry approach, it can be argued that the teacher training aspect of the exercise has been achieved as well.

Based on the results of the study, it can be further suggested that if prospective teachers are given opportunity to acquire hands-on experience by designing experiments at different levels of inquiry, they are able to successfully develop these experiments and determine which skills can be taught to students using these experiments. Moreover, comprehending the method used teacher candidates improved their self-confidence in practice. In line with these findings, it can be maintained that giving the prospective primary school teachers the opportunity to design and implement inquiry based laboratory activities at the Science and Technology Laboratory Practices courses will contribute to the raising of science literate individuals.

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Appendix 1. Acquired Science Process Skills

Science Process Skills	*Skills that can be taught through the experiments in the course book*	*Skills that can be taught through the first experiment developed*	*Skills that can be taught through the second experiment developed*
Observing			
Comparing - classifying			
Inferring			
Guessing			
Predicting			
Setting the variables			
Designing an experiment			
Knowing and using experiment tools and materials			
Measuring			
Collecting information and data			
Recording the data			
Processing the data and formulating models			
Interpreting and making conclusions			
Presenting			

Appendix 2. Selected Experiments for Application in the Classroom.

EXPERIMENT 1

FOURTH GRADE, Chapter 2: Let us learn about matter

Subject:Change of matter due to heat

Name of The Experiment: Does the mass of matter change when it is heated?

Purpose of The Experiment: To comprehend whether heat is matter or not

Duration of the Experiment: 20 min.

Tools and Materials: Beakers, a glass of water, a glass of olive oil, the precision scales, a thermometer, a spirit stove

Instructions for The Experiment:

1. Measure and record the masses of empty beakers.
2. Pour down olive oil into a beaker and measure and record its mass.
3. Calculate the mass of olive oil by subtracting this mass from the mass of olive oil.
4. Heat the olive oil inside the beaker up to 60°C and re-measure its mass.

Results of the Experiment:

- Did the mass of olive oil change after heating?
- If the heat had any mass, would the mass of olive oil change?

EXPERIMENT 3

FIFTH GRADE, Chapter 7: Light and sound

Subject:What happens when light is blocked?

Name of the Experiment:Let us stop the light

Purpose of the Experiment:To comprehend the light transmitting and opaque materials.

Duration of the Experiment:20 min.

Tools and Materials: A flashlight, frosted glass, window glass, a piece of wood

Instructions for the Experiment:

1. Arrange the classroom so as to prevent all light from outside.
2. Light up a wall using the flashlight.
3. Place the frosted glass, the window glass, and the piece of wood between the flashlight and the wall.

4. Observe the changes in the illuminated area.
5. Repeat this procedure with other objects from the classroom.

Results of the Experiment:

- What did you see after placing the window glass, the frosted glass and the piece of wood between the light source and the wall?

EXPERIMENT 5

FOURTH GRADE, Chapter 2: Let us learn about matter

Subject: Can mixtures be separated?

Name of the Experiment: Let us sort out the mixed materials

Purpose of the Experiment: To separate the materials that are mixed up from each other

Duration of the Experiment: 20 min.

Tools and Materials: Filter paper, a magnet, a funnel, iron powder, sand, gravel, salt, two watch glasses, a spirit stove, wire mesh, a sieve, three 250-ml beakers

Instructions for the Experiment:

1. Put sand and gravel on one watch glass and iron power and sand on the other and mixed them.
2. Fill the beakers with water by half. Put iron power into the first baker, sand to the second and salt to the third and mix them.
3. Try to separate the resulting mixtures using various methods and taking into consideration the characteristics of matter.

Results of the Experiment: Which method did you use to separate each mixture?