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The Effect of Engineering Design Activities on Pre-Service Elementary Teachers' STEM Awareness and Engineering Perceptions[#]

Elif Şahiner[1,a,*], Zeynep Koyunlu Ünlü[2,b]

[1]*Elementary School Teacher, Yozgat/Turkey*
[2]*Yozgat Bozok University, Depertment of Primary Education, Yozgat/Turkey*
**Corresponding author*

Research Article

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ABSTRACT

Today, STEM education has become prominent with the concept of producing individual gaining importance and has taken its place in the curriculum of many countries. In this context, pre-service elementary school teachers who are future practitioners of the program should be equipped with STEM training. The aim of the current research is to improve the STEM awareness and engineering perceptions of pre-service elementary school teachers through activities related to the Engineering Design Process, one of the STEM applications, and to elicit the views of pre-service elementary school teachers about these activities. The participants of the study consisted of 39 pre-service elementary school teachers (28 female, 11 male) attending the second year of a classroom teaching program in a university. This study was designed as a mixed model. The data was collected with STEM Awareness Scale and Draw an Engineer Test. In addition, at the end of the implementation, the students were asked to offer an opinion regarding the activities that were performed. As a result, it can be stated that the STEM awareness of the pre-service elementary school teachers positively developed. Also, there was an increase in the number of pre-service teachers who drew female engineers. In addition, in the post Draw an Engineer Test, the preservice teachers offered more views concerning the characteristics that an engineer should possess. It has been suggested that it is inevitable to cooperate with different organizations in the implementation of STEM education.

Keywords: STEM awareness, Perception of engineering, Pre-service elementary teachers

Mühendislik Tasarım Süreci Etkinliklerinin Sınıf Öğretmen Adaylarının STEM Farkındalıkları ve Mühendislik Algıları Üzerine Etkisi

Bilgi
[#]Bu çalışma, birinci yazarın yüksek lisans tezinin bir bölümünü içermektedir.

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ÖZ

Günümüzde üreten birey yetiştirmenin önem kazanmasıyla STEM eğitimi, ön plana çıkmış ve birçok ülkenin öğretim programında yerini almıştır. Bu bağlamda programın gelecekte uygulayıcıları olan sınıf öğretmen adaylarının STEM eğitimi ile donatılması gerekmektedir. Bu araştırmanın amacı, STEM uygulamalarından biri olan Mühendislik Tasarım Süreci ile ilgili etkinliklerle sınıf öğretmeni adaylarının STEM farkındalıklarını ve mühendislik algılarını geliştirmek ve sınıf öğretmeni adaylarının bu konudaki görüşlerini ortaya çıkarmaktır. Araştırmanın katılımcılarını, bir üniversitede sınıf öğretmenliği programının ikinci sınıfına devam eden 39 sınıf öğretmeni adayı (28 kadın, 11 erkek) oluşturmuştur. Bu çalışma karma model olarak tasarlanmıştır. Veriler STEM Farkındalık Ölçeği ve Bir Mühendis Çizme Testi ile toplanmıştır. Ayrıca uygulama sonunda öğretmen adaylarından gerçekleştirilen etkinliklerle ilgili görüş bildirmeleri istenmiştir. Sonuç olarak sınıf öğretmeni adaylarının STEM farkındalıklarının olumlu yönde geliştiği söylenebilir. Ayrıca kadın mühendis çizen öğretmen adaylarının sayısında da artış olmuştur. Ayrıca son Mühendis Çiz Testinde bölümünde, öğretmen adayları bir mühendisin sahip olması gereken özelliklerle ilgili daha fazla görüş sunmuşlardır. Sonuçlardan yola çıkarak STEM eğitiminin uygulanmasında farklı kuruluşlarla iş birliği yapılmasının kaçınılmaz olduğu öne sürülmüştür.

Anahtar Kelimeler: STEM farkındalığı, Mühendislik algısı, Sınıf öğretmen adayları

[a] *elfsahiner@gmail.com* *orcid.org/0000-0002-7199-3826* | [b] *zeynepko.unlu@gmail.coml* *orcid.org/0000-0003-3627-1809*

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Introduction

Nowadays, it has become important to cultivate youth who are able to produce with an interdisciplinary approach instead of raising individuals who think only within a single discipline. In this sense, reforms made within science education, where the foundations of science and technology are laid, have stressed the need for implementing more than one discipline in combination and for integration of engineering with other fields. Science, technology, engineering, mathematics (STEM) education has been included in the curriculum of several countries (Korean Ministry of Science and Technology Education, 2011; Ministry of National Education [MoNE], 2018; Next Generation Science Standards [NSSS], 2013). STEM education aims to raise individual citizens who have 21st century skills, who can set up associations between STEM disciplines, and who are informed about the occupations in the area (Partnership for 21st century learning [P21], 2017). Based on these developments, the curriculum for science education which was last updated in Turkey in 2018, and the domain of "Science and Engineering Applications" was added. The curriculum expects students primarily to describe a daily life problem related to the subjects considered within the scope of science, engineering, and entrepreneurship applications. The problem should aim to develop designs for practical instruments that would be used in a person's daily life. Learners are expected to choose alternative ways of solving the problem in their solutions. They outline plans for the best solution that is chosen from among all of their proposed solutions. After that, the learners are expected to put forward a product which is designed at school. Students are expected to make trials at the stage of product development, record the data they collect and the observations they make at the end of their trials, and evaluate the results with their graph reading skills (MoNE, 2018).

STEM education aims to inculcate in students such skills as problem solving and creativity (Bybee, 2013). It is important that teachers use these practices to guide student learning in their clasroom in order for STEM education to be successful. Teachers need to be open to learning and innovation, have scientific processing skills, be open to cooperation, be patient, have problem-solving skills (Mesutoğlu & Baran, 2020).

There are teacher professional development programmes for the integration of engineering at the level of K-12. The practices, engineering concepts and applications such as trips to the field, workshops and follow up activities used within the scope of the curriculum can develop such components as belief in and attitudes towards engineering (Mesutoğlu & Baran, 2020). On the other hand, teachers' lack of knowledge and skills in STEM can hinder their employment of STEM and engineering design process (EDP) effectively in their classes. A study on elementary school teachers conducted in recent years, for instance, revealed that the participants had weak pedagogical content knowledge of engineering, engineering design process and practising engineering in the classroom (Hammack, 2016). Any practice to be made in this sense is meaningful and valuable. Preservice teachers who will become the implementers of the curriculum in the future should have strong pedagogical and content knowledge about STEM education. However, a recent study revealed that preservice teachers has limited interdisciplinary understandings (Ryu, Mentzer, & Knobloch, 2019). In addition, there don't appear to be any studies available in the current literature concerning the integration of engineering into science education, raising preservice teachers' awareness and developing their perceptions in this sense. In this sense, it is thought that the results of this study will contribute to the STEM education literature.

Engineering Design Process

A way of implementing STEM is EDP. It is the way engineers use in designing an instrument to design it in the best way (Katehi, Pearson & Feder, 2009). EDP can be used by integrating it into several methods and techniques such as open-ended questions, problem scenarios, laboratory activities and writing activities. Although the stages of implementing it can differ, the stages are generally labelled as drawing, make, test, and redesign (Arık & Topçu, 2020). NGSS (2013) describes the engineering design process as having three phases called define, design, and optimise. At the stage of defining, the problem of engineering should be clearly and comprehensibly explained. The criteria and limitations should be given that are necessary to solve the problem. At the stage of designing, the probable solutions to the problem are identified and the one suitable to the criteria and limitations is chosen from them. And at the stage of optimising, the solution is tested. The process in general sense starts by determining the needs, then engineers describe the limitations, they analyse the properties of systems and make plans for the solutions. Solutions can be in the form of developed processes as well as in the form of products. Capobianco, DeLisi and Radloff (2018, p. 346) list the stages of design as problem scoping and information gathering, solution formulation, solution production and performance, communication and documentation of results and optimisation.

Engineering design process integrates STEM disciplines together since it is necessary to use basic engineering knowledge and skills and science and mathematics disciplines in combination (Cantrell, Pekcan, Itani & Velasquez-Bryant, 2006; Householder & Hailey, 2012; National Academy of Engineering & National Research Council [NAE & NRC], 2009). EDP- which has stages- integrates the domains of engineering, science, technology, and mathematics together (Felix & Harris, 2010; NAE & NCR, 2009). Students learn through their own performance in the process, they generate alternative solutions to a scientific problem, they develop their skills in real environments, they gain the ability to adapt into different environments and they configure the existing knowledge by integrating it into new knowledge. The teacher plays the role of an individual who guides students, who gives them the opportunity to think, and who offers them environments conducive to upper order thinking instead of playing the role of a classical teacher (Wendell & Lee, 2010).

Insufficient time, teachers' pedagogical weakness, lack of materials and lack of support for teachers to integrate EDP into the curriculum can be obstacles in front of implementing EDP in the classroom (Hammack, 2016).

Perception of Engineer

Engineering is defined as "the process of designing human-made world" in the framework of science and engineering literacy prepared by National Assessment of Educational Progress (NAEP, 2014). According to the dictionary prepared by Turkish Linguistic Association, an engineer is "The person who is specialised and received education in areas of public works such as constructing roads, bridges and buildings; food such as nutrition; science such as physics, chemistry, biology, electricity and electronics; and technical and in social and technical areas such as aeroplanes, automobiles, engines and construction equipment- which are all directed to meet any type of human needs."

Students' perceptions of engineers and engineering should be identified and educational environments should be organised according to the current situation for effective STEM education and for raising students' occupational awareness. A study conducted with the participation of 3724 secondary school students indicated that students' perceptions of engineering influenced their choice of occupation (Chan, Yeung, Kutnick and Chan, 2019). Studies of review (Capabianco, Diefes-Dux, Mena & Weller, 2011; Chan, Yeung, Kutnick, & Chan, 2019; Cunningham, Lachapelle, & Lindgren-Streicher, 2005; English, Dawes, & Hudson, 2011; Ergün & Balçın, 2019; Fralick, Kearn, Thompson & Lyons, 2009; Hsu, Purzer, & Cardella, 2011; Kőycű & Vries, 2016; Liu & Chiang, 2019) and applied studies (Deniz, Kaya, Yesilyurt & Trabia, 2019; Hammack, Ivey, Utley & High, 2015; Pleasants, Olson & Cruz, 2020; Oware, Capobianco & Diefes-Dux, 2007; Thompson & Lyons, 2010) are available in the literature in relation to perceptions about engineers. It is remarkable that the number of applied studies have increased in recent years with the integration of engineering into science education (NGSS, 2013).

Studies of review type concerning perceptions about engineers were conducted at several levels of instruction. The results obtained from the studies demonstrated that students had wrong perceptions of engineering as equipment repairing, fixing, and installation and of engineers as people who work outdoors and do heavy jobs. Many studies have also demonstrated that engineering is perceived as men's job (Cunnignham, Lachapelle, & Lindgren-Streicher, 2005; Fralick, Kearn, Thompson, & Lyons, 2009; Karataş, Micklos, & Bodner, 2011; Koyunlu Ünlü & Dökme, 2017; Lu & Chiang, 2019). Therefore, it was necessary to eliminate such prejudices and stereotyped thoughts about engineering held in society. When considered in the context of education and teaching, interventional studies are inevitable for improvement in students' preservice teachers' and teachers' perceptions of engineers. The nature of engineering (NOE) was identified in an interventional study conducted recently, and the development in primary school teachers' views on NOE was investigated through a three-day professional development programme. The aspects of NOE were identified as demarcation, EDP, empirical basis, tentativeness, creativity, subjectivity, social aspects of engineering and social and cultural embeddedness. Teachers' views on the nature of engineering developed through problems of engineering design prepared within the scope of the research (Deniz, Kaya, Yeşilyurt, & Trabia, 2019). In another applied study, a 4-day summer camp was organised for secondary school students, and as a result, the students' attitudes towards engineering changed in positive ways. Besides, development was observed also in students' content knowledge about chemical engineering through activities done (Hammack, Ivey, Utley, & High, 2015). In another summer camp related to engineering, changes were found in the views of most students about engineering compared to the beginning of the camp (Oware, Capobianco & Diefes-Dux, 2007). Another experimental study was performed with the inclusion of the 6th graders. The experimental group was composed of students who had participated in the Engineering Fellows programme previously while the control group was composed of students who had not joined the programme before. As a result, the study found that Engineering Fellows programme influenced students' perceptions of engineering considerably and that the students in the experimental group recognised better the equipment engineers used and the jobs engineers typically did. The study also found that the experimental group students perceived engineering correctly as designing and problem solving (Thompson & Lyons, 2010). Professional development programme organised for primary school teachers also concluded that teachers described engineering design process more clearly at the end of the programme (Pleasants, Olson, & Cruz, 2020).

Aim of This Study

This study aims to develop preservice elementary school teachers' STEM awareness and their perceptions of engineering through engineering design process (EDP) activities- a way of implementing STEM- and to obtain their views on the activities at the end of the implementation. In accordance with its purpose, this study seeks answers to the following research questions:

(RQ1) What are the effects of EDP activities on preservice teachers' STEM awareness?

(RQ2) What are the effects of EDP activities on preservice teachers' perceptions of engineering?

(RQ3) What are the preservice teachers' views on the process of doing EDP activities within the scope of STEM education?

Method

The data were collected in both quantitative and qualitative research techniques in this study. Since the qualitative and quantitative data collected within the scope of this research were interpreted by comparing, the convergent parallel design was used which is one of the mixed method. Mixed method is defined as a research approach in which researchers collect both quantitative (closed ended) data and qualitative (open-ended) data to understand the research problems, they integrate the two data sets and make inferences by using the advantages of integrating the two data sets (Creswell & Plano Clark, 2011). In Figure 1 below, the relationship of this research with the convergent parallel design is presented visually.

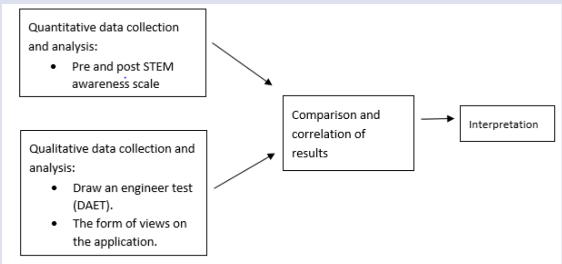

Figure 1. The design of this study

The Study Group

39 preservice teachers (28 female, 11 male) who were second-year students in the elementary school teaching department of a state university in Central Anatolia region in Turkey were included in the study group. Criterion sampling was used in choosing students for the study group. The criteria for inclusion as participants were (1) being a preservice elementary school teacher and (2) not having received education in STEM before. The average age of the preservice teachers was 20. Preservice teachers are placed in universities after a centrally held test in Turkey. They took basic courses in physics, chemistry and biology but they were weak academically at the courses. The research was conducted on one group to develop their STEM awareness and perceptions of engineering. The preservice teachers' names other information about them were not used in the study for ethical concerns. They were coded as PsT1, PsT2, … PsT39 instead of using names. The preservice teachers took part in the research on the basis of volunteering.

Data Collection Tools

"STEM awareness scale", "Draw an Engineer Test (DAET)" and Form for Views on the Application" were used as the tools of data collection. The STEM awareness scale and Draw and Engineer Test were given before and after EDP activities. The form of views on the application was given at the end of the EDP activities.

STEM awareness scale. The STEM awareness scale was given as the pre-test and the post-test to find the extent to which preservice teachers' STEM awareness changed through EDP activities. The STEM awareness scale-which was developed by Çevik (2017) is a five-pointed Likert type scale with 15 items and 3 factors. The factors in the scale were as in the following: (1) The effects of STEM on students, (2) the effects of STEM on the course, (3) the effects of STEM on the teacher. The measurement reliability was found to be .82 for the whole scale, and.81, .71 and .70 for the sub dimensions respectively. The STEM awareness scale included 3 negative and 12 positive items. It was a scale developed in order to identify the STEM awareness levels of science, technology, engineering and mathematics domain (STEM) teachers working in secondary schools (teachers of mathematics, physics, chemistry, biology and information technologies) and of preservice teachers. The positive items in the scale were marked as totally disagree=1 point, disagree=2 points, indecisive=3 points, agree=4 points and totally agree=5 points. The negative items in the scale were marked inversely. The participants were allowed 10 minutes to respond to the items in the scale. Some of the samples for scale items are as in the following: (1) STEM education develops students' analytical thinking skills. (2) Reflections of STEM education to into daily life are inevitable. (3) STEM education is an opportunity for teachers' self-development.

Draw an engineer test (DAET). Draw an engineer test (DAET) was given as the pre-test and post-test to find the extent to which preservice teachers' perceptions of engineers changed through EDP activities. DAET was developed by Knight and Cunningham (2004). The test was used in several studies to determine K-12 level students' (Capobianco et al., 2011; Cunningham et al., 2005; Ergün & Balçın, 2019; Thompson & Lyons, 2010) and teachers' (Pleasants, Olson & Cruz, 2020) image of engineers. The preservice teachers were allowed approximately 30 minutes to make drawings and answer the questions in DAET. They were given a sheet of A4 paper and were asked to draw an engineer who is doing his/her job. The y were assured that their drawings would not be evaluated as right or wrong to that they could feel relaxed. Afterwards, the participants were asked to answer the following questions: (1) What is the gender of the engineer you have drawn? (2) What is the engineer that you have drawn doing? (3) What qualities do you think an engineer has? (4) What types of engineering do you know?

The form of views on the application. The preservice teachers were asked to complete the "form of views on the application" at the end of the application to obtain their view on the EDP activities done with them. The form contained the question "What do you think of the EDP activities we did within the scope of the science and technology laboratory course? Explain your thoughts." The preservice teachers were allowed approximately thirty minutes to complete the form.

The Implementation Process

The research was conducted and the research data were collected in the fall semester of 2019 academic year by the first researcher. The research was carried and the data was collected in science and technology laboratory classes. The science and technology laboratory course is an applied course and two hours a week. Doing the EDP activities in science and technology laboratory classes was considered to be appropriate since it was an applied course. The application lasted 9 weeks and the data collection tools were used in the first and the final weeks. Different EDP activities were designed for seven weeks. Special care was taken so that the materials and equipment used in the activities were simple and of the type that the preservice teachers could easily find. They did the activities in groups of four or five. Each activity was a design. The preservice teachers made the designs in groups. After that, they described the stages of EDP they had gone through (1. Identifying the problem/ asking questions, 2. Imagining, 3. Planning, 4. Creating) and the domains of science, technology, engineering and mathematics available in designing. Finally, they had a discussion on their thoughts about designing and the contributions designing can make to students. The implementation process is shown in Table 1 below. The preservice teachers who came to classes with preparation were asked to do the activities by using the simple materials they had brought with them (such as juice and bottle cartons). At the end of the activities, discussion was made with the preservice teachers on whether the activities were related to STEM, the limitations of the activities, which STEM disciplines the activities contained and differing materials that could be used. Then, the preservice teachers were asked to complete the relevant parts in the activities file. They were also asked to write down their views on the activities in the relevant part in the activities file until the following week.

Data Analysis

The quantitative data were analysed on the SPSS programme whereas the qualitative data were put to content analysis in this study. First the skewness, kurtosis and Kormogorow Smirnow values were checked, and then normality of distribution was examined. Wilcoxon signed rank test was used on the SPSS programme because the pre and post STEM awareness scale (SAS) factors and the total scores did not have normal distribution. For the qualitative data first, codes were created to compare the pre and post DAET scores, then the codes were divided into categories. The procedures were done by the researchers, and a consensus was reached at all stages. Coding was made over a long period of time to avoid errors. In addition, based on the researchers' analysis reliability coefficient was calculated as 94% (Miles & Huberman, 1994). Reliability was achieved in this way.

Findings

Research Question (1): The Changes in Preservice Teachers' STEM Awareness

The results for Wilcoxon signed rank test which was done to determine the changes in preservice teachers' STEM awareness are shown in Table 2 below.

As clear from Table 2, positive changes were found in preservice teachers' total STEM awareness scores ($z=4.35$, $p<0.05$, $r=0.7$) as well as in the factors of the effects of STEM on students ($z=4.42$, $p<0.05$, $r=0.7$), the effects of STEM on the course ($z=3.28$, $p<0.05$, $r=0.52$) and the effects of STEM on the teacher ($z=3.16$, $p<0.05$, $r=0.7$). The fact that the difference was in favour of positive ranks indicated that the EDP activities had significant effects on raising preservice teachers' awareness of STEM education. The figures for effect size demonstrate that the changes in preservice teachers' STEM awareness caused by EDP activities were medium and strong.

Table 1. The implementation process

Weeks	Application	
1	The "STEM Awareness Scale" and the "Draw and Engineer Test (DAET)" were given as the pre-test. The preservice teachers were informed of the activities and they were asked to bring the materials needed for the activities and also to get prepared for the lesson.	
2	*Activity 1.* Making a car which works with balloon: ıt is related to transforming potential energy into motional energy.	Engineering Design Process: (1) Identifying the problem/asking questions (2) Imagining (3) Planning (4) Creating
3	*Activity 2.* Making a wind vane: It is related to transforming motional energy into electrical energy.	
4	*Activity 3.* Making a hydraulic lift: It is related to liquids' pressure transmission.	
5	*Activity 4.* Making a catapult: It is related to transforming potential energy into motional energy.	
6	*Activity 5.* Making a periscope: It is related to reflection and image in the mirror.	
7	*Activity 6.* Making a solar-powered car. It is related to transforming solar energy into motional energy.	
8	*Activity 7.* Building a bridge: It is related to the centre of balance and centre of gravity.	
9	The "STEM awareness scale", "DAET" and the Form of Views on the Application were given as the post-test.	

Table 2. The Wilcoxon signed rank test results for preservice teachers' STEM awareness pre-test and post test scores

	Pre		Post				
Factors	M	SS	M	SS	z	p	r
Factor 1: The effects of STEM on students	20.9	3.32	25.7	4.9	4.42	.00	0.7
Factor 2: The effects of STEM on the course	16	2.19	18.3	3.46	3.28	.00	0.52
Factor 3: The effects of STEM on the teacher	13.8	2.48	15.6	3.01	3.16	.00	0.5
Overall SAS	50.8	6.48	59.6	9.75	4.35	.00	0.7

Table 3. The categories and codes obtained from preservice teachers' drawings for the pre and post DAET

Categories	Codes	Pre (f)	Post (f)
Gender	female	5	18
	male	34	20
Environment	outdoors	23	21
	indoors	11	11
	uncertain	4	5
Jobs done	repairing/fixing	2	2
	supervision	14	10
	software	3	4
	measurement	4	2
	design	8	8
	manufacturing	7	9
	uncertain	-	2
Materials used	electronic	8	5
	non-electronic	29	18
	no materials	7	15
Characteristics	cognitive skills	51	79
	affective skills	12	17
	psychomotor skills	10	15
	other	5	8
	none	2	0
Safety	uniform	10	6
	helmet	18	17
	goggles	3	3
What is in the environment	electronic equipment	3	9
	materials for drawing	6	5
	building materials	10	7
	office equipment	13	24
	transport vehicles	4	4
	employees	4	2

Research Question (2): The Changes in Preservice Teachers' Perceptions of Engineers

DAET was given to the preservice teachers prior to and after the EDP activities to determine the changes in their perceptions of engineers. Their drawings were divided into the following categories: Gender of the engineer drawn, environment, jobs done, the materials used, the characteristics of an engineer, safety and what is in the environment. Table 3 below shows the frequencies for the categories and codes obtained from the drawings for the pre and post DAET.

According to Table 3, there is an increase in the number of preservice teachers who drew pictures of female engineers in the post-DAET (18) compared to the pre-DAET (5). In addition to that, the preservice teachers also stated more opinions about the characteristics of an engineer in the post-DAET. Yet, no remarkable changes were found in preservice teachers' views on the jobs engineers did, their work environment and the materials they used. In Fig 2, Fig 3, and Fig 4 samples for drawings the preservice teachers made before and after EDP activities can be seen.

The drawings seen in Fig 2 were drawn by PsT5 who is male. It is seen that the gender of the engineer in the pre-DAET test is male with office equipment inside. In the post-DAET, it is seen that the PsT5 drew a female engineer working in the construction field, outside. PsT5 initially drew a civil engineer working in the construction field, in the post DAET that drew. In Fig 3, the engineer drawings of PsT19, a female student, obtained from the pre and the post-DAET can be seen.

It is seen that PsT19 initially draw a male engineer wearing a helmet and inspecting the construction field. In the pre-DAET, PsT19 drew a civil engineer and, in the post-DAET drew a computer engineer. In Fig 4 below, the engineer drawings of PsT27, a female student, obtained from the pre and the post-DAET can be seen.

Figure 2. Samples for drawings made by the PsT5 prior to and after EDP activities

Figure 3. Samples for drawings made by the PsT19 prior to and after EDP activities

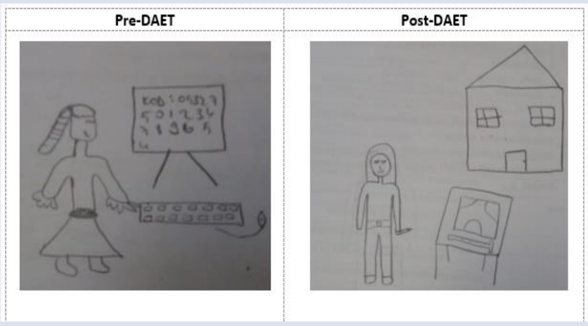

Figure 4. Samples for drawings made by the PsT27 prior to and after EDP activities

In the Fig 4, it is seen that PsT27 drew a female computer engineer who coded inside in pre-DAET of in. In the last DAET, she drew a female civil engineer who was designing in the construction field.

Research Question (3): Preservice Teachers' Views on the EDP Activities

The participants' views on the STEM activities that they had done through EDP activities were divided into seven categories labelled as "thinking skills", "psychomotor skills", "learning process", "social skills", "affective skills", "recognise themselves" and "STEM awareness". Table 4 below shows the results of content analysis of the participants' views on STEM education which was performed through EDP activities.

Accordingly, the EDP activities increased awareness of interdisciplinary interaction. Participant PsT1, for instance, made the statement "*They will be beneficial in the development of engineering skills, mathematical skills and science-related skills*" in relation to the EDP activities. Another participant, PsT5, said, "*We can inculcate in children the ability to use the domains of science, technology, engineering, mathematics together. They learn to put theory into practice.*"

A group of preservice teachers, on the other hand, stated that the EDP activities supported the learning process. Some of the statements made in this respect by the participants were as in the following: PsT14: "*They enable students to use mathematics and physical sciences in daily life, they make them creative, they enable them to generate solutions to problems and to cooperate. Students try to learn with their efforts and thus the areas in which they are interested emerge gradually*." PsT19: "*They enable more permanent and fun learning and teaching*."

Several of the preservice teachers argued that the EDP activities supported psychomotor skills. In relation to developing psychomotor skills, they made statements as in the following: PsT12: "*Children's psychomotor also develops. Children implement scientific knowledge through alternative ways of solution*." PsT21: "*I think they enable psychomotor development, teach how to have brainstorming, how to think, how to take on responsibility, how to work in groups, enable to think creatively, teach how to use simple materials and recycled materials , increase communication, develop hand skills and problem solving skills*." PsT36: "*They should be used because children will learn by having fun. I believe they will develop children's hand skills*." PsT37: "*students gain such skills as active participation, learning by doing, making students adapt into the environment and different environments, discovering students hand skills and abilities, blending their new knowledge with prior knowledge and thus becoming a challenger, working in groups with love and respect, implementing alternative solutions to problems*." PsT15: "*I think they will develop their creativity, sense of responsibility, their cooperation with their friends, their hand skills and students will be more active in classes, and they will learn by doing and experiencing.*" PsT11: "*using STEM in primary school is important because students will discover their interests and abilities by imagining and designing*."

Some of the participants thought that the activities might influence students' choice of jobs. Participants PsTt8, PsT13, PsT27 and PsT23, for instance, stated their views as in the following: PsT8: "*the relations of STEM courses are also easy to teach. They also help in choosing jobs.*" PsT13: "*with advancing technology in our country, new generations adjustment into it and their making use of STEM in their choice of jobs influences them and develops them*." PsT27: *"In this way, children's imagination will develop at earlier ages, and they will become individuals who can generate new ideas. They will be useful in the jobs they will choose in the future*." PsT23: "*The STEM approach inculcates in students such advantages as being able to* *brainstorm, learn by having fun, generate new ideas and express themselves, have ideas about their future jobs and so on*."

Some others, however, stated that the EDP activities supported group work. They stated their views in this respect as in the following: PsT2: "*They make science classes fun and lovable by combining students' creativity through group work in collaboration. They arouse student's curiosity*." PsT16: "*.... Transforming theory into practice and manufacturing a product. They offer lots of benefits such as making students learn by doing and experiencing, developing their imagination and creativity, facilitating their communication with their friends by doing group work in experiments and enabling the emergence of new ideas.*"

Table 4. The preservice teachers' views on the EDP activities

Categories	Codes
Thinking skills	problem-solving skills (18), creative thinking skills (14), interdisciplinary thinking skills (10), develop imagination (7), systematic thinking skills (3), practical thinking skills (3), enable students to have brainstorming (2), critical thinking skills (1), analytical thinking skills (1)
Psychomotor skills	hand skills (15), motor skills (1)
Learning process	permanent learning (7), learn by doing (6), apply theoretical knowledge (6), fun (6), associate their learning with daily life (4)
Social skills	cooperation skills (17), communication skills (5)
Affective skills	sense of curiosity (6), self-confidence (5), responsibility (3)
Recognise themselves	abilities and interests (8), choosing a job (8)
STEM awareness	interest and attitudes towards STEM disciplines (4)

Discussion and Conclusion

This paper aimed to improve preservice elementary school teachers' STEM awareness and their perceptions of engineering through EDP activities-one of STEM applications. As a result, positive changes were found in participants' total STEM scores and in the scores received from all three factors- that is to say, the effects of STEM on students, the effects of STEM on the course, and the effects of STEM on the teacher. The fact that the difference in scores was in favour of positive ranks indicated that the EDP activities had significant effects on raising preservice teachers' awareness of STEM education. Based on this finding, it can be said that the preservice teachers' STEM awareness developed in positive ways through this application. The result obtained in this study, which is that STEM activities raise awareness of STEM education, is consistent with the findings obtained in the literature (Aslan-Tutak, Akaygün, & Tezsezen, 2017; Capobianco, DeLisi, & Radloff, 2018; Karışan, Macalalag, & Johnson, 2019; Kim & Bolger, 2017; Maeng, Whitworth, Gonczi, Navy & Wheeler, 2017). The descriptions of STEM education made by preservice teachers who were fourth year students at a university, for instance, changed at the end of collaborative STEM education in a way that was reflective of the integrative structure of STEM education (Aslan-Tutak, Akaygün, & Tezsezen, 2017). The STEM lesson plans prepared during undergraduate education by preservice teachers studying in Korea improved their awareness of and abilities in STEM. Additionally, the ties they set up between disciplines of science, technology, engineering, mathematics and art were also strengthened in this way (Kim & Bolger, 2017). A study concerning teachers found that teachers became more and more enthusiastic in doing engineering design-based activities as the time devoted to engineering design-based science activities increased (Capobianco, DeLisi, & Radloff, 2018). Lin and Williams (2016), in a study on preservice teachers, concluded that positive attitudes and knowledge were indirectly related to intention to use STEM in classes. Another study conducted with the participation of 364 primary school teachers from 143 schools found that the teachers who had participated in a professional development programme about the principles of EDP integrated engineering design into science classes more than the teachers who had not participated in the programme (Maeng, Whitworth, Gonczi, Navy, & Wheeler, 2017).

Other findings of the study were obtained from DAET. The number of participants who drew pictures of female engineers increased in post-DAET. It was a finding consistent with the ones obtained in the literature in that it eliminated the thought that engineering was men's job (Koyunlu Ünlü, Umucu & Şen, 2018). In addition to that, the preservice teachers also suggested more views on the characteristics that engineers should have in the post-DAET. The participants worked like engineers in the process. Yet, no remarkable changes were observed in their drawings about the jobs engineers do, their work environment and the materials they used. The finding was attributed to the fact that the participants had not seen the real work environment of engineers. In this context, engineering faculties of universities and the institutions and organisations where engineers work could be visited. Partnership to be established between relevant institutions is likely to contribute to the improvement of perceptions about engineering. For instance, Hammock et al (2015) found that students' perceptions of engineering improved in summer camps organised for secondary school students under the partnership of secondary school teachers and engineering faculty. The researchers stressed the importance of partnership between teachers and engineering faculty in the success of the camp. In fact, engineering is not independent of the domain of physical sciences. Yet, teachers and preservice teachers are not familiar with teaching the concepts of engineering (Cox, Reynolds, Schuchardt, & Schunn, 2016; MoNE, 2018). The practice to be made in this sense at school and outside the school will improve teachers' and preservice teachers' knowledge and skills.

According to the findings obtained from the analysis of the interview data collected from the preservice teachers' views on the STEM activities were divided into seven categories labelled as "thinking skills", "psychomotor skills", "learning process", "social skills", "affective skills", "recognise themselves" and "STEM awareness". The findings indicated that preservice teachers had positive views of STEM education and on EDP. Teachers' and preservice teachers' positive views about STEM education influence their practice of STEM education in their classes in positive ways whereas their negative views cause them to avoid STEM education in their classes (Thibat, Knipprath, Dehane, & Depaepe, 2018). In this sense, preservice teachers' having positive views of STEM education and on EDP was pleasing for us because having knowledge and skills about STEM also reveals intention to apply STEM education (Lin, & Williams, 2016).

It should not be forgotten that this study was restricted to participants, data collection tools and the researchers' knowledge and skills. Rubrics for EDP suitable to levels of instruction could be developed in future studies. The results obtained here may serve as a guide for individuals who have an interest in STEM education. On the other hand, applied studies at K12 level of instruction are needed in relation to changing the perceptions about engineers. Thus, studying what applications might serve to reduce stereotyped thoughts about engineering should be developed and research findings should be considered. Valid and reliable measurement tools other than DAET can be developed in this context. Interdisciplinary interactions and cooperation should be considered important so that preservice teachers trained in educational faculties could gain a deeper understanding of STEM and EDP. In this way, future teachers can gain foundational knowledge and skills in such areas of science, technology, engineering, and mathematics of STEM. Alternatively, cooperation with engineering-related organizations can help eliminate stereotypes on engineering.

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