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The Associating Abilities of Pre-Service Teachers Science Education Program Acquisitions with Engineering According to STEM Education

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Abstract
The aim of this study is to determine the associating abilities of elementary education pre-service teachers science education program acquisitions with engineering using STEM education. In the study which is a case study, firstly pre-service teachers were trained about the STEM education approach. Then "Elementary School Science Education Program Acquisitions-STEM Activities Form" was applied asking the subjects to prepare activities associating elementary education science lessons acquisitions with engineering. After the application of the form, semi-structured interviews were conducted to ask pre-service teachers' opinions about STEM education, using STEM in elementary education science lessons and the activities they had written in the form. An analysis of the data showed that pre-service teachers could easily associate elementary school science program acquisitions and the field of engineering. A variety of activities were given that could be conducted in the elementary education science lessons. Interviewed teachers gave positive feedback to the approach and stated that it is an educational approach that must be applied to lessons.
Keywords: elementary education, pre-service teachers, STEM education

1. Introduction

In the world, the innovative approaches draw attention day by day in the field of education. STEM (Science, technology, engineering and mathematics) is an education approach which focuses on innovation and interdisciplinary works among science, technology, engineering, mathematics and it is applicable for all education levels from pre-school education to doctorate (Gonzalez & Kuenzi, 2012). STEM education includes knowledge, skills and beliefs constructed at the intersection of more than one STEM subject area (Çorlu, Capraro & Capraro, 2014). That the structure and meaning of the expressions' detached from each of the existing educational systems is the center of this approach and to enhance the innovation of the courses in this approach as interdisciplinary study STEM must be addressed (Altun, 2014).

Bybee (2010) implies that STEM literacy must be turned into an educational priority for all students at once. It has been stated that STEM has attracted the attention of many in the last few years and there has been a lot of research done, papers published and investment made (Kuenzi, 2008; Labov, Singer, George, Schweingburger and Hilton, 2009; Zollman, 2012). When the definitions of STEM were analyzed, in all fields (science, technology, engineering, mathematics definitions) they emphasize on economical and social needs (Zollman, 2012). By STEM approach, it is aimed to educate individuals who can associate science, technology, engineering and mathematics fields with each other and whose innovative abilities had been improved. Çorlu (2014) emphasizes that for improving Turkey's innovation capacity, the necessity of advanced manpower who were educated on STEM fields and well educated teachers to use STEM while teaching, is obvious. But he also says that teachers start their working life without the knowledge of associated teaching abilities to teach using STEM education. While it was noticed that the unqualified STEM teachers are the reason for the problems on STEM, universities can be part of the solution (Hagedorn & Purnamasari, 2012); some research showed that, the universities which has STEM education are not at the desired level of education. (Breiner, Harkness, Johnson & Koehler, 2012; Smith, Vinson, Smith, Lewin & Stetzer, 2014).

By the improving interest on STEM, it is observed that studies on it intensified in recent years. As part of STEM education, to improve students mathematics and science usage, in some researches trial robot has been designed (Mataric, Koenig and Feil-Seifer, 2007) and robot design contests were organized (Chung, Cartwright & Cole, 2014). There are also studies focused on integrating engineering into education programs, the improvement of education systems in terms of STEM and training students and teachers on STEM (Chacko, Appelbaum, Kim, Zhao& Montclare, 2015; Gülhan & Şahin, 2016; Johnson 2012; Öner& Capraro, 2016; Rogers, Pfaff, Hamilton& Erkan, 2015; Rogers & Portsmore, 2004; Sungur-Gül&Marulcu, 2014; Zhan 2014). The results of studies showed that students were highly improved in their mathematics and science abilities and they willingly want to join the STEM programs (Chung, et all. 2014; Şahin, Ayar &Adıgüzel, 2014).

In the STEM education program when planning the activities, the associating abilities of teachers and pre-service teachers the science program acquisitions with the field of engineering is so important. However, it is noteworthy that, there is no study on how to determine pre-service teachers' abilities of associating their approaches with the engineering field. Thus, this study carried out for analysing pre-service teachers' abilities

while associating their elementary school science course acquisitions with engineering field by using STEM approach. Therefore, it is expected to contribute to the field of study. Accordingly, the sub- problems of this study can be expressed as;

A. In the context of STEM education approach, how are the pre-service teachers abilities of associating by using;

1. *"The impact of force"*
2. *"Lighting and sound technologies from past to present"*
3. *"Simple electrical circuits and electrical tools in our lives"* subjects' acquisitions on engineering field?

B. What are the opinions of pre-service teachers about integrating STEM activities to elementary school science lessons?

2. Methods

2.1. Research Design

The study has been designed to use case study from qualitative research methods and the main feature of case study is the investigation of the situation. A series of related factors to a case are explored using the holistic approach and focus on how they are affected and how they affect related cases (Yıldırım & Şimşek, 2011, p. 77). In this study, pre-service teachers' abilities to combine elementary school science program acquisitions and engineering were examined.

2.2. Sample

The study was conducted in the 2014-15 school year spring semester in the faculty of education in Ondokuz Mayis University. Participants of the study consisted of 13 male and 33 female subjects, 46 college sophomores in total. Sophomores were used because the Science and Technology Practice course is a sophomore course and thus purposive sampling method was used in this study. When their academic grades were taken into consideration it was observed that the grade averages of 26 of students were between 3.00 and 4.00 and 20 between 2.00 and 3.00. At the end of the study semi-structured interviews were conducted with 10 of the participants, chosen by ramdom sampling, in order to determine their ideas about the application of STEM activities.

2.3. Research Instruments

To measure the participants associating abilities the science education program acquisitions with engineering, a form was created entitled "Elementary School Science Education Program Acquisitions-STEM Activities Form". It consisted of the subjects that are in elementary school grade 3 and 4 science education program acquisitions and subject concepts. The subjects are that;

1. The impact of force
2. Lighting and sound technologies from past to present
3. Electrical tools in our lives and Simple electric circuits

In addition the form included a section for the activities the participants intended to prepare. The form was submitted for 2 different expert opinions and as a result of their analysis the relevant corrections were made. The form was finalized after a preliminary form was given to pre-service teachers and incomprehensible sections were identified and corrected.

At the end of implementation, semi-structured interviews were conducted with the participants. The interview questions are about the pre-service teachers' opinions about STEM education and the activities they wrote on the form. After expert opinions were consulted, corrections on the questions were made and the form was applied.

2.4. Procedure

During the study, firstly pre-service teachers were trained on STEM approach. For this purpose, STEM education approach, its aims and sample activities about STEM were explained. The participants were then given "Elementary School Science Education Program Acquisitions-STEM Activities Form" and they were asked to complete the form and design some science activities associated with engineering field. An attempt was made to evaluate the abilities of associating science program acquisitions and the field of engineering on the part of pre-service teachers. At the end of the study semi-structured interviews were conducted about the opinions of pre-service teachers on STEM education and the activities they had written.

2.5. Data Analysis

Data obtained from the study was analyzed using content analysis. The main procedure for content analysis is collecting similar data within the context of specific themes and concepts, gathering, organizing and interpreting

it to make it meaningful to readers (Yıldırım & Şimşek, 2011). Firstly, the themes were determined by the responses of the participants. The activities were categorized by the researcher and related themes were determined. Common themes were reached after organizing the most repeating activities. Similarly, ideas given from the participants in the form were given as an example to make the process of coding more clear. For deciding whether or not the activities were pertinent to engineering, 'What is engineering' (WE) and 'Engineering Attitudes'(EA) by Engineering is Elementary (Boston Museum of Science) were taken into consideration and the duty areas of engineering were determined. These tasks were given over to expert opinion. After expert approval, activities written by the students were analyzed according to these tasks. Some of these tasks are;

1. To invent new things
2. Designing bridges, tunnels and skyscrapers
3. Designing cars
4. Setting up and testing machines
5. Learning how things are working and testing them
6. Discovering new and better ways of inventing something
7. Trying to improve human life

When analysing the interviews, firstly the data that was collected from the semi-structured interviews was transcripted to computer. The ideas were gathered and integrated under common themes by descriptive analysis. Samplings were also made of responses of participants in the interview stage.

The data was coded independently for reliability by researcher. When the coding was compared to the original it was seen as being faithful to the original. All the coding was given for expert opinion and the necessary corrections were made. In this way the coding process was completed without prejudice but was exactly reflected in a common perspective with the main transcripts and expert opinion.

3. Results

3.1. The Associating Abilities of Pre-Service Teachers Science Education Program Acquisitions with Engineering According to STEM Education

Activities which elementary school pre-service teachers' prepared according to the Elementary School Science Education Program Acquisitions-STEM Activities Form's Impacts of Force section were analysed and the themes were shown on Table 1.

Table 1. Activity themes for "The impact of Force" subject

Subject/ Grade	Acquisitions	Themes	f	%
The impact of force /4	1. Students conduct experiments to see how force makes changes on objects shapes and movement and then discuss.	Examples of different experiments designed to see the effect of the force.	31	67
	2. Students know what is magnet and know what is magnetic poles. 3. Students discover through experiments that what kind of materials effected from magnets. 4. Students give real life examples on how and where magnets are used in our daily lives.	Activities designed to show a magnets structure and their areas of usage.	30	65
		Designing a new equipment using magnets.	7	15

Table 1 shows that 31 pre-service teachers (67 %) designed different experiments to demonstrate how force makes changes on objects and their movement. 30 pre-service teachers (65 %) designed activities on magnets, tools with magnets and examining their daily use. 7 pre-service teachers (15 %) designed elementary school level tools by using magnets. Some of the activities proposed by the pre-service teachers are as follows;

1. Demonstating the impact of force by crashing 2 toy cars.
2. Observing the results of traffic accidents and listing ideas on how to make cars more durable.
3. Designing fridge magnets.
4. Designing a model of lift.
5. Designing and floating a model ship.

Activities which pre-service teachers' prepared according to *Lighting and Sound Technologies From Past to Present* subject were analysed and the results were shown on Table 2.

Table 2. Activity themes for Lighting and Sound Technology From Past to Present

Subject/ Grade	Acquisitions	Themes	f	%
Lighting and sound technologies from past to present /4	1. Students compare different lighting technology in daily life and notice the contribution of technology to the development of lighting devices 2.Students research 'proper lighting' what it means and how it should be implemented and present their ideas 3.Students explore the importance of efficient forms of lighting technology in terms of the family and the national economy. 4.Students examine the causes of light pollution 5.Students try to find solutions for the reduction of light pollution. 6.Students compare the technology of sound from past to present. 7.Students explain the harm of noise pollution on people and the environment. 8.Students try to find solutions to the problems of noise pollution.	Measuring the intensity of sound and conducting different experiments to show the effects of noise pollution.	31	67
		Designing different kinds of activities on 'proper lighting' and light pollution.	29	63
		A project on comparing old and new lighting devices and their development over time.	26	56
		A project on precautions for noise pollution.	13	28
		Designing a lightening instrument	11	24
		A project on efficient usage of lightening instruments.	8	17

When Table 2 is examined it can be seen that a large amount of the participants chose experiments on the intensity of sound and noise pollution (f=31, 67 %). 29 of the subjects (63 %) opted for the awareness of proper lighting and light pollution. 56 % (f=26) of pre-service teachers chose the development of lighting devices over time.13 pre-service teachers (28 %) proposed activities on the prevention of noise pollution,11 pre-service teachers (24 %) were involved in activities for the design of a lighting instrument and 8 of the subjects (17%) opted for a project on the efficient use of lighting devices. Some of the proposed activities are listed below.

1. Designing a night light using electric circuits.
2. The structural analysis of a gas lamp and comparing it with modern lighting eqipment.
3. An examination of the features of audio recording and the design of an audio recorder toy.
4. Examining the working principles of microphones and speakers.
5. Making a gas lamp.

The activity themes about *Electrical Tools in Our Lives* and S*imple Electric Circuits* subjects are shown in Table 3.

Table 3 – Activity themes for *Electrical Tools in Our Lives* and *Simple Electric Circuits*

Subject/ Grade	Acquisitions	Themes	f	%
Electrical tools in our lives /3 Simple electrical circuits /4	1.Students explain the importance of electricity and give examples of electric devices they use in their daily lives. 2.Students categorize electrical instruments by the type of energy they use. 3.Student dicuss the harm of waste batteries and find solutions to preserve the environment. 4. Students make a research on using electricity safely and comprehend the situations that can cause electric shock. 5.Students identify how an electric circuit works and design a simple circuit. 6. Students inference that between bulbs and buttons, there are connection cables inside the walls.	Different activity proposes for designing electrical circuits.	30	65
		A project on the avoidance of electric shocks.	24	52
		A project on avoiding the harms of waste batteries and designing waste battery boxes.	19	41
		Different activities to explore the internal structure of electrical devices and their working principles.	17	37
		Researches on the use of electricity in our daily lives.	16	35
		Designing a simple device that Works off a battery.	11	24
		Examining the internal structure of a light bulb.	8	17

The breakdown of the results in Table 3, can be expressed as;
30 students (65%) "different activity proposes for designing electrical circuits".
24 students (52%) "the avoidance of electric shocks".

19 students (41%) “avoiding the harm of waste batteries/ designing a waste battery box”.
17 students (37%) “activities to explore the internal structures of electrical insruments and their working principles”.
16 students (35%) “researches on the use of electricity in our daily lives”.
11 students (24%) “the design of a simple insrument that Works off a battery”.
8 students (17%) “exploring the internal structure of a light bulb”.
Some of the activities proposed are as follows;

1. Exploring the working principles of electrical devices we use at home.
2. Designing a simple electric circuit.
3. Designing an electric circuit on a model house.
4. Exploring how a remote controlled car Works.
5. How an electric heater heats water by examining its internal structure.

3.2. The Opinions of Pre-Service Teachers About Using the STEM Approach in Elementary School Science Lessons

During the interviews pre-service teachers stated that, they look favourably on approaching STEM in the elementary school science lessons because it is necessary and positive for the students. One of students explained his thoughts like: *‘I definitely think it should be included in our education system. Learning can be made more effective by associating it to issues in daily life.’* They also thought that using this approach would help the students to link things from everyday life to the things they learn at school and also help them to understand and interested in the technological equipment and inventions. Some of the pre-service teachers’ stated their opinions: *‘By exploring how a remote controlled car works, students can imagine and identify the working internal structures of other devices and can produce.’ ‘STEM activities, either visual or operative, include the element of trial and error learning. Students easily link their knowledge with their daily life and this helps them to learn more effectively.’* Overall pre-service teachers agreed that STEM should be applied to the education system because it would increase the quality and effectiveness of learning.

Teacher trainees said that STEM activities increase interest in technology and the awareness that technological developments are always continuous. They believe that students will grow by exploring, developing, generating new ideas and being more creative. Their innovative abilities will grow as a result of the experiments they have done. A pre-service teacher’ opinions is given here: *‘With the help of these activities children become aware of technological innovations and developments both in the world and in their own environment. Thus it can be ensured that a child’s world of dreams can take shape.’*

4. Discussion

STEM is an approach that is increasingly being used in education systems around the world. This study tested the associating abilities of pre-service teachers science education program acquisitions with engineering fields using STEM education. It was observed in the study that pre-service teachers could easily associate acquisitions with engineering and create activities. STEM’s improved students’ success has already been proved by the results of other studies (Chacko et al., 2015; Chung et al., 2014; Gülhan & Şahin, 2016; Labov et al., 2009; Öner& Capraro, 2016; VanMeter-Adams, Frankenfeld, Bases, Espina & Liotta, 2014). Teaching pre-service teachers in the use of STEM during their college years allows them to apply it easily to their lessons during their vocational life. But researches showed that teachers start their working life without the knowledge of integrated teaching abilities to apply STEM in their lessons (Çorlu, 2014). Such as a study’s results that was applied engineering based activities to two groups of teachers and pre-service teachers of science, concluded that they had some knowledge of engineerig but lacked the ability to prepare engineering based activities and materials as an approach for teaching science (Sungur-Gül & Marulcu, 2014). Training pre-service teachers would be beneficial for the aim that they would be more experienced on STEM, thus providing the pre-service teachers’ joining to the STEM activities is necessary. Importance of this was also highlighted by other researchers (Donner&Wang, 2013).

In the study, a variety of activities were given on different subjects and it was found that the participants had the ability of associating science education program acquisitions with engineering. During the interviews pre-service teachers mentioned the benefits of the activities they wrote and STEM education. They stressed that using this approach would be useful for students and our education system as a whole. They also said that this approach would help students to increase their interest in engineering, changing technological developments and that the learning processes would be more effective. The similar effective results of STEM education were seen on different studies (Adams, Miller, Saul & Pegg, 2014; Bozkurt Altan, Yamak& Buluş Kırıkkaya, 2016; Brown, Concannon, Marx, Donaldson & Black, 2016; Labov et al. 2009; Rogers et al., 2015; Şahin et al., 2014; Zhan, 2014). Labov et al. (2009) persued two different workshops for students on STEM training. At the end of the workshops it was proven that the workshops had the effect of students’ long term recall and conceptual learning

and could easily get student attention to the subjects they teach. Another study was conducted in a school which applies after school STEM activities and four main themes were found as an outcome: The importance of cooperative learning groups, the popularity of after school activities, interest in STEM activities and the contribution of STEM to 21st century learning skills (Şahin et al., 2014). Another study in this field revealed that pre-service science teachers assess the most powerful dimensions of STEM process as; it enhances the learning by doing , the goal of major design task is motivating, it leads permanent learning, and it is based on questioning (Bozkurt Altan, et al. 2016). As a result, it can be argued that more effective education and more succesful students would be provided thanks to STEM.

Suchman (2014) notices that, to take students' interests to STEM, it is important to create active learning environments and gather enough source; and for a constant development there must be a cultural change. Results suggest that during the undergraduate education process, pre-service teachers should be trained on STEM. Because they have the ability to implement STEM activities.

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