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The Effect of Engineering Design-Based Science Teaching on The Perceptions of Classroom Teacher Candidates Towards STEM Disciplines

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Abstract

The aim of this study is to reveal the effect of the engineering design-based teaching process in primary school science course of classroom teacher canditates perceptions about the disciplines of STEM (Science, Technology, Engineering and Mathematic). The study, pre-posttest single-group experimental design was used. The study group consisted of 28 classroom teacher candidates studying of university in Ankara. The data collected by the "STEM Semantic Difference Scale" were used for normal and dependent groups t-test. Eventually, it was found that the engineering design-based teaching process had a positive and significant increase in the perceptions of the prospective teachers about science, engineering and career disciplines ($p < 0,05$). Although there was a positive increase in the perception of mathematics and technology discipline, this increase was not statistically significant ($p > 0.05$). It was also observed that positive and meaningful changes ($p < 0.05$) were observed in the perceptions of general STEM disciplines.

Keywords: STEM education, engineering design-based teaching process, classroom teacher canditates, experimental study, STEM discipline perceptions.

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INTRODUCTION

After World War II, especially in the 1980s, it is seen that the economic process was based on liberalization basic all over the world. This liberalization has not been limited to the economic field only, but also spread over the social entire; an openness and liberalization-based global structure have occurred in technological, socio-cultural and political spheres. In today's world where the world transforms into a global marketplace and where the frontiers between the countries are removed in many areas, especially in economy, societies that produce information and transform the produced information into products within the framework of technological and sustainable development principles can become strong countries with high levels of welfare. Developed countries are technology producing countries, and developing countries are the countries that purchase technology. The countries that transfer technology and give importance to R&D activities by paying millions of dollars every year fall into the "developed countries" category and have a voice in the global competition. Briefly, land and raw materials owned by countries in the 19^{th} and 20^{th} centuries were very important, whereas, in the 21^{st} century, producing, R&D and innovation has become significant.

The best example of this is the Asian countries, which gained strength in global competition by means of R&D and innovation after the 1950s. A technology race started between United States of America (USA) and Russia in 1957, when Russia launched the Sputnik satellite vehicle into space. Japan in the 1980s and China in the 2000s has begun to progress rapidly in terms of economy and technology and overtook the USA in this race. In the USA, despite the investments and initiatives in those years, the desired results could not be achieved and the employers could not reach the quality workforce, so the business world intervened in this course.

It is emphasized that there is a need for innovations in science, engineering, technology, and mathematics education so that the US does not lag behind the rapid developments in Asian countries and to advance in the field of science and technology. In particular, the concern of the US's weakening of the power in global competition and the loss of power has led the country to pioneer the reform movements in education (Altunel, 2018). In order to gain the knowledge and skills that are required by the American business world in the school environment, it is necessary to gain knowledge based on research and curiosity in the classroom environment (Eryaman, 2007; Akgündüz, Aydeniz, Çakmakçı, Çavaş, Çorlu and Özdemir, 2015; Çepni and Ormancı, 2018). As the world develops each day, it gets more complicated and needs individuals who are searching, questioning, using the scientific method to solve the problems they face, associating the knowledge they have learned with their daily life and looking at the world through the eyes of scientists. This can be achieved only through STEM (Science, Technology, Engineering, Mathematics) training. In 1990, the National Science Foundation (NSF) started using the SME & T concept for the first time in its report on education. Then Dr. Smaley who spoke in the same program has called this STEM (Sanders, 2009; Karataş, 2018) and since then STEM (Science, Technology, Engineering, Mathematics) concept has been widely used in education processes. Although the disciplines were dealt with one by one at first, the inadequacy of the outputs led to the emergence of the integrated STEM concept. Integrated STEM is based on the principle of integrating all of them rather than considering each discipline separately, i.e. combining four disciplines of science, technology, engineering and mathematics on the real-world problem (Karataş, 2008, Moore, Glancy, Tank, Kersten, Smith, Stohlman, 2014; Blackley and Howell, 2015).

Although the National Science Education Standards and the Common Core State Standards are major educational reforms in the United States, science education which had been based on research/questioning for many years has been enriched with an engineering design approach with the Next Generation Science Standards reform in 2010. In 2009, Barack Obama emphasized the STEM as one of the goals of education in order to continue through USA's aim of becoming the world's leader in economic and technological development. In order to achieve this goal, 3 billion dollars of funds have been provided annually. Additionally, STEM Centers, Science Centers, and museums have a very important role in STEM areas. The purpose of all this is to enable the US to continue its goal of becoming the world leader in the economic and technological development. It was observed that these studies about STEM in the USA increased the self-efficacy of teachers about this field and they were willing to apply STEM in their courses. In addition, it was observed that they emphasized the necessity of integrated STEM education (Radloff, J., & Guzey, S. 2017; Havice, Havice, Waugaman, & Walker, 2018). However, even if the teachers received STEM training, they had difficulty in mastering the concepts related to this field and experienced problems in conceptualizing them (Breiner, Harkness, Johnson, & Koehler, 2012; Kloser, Wilsey, Twohy, Immonen, & Navotas, 2018). For an effective STEM education approach, there is a need for a large number of financially supported researches. As seen in the US example, education policies of states and governments are changing according to the interests of the country. In this economic system which is guided by scientific and technological developments, it is necessary to have a creative workforce which is equipped with the knowledge and skills of the STEM (Science, Technology, Mathematics, and Engineering) areas. Additionally, the way to solve increasing energy, environment, health and safety problems of the countries and to find solutions to these problems in this axis also depends on labor which has knowledge and skills of the STEM areas. In the 21st century, there is a requirement for a program to integrate science education with engineering and scientific fields in order to be technically advanced and become a production society (National Research Council [NRC], 2012; Akgündüz et al. 2015; Kaptan, Kuşakçı, 2002; Karahan, Bilici, Ünal, 2015). Our country should not be leg behind the economic race in the world. Besides, it should be a front runner and be able to maintain it. This, therefore, depends on investing innovative and rationalist moves in the field of STEM education and updating the STEM curriculum and STEM teacher education according to the needs of today. To increase the innovation capacity of our country with qualified STEM workforce, there is a need to develop skills of young people, in particular female students, in the field of STEM, from the first years of their education, and a professional orientation is needed (Çorlu, 2014). When we look at the Turkish Report on STEM education, it was observed that 100 students who were the most successful in the university exams between 2000 and 2014 dropped their selection rate of professions in STEM fields from 85.63% to 38.23%. Just like Enderun schools in the Ottoman period, there are science high schools, science arts centers, STEM laboratory in universities and children's universities nowadays. It is very important that gifted students in these educational institutions have an innovative, innovative perspective. In addition, during the compulsory education period from pre-school to university, curricula need to be prepared in the 21st century in order to educate individuals with problem-solving skills in knowledge-based life (Akgündüz, Aydeniz, Çakmakçı, Çavaş, Çorlu, Öner, & Özdemir,2015). Due to all these requirements, in 2018, the curriculum of the Science Education program was updated by the Ministry of National Education and science and engineering practices about STEM education were added to the curriculum. The aim of the program is to educate individuals who have knowledge, skills, positive attitude, moral and national values about sciences, approaches of science about engineering, technology, society and environment, and psychomotor skills. Moreover, according to the renewed curriculum, students will design scientific and innovative products in the science courses and introduce them to the innovative science festivals which will be organized at the end of each year. In this process, teachers will guide the students to integrate science, technology, engineering, and mathematics, and try to bring them to a high level of thinking, product development, invention, and innovation. The realization of all this will be possible by integrating engineering design-based science education into the program or curriculum.

To be able to apply STEM training, it is crucial to know the engineering design cycle by teachers. Design-based science education which has been introduced by Wendell, Connolly, Wright, Jarvin, Rogers, Barnett, Marulcu (2010) is consisting of following steps (Ercan, 2014):

1.Determination of problem or requirement

2.Developing possible solutions

3.Determination of the most suitable solution

4.Prototype construction and testing

5. Communication.

In the international researches, it is emphasized that STEM education practices should be in the K-12 education system. It is stated that, especially in primary education, engineering design based applications should be included (Rogers, Postmore, 2004; Wendell, Rogers, 2013; Kolodner, Ryan, Crismond, Fasse, Gray, Holbrook, Camp, 2003; Adams, 2014; Brown, Taylor, Ponambalum, 2016). When the 2018 science education program or curriculum is examined, it can be seen that science and engineering applications are not sufficient to achieve adequate acquirement in the sub-learning field and there are not enough engineering examples in the textbooks. One of the major problems in STEM education is that teachers do not have appropriate pedagogy for STEM education. In this training, teachers need pedagogical knowledge out of their specialized areas (Çorlu, Capraro and Capraro, 2014). The role of teachers in implementing STEM education approach in teaching environments is quite large. Therefore, it is very important to determine the STEM awareness of the teachers, to take the opinions of teachers about STEM and to identify the deficiencies and to train the STEM teachers according to those deficiencies.

When we look at engineering design based researches in our country, it is seen that these are mostly done with undergraduate students or secondary school students (Brown, et al. 2016; Bozkurt Altan, Yamak, Buluş Kırıkkaya, 2016). There is not enough research on the implementation of the engineering design process in the primary school education level. There is no a study in the literature, searching the effect of STEM education on the engineering and technological perceptions of classroom teacher candidates. However, particularly, it is necessary to evaluate primary school years in which basic learning of individuals occurs and their basic skills are shaped. In order to apply STEM training in the courses, teachers must be competent in STEM education. When the studies in the field are examined, it is seen that the studies that reveal the attitudes and perceptions of the classroom teachers or teacher candidates towards the STEM disciplines are lacking.

In this context, the aim of this study is to investigate the effect of engineering design-based science teaching on classroom teachers' perceptions about the areas of STEM disciplines (science, technology, engineering, mathematics, and career).

METHOD

Research Model

This study was carried out in accordance with the single group pretest-posttest design from weak experimental design. In this design, the independent variable is applied to a group and its effect on the dependent variable is investigated (Table 1). Data are obtained by performing certain measurements before and after the independent variable applied to the group (Karasar, 2015).

Table 1 Pre-Test – Post-Test Weak Experimental Pattern with Single Group

Group	Pre-test	Process	Pro-test
Experimental group Classroom Teacher Candidates	Semantic Differential Scale of STEM	Science Education of Engineering Design Process	STEM Semantic Differential Scale

Study Group

In this research, the study group was determined with an easily accessible method. The study group was composed of 28 teacher candidates, 26 of which were female and 2 were male, from a public university in Ankara Province in the spring term of the 2017-2018 academic year. Before starting the applications, the Ethics Committee Permit was obtained from the relevant university and the application permission was received from the faculty where the study will be conducted. Additionally, before the application, approval of the teacher candidates in the study group were taken and thus volunteers participated in the study.

Data Collection Tool

In this study, STEM Semantic Differential Scale which has been developed by Tyler-Wood, Knezek, and Christensen (2010) and adapted to Turkish by Kızılay (2011) was used.

The scale of Tyler-Wood, et al. (2010) which is consisting of 25 items, applied to 164 middle-school teachers and calculated Cronbach's alpha internal consistency coefficient in the light of the obtained data. The scale consists of five sub-factors: science, technology, engineering, mathematics, and career. Each of these sub-factors contains five articles. The reliability of the sub-factors of the scale was determined between 0,84 and 0,93 by Tyler-Wood, et al. (2010). According to the factor analysis, the factor loadings of the articles vary between -0,545 and 0,914. Adaptation study of the scale to Turkish has been carried out by Kızılay (2011). 132 science and primary school mathematics teacher candidates studying at Erciyes University Faculty of Education voluntarily participated in the research process. According to the analysis of acquired data, the KMO value of the STEM Semantic Differential Scale was 0.77; the result of Bartlett's test was significant ($p <0.05$). The Cronbach alpha reliability coefficient of the whole scale was α = 0,82 and the sub-factors were respectively, science α = 0,91; technology α = 0.84; engineering α = 0.86; mathematics α= 0,92 and, career α = 0,87.

In this study, the reliability coefficient of the scale was applied to 57 teacher candidates, other than the teacher candidates already finished the application, who were studying in the second grade of Division of Classroom Instruction Education and the Cronbach alpha internal consistency coefficient was determined as 0.93.

Application Process

The study was carried out in the Science and Technology Laboratory Practices-II class with classroom teacher candidates who were studying in the second grade of Department of Classroom Education within the spring semester of the 2017-2018 academic year. The courses were taught according to a 5E learning model. 5E Learning Cycle Model is one of the most used models of the constructivist approach. It was developed in 1997 by Rodger Bybee et al. (2006). This learning model which is implemented in five stages, consists of these following: "Enter/Engage", "Exploration", "Explain", "Elaborate" and "Evaluate". What to do at each step of the 5 E model is given below:

1. Enter: The student's foreknowledge/preliminary information is assessed, curiosity in the class is aroused and students' attention is gotten.

2. Exploration: Students are encouraged to make researches and observations about the new topic based on the preliminary information of the students. Students test their predictions and hypotheses. And students produce new predictions and hypotheses. They conduct different experiments and discuss with their friends. They record their observations and ideas.

3. Explanation: By encouraging students, the teacher asks them to describe concepts in their own words and shed light on students by explaining the actual, relevant information about the subject.

4. Elaboration: The teacher asks the students to integrate their concepts, explanations, and definitions into what they have previously acquired. The teacher encourages students to broaden the concepts they have learned or the skills they gain or apply them to new situations. Reminds students of different (alternative) descriptions. Thus, the students synthesize their preliminary information and discover the teacher's explanations and implement new knowledge in a different situation. Given information is associated with daily life. In this way, students' conceptual understanding skills develop. Through new experiences and deeper understanding, their comprehension is broadened.

5. Evaluation: Students' knowledge and skills are evaluated.

The application process in this study is as follows. Before the study, the problem situations related to the learning areas and achievements included in the 2018 Science curriculum were prepared. Expert opinion was taken to determine the suitability of the problems for STEM training. Before starting to practice, "STEM Semantic Differential Scale test was applied as a pre-test to 28 teacher candidates. In the first week of the study, teacher candidates were informed about STEM education and engineering design cycle by the researcher. Teacher candidates in the study group were divided into 6 heterogeneous groups according to their mean score in the preliminary tests and an innovation study was conducted with groups in order to make them understand the engineering design process better. In this study, students were asked to revise, develop and revise a toolkit in their classrooms by considering technological and scientific developments in the following 10 years. During the innovation study, students in the groups presented their ideas individually and then presented their ideas to their group friends. Then in order to determine the most appropriate opinion about innovation, the group discussed the matter. Each group was asked to draw a detailed prototype of the design for their decision about their innovation. Thus, students had the chance to experience the problem of defining, data gathering, decision making, planning and implementation phases in an engineering design cycle.

After the sample application, the main application was started. 5 E model was used while the lectures were covered by the researcher. During the elaboration stage, problem statuses in which teacher candidates could use the engineering design process were given to them and they were asked to design the products to solve the problems. Why the elaboration stage is chosen? The reason behind this choice is encouraging the student to adapt the knowledge in his/her daily life. It should be remembered that this knowledge is obtained in the elaboration stage of this course. For this reason, students were faced with new problem statuses during the application process. Engineering design-based applications lasted 14 weeks, 2.5 hours per week. At the end of the study, test "STEM Semantic Differential Scale" was used as a final test for teacher candidates.

Data Analysis

Quantitative analysis was used to analyze the data collected in the study. In order to be able to analyze with a parametric test, conditions such as the normal distribution of data and homogeneity of the main mass variances are required. Therefore, the normality test for the perception points towards STEM disciplinary areas of classroom teacher candidates was conducted. Before and after the class of Science and Technology Laboratory Practices –II based on engineering design, in comparison of the mean scores of classroom teacher candidates for STEM disciplines (science, technology, engineering, mathematics and career), as the data met the assumptions of parametric tests, dependent groups t-test was used. SPSS 22 package program was used in data analysis.

RESULTS

The findings of this research, in which the effects of engineering design-based science teaching on the perceptions of teacher candidates in STEM disciplines (science, technology, engineering, mathematics, and career) are examined, are presented below as tables.

In order to analyze with a parametric test, conditions such as a normal distribution of data and homogeneity of the main mass variances are required. In this study, the normality test was conducted in order to see whether the perception scores of classroom teacher candidates in STEM disciplinary areas are normal. According to Ozturk (2002), when pre-test and post-test score distributions are being examined, if the group size is smaller than 50, Shapiro-Wilk test is performed and if the sigma value is less than 0,005, H0 hypotheses are accepted in the pre-test and post-test groups. This result shows that the data is normally distributed in the 95% confidence interval (Pallant, 2016). Because there is a normal data distribution in this study, a t-test was used by the groups that are dependent on parametric tests.

There were teacher candidates who are taken the courses according to engineering design-based learning. In order to determine whether there is a significant difference between the average STEM science discipline perception scores of these teacher candidates, a t-test was conducted for the dependent groups and results are given in Table 2.

Table 2 Science Discipline, Dependent Sample T-Test Results

Science Discipline	N	$\bar{X}$	sd	T	P
Pre-test	28	4.61	1.16	-3.456	0,002 *
Post-test	28	5.33	1.40		

p<0.005* The effect size Cohen's d was found to be 0.56. This value is of medium size according to Cohen (1988).

As seen in Table 2, the difference between the average scores of the classroom teacher candidates in the science disciplines with EDBT was found statistically significant in favor of the post-test, t (-3,456), p<0.05. It can be said that, among the average scores of classroom teacher candidates' perceptions of science discipline, the difference of 0,73 in favor of the post-test was arisen from EDBT.

To understand whether there is a significant difference between the average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in STEM mathematics discipline before and after the process, the dependent groups t-test was performed and the results are given in Table.3.

Table 3 Mathematics Discipline, Dependent Sample T-Test Results

Science Discipline	N	$\bar{X}$	sd	T	p
Pre-test	28	4.77	1.25	-.797	.443*
Post-test	28	5.00	1.39		

p> 0.005

As seen in Table 3, although the post-test average score of the classroom teacher candidates, who take their lessons within the scope of EDBT, for mathematics discipline, which is among the STEM disciplines, was higher than the pre-test average score, the difference between the pre-test and post-test average scores was not statistically significant, t (-796), p> 0.05. Although the difference between the pre-test and post-test average scores is not significant, it can be said that the increase of 0,23 was arisen from EDBT practices.

To understand whether there is a significant difference between the average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in STEM engineering discipline before and after the process, the dependent groups t-test was performed and the results are given in Table.4.

Table 4 Engineering Discipline, Dependent Sample T-Test Results

Science Discipline	N	$\bar{X}$	sd	T	p
Pre-test	28	4.48	1.28	-3.599	0.001*
Post-test	28	5.36	1.12		

*p< 0.001 The effect size Cohen's d was found to be 0.73. This value is of medium size according to Cohen (1988).

As seen in Table 4, the difference between the average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in the engineering discipline, which is among the STEM disciplines, was found statistically significant in favor of the post-test, (-3,081), p<0,05. It can be said that, among the pre and post-EDBT perception average scores of classroom teacher candidates for engineering discipline, it can be said that the difference of 0,88 was arisen from EDBT.

To understand whether there is a significant difference between the average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in STEM technology discipline before and after the process, the dependent groups t-test was performed and the results are given in Table.5.

Table 5 Technology Discipline, Dependent Sample T-Test Results

Science Discipline	N	$\bar{X}$	sd	T	p
Pre-test	28	5.20	1.23	-2.175	0.039
Post-test	28	5.76	1.15		

p> 0.005

As seen in Table 5, the difference between the perception pre-test and post-test average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, for technology discipline, which is among the STEM disciplines, was not statistically significant, t(-2,175), p>0,05. Among the perception average scores of classroom teacher candidates for technology discipline before and after EDBT, although the difference of 0.56 in favor of the post-test is not statistically significant, it can be said that this difference was arisen from the positive effect of EDBT.

To understand whether there is a significant difference between the perception average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in STEM career discipline before and after the process, the dependent groups t-test was performed and the results are given in Table.6.

Table 6 Career Discipline, Dependent Sample T-Test Results

Science Discipline	N	$\bar{X}$	sd	T	p
Pre-test	28	4.67	1.08	-3.598	0.001*
Post-test	28	5.41	1.30		

* p< 0.001 The effect size Cohen’s d was found to be 0.61. This value is of medium size according to Cohen (1988).

As seen in Table 6, the difference between the perception pre-test and post-test average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, for career discipline, which is among the STEM disciplines, was statistically significant, t(-3,598), p<0,05. Among the perception average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, for engineering discipline, it can be said that the difference of 0.74 in favor of the post-test was arisen from EDBT practices.

To understand whether there is a significant difference between the perception average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, in general perception average scores for STEM discipline before and after the process, the dependent groups t-test was performed and the results are given in Table 7**.**

Table 7 General STEM Disciplines, Dependent Sample T-Test Results

Science Discipline	N	X̄	sd	T	p
Pre-test	28	4.75	1.01	-3.299	0.003*
Post-test	28	5.37	1.11		

* $p< 0.005$ The effect size Cohen's d was found to be 0.58. This value is of medium size according to Cohen (1988).

As seen in Table 7, pre-test average scores of the classroom teacher candidates, who take their lessons within the scope of EDBT, concerning the general perception of STEM disciplines, was found as 4,75 and average scores of post-test was found as 5,35. Between pre-test and post-test average scores, there was a statistically significant difference in favor of the post-test, t (-3,140), $p <0.05$. As a result, it can be said that the difference of 0,62 between the average scores before and after EDBT of the general perception of the EDBT classroom teacher candidates in the favor of post-test, was arisen from the practices.

CONCLUSION

In this study, in the context of Science and Technology Laboratory Practices -II course, engineering design-based teaching was applied to teacher candidates. STEM Semantic Awareness Scale was conducted as a pre- and post-test to 28 classroom teacher candidates who were in the study group. In this way, it was aimed to reveal the perceptions of classroom teacher candidates about STEM disciplines. When the data obtained according to sub-dimensions of scale are examined;

The study, it was observed that STEM activities applied to classroom teacher candidates, changed the *perception towards science discipline* positively. Yamak, Bulut, Dündar (2014) examined the effects of FeteMM activities on the attitudes of 20 middle school 5. grade students towards science in their study. At the end of the study, it was observed that secondary school students positively changed their attitudes towards science. Teachers and teacher candidates can change students attitudes and perception towards a course or discipline. In another study conducted by Hacıoğlu, Yamak, Kavak (2016), it was observed that engineering-based science education positively influenced teachers' opinions. Additionally, teachers who participated in the study emphasized that they were willing to apply engineering design-based science education in their own courses but there should be supportive training on this subject (Hacıoğlu, Yamak, Kavak, 2016). Yildirim and Selvi (2017), in a part of their study, examined the impact of STEM practices and complete learning on the secondary school students' attitudes towards STEM and their motivation for science, and they concluded that both of these activities contributed positively. In this study, it was determined that the perceptions of teacher candidates towards science differed significantly and statistically at the end of the application. This result can be interpreted that the engineering design-based process has a positive effect on students' perceptions about science. In addition, based on this conclusion, it is clearly seen that new approaches are needed in the science courses in order to gain students' interest in science.

At the end of the study, it was concluded that the classroom teacher candidates' *perceptions about mathematics discipline* changed but this change was not statistically significant. Similarly, Guzey, Moore, Harwell (2016) carried out 20 engineering design based STEM applications in their research with 48 teachers. As a result, it was concluded that the relationship between mathematics, science, and engineering did not have a strong impact. Pekbay (2017) examined the impact of FeteMM activities on secondary school students' ability to solve daily life problems and their interest in FeteMM areas. Similarly, at the end of the research, it was observed that applied activities did not make a difference in the fields of mathematics and engineering and its effect was low. Gülhan and Şahin (2016) examined the impact of STEM integration on the perceptions and attitudes of the 5th-grade students in STEM disciplines. As a result, in perception test, especially, engineering, technology, and career were in the forefront, and they found that there was no increase in attitude towards mathematics although there was an increase in attitude towards science. Especially in the mathematical dimension, the desired level of development has not been achieved in subjects such as perception, interest, and attitude. This may be caused because teacher candidates get negative perceptions and attitudes towards their mathematics courses. It may also affect the perception, interest, and attitude of mathematics, which is difficult and time-consuming. Nevertheless, there are studies in the literature stating that studies conducted by applying STEM activities increase awareness of STEM in science and mathematics (Yıldırım, 2017; Gökbayrak, Karışan, 2017). It is stated that the activities that will change teacher candidates' perception of mathematics, will enrich the knowledge of mathematics and give an opportunity to use it in their lives will affect the perception of mathematics positively.

It is concluded that engineering design based applications improve teacher candidates' *perceptions about engineering discipline*. In a study conducted by Sumen and Çalışıcı (2016), after the STEM education, it was asked to teacher candidates whether there was a relationship between science course gains and engineering-based STEM education. In general, teacher candidates stated that there would be a harmonious relationship if science program and field of engineering integrated. Additionally, they made a positive feedback on STEM approach. Marulcu and Sungur (2012), in their study with 44 teacher candidates, concluded that teacher candidates had some basic knowledge about engineering but did not have enough knowledge about engineering process to be able to use it in science and technology concepts. Similarly, Sungur Gül, Marulcu (2014) in their study which was conducted with candidates of science teachers, researched the effect of lego use on the perspectives of teachers on the application of courses which was covered through engineering design method. As a result of the study, the importance of engineering and familiarity with engineering and the importance of lego usage and familiarity with legos were examined. It was seen that there was a significant difference between the pre-test and post-test scores of the teachers when the result of these examinations was analyzed. However, in the same study, there was no significant difference between the pre-test and post-test scores of the teachers about the characteristics of the engineers. As a result, it is seen that teacher candidates support covering science courses through engineering basis but they do not have a broad knowledge about the meaning of the engineering term, its professional content and how to integrate them with the education system. In Short, after the courses which are processed by engineering design-based process, there are positive changes in teacher perceptions.

Another result of the study, although the mean scores of classroom teacher candidates about *technology discipline* were higher in the post-test it was seen that the difference between the pre-test and post-test was not significant. During the applications, teacher candidates benefited from technology tools such as design programs, coding systems and so on. However, the rise in technology perceptions during the study is not significant. This may be caused because of inadequate emphasize on technology discipline. Altas (2018) investigated the effects of STEM applications on the technological perceptions of teacher candidates in a stage of his postgraduate thesis. While there was a significant difference in "Positive Faith to Technology in Education" subtitle, there was no significant difference in "Impact of Technology on Undergraduate Program" subtitle. While technological processes used between beginning and end of the application vary, from this, the constitution of no difference in regard to quantitative perception, does not mean that there is no positive progress among them in this understanding. Individuals can achieve more effective results by enriching the ways of revealing their perceptions of technology. Additionally, the fact that teacher candidates think that they should already benefit from technology in the 21st century and they already have a technology perception as a STEM discipline at the beginning of the study could be the causes of this result.

Also, positive developments were observed in the *perceptions of teacher candidates about career discipline* pre and post-application. In a study conducted with 246 secondary school students within the scope of STEM projects, Knezek, Christensen, Tyler-Wood & Periathiruvadi (2013) investigated the effects of their application to students STEM content information and perceptions. As a result of this research, similarly, there have been positive developments in students' perceptions about STEM content information, STEM issues and their careers. In his doctoral thesis, Ercan (2004) conducted a seven-week course with 30 secondary school 7th-grade students. In the applications for "Force and Motion" unit, students' academic achievements, decision-making skills, and engineering knowledge were examined. At the end of the applications, students who do not think engineering as a profession changed their mind and they started considering engineering as an alternative profession. They also added their perception that engineering was a male-only profession has been changed. Pekbay (2017) examined the effects of FeteMM activities on secondary school students' skills in solving daily life problems and their interest in FeteMM areas. He added that students who had little knowledge about the professions in this field had a comprehensive knowledge at the end of the study. In his postgraduate thesis, Altas (2018) investigated the effects of STEM education approach on the engineering perceptions of classroom teacher candidates and a positive change in the engineering perceptions of the classroom teacher candidates were observed. When evaluated in light of similar studies, it can be mentioned that STEM education practices constitute positive experiences related to engineering and engineering profession.

Finally, a statistically significant difference was found in favor of posttest among the classroom teacher candidates' general perception mean scores for STEM disciplines and science lessons covered according to engineering design-base. When the studies are checked, it is seen that the perceptions of the STEM disciplines as a whole have been positive with the results of the separate disciplines (Gökbayrak, Karışan, 2017; Pekbay, 2017; Yıldırım, 2017). In their study, Gülhan and Şahin (2016) found that STEM integration makes 5th-grade students' to comprehend more effectively the 5th-grade science concepts by improving their perceptions about engineering and their tendency towards occupations in STEM-related fields.

In brief, in this study, generally, a positive change has taken place in the perceptions of classroom teacher candidates towards STEM disciplines. It is an important step in the name of education that future teachers of students will be educated as individuals who are dominant in the changing and renewed educational programs and apply them effectively. The perceptions of teacher candidates will have an impact on their teaching methods and will make it easier to reach the targeted achievements.

RECOMMENDATIONS

When the results of this research are evaluated, it is determined that in general, the interaction between science and engineering design based process is positive but there are some points to be developed about some disciplines. More studies should be conducted about how STEM education process examines especially mathematics and technology fields. It should be understood that the importance of the integrated STEM approach by incorporating science, mathematics, technology and engineering disciplines into the process, without forgetting that each discipline has a special and separate contribution to STEM Education. The use of technology in education should be followed up and applied in classrooms. In order to develop engineering skills, the level of knowledge about this area needs to be increased. Thus, students can understand the processes of STEM-related professions and deal with them. Individuals should have 21st-century skills such as problem-solving, critical thinking, creative thinking, whatever profession they choose in the direction of their career. In this respect, professions and job descriptions can be emphasized during lessons. In order to find a seat among the strongest societies of the future, it should be remembered that individuals should have the innovative vision and productive skills. By taking advantages of the results of this and similar studies, solutions should be developed about what kind of problems are encountered in which discipline and how to solve them.

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