iojes
www.iojes.net

International Online Journal of Educational Sciences

ISSN: 1309-2707

# Determination of the Effects of Problem-Based STEM Activities on Certain Variables and the Views of the Students

*Research Article*

**Mustafa UGRAS**[1]

[1]*Firat University, Faculty of Education, Elazig, Turkey,* ORCID: 0000-0001-6921-0178

**To cite this article:** Ugras, M. (2019). Determination of the Effects of Problem-Based STEM Activities on Certain Variables and The Views of the Students, *International Online Journal of Educational Sciences*, 11(1), 1-22.

ARTICLE INFO

*Article History*:
Received: 03.01.2019

Available online:
16.02.2019

ABSTRACT

The aim of the present study was to investigate the effects of the problem-based STEM activities on STEM profession interests, STEM attitudes and self-efficacy perceptions of eighth grade students and to determine their views on STEM education. Thus, a mixed research method was used. In the quantitative section of the study, pre-test-post-test single-group research model and case study methodology was used in the qualitative section of the study. STEM Career interest Scale, STEM Attitude Scale, Self-Efficacy Resources Scale, and an interview form, developed to determine the student views on STEM educational approach, and student and researcher diaries were used as data collection instruments. Forty-eight (28 female, 20 male) eighth grade students attending a school in Elazığ province urban center participated in the study. Participating students attended an 8-week STEM education program (4 hours per week). Kolmogorov-Smirnova test was applied to determine normal distribution of the collected data and it was determined that the data exhibited normal distribution. Paired samples t-test results demonstrated that there was a significant difference between STEM profession interests, STEM attitudes and self-efficacy perceptions of the students. It was determined that the participating students expressed views that STEM education was didactic and entertaining, improved their creativity, was motivating and elaborated their skills. Furthermore, the students stated that STEM education allowed them to utilize their knowledge, developed their creativity, improved their professional preferences, groupwork, and possibility to achieve better results in the course.



**Keywords:**
STEM career interest, STEM attitude, self-efficacy perception, problem-based STEM activities, student views.

## Introduction

Science, technology, engineering and mathematics (STEM) education in the 21st century, known as the age of technology, plays an important role in cultural and economic development with an innovative, creative

[1] Corresponding author's address: Firat University, Faculty of Education, Elazig, Turkey,
Telephone:
Fax:
e-mail: mugras@firat.edu.tr
DOI: https://doi.org/10.15345/iojes.2019.01.001

and problem-solving approach (Cooper & Heaverlo, 2013). The acronym STEM (science, technology, engineering and mathematics), proposed by the American National Science Foundation (NSF), is now widely accepted and used to express a specific knowledge and application area today (Dugger, 2010). The term science (S) tackles physics, chemistry and biology disciplines, the laws of nature and the functioning and application of the related facts, principles and concepts (Bal, Pearson and Schweingruber, 2014, p. 14). Technology (T) includes tools, information systems, organizations and devices that allow the design and use of the technological products that are produced to meet the needs of individuals. Engineering (E) tackles the knowledge on the development of products, the design and resolution of problems. Mathematics (M) deals with models and relationships between quantities, numbers and spatial objects (Honey et al., 2014). Due to the benefits of STEM education on national economy, teachers and educational institutions work hard to achieve the desired level of integration of STEM and science education (David & Sharon 2006; Tseng, Chang, Lou, & Chen, 2013).

The problem-based learning strategy that allows the students to conduct research, integrates theory and practice, and allows the application of knowledge in schools where STEM education is adopted (Savery, 2006). Problem-based learning was initially used in medical schools 40 years ago and is a significant educational approach (Savery, 2006). The constructivist nature of problem-based learning was designed to replace traditional course instruction methods in medicine to allow interdisciplinary learning and to allow the students to guide themselves through real-world problem solving (Barrows, 1996). It was determined that problem-based learning leads to an entertaining educational process and the participation of the students in STEM topics increases (Barrows, 1996; Baran & Maskan, 2010; Cerezo, 2015; Massa, Dischino, Donnelly & Hanes, 2009; Mergendoller, Maxwell & Bellisimo, 2006). Previous studies demonstrated that problem-based learning could develop creativity (Bell, 2010), critical thinking and problem-solving skills (Albanese & Mitchell, 1993; Ertmer, Schlosser, Clase & Adedokun, 1993), reflective thinking skills (Dominguez & Jamie, 2010), communication and collaboration skills (Bell, 2010; Dominguez and Jamie, 2010; Allen, Duch & Groh, 1996; Lou, Shih, Ray-Diez and Tseng, 2010) and self-learning skills (Bell, 2010; Albanese & Mitchell, 1993; Norman & Schmidt, 2000) of the students. Furthermore, teachers stated that they were able to integrate the 21st century skills in the instruction and evaluation processes when utilizing the problem-based learning (Ravitz, Hixson, English & Mergendoller, 2000). Eberlein et al. (2008) suggested problem-based learning in STEM education, since students would learn about the topics more effectively and permanently when they discuss the topic and apply their knowledge in a real-life problem. Since problem-based learning strategies often emphasize real-world problem-solving and 21st-century skills, several STEM educators allow the students to connect the knowledge learned in the classroom and the real-life applications of the same knowledge. It was considered that problem-based learning would contribute positively to STEM career interests, STEM attitudes and self-efficacy beliefs.

Although the number of STEM-based occupations has increased in recent years, there has been a decrease in the number of individuals who preferred STEM careers (Medeiros, 2011; Ramsey & Beathe, 2013; Ramsey & Beathe, 2013; , 2012). Countries such as Austria, France, Germany, Honduras, Mexico, the Netherlands and Switzerland do not have sufficient number of qualified individuals who could utilize and develop technologies that could increase domestic production (Schwab & Sala-i-Martín, 2012). Although Turkey needs about 1 million individuals in STEM fields until 2023, only 31% of this requirement will be met (TUSIAD, 2017). Similarly, in several countries, a higher number of individuals are required to be employed in the fields of science, technology, engineering and mathematics (Hill, Corbett & Rose, 2010; Regisford, 2012; Yıldırım & Selvi, 2015). Political leaders around the world collaborate with large businesses, organizations and teachers to employ more individuals in STEM fields, train more individuals, expand career opportunities for women and minorities, and develop STEM innovations in the future (e.g., White House Science and Technology Policy Office, 2012; Regisford 2012; Tech Women, 2013).

STEM professions play an important role in national economic growth and development. Thus, these professions are considered as occupations of the future (Langdon, Mckittrick, Beede, Khan & Doms, 2011). Children between the ages of 11 and 14 begin to discover and recognize the accupations that may be associated with their interests and skills (Super, 1953). Tai, Liu, Maltese and Fan (2006) stated that the career choice of the students is shaped at middle school level. Similarly, Sadler, Sonnert, Hazari and Tai (2012) reported that the best predictor of the occupational interests of students at the end of high school was to determine the career interests of the students at the beginning of the high school and emphasized the importance of pre-high school experiences in the development of these interests. Furthermore, a student's beliefs on competences and interests begin to form in the same period (Simpkins et al., 2006). Relevant institutions emphasized that students should specialize in STEM professions and their interest in these professions should start during the middle school education (Kier, Blanchard, Osborne & Albert, 2013; Sadler et al., 2012). Students are required to participate in problem-based, project-based and applied instructional activities that include various strategies about personal and real-world interests to develop interest in STEM professions at an early age (Christensen & Knezek, 2015). Palmer (1997) stated that students need experiences to recognize that science is associated with them and a career in science is a viable option. Certain studies demonstrated that STEM initiatives and early experiences positively affect the perceptions and plans of secondary school students (Dejarnette, 2012).

Social Cognitive Career Theory (SCCT) was proposed by Lent, Brown and Hackett (Lent, Brown & Hackett, 1994) and based on Bandura's general Social Cognitive Theory (Bandura, 1986). The SCCT emphasizes the correlation between personal, environmental and behavioral variables that could predict an individual's interests and career choice, and aims to test specific hypotheses on the correlation between various structures related to career interests and intentions (Lent, Brown, & Hackett, 1994; Lent, Brown, & Hackett, 1996; Lent & Brown, 2006). STEM attitudes and career interests are the main components of SCCT (SCCT; Lent, Sheu, Gloster & Wilkins, 2010).

For the achievements of students in STEM education, their attitudes towards science, technology, engineering and mathematics disciplines are significant. The increase in these attitudes would lead to an increase the STEM career interests. Students' attitudes towards science generally deteriorate as the education level increases (Osborne, 2003; Simpson & Oliver, 1990). Thus, it is of great importance to improve student attitudes towards these disciplines during the first stages of education. There are certain views arguing that educational and instructional environment of the students could affect their motivational beliefs and attitudes towards scientific fields positively (Fortus & Vedder-Weiss, 2014; Vedder-Weiss & Fortus, 2010). Students' attitudes and motivations could be improved by education programs that are designed to aim active participation of the students in the education process (Schnittka, Evans, Won, & Drape, 2015; Cutucache, Luhr, Nelson, Grandgenett, & Tapprich, 2016; Chittum, Brett, Sehmuz & Ásta, 2017). It was suggested that students' attitudes would increase with STEM education that allows active participation of the students.

The SCCT is based on the principle that when an individual believes in his/her skills and expects positive outcomes, the interest of the individual in that career would develop and the individual would have the intent to pursue that career (Lent, Brown & Hackett, 1994). The SCCT argues that individuals' self-efficacy and beliefs on the outcome of their efforts improve their interests (whether they like the related conditions or not). Therefore, individuals are interested in activities that they believe they can perform well. Thus, individuals develop goals to pursue academic or career activities that are compatible with their interest areas as well as their self-efficacy and outcome expectations (Sheu et al. 2010). SCCT stated that self-efficacy beliefs were among the significant predictors of career interest. Bandura (1994) defined self-efficacy as the impression about an individual's ability to conduct certain activities. Self-efficacy beliefs indicate the ability of an individual to conduct a certain behavior under difficult and stressful conditions (Bandura, 1997). For example, it is about whether or not the students believe they could be successful in science or mathematics. Study findings demonstrated that one of the important reasons for the fact that secondary school students do not prefer STEM careers was their low self-efficacy beliefs about STEM topics (Betz & Hackett, 1983; Borgen & Betz, 2008; O 'Brien, Martinez-Pons, & Kopala, 1999; Wigfield. & Eccles, 2000). Students' interest and self-efficacy are the most important factors for career choice (Armstrong & Vogel, 2009; Lent et al., 2010). In a study conducted by Byars-Winston (2010), it was concluded that high school students with high self-efficacy in mathematics and science were more interested and more willing to study in STEM. The stronger a student's interest and self-efficacy belief, the higher her or his determination for a career choice (Tracey, 2010) and the permanence of this choice (Lent et al., 1994).

There are limited number of studies in the literature on STEM education with active student participation. Doğanay (2018) analyzed the effects of problem-based STEM activities on the academic achievement of 7th grade students and their science attitudes. Study findings demonstrated that the activities affected the academic achievement of the students and their science attitudes. In a study by Cho and Lee (2013), the effect of STEM education-based courses on problem solving and creative personality skills of the students was investigated. Study findings demonstrated that although the students were challenged at the beginning, their achievements, problem solving and creativity skills improved in the following weeks. Babemović, Pale and Burušıć (2018) conducted STEM activities with 1484 10-12 years old students. They determined that there was a positive change in students' attitudes towards scientists and STEM career interests. In a study, Vennix, Den Brok, and Taconis (2018) found positive attitudes and motivation towards STEM in students who participated in STEM-supported activities. Yamak, Bulut, and Dündar (2014) investigated the impact of STEM activities on fifth grade students' scientific process skills and attitudes towards science in a study. They concluded that the STEM activities improved the students' scientific process skills and attitudes towards science.

Although there is a need for 1 million individuals in STEM fields in Turkey until 2023, only 31% would be available by that date (TUSIAD, 2017) and the low standing of Turkish students in TIMSS and PISA exams among OECD countries, led to the fact that there are certain problems in the country. In order to develop the skills that these exams aim to measure and to meet the qualified manpower requirements in Turkey, STEM education should be extended. Since STEM education would contribute to the students' skills to adapt their knowledge to real life conditions and to use this knowledge both in and out of the school, it would also improve their orientation towards STEM careers. Thus, the number of studies on STEM education should increase. Literature review demonstrated that studies on the effects of STEM education on certain variables were limited. Based on the above-mentioned information, the present study aimed to conduct an education program with problem-based activities to instruct STEM topics and concepts to 8th grade students and to determine the student views on STEM career interests, STEM attitudes, self-efficacy beliefs and STEM education. It was considered that the findings would contribute to the literature.

**The Aim of the Study:**

The aim of the present study was to investigate the impact of problem-based STEM activities on STEM career interests, STEM attitudes, and self-efficacy perceptions of eighth grade students and to determine the views of these students on STEM education. Based on these objectives, the following sub-problems were determined.

1. Is there a significant difference between pretest and posttest STEM career interest scores of eight grade students that participated in STEM activities?

2. Is there a significant difference between pretest and posttest STEM attitude scores of eight grade students that participated in STEM activities?

3. Is there a significant difference between pretest and posttest self-efficacy scores of eight grade students that participated in STEM activities?

4. What are the views of the students on STEM education?

## Method

In the study, a mixed research design that included both quantitative and qualitative methods was used in the study to conduct a detailed analysis of the research problem (Creswell, 2009). The quantitative study data were collected with pretest-posttest single group experimental design. The experimental design used in the study leads to the determination of the success or failure of the implemented program based on the change and the development between the results (Shea, Arnold & Mann, 2004). The experimental design used in the study was preferred due to the emphasis by Creswell (2012) that the preference of the pretest posttest experimental design in development and implementation of a new educational approach is natural for this type research. In the qualitative dimension, the case study method was used. The case study method is used in studies that require the analysis of one or more cases in depth, where the factors that affect these cases of affected by the case are investigated with a holistic approach (Yıldırım & Şimşek, 2013).

**Table 1.** Experimental Model

| Pretest | Application | Posttest |
|---|---|---|
| STEM Career Interest Scale,<br>STEM Attitude Scale,<br>Self-Efficacy Scale | Educational program assisted with problem-based STEM activities | STEM Career Interest Scale,<br>STEM Attitude Scale,<br>Self-Efficacy Scale,<br>Semi Structured Interview |

### The Study Group

The study group included 48 eighth grade students attending a school in Elazığ province, Turkey. Twenty-eight of the volunteering students in the study were female and 20 were male (Table 2) and none received previous STEM-based training. The convenience sampling method was used to determine the students that would participate in the study. The students who participated in the study were assigned codenames such as T1, T2, T3,… T48 due to ethical concerns.

**Table 2.** Number of participating students

| Gender | *f* | % |
|---|---|---|
| **Female** | 28 | 58,34 |
| **Male** | 20 | 41,66 |
| **Total** | 48 | 100 |

### Application Process

In the present study, an educational program was developed to determine the effects of problem-based STEM activities on eighth grade students' STEM career interests, STEM attitudes and self-efficacy perceptions and to observe their views on STEM education. In the program, the activities listed below were implemented with the students for 8 weeks, 4 hours a week, outside the school hours. The program was developed based on the STEM concepts and the achievements listed in Ministry of National Education middle school curricula. For the activities included in the program, scenarios based on daily life were developed as detailed in the examples below and the activities were conducted based on these scenarios. Initially, the students were allowed to assess the problems, the information required for the solutions of these problems and the required guidance were provided, and research was conducted to prevent incomplete knowledge. Then, products for the solution of problems were developed with collaboration within work groups, and finally, the products were assessed. During the first week of the training program, general information was instructed, and problem-based learning approach and logic of STEM education were explained using sample applications. During the last week, a general discussion was conducted on STEM education with the students.

**Catapult:** In the context of energy transformation, a catapult that is capable of kinetic and potential energy transformation was designed. These catapults designed by the students were used to conduct competitions among the groups.

**Dynamometer and equal arm scale:** A dynamometer was designed to measure weight, and equal-arm scales were designed for measurement of mass. The concepts of mass and weight were compared. A competition was organized using the dynamometer and equal arm scales designed by the students to allow them to assess the products they designed.

**Fun train:** A fun train was designed to demonstrate the correlation between work and energy concepts, kinetic and potential energy transformations. Railroads with different heights and properties were constructed and the train ranges were compared.

**Hydraulic elevator:** An elevator that lifts with liquid pressure to different elevations using different injectors was designed. Force was applied to injectors of different sizes and elevators that lift to further elevations and those who bear higher loads were designed. Due to the force exerted on the injector, elevators that lift to further elevations and those who bear higher loads were designed.

**Heat-insulated structures:** Heat-insulated storage containers were designed. Changes in the temperature were measured by a thermometer. Temperatures in storage containers produced with different insulation material were measured.

**Periscope:** A periscope was designed to allow short students to watch their peers while playing in the school yard. The products were designed by determining the reflections of the light on smooth and rough surfaces, the degrees of light reflection on different types of mirror and the position of the mirrors.

**Ramp:** The correlation between the concepts of work and energy was applied to the theme of kinetic and potential energy. While holding the inclined plane at a constant height, different masses were placed on a vehicle, and the vehicle was placed on the inclined plane, finally hit the wedge at the bottom and the drag of the wedge with the impact of the vehicle was recorded. This application was repeated by holding the inclined plane at different heights.

**Sample scenario:** The rivers have risen this year due to torrential rain. Problems were encountered in delivering food to animals living across the river. A low cost and reliable platform was required within a short period of time. How would you design this platform?

### Data Collection Instruments

In the present study, STEM Career Interest Scale, STEM Attitude Scale, Self-Efficacy Resources Scale, an interview form, student and researcher diaries were used to determine the impact of problem-based STEM activities on STEM career interests, STEM attitudes and self-efficacy perceptions of students and their views on STEM education. The interview form was developed by the author and finalized after the views of an educator in the field were obtained. Students who participated in the program were asked to make a journal entry about the activities at the end of every week of training. The students were not limited about their journal entries. Furthermore, a researcher journal was used to record the observations and considerations of the participants during the study (Johnson, 2015). Semi-structured interview technique was used to determine the views of STEM students at the end of the training program. In semi-structured interviews, the participants can express the world they perceive in their own words (Merriam, 2013).

For the internal validity of the qualitative dimension of the study, data variation including interviews, student and researcher journals was ensured. An interview form was developed by the author based on expert opinion. Then, two different students were asked to evaluate the form for comprehensibility. The interview form was finalized based on the opinions of the experts and students. The answers of the students to the questions were reconfirmed. The interviews lasted about 15-25 minutes. The answers of the students are presented in the findings section. Furthermore, interviews were recorded with a voice recorder and data loss was prevented to ensure internal reliability. In addition, the findings were presented directly without interpretation of the authors. To establish the external validity of the study, the research method, study group, data collection instrument, data collection, data analysis and findings were clearly described. Furthermore, the data obtained were analyzed and the author aa different field expert. Finally, the findings were compared with the results of various studies.

***STEM Career Interest Scale***

STEM-CIS, developed by Kier, Blanchard, Osborne and Albert (2013) based on Bandura's Social Cognitive Learning Theory, was used to determine students' interest in STEM careers. The original scale includes four sub-dimensions (science, technology, mathematics and engineering) and 44 items. The scale was adapted into Turkish language by Koyunlu-Ünlü, Dökme & Ünlü (2016). The Turkish adaptation of the scale is a 5-point Likert type scale that includes four sub-dimensions (science, technology, engineering and mathematics) and 40 items. The Cronbach alpha coefficients of the scale were science $\alpha$ = .86, technology $\alpha$ = .88, engineering $\alpha$ = .94, and mathematics $\alpha$ = .90, respectively.

***STEM Attitude Scale***

The STEM Attitude Scale was developed by Faber, Unfried, Wiebe, Corn, Townsend and Collins (2013) and translated into Turkish language by Yıldırım and Selvi (2015). The 5-point Likert type scale includes 37 items. The Cronbach alpha coefficient for the entire scale was calculated as 0.94. Furthermore, factor analysis results for the scale were as follows: CFI = 0.90, NFI = 0.95, GFI = 0.86, AGFI, 0.84, IFI = 0.96, SRMR = 0.53 and RMSEA = 0.063.

***Self-Efficacy Resources Scale***

In order to determine the self-efficacy perceptions of eighth grade students, the Self-efficacy Resources Scale, developed by Lent et al. (1991) and translated and adapted to Turkish language by Kiran (2010), was used. The scale includes four sub-dimensions: past experiences, indirect experiences, verbal persuasions and psychological status. The Cronbach alpha coefficients of the scale subscales vary between .54 and .83.

**Data Analysis**

Data were collected before and after the implementation of STEM activities. In order to determine normal distribution of the data, Kolmogorov-Smirnova, which is recommended for use when the sample size is over 30, was used (Ak, 2008). The finding is presented in Table 3. Table 3 would demonstrate that the p value was greater than 0.05 evidenced the normal distribution of the dataset. Thus, paired samples t-test, a parametric test, was applied. In cases, where there was a significant correlation between the variables, effect sizes were examined and the impact on the variables was interpreted. In paired samples t test, the effect size was calculated by the ratio of t to the square root of the sample size (Green & Salkind, 2005).

**Table 3.** Normality Test Results

| | Kolmogorov-Smirnova | | |
|---|---|---|---|
| | **Statistic** | **df** | ***p*** |
| **STEM Attitude** | .088 | 48 | .200 |
| **Scientific Creativity** | .089 | 48 | .200 |
| **Motivation Belief** | .113 | 48 | .162 |

The data obtained with the interviews conducted with the students and student and researcher journals were analyzed with the content analysis method. Content analysis was used to identify and quantify the presence of words, concepts, themes, idioms, characters or sentences in one or more texts (Kızıltepe, 2017). In content analysis, reliability is calculated by determining the agreement between the descriptions made by the researchers. In the present study, the interview manuscripts were analyzed separately by the researcher and an educator in the field. In order to determine the reliability of the content analysis, the agreement rate formula, agreement = agreement / (agreement + disagreement) x 100, was used (Miles & Huberman, 1994). The intercoder agreement was calculated as .88. At least 70% intercoder agreement is required for reliability (Miles & Huberman, 1994). Due to the fact that the intercoder agreement was over 70%, the coding conducted in the study was considered reliable. After this stage, data were organized and grouped. Grouped data are presented with frequency and percentage values.

## Findings

The paired samples t test analysis results conducted to determine the change in STEM career interests of the participating eighth grade students in the study are presented in Table 4.

**Table 4.** Paired Samples t-Test Results for STEM Career Interest Levels of Eight Grade Students

| | n | *X* | Sd. | *t* | *p* |
|---|---|---|---|---|---|
| **Pretest** | 48 | 3.07 | .08 | -19.540 | .00 |
| **Posttest** | 48 | 3.19 | .06 | | |

*$p$<0,05

Table 4 demonstrates that there is a statistically significant difference between pre-test and post-test scores ($p$<.05). Thus, it was concluded that problem-based STEM activities improved the STEM career interest levels of eighth grade students. Test result effect size (d) was calculated as 2.82. The fact that the effect size was over 1 indicated that the difference between the groups was quite high (Green & Salkin, 2005).

**Table 5.** Paired Samples t-Test Results for STEM Attitudes of Eight Grade Students

| | n | *X* | Sd. | *t* | *p* |
|---|---|---|---|---|---|
| **Pretest** | 48 | 3.09 | .08 | -15.115 | .00 |
| **Posttest** | 48 | 3.20 | .07 | | |

*p<0,05

Table 5 demonstrates that there is a statistically significant difference between pre-test and post-test results ($p$<.05). Thus, it was concluded that problem-based STEM activities improved the STEM attitudes of eighth grade students. Test result effect size (d) was calculated as 2.18. The fact that the effect size was over 1 indicated that the difference between the groups was quite high (Green & Salkin, 2005).

**Table 6.** Paired Samples t-Test Results for Self-Efficacy Perceptions of Eight Grade Students

| | n | X | Sd. | t | p |
|---|---|---|---|---|---|
| **Pretest** | 48 | 3.20 | .11 | -15.579 | .00 |
| **Posttest** | 48 | 3.28 | .10 | | |

*p<0,05

Table 6 demonstrates that there is a statistically significant difference between pre-test and post-test results (*p*<.05). Thus, it was concluded that problem-based STEM activities improved the self-efficacy perceptions of eighth grade students. Test result effect size (d) was calculated as 2.24. The fact that the effect size was over 1 indicated that the difference between the groups was quite high (Green & Salkin, 2005).

**Table 7.** Student views on STEM education

| **Codes** | *f* | % |
|---|---|---|
| Instructive | 38 | 34.55 |
| Fun | 25 | 22.73 |
| Develops creativity | 20 | 18.18 |
| Motivating | 15 | 13.64 |
| Raises awareness on skills | 12 | 10.90 |

Table 7 demonstrates that majority of the students stated that STEM education was instructive (34.55%) and fun (22.73%). The remaining students stated that STEM education improved creativity (18.18%) and motivation (13.64%) and raised awareness about the skills (10.90%).

Sample student responses to the question "What do you think about STEM education?" are presented below.

*"I am quite bored in the science course and my performance is very low. However, I recognized the importance of science topics in this process. After I realized the uses and application areas of the knowledge I acquired in the course in daily life, I started to think that I could be successful in this course… (T9)"*

*"I used to get bored in science and math classes, but the fact that the course was applied was entertaining for me. I never looked at the topics from an applied perspective before. When I realized that all knowledge could be applied, my perspective towards the courses changed… (T26)"*

Sample student journal entries on STEM education are presented below:

*"After participating in the problem-based STEM activities program, I realized that there are several problems that need to be solved around us. In fact, my problem was not considering problems as problems. Then, I started to think that if there is a problem, it should be solved. I realized that I could be successful in these areas after seeing the real-world applications of boring topics…(T32)"*

*"I realized my dexterity when conducting the activities. I was sorry to have not noticed that before. I enjoyed it so much, it was fun and very instructive. I even comprehended certain topics for the first time. So, each topic could be comprehended… (T40)"*

**Table 8.** The student views on the contribution of the training

| **Codes** | *f* | % |
|---|---|---|
| Using knowledge | 32 | 23.36 |
| Creativity | 25 | 18.25 |
| Career choice | 23 | 16.79 |
| Studying in work groups | 15 | 10.95 |
| Noticing their predisposition to the field of engineering | 14 | 10.22 |
| Considering that they could be successful in science course | 13 | 9.49 |
| Motivation | 10 | 7.30 |
| Patience | 5 | 3.64 |

As seen in Table8, most students stated that STEM education allowed them to use their knowledge (23.36%), improved their creativity (18.25%) and contributed to their career choices (16.79%). The remaining students stated that the training improved their ability to study in work groups (10.95%), awareness about their engineering skills (10.22%), the belief that they could be successful in the science course (9.49%), their motivation (7.30%) and patience (3.64%).

The sample answers of the students to the question "What do you think the contributions of the activities are?" are presented below.

*"…I realized that the topics instructed in the class could be used outside the exams. I wish the topics were instructed that way before, so we could know why we should learn these topics. When we learn only for the exam, the natural boring character of the topics gets bigger … (T43)"*

*"…My grades are generally bad, I consider the topics very boring and incomprehensible. But for the first time, I understood some things clearly. I think I can be successful if they continue to instruct the course this way … (T17)"*

Sample student journal entries on the contributions of the STEM education are presented below:

*"I wanted to be a doctor and save people since I was a child. In this process, I realized that I could be an engineer and save more people. I realized that I could be successful in the products we designed to solve the problems and that made me happy and I decided I should definitely be an engineer … (T32)"*

*"…I always studied alone for the courses. I thought I understood it better that way. But in this process, I noticed my mistakes and miscomprehension when we were reviewing the topics with my friends in the group. The fact that everyone added different things to the products we produced allowed us to create beautiful and successful products … (T14)"*

**Table 9.** The student responses to the question "What do you think about the implementation of STEM education?"

| **Codes** | ***f*** | **%** |
|---|---|---|
| It should be conducted | 48 | 100 |

Analysis of the Table 9 demonstrated that all students shared the view that STEM education should be implemented (100%).

**Table 10.** The student responses to the question "What are your recommendations for the success of STEM education?"

| **Codes** | ***f*** | **%** |
|---|---|---|
| It should be started in preschool period | 48 | 40.00 |
| Should be conducted as an extracurricular activity | 35 | 29.17 |
| Extensive facilities should be available | 25 | 20.83 |
| Should not include grade concerns | 12 | 10.00 |

As seen in Table 10, a large section of the students stated that for an effective STEM education, it should be started in pre-school period (40%), conducted as an extracurricular activity (29.17%), extensive facilities should be made available (20.83%), and grade anxiety should be avoided (10%).

The sample answers of the students to the question "What are your recommendations for the success of STEM education?" are presented below.

*"… A perspective should be formed on STEM education, I think that the sooner this perspective is formed, the more successful the education will be. For this reason, STEM-based education should be conducted starting from the preschool level … (T45)"*

*"…I think it would be better to have an environment other than a classical classroom approach for the implementation of these activities during the training program. It should be conducted with wide choice of material in an abundant physical environment. There should be visuals that represent STEM activities in the training environment, the environment should pump us and our products to feel important …(T14)"*

*"…The training program was very efficient and fun. However, the fact that the activities were not included in the exam and were conducted as an extracurricular activity made me to act naturally. I thought that if they were included in the exam, would I think about the exam and lose my concentration. Therefore, I think it would be more effective when conducted as an extracurricular activity without exam stress … (T38)"*

*"…I encountered STEM education for the first time. So, it took me a while to realize what it was about. Until now, I had a particular habit for course instruction, so it was difficult to adapt. Therefore, I think that the earlier the training would be provided, the more efficient it would be … (T19)*

The researcher journal entries reflected that the participating students experienced difficulties in understanding the STEM education initially. Interdisciplinary education approach is considered difficult since it is different from the instruction that they were accustomed to. In the following weeks, it was determined that they were involved in the process quite enthusiastically. It was determined that most students did not have a positive attitude towards mathematics and science courses, and thus they experienced difficulties during the initial activities. Afterwards, it was determined that the students expressed positive views about these courses when they experienced how and where the academic knowledge could be used. It was observed that the students who were not successful in the courses stated that they were active in the activities, studied well and understood the meaning of engineering profession within the context of occupational tendencies. It was determined that the fact that certain students were distant from the training was due to their fear of failure and when they were participated in the activities, their views changed. In general, it was determined that problem-based STEM activities were received positively by the students, they had fun and they conducted successful group studies.

## Conclusion and Discussion

The present study was conducted to determine the impact of problem-based STEM activities on STEM career interests, STEM attitudes, and self-efficacy perceptions of eighth grade students, and their views on STEM education.

It was determined that there was a significant difference between the pre-test and post-test scores of the students that were applied to determine the change in their career interests ($p<.05$). Based on this finding, it was concluded that the problem-based STEM activities improved the career interests of the students. In a study conducted by Alıcı (2018) to investigate the effects of problem-based STEM education on the attitudes, career perceptions and career interests of students and to determine the views of students on STEM education, it was concluded that STEM education had positive effects on students' career perceptions. In a study conducted by Gülhan and Şahin (2016) with 5th grade students, it was reported that integrated STEM education increased the students' comprehension of scientific content, improved their perceptions on engineering and increased their interest in STEM occupations. In a study conducted by Baran, Bilici and Mesutoglu (2015), it was determined that the conducted activities made the students think about STEM fields in their future career choices, improved their collaboration and communication skills, and the flexibility and fun in the activities motivated the students. Those who advocate STEM education in primary education argued that it could improve the interest, achievements and motivation of the students with topics that include real-life problems, and thus they advocated that STEM would help increase the number of students that aim to make a career in these fields (Honey, Pearson, & Schweingruber, 2014). Creating and improving STEM career interest are important for the selection of STEM careers in the future (Knezek et al., 2013). Although Turkey needs about 1 million individuals in STEM fields until 2023, it would be possible to reach only 31% of this requirement (TUSIAD, 2017). Thus, he number of individuals who study in STEM fields should be increased in Turkey. Therefore, it is important to improve the career interests. Based on the present study findings, problem-based STEM activities are very effective in improving the STEM career interests of middle school students.

It was determined that there was a significant difference between the pre-test and post-test scores of the study group students that aimed to determine the change in their STEM attitudes ($p<.05$). Based on this finding, it was concluded that the activities that the students participated during the study improved their attitudes towards STEM. Alıcı (2018) concluded that STEM education had positive impact on STEM attitudes of the students in problem-based learning environment. Rehmat (2015) also reported that problem-based STEM activities improved the attitudes of fourth year students towards STEM. In a study conducted by Uğraş (2018), it was reported that STEM activities improved STEM attitudes of seventh grade students. In a study, Güzey, Harwell and Moore (2014) found a significant difference favoring of students attending STEM-based schools when they compared STEM attitudes in STEM-based and non-STEM-based schools. Based on the findings of the above-mentioned studies, it can be suggested that problem-based STEM activities improve the STEM attitudes of the students.

It was determined that there was a significant difference between the pre-test and post-test scores that aimed to determine the change in self-efficacy perceptions of the students ($p<.05$). Based on this finding, it was concluded that the activities that the students participated improved the self-efficacy perceptions of the students. The self-efficacy beliefs of the students who participated in an applied STEM course was investigated by Cameron and Plasman (2017). The study findings demonstrated that self-efficacy beliefs of the students improved as a result. In the study conducted to determine the effects of student traits on the formation of STEM career interest among 12th grade students by Wang (2013), the 2002 Longitudinal Education Study data were used. The study findings demonstrated that STEM fields interest levels were directly associated with the 12th grade mathematics achievement, whether they took mathematics and science courses, and self-efficacy beliefs of the students.

In relation to STEM education, the students stated that it was instructive and fun, developed creativity, was motivating and made the students aware of their skills. Furthermore, it was determined based on the student views that the problem-based STEM education contributed to the use of knowledge by the students, development of their creativity, determination of career choices, their ability to study in workgroups, determination of the fields that they were predisposed to, recognition that they could be successful in these courses, and their motivation and patience. Similar findings were obtained during the analysis of student and researcher journals. In the literature, similar findings were reported (e.g., Uğraş, 2018; Gökbayrak & Karışan, 2017; Gülhan & Şahin, 2016; Şahin et al., 2014; Marulcu & Sungur, 2012). In a study conducted by Uğraş (2018), it was determined by the student views that design-based STEM activities were instructive, improved creativity and were motivating. In a study by Karahan, Cambazoğlu-Bilici and Unal (2015), it was reported that applications improved student attitudes, developed positive attitudes towards collaboration, and developed communication among group members. A study conducted by Lewis (2009) reported that design-based activities improved student creativity. Ohio STEM Learning Network (2012) emphasized that STEM education developed students' creative thinking skills. Park and Yoo (2013) examined the effect of STEAM education on students 'learning motivations, interests and scientific process skills and concluded that the student motivations increased as a result. In a study conducted by Baran, Bilici and Mesutoglu (2015), it was determined that conducted activities developed the attitudes and knowledge of students on science, engineering, technology and mathematics fields. Doppelt et al. (2008) emphasized that STEM education had a potential impact on student interests in science, improved their willingness to learn and achievements. In the study conducted by Alıcı (2018), it was determined that problem-based STEM activities developed teamwork, problem-solving, collaboration, critical thinking and creativity skills, as well as student attitudes towards science. Seong-Hwan, (2013) stated in a study that STEAM activities increased the interest of students in STEM fields. Demirel and Dağyar (2016), in a meta-analysis, conducted to investigate the effects of problem-based learning on student attitudes, found that this learning method was effective acquisition of a positive attitude by the students towards science.

It was emphasized by the participating students that STEM education should be initiated in pre-school educations and activities should be conducted as extracurricular activities utilizing extensive facilities and these activities should not be graded to prevent grade anxiety. Several successful models in STEM education have been conducted in completely restructured schools such as High-Tech High (Hardy, 2001). Thus, it was suggested that the structure of the school, the curriculum, teacher qualifications and the evaluation process would affect the success of STEM instruction. Furthermore, the student views that it is necessary to start STEM education in preschool education, which is considered important for an efficient STEM education, were consistent with the literature. Preschool children are defined as creative individuals with a potential to become scientists, problem solvers, engineers, and leaders (Torres-Crospe, Kraatz & Pallansch, 2014). The skills that children acquire as a result of the education process from the pre-school period would determine their future lives. Introduction of STEM education to the students in this period would guide them to STEM fields in the future (Gonzalez & Freyer, 2014). It was emphasized by Jipson, Callanan, Schultz and Hurst (2014) that the preschool period should not be neglected in order to provide a basis for STEM learning and to support STEM literacy throughout life. The views of the participating students in the present study on the efficiency of STEM education were consistent with the literature.

**Recommendations**

Certain recommendations are presented below based on the current study findings.

1. STEM education should start in early ages.

2. Teachers and pre-service teachers should be trained to acquire an accurate interdisciplinary perspective on STEM education and applications.

3. The number of studies on STEM education should be increased.

4. The STEM activities that are considered to be effective on STEM career interests, STEM attitudes and self-efficacy beliefs of the students should be generalized at schools and in extracurricular activities.

# GENİŞLETİLMİŞ ÖZET

## Probleme Dayalı STEM Etkinliklerinin Bazı Değişkenlere Etkisinin ve Öğrenci Görüşlerinin Belirlenmesi

### Giriş

Teknoloji çağı olarak bilinen 21. yüzyılda fen, teknoloji, mühendislik ve matematik (STEM) eğitimi; yenilikçi, yaratıcı ve problem çözme bakış açısıyla kültürel ve ekonomik kalkınmanın şekillenmesinde önemli bir rol oynamaktadır (Cooper ve Heaverlo, 2013). Amerikan Ulusal Bilim Vakfı (NSF) tarafından oluşturulan STEM (bilim, teknoloji, mühendislik ve matematik) kısaltması günümüzde yaygın olarak kabul görmekte ve belirli bir bilgi ve uygulama alanı için kullanılmaktadır (Dugger, 2010). Bilim (S) terimi, fizik, kimya ve biyoloji disiplinleri ile ilgili doğa yasalarını ve doğal dünyanın çalışmasını içeren ayrıca bu disiplinler ile ilgili gerçeklerin, ilkelerin ve kavramların işleyişi ve uygulanması ile ilgilenir (Bal, Pearson ve Schweingruber, 2014, s. 14). Teknoloji (T), insanların ihtiyaçlarını karşılamak için oluşturdukları teknolojik eserlerin tasarlanmasını ve kullanılmasını sağlayan araçları, bilgi sistemlerini, organizasyonları, cihazları içerir. Mühendislik (E), eserlerin oluşturulması, problemlerin tasarlanması ve çözülmesi süreçleri hakkındaki bilgiler ile ilgilidir. Matematik (M) ise nicelikler, sayılar ve uzay nesneleri arasındaki modeller ve ilişkiler ile ilgilenir (Honey vd., 2014).

### Çalışmanın Amacı:

Bu çalışmanın amacı, probleme dayalı STEM etkinliklerinin; sekizinci sınıf öğrencilerinin FeTeMM Meslek ilgilerine, STEM tutumlarına ve öz yeterlik algılarına olan etkisini ve öğrencilerin STEM eğitimi hakkındaki görüşlerini belirlemektir.

### Yöntem

Araştırmada, araştırma probleminin ayrıntılı incelenmesini sağlamak amacıyla nicel ve nitel yöntemlerin birlikte kullanıldığı karma araştırma deseni kullanılmıştır (Creswell, 2009). Araştırmanın nicel boyutunda veriler, ön test-son test tek gruplu deneysel deseni uygulanarak toplanmıştır. Araştırmada kullanılan deneysel desen, sonuçlar arasındaki değişim ve gelişime göre uygulanan programın başarılı ya da başarısız şekilde tanımlanmasını sağlamaktadır (Shea, Arnold ve Mann, 2004). Araştırmada kullanılan deneysel desen türü, Creswell' in (2012) "Yeni bir eğitim yaklaşımının geliştirilip uygulanmasında tek gruplu ön test-son test deneysel desenin tercih edilmesi araştırmanın doğası gereğidir." şeklindeki vurgusundan dolayı tercih edilmiştir. Araştırmanın nitel boyutunda ise durum çalışmasından yararlanılmıştır. Araştırmalarda, bir veya birden çok durumun derinlemesine incelenmesi, bunlara etki eden faktörlerin bütüncül bir yaklaşım ile araştırılması, bu faktörlerin söz konusu durumu nasıl etkilediğinin ve bunlardan nasıl etkilendiğini belirlenmesi söz konusu olduğunda durum çalışması kullanılmaktadır (Yıldırım ve Şimşek, 2013).

### Sonuç ve Tartışma

Öğrencilerin, FeTeMM meslek ilgilerindeki değişimin belirlenmesine yönelik uygulanan ön test-son test sonuçları arasında anlamlı bir farklılık olduğu belirlenmiştir ($p<.05$). Bu sonuca göre probleme dayalı STEM etkinliklerinin, araştırmaya katılan öğrencilerin FeTeMM meslek ilgilerini olumlu yönde geliştirdiği sonucuna ulaşılmıştır. Alıcı (2018) tarafından probleme dayalı öğrenme ortamında STEM eğitiminin öğrencilerin tutumlarına, kariyer algılarına ve meslek ilgilerine etkisini incelemek ve uygulamalar hakkında öğrencilerin görüşlerini belirlemek amacıyla yaptıkları çalışmada, STEM eğitiminin öğrencilerin kariyer algılarını olumlu etkilediği sonucuna ulaşılmıştır. İlköğretimde STEM eğitimini savunanlar, gerçek dünya problemlerini içeren konularla öğrencilerin ilgi, başarı ve motivasyonlarının artırılabileceğini; buna bağlı olarak da STEM alanlarıyla ilgili kariyer yapan öğrenci sayısının artmasına yardımcı olacağını savunmaktadırlar (Honey, Pearson ve Schweingruber, 2014). STEM meslek ilgilerini oluşturmak ve arttırmak, bireylerin gelecekte STEM alanlarında seçeceği meslekler açısından önem taşımaktadır (Knezek vd., 2013). Türkiye'nin 2023 yılına kadar STEM alanlarında yaklaşık 1 milyon kişiye ihtiyacı olmasına rağmen bunun sadece % 31'i karşılanabilecektir (TÜSİAD 2017). Bu da göstermektedir ki Türkiye'de STEM alanlarında çalışan insan sayısının artırılması gerekmektedir. Bu nedenle FeTeMM meslek ilgilerinin arttırılması önem taşımaktadır. Bu çalışma sonuçlarına göre, probleme dayalı STEM etkinlikleri ortaokul öğrencilerinde STEM alanlarına yönelik meslek ilgilerinin artmasında oldukça etkilidir.

Çalışma grubu öğrencilerinin, STEM' e karşı tutumlarındaki değişimin belirlenmesine yönelik uygulanan ön test-son test sonuçları arasında anlamlı bir farklılık olduğu belirlenmiştir ($p<.05$). Bu sonuca göre etkinliklerin araştırmaya katılan öğrencilerin STEM' e karşı tutumlarını olumlu yönde geliştirdiği sonucuna ulaşılmıştır. Alıcı (2018) tarafından probleme dayalı öğrenme ortamında STEM eğitiminin öğrencilerin STEM' e yönelik tutumlarını olumlu etkilediği sonucuna ulaşılmıştır. Rehmat (2015) da yaptığı çalışmada probleme dayalı STEM etkinliklerinin dördüncü sınıf öğrencilerinin STEM' e karşı olumlu tutumlarını artırdığını belirtmiştir. Uğraş (2018) tarafından yapılan çalışmada STEM etkinliklerinin yedinci sınıf öğrencilerinin STEM' e karşı tutumlarını arttırdığı sonucuna ulaşılmıştır. Güzey, Harwell ve Moore (2014) yaptıkları çalışmada STEM odaklı okullar ile STEM odaklı olmayan okulların STEM alanlarına karşı tutumlarını karşılaştırdıklarında STEM odaklı okullarda öğrenim gören öğrenciler lehine anlamlı bir fark tespit etmişlerdir.

Öğrencilerin, öz yeterlik algılarındaki değişimin belirlenmesine yönelik uygulanan ön test-son test sonuçları arasında anlamlı bir farklılık olduğu belirlenmiştir ($p<.05$). Bu sonuca göre etkinlikleri araştırmaya katılan öğrencilerin öz yeterlik algılarını olumlu yönde geliştirdiği sonucuna ulaşılmıştır. Cameron ve Plasman (2017) tarafından uygulamalı STEM kursuna katılan öğrencilerin öz yeterliği araştırılmıştır. Çalışma sonucunda araştırmaya katılan öğrencilerde öz yeterlik inançlarının geliştiği belirlenmiştir. Wang (2013) tarafından, STEM alanlarına ilgilerinin oluşmasında

Öğrencilerin STEM eğitimi ile ilgili olarak; öğretici, eğlendirici, yaratıcılığı geliştiren, motive edici ve becerileri fark ettirici olduğuna yönelik görüşleri belirlenmiştir. Ayrıca probleme dayalı STEM eğitiminin öğrencilerin bilgileri kullanabilme, yaratıcılıklarını geliştirme, meslek tercihlerini belirlemede, gruplar halinde çalışabilmeye, yatkın oldukları alanları belirlemede, derslerde başarılı olunabileceğini fark etmede, motive ve sabırlı olma noktasında katkı sağladığına yönelik bir katkı sağladığına yönelik görüşleri belirlenmiştir. Ayrıca etkinlikten sonra tutulan öğrenci ve araştırmacı günlüklerinin analizinde de bunlara benzer sonuçlara ulaşılmıştır. Literatürde bu sonuçlara paralel çalışma sonuçları bulunmaktadır (Ör: Uğraş, 2018; Gökbayrak ve Karışan, 2017; Gülhan ve Şahin, 2016; Şahin vd., 2014; Marulcu ve Sungur, 2012). Uğraş (2018) tarafından yapılan çalışmada, tasarım temelli STEM etkinliklerinin; öğretici, eğlendirici, yaratıcılığı geliştiren ve motive edici olduğuna yönelik öğrenci görüşleri tespit edilmiştir. Karahan, Cambazoğlu-Bilici ve Ünal (2015) tarafından yapılan çalışmada, uygulamalar sonucunda öğrencilerde tutumlarının geliştiği, iş birliğine yönelik pozitif tutumların geliştiği, grup üyeleri arasında iletişimin geliştiği belirlenmiştir. Lewis (2009) tarafından yapılan çalışma sonucunda tasarım temelli etkinliklerin öğrencilerin yaratıcılıklarını geliştirdiği tespit edilmiştir. Ohio STEM Learning Network'da (2012), STEM eğitiminin öğrencilerin yaratıcı düşünme becerilerini geliştirdiğini vurgulanmıştır. Doppelt vd. (2008) STEM eğitiminin, öğrencilerin fen konularına ilgisini çekmenin, öğrenme arzusunun ve başarılarının artırılmasında potansiyel bir etkisinin sahip olduğunu vurgulamıştır. Alıcı (2018) tarafından yapılan çalışmada probleme dayalı STEM etkinliklerinin takım çalışması, problem çözme, iş birliği, eleştirel düşünme ve yaratıcılık becerilerini ayrıca fene karşı tutumu da geliştirdiği belirlenmiştir. Seong-Hwan, (2013) yaptığı çalışmada STEAM etkinliklerinin öğrencilerin STEM alanlarına ilgilerini arttırdığı belirtmiştir.

Araştırmaya katılan öğrencilerin STEM eğitiminin verimli olması için, okul öncesi dönemden itibaren başlanması gerektiğini, etkinliklerin sınıf dışında geniş imkanlar ile yapılması vurgulanmış ve bu etkinlikler gerçekleştirilirken not kaygısının da olmaması gerektiğine yönelik görüşleri belirlenmiştir. STEM öğretimindeki başarılı modellerin birçoğu High Tech High gibi tamamen yeniden yapılandırılmış okullarda gerçekleşmektedir (Hardy, 2001). Bu nedenle okulun yapısı, uygulanan müfredatı, öğretmen niteliği ve değerlendirme süreçlerinin STEM öğretiminin başarısını etkileyeceği düşünülmektedir. Ayrıca verimli bir STEM eğitimi için önemli olduğu belirtilen okul öncesi dönemden itibaren başlanması gerektiğine yönelik öğrenci görüşleri literatürle paralellik göstermektedir. Okul öncesi dönem çocukları, bilim insanı, problem çözücü, mühendis, yaratıcı, liderlik potansiyeline sahip bireyler olarak tanımlanmaktadır (Torres-Crospe, Kraatz ve Pallansch, 2014). Jipson, Callanan, Schultz ve Hurst (2014) tarafından, STEM öğrenmeye bir temel oluşturmak ve yaşam boyunca STEM okuryazarlığını desteklemek için okul öncesi dönemin ihmal edilmemesi gerektiği vurgulanmaktadır.

## REFERENCES


Ak, B. (2008). *Verilerin düzenlenmesi ve gösterimi. Kalaycı, Şeref (yayına hazırlayan) SPSS Uygulamalı Çok Değişkenli İstatistik Teknikleri içinde (ss.3-47).* Ankara. Asil Yayın Dağıtım.

Albanese, M.A.; Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Acad. Med., 68,* 52–81.

Alıcı, M. (2018). *Probleme Dayalı Öğrenme Ortamında STEM Eğitiminin Tutum, Kariyer Algı ve Meslek İlgisine Etkisi ve Öğrenci Görüşleri* (YayınlanmamışYüksek Lisans Tezi). Kırıkkale Üniversitesi Fen Bilimleri Enstitüsü, Türkiye.

Allen, D.E.; Duch, B.J.; Groh, S.E. (1996). The power of problem-based learning in teaching introductory science courses. New Dir. Teach. Learn., 6, 43–52.

Armstrong, P. I., & Vogel, D. L. (2009). Interpreting the interest-efficacy association from a RIASEC perspective. *Journal of Counseling Psychology, 56*, 392–407.

Babarović, T., Pale, P. & Burušić, J. (2018). The Effects of the Elementary School STEM Intervention Program on Students' Attitudes and Interests: The Application of Propensity Score Matching Technique. *Društvena istraživanja, 27*(4), 583-604.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs: Prentice-Hall.

Bandura, A. (1997), *Self-efficacy: Theexercise of control.* New York: Freeman.

Baran, E., Canbazoğlu-Bilici, S., ve Mesutoğlu, C. (2015). Fen, teknoloji, mühendislik ve matematik (FeTeMM) spotu geliştirme etkinliği. *Araştırma Temelli Etkinlik Dergisi(ATED), 5*(2), 60-69.

Baran, M., & Maskan, A. (2010). The effect of project-based learning on pre-service physics teachers electrostatic achievements. Cypriot J. Educ. Sci*., 5,* 243–257.

Barrows, H.S. (1996). Problem-based learning in medicine and beyond: A brief overview. New Dir. Teach. Learn. *, 68*, 3–12.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. Clear. *House J. Educ. Strateg. Issues Ideas, 83*, 39–43.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23,* 329–345. https://doi.org/10.1016/0001-8791(83)90046-5

Borgen, F. H., & Betz, N. E. (2008). Vocational self-efficacy and personality: Linking vocational confidence and the healthy personality. *Journal of Vocational Assessment, 16,* 22–43. https://doi.org/10.1177/1069072707305770

Byars-Winston, A., Estrada, Y., Howard, C., Davis, D., & Zalapa, J. (2010). Influence of social cognitive and ethnic variables on academic goals of underrepresented students in science and engineering: A multiplegroups analysis. *Journal of Counseling Psychology, 57,* 205–218

Cameron, S. & Plasman, J-S. (2017). How Does Applied STEM Coursework Relate to Mathematics and Science Self-Efficacy Among High School Students? Evidence from a National Sample. *Journal of Career and Technical Education, 32*(1), 29-50.

Cerezo, N. (2015). Problem-based learning in the middle school: A research case study of the perceptions of at-risk females. *RMLE Online, 27,* 1–13.

Chittum, J.R., Brett D.J., Sehmuz, A. & Ásta B.S. (2017). The effects of an afterschool STEM program on students' motivation and engagement. *International Journal of STEM Education, 4*(11), 1-16.

Cho, B. and Lee, J. (2013, November). *The Effects of Creativity and Flow on Learning through the STEAM Education on Elementary School Contexts*. Paper presented at the International Conference of Educational Technology, Sejong University, South Korea.

Christensen, R. & Knezek, G. (2015). Active learning approaches to integrating technology into middle school science classrooms: Reconceptualizing a middle school science curriculum based on 21st century skills. In X.Ge, D. Ifenthaler, & J.M. Spector (Eds.). *Full Steam Ahead: Emerging Technologies for STEAM.* New York: Springer Academic.

Cooper, R. ve Heaverlo, C. (2013). Problem solving and creativity and design: What influence do they have on girls' interest in STEM subject areas? *American Journal of Engineering Education, 4*(1), 27-38.

Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative and Mixed Method Approaches.* Los Angeles: Sage Publication.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.).* Boston, Pearson.

Cutucache, C. E., Luhr, J. L., Nelson, K. L., Grandgenett, N. F., & Tapprich, W. E. (2016). NE STEM 4U: An out-of-school time academic program to improve achievement of socioeconomically disadvantaged youth in STEM areas. *International Journal of STEM Education, 3*(6), 1–7. doi:10.1186/s40594-016-0037-0

David, G. H. & Sharon, K. S. (2006). Conference Prologue. In G. H. David & K. S. Sharon (Eds.), *Proceedings of the conference on K-12 outreach from university science departments.* (pp. 6-7). Raleigh, NC: The Science House, North Carolina State University

Dejarnette, N. K. (2012). America's children: Providing early exposure to STEM (science, technology, engineering and math) initiatives. *Education, 133*(1), 77–84.

Demirel, M. ve Dağyar, M. (2016). Effects of Problem-Based Learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(8), 2115-2137.

Doğanay, K., (2018). *Probleme Dayalı STEM Etkinlikleriyle Gerçekleştirilen Bilim Fuarlarının Ortaokul Öğrencilerinin Fen Bilimleri Dersi Akademik Başarılarına ve Fen Tutumlarına Etkisi* (Yüksek Lisans Tezi). Kastamonu Üniversitesi Fen Bilimleri Enstitüsü, Kastamonu.

Dominguez, C., Jamie, A. (2010). Database design learning: A project-based approach organized through a course management system. Comput. Educ., 55, 1312–1320.

Doppelt, Y., Mehalik, M. M., Schunn, C. D., Silk, E. ve Krysinski, D. (2008). Engagement and achievements: a case study of design-based learning in a science context. *Journal of Technology Education, 19*(2), 22-39.

Dugger Jr,, W. E. (2010). *Evolution of STEM in the United States.* Retrieved from http://www.iteaconnect.org/Resources/PressRoom/AustraliaPaper.pdf

Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R. S., Platt, T. ve White, H. B. (2008). Pedagogies of engagement in science. *Biochemistry and Molecular Biology Education, 36*(4), 262–273.

Ertmer, P.A.; Schlosser, S.; Clase, K.; Adedokun, O. (2014). The grand challenge: Helping teachers learn/teach cutting-edge science via a pbl approach. *Interdiscip. J. Probl. Based Learn., 8.*

Fortus, D. & Vedder-Weiss, D. (2014). Measuring students' continuing motivation for science learning. *Journal of Research in Science Teaching, 51*(4), 497-522.

Gonzalez, M & Freyer, C. (2014). A Collaborative Initiative: STEM and Universally Designed Curriculum for AtRisk Preschoolers. Nation*al Teacher Education Journal, 7*(3),21-29.

Green, S.B., Salkind, N.J. (2005). *Using SPSS for windows and macintosh: Analyzing and Undestanding data (4th Edition).* New Jersey: Pearson.

Gülhan, F. ve Şahin, F. (2016). Fen-teknoloji-mühendislik-matematik entegrasyonunun (STEM) 5. sınıf öğrencilerinin bu alanlarla ilgili algı ve tutumlarına etkisi. *International Journal of Human Sciences, 13* (1), 602- 620, 2016.

Güzey, S. S, Harwell, M., Moore, T. (2014). Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM). *School Science and Mathematics, 114*(6), 271–279.

Hardy, L. (2001). High tech high. *American School Board Journal, 188*(7), 12–15.

Hill, C., Corbett, C., St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington: American Association of University Women. Erişim Tarihi: 02. 04. 2018 http://www.aauw.org/ files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

Honey, M., Pearson, G., & Schweingruber, H. (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. Washington, DC: National Academies Press.

Jipson, J. L., Callanan, M. A., Schultz, G. & Hurst, A. (2014). *Scientists not sponges: STEM interest and inquiry in early childhood.* In J. G. Manning, J. B. Jensen, M. K. Hemenway, and M. G. Gibbs (Eds), Ensuring STEM Literacy (pp. 149-156). San Francisco: Astronomical Society of the Pacific.

Karahan, E., Canbazoglu-Bilici, S., ve Unal, A. (2015). Integration of media design processes in science, technology, engineering, and mathematics (STEM) education. *Eurasian Journal of Educational Research,* 60, 221-240. doı: 10.14689/ejer.2015.60.15

Kıran, D. (2010), *A Study on Sources and Consequences of Elementary Students' Self-Efficacy Belıefs in Scıence and Technology Course.* (Unpublished doctoral dissertation). Middle East Technical University, Ankara, Turkey.

Kızıltepe, Z. (2017). *İçerik analizi [Content analysis].* In F. N. Seggie ve Y. Bayyurt (Eds.), pp. 253–266. Ankara: Ani Publication.

Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2013). The development of the STEM career interest survey (STEM-CIS). *Research in Science Education, 44*(3), 461–481.

Knezek, G., Christensen, R., Wood, T.T. and Periathiruvadi, S. (2013). Impact of environmental power monitoring activities on middle school student perceptions of STEM. *Science Education International, 24* (1), 98-123.

Koyunlu Unlu, Z., Dokme, I., & Unlu, V. (2016). Adaptation of the science, technology, engineering, and mathematics career interest survey (STEM-CIS) into Turkish. *Eurasian Journal of Educational Research, 63,* 21-36, http://dx.doi.org/ 10.14689/ejer.2016.63.2

Langdon, D., Mckittrick, G., Beede, D., Khan, B. ve Doms, M. (2011). STEM: Good jobs now and for the future, *U.S. Department of Commerce Economics and Statistics Administration, 3*(11).

Lent, R. W., & Brown, S. D. (2006). On conceptualizing and assessing social cognitive constructs in career research: A measurement guide. *Journal of Career Assessment, 14*, 12-35.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*, 79–122.

Lent, R. W., Brown, S. T., & Hackett, G. (1996). Career development from a social cognitive perspective. In D. Brown & L. Brooks et al. (Eds.) *Career choice and development* (pp. 373-422). San Fransisco: Jossey-Bass Publishers

Lent, R. W., Brown, S., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45,* 79–122

Lent, R. W., Sheu, H., Gloster, C. S., & Wilkins, G. (2010). Longitudinal test of the social cognitive model of choice in engineering students at historically Black universities. *Journal of Vocational Behavior, 76,* 387–394.

Lent, R. W., Sheu, H., Gloster, C. S., & Wilkins, G. (2010). Longitudinal test of the social cognitive model of choice in engineering students at historically Black universities. *Journal of Vocational Behavior, 76*(3), 387–394.

Lewis, T. (2009). Creativity: A framework for the design/problem solving discourse in technology education. *Journal of Technology Education, 17*(1), 35-52.

Lou, S.-J.; Shih, R.-C.; Ray Diez, C.; Tseng, K.-H. (2010). The impact of problem-based learning strategies on stem knowledge integration and attitudes: An exploratory study among female Taiwanese senior high school students. Int. J. Technol. Des. Educ., 21, 195–215.

Marulcu, İ., ve Sungur, K. (2012). Fen bilgisi öğretmen adaylarının mühendis ve mühendislik algılarının ve yöntem olarak mühendislik-dizayna bakış açılarının incelenmesi. *Afyon Kocatepe Üniversitesi Fen Bilimleri Dergisi, 12*(2012), 13-23.

Massa, N.; Dischino, M.; Donnelly, J.; Hanes, F. (2009). Problem-based learning in photonics technology education: Assessing student learning. In Proceedings of the 11th Education and Training in Optics and Photonics, Wales, UK, 5–7 June 2009; Optical Society of America: Washington, DC, USA.

Medeiros, D. J. (2011). The influence of female social models in corporate STEM initiatives on girls' math and science attitudes (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 894252905).

Mergendoller, J.R.; Maxwell, N.L.; Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional methods and student characteristics. *Interdiscip. J. Probl. Based Learn, 1.*

Merriam, S. B. (2013). *Nitel araştırma Desen ve Uygulama için Bir Rehber* (Çev. : Selahattin Turan, Çev. Ed.: Selahattin Turan). Ankara: Nobel yayın dağıtım.

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded Sourcebook. (2nd ed).* Thousand Oaks, CA: Sage.

Natural Sciences and Engineering Research Council of Canada. (2010). *Women in science and engineering in Canada*. Ottawa, Canada: Author.

Norman, G.R.; Schmidt, H.G. (2000). Effectiveness of problem-based learning curricula: Theory, practice and paper darts. Med. Educ., 34, 721–728.

O'Brien, V., Martinez-Pons, M., & Kopala, M. (1999). Mathematics self-efficacy, ethnic identity, gender, and vocational interests related to mathematics and science. The Journal of Educational Research, 92, 231–235. https://doi.org/10.1080/ 00220679909597600

Osborne, J. (2003). Attitudes towards science: a review of the literature and its implications, *International Journal of Science Education, 25*(9), 1049-1079.

Palmer, D. H. (1997). Investigating students' private perceptions of scientists and their work. *Research in Science & Technological Education, 15*(2), 173-184.

Park, S.J. & Yoo, P.K. (2013). The Effects of the learning motive, interst and science process skills using the "Light" unit in science-based STEAM. *Elementary Science Eucation, 32*(3), 225-238.

Ramsey, K., & Baethe, B. (2013). The keys to future STEM careers: Basic skills, critical thinking, and ethics. *Delta Kappa Gamma Bulletin*, *80*(1), 26–33.

Ravitz, J.; Hixson, N.; English, M.; Mergendoller, J. (2012). Using Project Based Learning to Teach 21st Century Skills: Findings from a Statewide Initiative; American Educational Research Association Conference: Vancouver, BC, Canada,; Available online: http://www.bie.org/research/study/PBL_21CS_WV (accessed on 25 April 2018).

Regisford, K. (2012). *Life and work in a global city—The need to improve STEM education.* The Recruitment & Employment Confederation. Erişim Tarihi: 15.06.2018 http://www.rec.uk.com/ press/news/2253

Rehmat, A. P. (2015). Engineering the Path to Higher-Order Thinking in Elementary Education: A Problem-Based Learning Approach for STEM Integration. UNLV Theses/Dissertations/Professional Papers/Capstones. Paper 2497. http://digitalscholarship.unlv.edu/thesesdissertations adresinden 02.11.2015 tarihinde erişilmiştir.

Sadler, PM, Sonnert, G, Hazari, Z, Tai, R. (2012). Stability and volatility of STEM career interest in high school: a gender study. *Science Education, 96*(3), 411–427.

Savery, J.R. (2006). Overview of problem-based learning: Definitions and distinctions. T*he Interdisciplinary Journal of Problem-based Learning (IJPBL), 1*, 8–20

Schnittka, C. G., Evans, M. A., Won, S., & Drape, T. D. (2015). Looking for learning in afterschool spaces: Studio STEM. *Research in Science Education*. doi:10.1007/ s11165-015-9463-0

Schwab, K. & X. Sala-i-Martín (2012). *The Global Competitiveness Report 2012-2013*, World Economic Forum.

Seong-Hwan, C., (2013). The Effect of robots in education based on STEAM. *Journal of Korea Robotics Society, 8*(1), 58-65.

Shea, J. A., Arnold, L., & Mann, K. V. (2004). A RIME perspective on the quality and relevance of current and future medical education research. *Academic Medicine*, 79, 931–938.

Sheu, HB, Lent, RW, Brown, SD, Miller, MJ, Hennessy, KD, Duggy, RD. (2010). Testing the choice model of social cognitive career theory across Holland themes: a meta-analytic path analysis. *Journal of Vocational Behavior, 76,* 252 –264.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42,* 70–83. doi: 10.1037/0012-1649.42.1.70.

Simpson, R. D., & Oliver J. S. (1990). A summary of major influences on attitude and achievemevt in science among adolescent students. *Science Education, 74,* 1-18.

Super, D. E. (1953). A theory of vocational development. *American Psychologist, 8*, 185–190.

Şahin, A., Ayar, M.C. ve Adıguzel, T. (2014). Fen, teknoloji, mühendislik ve matematik içerikli okul sonrası etkinlikler ve öğrenciler üzerindeki etkileri. *Kuram ve Uygulamada Eğitim Bilimleri, 14* (1), 297-322.

Tai, R., Liu, C., Maltese, A., & Fan, X. (2006). Planning early for careers in science. *Science, 312*(5777), 1143–1144.

TechWomen. (2013). www.techwomen.org

Torres-Crospe, M. N., Kraatz, K. & Pallansch, L. (2014). From fearing STEM to playing with it: The natural integration of STEM into the preschool classroom. *SRATE Journal, 23*(2), 8-16.

Torres-Crospe, M. N., Kraatz, K. & Pallansch, L. (2014). From fearing STEM to playing with it: The natural integration of STEM into the preschool classroom. *SRATE Journal, 23*(2), 8-16.

Tracey, T. J. G. (2010). Relation of interest and self-efficacy occupational congruence and career choice certainty. *Journal of Vocational Behavior, 76,* 441–447.

Tseng, K., Chang, C., Lou, S., & Chen, W. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PBL) environment. *International Journal of Technology and Design Education, 23*(1), 87–102.

TÜSİAD. (2017). 2023'e doğru Türkiye'de STEM gereksinimi. Erişim Adresi: https://www.pwc.com.tr/tr/gundem/dijital/2023e-dogru-turkiyede-stem-gereksinimi.html

Uğras, M. (2018). The Effect of STEM Activities on STEM Attitudes, Scientific Creavity and Motivation Beliefs of the Students and Their Views on STEM Education, *International Online Journal of Educational Sciences, 10*(5), 165-182.

Vedder-Weiss, D., & Fortus, D. (2010). Adolescents ' declining motivation to learn science: Inevitable or not? *Journal of Research in Science Teaching, 48*(2), 199 –216. doi:10.1002/tea.20398

Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? *International Journal of Science Education,* 1-21. https://doi.org/10.1080/09500693.2018.1473659

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal, 50,* 1081-1121. doi:10.3102/0002831213488622

Watt,H.M., Shapka, J.D.,Morris, Z. A.,Durik,A.M., Keating,D. P. &Eccles, J. S. (2012).Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. *Developmental Psychology*, *48*(6), 1594–1611.

White House Office of Science and Technology Policy (2012). *Preparing a 21st Century workforce: Science, Technology, Engineering, and Mathematics (STEM) education in the 2013 Budget.* Erişim Adresi: 15.08.2018 http://www.whitehouse.gov/sites/default/files/microsites/ostp/fy2013rd_stem.pdf.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. Comtemporary Educational Psychology, 25, 68–81. https://doi.org/10.1006/ceps.1999.1015

Yamak, H., Bulut, N. ve Dündar, S. (2014). 5. sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTeMM etkinliklerinin etkisi. *Gazi Üniversitesi Eğitim Fakültesi Dergisi, 34*(2), 249-265. Erişim adresi: http://dergipark.ulakbim.gov.tr /gefad/article/view/5000078351

Yıldırım, A. & Şimşek, H. (2016). *Sosyal bilimlerde nitel araştırma yöntemleri.* Seçkin Yayıncılık.

Yıldırım, B. ve Selvi, M. (2015). Adaptation of STEM attitude scale to Turkish. *Turkish Studies International Periodical for the Languages, Literature and History of Turkish or Turkic,* Volume 10/3, Summer, 2015, p.1107-1120,ISSN: 1308-2140, www.turkishstudies.net, DOI Number: http://dx.doi.org/10.7827/TurkishStudies.7974, Ankara-Turkey.