
Article History
Received: 16.10.2021
Received in revised form: 08.12.2021
Accepted: 23.01.2022
Article Type: Research Article

International Journal of Contemporary Educational Research (IJCER)

www.ijcer.net

# Effect of Problem-Based STEM Activities on 7th Grade Students' Mathematics Achievements, Attitudes, Anxiety, Self-Efficacy and Views

**Yavuz Macun[1], Cemalettin Işık[2]**
[1]Ministry of National Education, 0000-0003-4983-2601
[2]Erciyes University, 0000-0001-6326-0043

**To cite this article:**

Macun, Y., & Işık, C. (2022). Effect of problem-based STEM activities on 7th grade students' mathematics achievements, attitudes, anxiety, self-efficacy and views. *International Journal of Contemporary Educational Research, 9*(1), 87-102. https://doi.org/10.33200/ijcer.1008456

**International Journal of Contemporary Educational Research**
IJCER
Volume 9, Number 1, March 2022, 87-102 ISSN: 2148-3868

# Effect of Problem-Based STEM Activities on 7th Grade Students' Mathematics Achievements, Attitudes, Anxiety, Self-Efficacy and Views*

**Yavuz Macun[1]**, Cemalettin Işık[2]**
[1]Ministry of National Education
[2]Erciyes University

## Abstract

This study investigates the effect of problem-based STEM (Science, Technology, Engineering, Mathematics) activities on 7th-grade students' mathematics achievement, attitude, anxiety, self-efficacy, interest, and views. At the same time, the effects of these activities on students' anxiety, self-efficacy towards mathematics, and interest in STEM occupations were also examined. The study sample, which was selected using the convenience sampling method, consisted of 115 7th grade students of a public middle school in Turkey. In the quantitative phase of the research, a quasi-experimental research model with pre-test and post-test control group was used to determine the students' mathematics achievement, attitudes, anxiety, self-efficacy towards mathematics and interests in STEM careers. In the qualitative phase semi-structured interview was used to understand students' views on problem-based STEM activities and mathematics lessons in the qualitative part. Within the scope of the research, 6 different problem-based STEM activities related to ratio-proportion and percentages were applied to the experimental group students. The data collected from both groups before and after the implementation process were analyzed with descriptive statistics, independent samples t-test, and paired sample t-test. The results showed that problem-based STEM activities affect students' mathematics achievement, self-efficacy, and interest in mathematics. It also helps students reducing their mathematics anxiety.

**Keywords:** STEM, Self-efficacy towards mathematics, 21st Century skills, Mathematics achievement, Problem-Based STEM activities and interest.

## Introduction

Technological changes and innovations have influenced industry from the past to the present and these developments have been called industrial revolutions. The first industrial revolution emerged with mechanical systems operating with water and steam power and the first mechanical weaving loom started to be used in 1784. Afterwards, systems that opened the doors of the second industrial revolution and mass production by utilizing electrical energy were invented. In this context, the moving belt system was used in slaughterhouses in 1870 (Yıldız, 2018). Then, the third industrial revolution began with the development of information systems and technologies and the emergence of programmable management systems that allow less use of workforce. Finally, fourth industrial revolution, or "Industry 4.0" by its popular name, originated and continues with the use of cyber-physical systems (manufacturing techniques + information and communication technology + internet). All these industrial revolutions have affected the production itself and the labor market and education systems (Benešová and Tupa, 2017). As a result of these changes, some jobs and occupations have disappeared and new ones have emerged. As a requirement of Industry 4.0, an emphasis has placed on the skills that individuals need to possess, and countries have started to change and develop their education systems accordingly.

Science, Technology, Engineering, Mathematics [STEM] education is an integrated education approach resulting from these industrial developments and includes integrated teaching of science, technology, engineering and mathematics and takes place in all levels of education system (Sanders, 2009). STEM, which is a concept that is frequently mentioned worldwide, is being implemented in education systems in different countries to gain the 21st century skills that future generations must have considered Industry 4.0. Researchers generally define 21st century skills as adapting to a different situation, having effective communication skills, solving different kinds

* This study was produced from Yavuz Macun's master's thesis and was funded by the Erciyes University Scientific Research Projects Unit with the project code SYL-2019-8749
**Corresponding Author: *Yavuz Macun, yavuzmacun@gmail.com*

of problems, having self-management and self-development skills, and analytical thinking within existing systems (Windschitl, 2009; Bybee, 2010). To improve students' knowledge, skills and competencies, significant studies have been initiated around the world. Accordingly, STEM has become the state's educational policy in the United States of America [USA]. For this purpose, to increase student participation in STEM activities and attract students' attention to STEM professions, a program called "Education to Innovate" was implemented in the USA (Obama, 2009). In this way, it will be possible to raise generations who will keep up with the rapidly changing technological developments and have the knowledge and skills required by the era. There is also increasing interest and demand for STEM in Turkey. The General Directorate of Innovation and Educational Technologies of the Ministry of National Education [MoNE] published a STEM Education Report in 2016 and a STEM Education Teacher Handbook in 2017. In the STEM Education Report, a model proposal was made for the transition to STEM education in Turkey, topics such as establishing STEM Education Centers, conducting STEM Education research, training teachers for a STEM education approach, updating educational programs according to STEM, and providing course materials necessary to create STEM education environments in schools were highlighted (MoNE, 2016; 2017). In addition, STEM research is carried out by STEM centers established within the body of Middle East Technical University and Bahçeşehir University. Turkish Industrialists' and Businessmen's Association (TÜSİAD) draws attention to STEM education at every opportunity. With its report "STEM Needs in Turkey Towards 2023" published in 2017, it both emphasizes the importance of STEM education and makes recommendations for STEM education in Turkey (TÜSİAD, 2017). These interests and studies on STEM education will bring a new perspective to the Turkish education system, moving towards being exam-oriented. Teachers who are monotonous in the education system generally do not pay enough attention to students' interests and thoughts. Together with STEM, teachers will create learning environments that address multiple disciplines and allow students to use different types of intelligence.

In recent years, STEM education has played an important role in educational researchers and economic competition. Furthermore, the relationship between labor and STEM fields is emphasized and the importance of encouraging and preparing future generations to choose these fields is highlighted. According to Yıldırım (2013), STEM education is an approach that encourages students to learn directly and enables them to reach their dreams and to transfer this learning to new and different problems. Moreover, the need for individuals to develop and use these skills in daily life, which are expressed in different terms in the literature, increases the importance of STEM literacy. Studies show students welcome integrated STEM activities and believe such courses are helpful in solving problems in daily life (McBride & Silverman, 1991; James, 2014; Aydagül & Terzioğlu, 2014; Çorlu, Capraro, & Capraro, 2014; Hefty, 2015; McClain, 2015). In this context, it is thought that the problem-based activities with the integration of science, technology, engineering and mathematics will be beneficial in examining the contribution of STEM literacy and the academic success, attitudes, anxiety and self-efficacy of students in these areas. For this purpose, we want to answer to the following research problems and sub-problems.

**Research Questions**

Do the problem-based STEM activities impact the mathematics achievement, attitudes, and views of 7th-grade students in the teaching of ratio-proportion and percentages?
Regarding this problem, we sought answers to the following sub-research questions:

1. What is the effect of problem-based STEM activities on 7th-grade students' math achievement?
2. What is the effect of problem-based STEM activities on 7th-grade students' attitude toward mathematics?
3. What is the effect of problem-based STEM activities on 7th-grade students' self-efficacy in mathematics?
4. What is the effect of problem-based STEM activities on 7th-grade students' anxiety in mathematics?
5. What is the effect of gender on the variables of the other sub-research questions?

## Literature Review

When we examined the studies about STEM, we saw that these studies mostly focus on the importance of STEM education. Almost all of the researches on STEM education conducted with teachers, prospective teachers and primary/middle school students about science course while there are very few studies on mathematics (Rogers & Portsmore, 2004; Kennedy & Odell, 2014; Şahin, Ayar & Adıgüzel, 2014; James, 2014; McClain, 2015; Balbağ & Yenilmez, 2016; Gökbayrak & Karışan, 2017b; Delen & Uzun, 2018; Doğanay, 2018). Most of the research on teachers is conducted as an experimental study or intended to determine teachers' views and opinions who have previously participated in STEM training. In the researches with primary and middle school students, the impact of the activities applied using STEM education on the students' academic achievements and attitudes towards science, problem solving and scientific process skills and coding learning was examined. Rogers and Portsmore

(2004) stated that incorporating engineering into the primary education curriculum provides students with ways to connect, apply and reinforce their knowledge of mathematics, science and design; also, it is possible to develop a new discipline that will be the basis for K-12 education by developing new classroom tools and additional curricula. Kennedy and Odell (2014) highlighted the importance of STEM education in globalized economic competition and emphasized the need for a good curriculum and evaluation process to involve students in high-quality STEM education. The study by Şahin, Ayar and Adıgüzel (2014) examined students' characteristics, experiences, and achievements in an after-school program at a private school in Southeast U.S. According to the research findings, these activities included open-ended studies involving collaborative scientific discoveries in STEM fields and enabling students to use different 21st century skills.

When the studies conducted for STEM students are examined, we saw that STEM's effect on science academic achievement, students' views on STEM activities and STEM fields are mostly discussed. In a quantitative study by James (2014), data analyses show that students taking traditional math and science courses experience significantly greater academic achievement and growth than students enrolled in STEM courses in both mathematics and science. McClain's (2015) quantitative study's findings show that STEM education can improve student achievement in standard assessments. Similarly, the study by Gökbayrak and Karışan (2017b) shows that students benefit from different aspects of STEM activities and wish to develop themselves more in the fields of Science, Technology, Engineering and Mathematics. In addition, they considered that the courses would be more beneficial for them if they were processed with STEM activities. Finally, Doğanay's (2018) study shows that the educational process including problem-based STEM activities made a significant difference in the academic achievement and science attitudes of the elementary students according to the constructivist training process.

In summary, when examining the studies in the literature, it was found that most of these studies determine the characteristics of STEM education, the studies conducted within STEM education, the attitudes of teachers and prospective teachers toward STEM education, and the attitudes and opinions of students toward STEM, while there are very few studies that examine academic achievement.

## Method

### Research Design

In this study, quantitative techniques have applied to understand the effect of STEM teaching methods on student achievement, attitude, anxiety and self- efficacy. Among the quantitative techniques, descriptive and semi-experimental research model with pre-test and post-test control groups were used to determine the students' academic achievement, attitude, anxiety and self-efficacy of the mathematics course. The survey research aims to show the characteristics of the current situation in the research subject in general and to provide a description (Büyüköztürk, Çakmak, Akgün, Karadeniz and Demirel, 2013). In this context, the relevant scales were applied to the students as pre-test and post-test, and the numerical data was analyzed in terms of some variables and then, generalizations were ended about the group. According to Fraenkel and Wallen (2010), the issue is how the data are distributed among the individuals in the sample rather than why the data obtained in the surveys were generated.

### Sample

The sample of the study selected using convenience sampling method consists of 115 students attending the 7th grade of a public middle school in Turkey. Since the one dimension of the study was about observing students' participation and attitudes towards the course, we preferred such a sampling method after obtaining the necessary legal permissions to conduct the course content and lesson plan in a healthy way. In doing so, experimental and control groups were created by providing an intact classroom environment. You can see the frequency values of the participants in Table 1 below.

Table 1. Frequency values of students in experimental and control groups

| Group | Gender | *f* | % | Total | % |
|---|---|---|---|---|---|
| Experimental | Female | 22 | 46.8 | 47 | 40.9 |
| | Male | 25 | 53.2 | | |
| Control | Female | 43 | 63.2 | 68 | 59.1 |
| | Male | 25 | 36.8 | | |
| Total | Female | 65 | 56.5 | 115 | 100 |
| | Male | 50 | 43.5 | | |

The mathematics grades of the 7th grade students from the previous classes were obtained from the online grade database of the school to form the experimental and control groups. The mathematics scores' means of the students were analyzed by independent samples t-test to form experimental and control groups. As a result of independent samples t-test, we saw that there was no statistically significant mean difference between the math grades of experimental ($\overline{X} = 74.22$) and control ($\overline{X} = 76.85$) groups at .05 level [$t(113) = -1.07$, $p = .29$]. In other words, the experimental and control groups are equal in mathematics achievement and the groups are formed appropriately according to the purpose of the research.

**Data Collection Tools**

*Short Form for Attitude Scale towards Mathematics (SFASTM)*

The short form of Attitude Towards Mathematics Inventory (ATMI) developed by Tapia and Marsh (2004), adapted by Lim and Chapman (2013) and in which Hacıömeroğlu (2017) performed the validity and reliability study performed the validity and reliability study in Turkish was used by obtaining the necessary permissions to determine the change in 7th grade students' attitudes towards mathematics. SFASTM consists of 17 items and has a Cronbach's Alpha value of 0.84.

*Math Anxiety Scale for Middle School Students (MASMSS)*

MASMSS developed by Bindak (2005) to measure the level of mathematics anxiety of elementary school students, was made up of as few items as possible by the researcher so that elementary school students did not take much time to answer. The primary purpose of the study was to prepare a scale that would facilitate the application and response of elementary school students. The scale was originally created with 16 items, then was reduced to 10 items due to factor analysis, and the reliability coefficient of the scale was calculated by Bindak (2005) to be 0.84. In this scale, where students' scores vary from 10 to 50, mathematics anxiety increases as the total score increases, and mathematics anxiety decreases as the total score decreases.

*Self-Efficacy Perception Scale for the Middle School Students (SEPSMSS)*

To measure 7th grade students' mathematics self-efficacy perception levels, we used the SEPSMSS, developed by Umay (2001), consisting of 14 items and has a reliability coefficient of 0.88. In factor analysis, self-perception/self-confidence (items 3, 10, 11, 12 and 13) of mathematics, awareness of mathematics topics and behaviors (items 4, 5, 6, 7, 8 and 9) to be able to transform mathematics into life skills (items 1, 2 and 14 were found to be collected in three factors.

*STEM Career Interest Scale (STEM-CIS)*

In order to measure 7th grade students' interest in STEM professions, we used the STEM-CIS, developed by Kier, Blanchard, Osborne, and Albert (2014), adapted to Turkish by Koyunlu Ünlü, Dökme and Ünlü (2016) and consisting of 40 items. The researchers calculated Cronbach's Alpha reliability coefficient as 0.93 of the scale adapted to Turkish. Also, Cronbach's Alpha reliability coefficient of the sub-fields was calculated as 0.86 for science, 0.88 for technology, 0.94 for engineering and 0.90 for mathematics.

*Ratio-Proportion and Percentages Achievement Test (RPPAT)*

It was developed by the researchers taking expert opinions were applied to experimental and control group students as pre-test and post-test. You can see the reliability values of data obtained from these scales from Table 2.

Table 2. Reliability values of the pre-test and post-test data

| Scale | | Pre-Test Cronbach's Alpha | Post-Test Cronbach's Alpha | Number of Items |
|---|---|---|---|---|
| SFASTM | | .88 | .93 | 17 |
| MASMSS | | .85 | .88 | 10 |
| SEPSMSS | | .84 | .88 | 14 |
| STEM-CIS | | .90 | .93 | 40 |
| | Mathematics | .85 | .91 | 10 |
| | Science | .90 | .92 | 10 |
| | Technology | .83 | .88 | 10 |
| | Engineering | .92 | .93 | 10 |
| RPPAT | | .73 | .86 | 10 |

Reliability test shows that the results obtained by applying all the scales used in the pre-tests and post-tests of the research are within the acceptable range (at least .70) for reliability (Morgan et al., 2004).

## Data Collection Process

After students in the experimental and control groups completed the pretests of all scales, the lesson plans, which included six different problem-based STEM activities, were used for two months as a treatment for students in the experimental group to teach ratios and percentages. Among the special objectives of the mathematics course curriculum are students' understanding of mathematical concepts and their ability to use these concepts in daily life (MoNE, 2018b). In this context, ratio-proportion and percentages have a great place in connecting with daily life. The fact that these subjects are related to other mathematics subjects further increases the importance of this situation. Therefore, ratio-proportion and percentages topics were chosen to apply problem-based STEM activities in the research, both because of its connection with daily life and because it requires mathematical, proportional and critical thinking skills. To carry out the teaching programs based on STEM activities for teachers, they must first prepare lesson plans following this philosophy. According to Ramaley (2007), the implementation of STEM-based activities in the classroom environment can only be achieved by preparing mathematics and science education programs, where technology and engineering are integrated within the framework of the lesson plans. Teaching programs that include these activities can enable students to embody what they have learned and connect with everyday life and increase their motivation in math and science classes. When the lesson plans created within the context of STEM are examined, it is seen that the course is built on a knowledge-based life problem (Çorlu and Çallı, 2017). In these lesson plans, the targeted achievements of each STEM discipline, the materials to be used, the problem situation and the course process are clearly stated. In addition, some of the lesson plans include the professional group targeted by the applied activities and the characteristics of this profession. We prepared five lesson plans: gear wheels, speed-time-path, elevator construction, bridge model and nutritional values. We created these lesson plans by consulting the opinions of different experts. Afterwards, we applied each lesson plan for a week (5 lesson hours per week) in the classroom with the students in the experimental group. Here we share the content and processing process of a lesson plan to give you an idea.

| | | | |
|---|---|---|---|
| **Subject:** | Ratio - Proportion | **Grade:** | 7th |
| **Duration:** | 5 hours | | |
| **Objectives:** | **Mathematics:**<br>• Determines the value that the other will receive if one of the multiplexes in the ratio is 1<br>• When one of the two multiplicities given the ratio to each other is given, finds the other<br>• Decides whether two multiplicities are proportional by examining real-life situations<br>• Expresses the relationship between two directly proportional multiplicities.<br>**Sciences:**<br>• Defines speed and expresses its unit<br>• Shows the relationship between path, time and speed on the graph<br>**Technology:**<br>• Develops an understanding of the features and scope of technology<br>• Develops an understanding of the features of design<br>• Understands the basic concepts of technology<br>• Understands the relationships between technologies and develops connections between technology and other fields<br>**Engineering:**<br>• Understands the working principle of motor vehicles. | | |
| **Teaching Method:** | Questioning-answering, discussion, group working, brainstorming | | |
| **Tools and Equipment:** | GeoGebra dynamic geometry software, toy cars, toy racetrack of different length, paper, pencil | | |

Figure 1. Example of the lesson plan about "Speed, Time, and Path"

One of the lesson plans prepared and used for the research was speed, time and path. You can see the objectives, teaching methods, tools and materials used in this lesson plan in Figure 1. The teacher completed the lesson preparation process by asking the following questions to the students. "What are the factors affecting the travel time?", "What criteria are important in calculating speed?", and "Which variable increases or decreases as time increases at constant speed?" Then, students are divided into groups of two and each group chooses a pull-back toy car. Students were given previously prepared ropes of different lengths and colours.

Figure 2. Classroom photos showing the process of the lesson plan about "Speed, Time, and Path"

As shown in Figure 2, the teacher asked each group to pull and drop the pull-back toy cars at the length of the ropes, respectively, and record the data they have obtained. As a result of the experiment, the students who completed the table were able to understand the basic principle of the formula x=v.t and how the others change when one variable is held constant. In the last part, the students were divided into four groups and tried to predict the result of the experiment with the GeoGebra application opened on the smart board as shown in Figure 3.

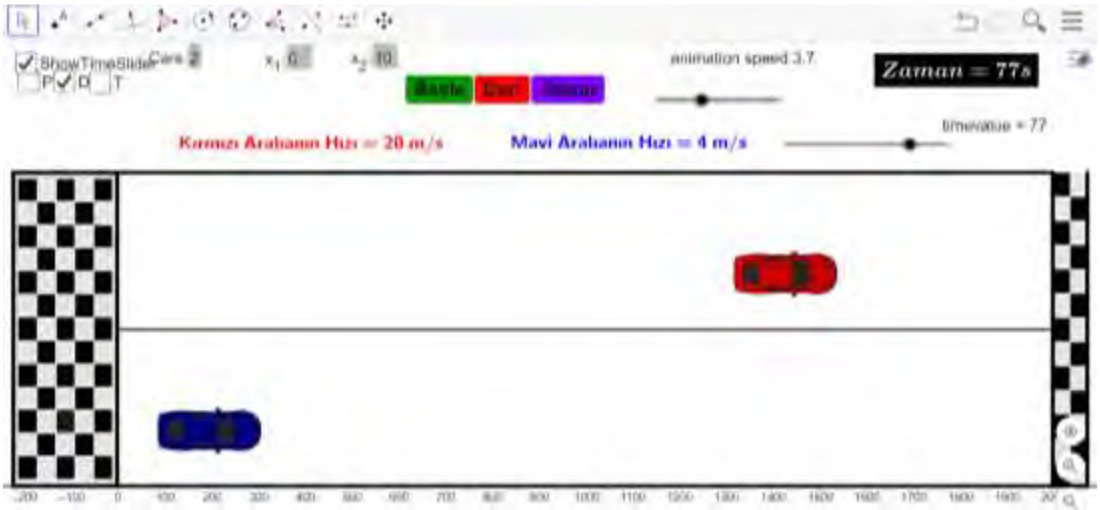


Figure 3. Photo showing the car racing experimentation about "Speed, Time, and Path" with GeoGebra

After two months of teaching process, all scales were re-applied as post-tests and the obtained data were analyzed. Each group that answered correctly got 10 points. The group with the most points as a result of five questions won the first place. Finally, the questions in the evaluation part of the lesson plan were discussed and solved by the whole class by applying the correct problem-solving steps.

**Analysis of Data**

The data collected from the scales applied to the experimental and control group students as pre-test and post-test were analyzed with IBM SPSS 22.0 program. Items 8, 9, 10, 11 and 12 that were negative in SFASTM were re-coded to be 1 = 5, 2 = 4, 4 = 2 and 5 = 1, and the scores obtained from this scale were collected and the lowest 17, highest 85 total attitude scores were calculated.

The 9th item, which was negative in MASMSS, was re-coded as 1 = 5, 2 = 4, 4 = 2 and 5 = 1, and the scores were summed to get the total anxiety score of each student as lowest 10 and highest 50 points. Likewise, the items 3, 6, 7, 10, 11 and 12, which were negative in the SEPSMSS used to measure students' mathematics self-efficacy, were re-coded to be 1 = 5, 2 = 4, 4 = 2 and 5 = 1. Each students' self-efficacy perception score for mathematics was calculated as 14 lowest and 70 highest.

Since there is no negative item in STEM-CIS, scores for mathematics, science, technology and engineering professions were calculated separately and STEM professions total score without the need for re-coding. The lowest score was 10 and the highest score was 50 for the four sub-domains, while the STEM occupations had a total score of 40 and a maximum of 200. According to the grade scoring key previously prepared in RPPAT, partial and full scores were calculated and the total success scores obtained to be the lowest 0 and the highest 100.

These scores of both experimental and control group students from pre-tests and post-tests were analyzed with descriptive statistics, independent sample t-test, dependent sample t-test and Pearson correlation. The significance level was 0.05 in all analyses.

## Results

To see whether the data obtained from the pre-tests and post-tests showed normal distribution, Shapiro-Wilks test was used for groups with less than 50 students, and Kolmogorov-Smirnov test was used for groups with more than 50 students.

Table 3. Normality test results of the pre-test and post-tests by experimental and control groups

| | | | Pre-Test | | | | Post-Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Df | Statistic | p | Skewness | Kurtosis | Statistic | p | Skewness | Kurtosis |
| | RPPAT | 115 | .138 | .000 | 0.96 | 0.23 | .071 | .200 | 1.327 | 1.676 |
| | Experimental | 47 | .847 | .000 | 1.06 | 0.15 | .958 | .090 | -.259 | -.891 |
| | Control | 68 | .127 | .008 | 0.98 | 0.60 | .093 | .200 | .460 | -.513 |
| | SFASTM | 115 | .077 | .092 | -0.78 | 0.60 | .085 | .042 | -.779 | .598 |
| | Experimental | 47 | .975 | .407 | -0.12 | -0.60 | .964 | .152 | -.635 | .783 |
| | Control | 68 | .122 | .013 | -1.18 | 1.49 | .103 | .069 | -.682 | -.039 |
| | MASMSS | 115 | .117 | .001 | 0.94 | 0.38 | .106 | .003 | .941 | .382 |
| | Experimental | 47 | .961 | .113 | 0.56 | -0.03 | .946 | .031 | .493 | -.702 |
| | Control | 68 | .174 | .000 | 1.36 | 1.56 | .140 | .002 | .561 | -.771 |
| | SEPSMSS | 115 | .065 | .200 | 0.50 | 0.21 | .093 | .016 | -.504 | .208 |
| | Experimental | 47 | .982 | .691 | -0.40 | 0.70 | .979 | .555 | .015 | -.681 |
| | Control | 68 | .097 | .188 | -0.53 | -0.26 | .132 | .005 | -.261 | -.802 |
| | STEM-CIS | 115 | .048 | .200 | -0.11 | -0.23 | .051 | .200 | -.11 | -.225 |
| | Experimental | 47 | .986 | .842 | -0.02 | -0.05 | .966 | .192 | -.623 | 1.289 |
| | Control | 68 | .062 | .200 | -0.17 | -0.24 | .062 | .200 | -.105 | -.451 |
| Subfields of STEM-CIS | Mathematics | 115 | .099 | .008 | -.688 | .540 | .081 | .064 | -.688 | .54 |
| | Experimental | 47 | .966 | .179 | -.362 | -.560 | .951 | .047 | -.549 | .057 |
| | Control | 68 | .135 | .004 | -.915 | 1.393 | .089 | .200 | -.567 | -.077 |
| | Science | 115 | .091 | .021 | -.575 | -.198 | .085 | .039 | -.575 | -.198 |
| | Experimental | 47 | .951 | .048 | -.631 | -.020 | .953 | .059 | -.575 | -.004 |
| | Control | 68 | .112 | .034 | -.449 | -.705 | .089 | .200 | -.628 | .113 |
| | Technology | 115 | .077 | .087 | -.580 | .091 | .108 | .002 | -.58 | .091 |
| | Experimental | 47 | .965 | .167 | -.441 | -.284 | .917 | .003 | -.931 | .579 |
| | Control | 68 | .076 | .200 | -.619 | .175 | .105 | .062 | -.713 | .029 |
| | Engineering | 115 | .094 | .014 | -.602 | .175 | .085 | .041 | -.602 | .175 |
| | Experimental | 47 | .965 | .177 | -.371 | .051 | .949 | .038 | -.210 | -.723 |
| | Control | 68 | .107 | .052 | -.684 | .144 | .121 | .015 | -.890 | .616 |

Table 3 shows that the data from the pre-tests and posttests of all scales have a normal distribution when students are classified either in terms of significance, skewness, and kurtosis or in terms of both groups as experimental and control. In the Kolmogorov-Smirnov test, it is assumed that the data are normally distributed when $p > .05$. In addition, it is stated in some studies that skewness and kurtosis values are accepted as perfect in the range of ±1 for most psychometric purposes, but a range of ±2 is seen as an adequate criterion for normality in most cases (George & Mallery, 2010; Gravetter & Wallnau, 2014). Thus, to see whether between experimental and control group have significant mean differences on the scores of the scales, parametric tests can be applied.

To begin with, data obtained from the pre-test and post-test of RPPAT applied to both experimental and control groups to understand the effect of the problem-based STEM activities on the teaching process of the ratio-proportion and percentages to the experimental group students on the academic achievement. As a result of the pre-test, there was no significant difference between the mean scores of the experimental ($\overline{X} = 18.51$) and control ($\overline{X} = 20.51$) group students [t(113) = -0.56, p = .58]. However, looking at the data from the posttest of the RPPAT, we conclude that there is a significant difference between the mean scores of students in the experimental group ($\overline{X} = 69.00$) and the control group ($\overline{X} = 40.88$) [t(113) = 6.82, p = .Considering the success levels of the experimental group students regarding the ratio-proportion and percentages after the implementation of the problem-based STEM activities by gender, there is not a significant difference in the means obtained by the female students ($\overline{X} = 63.55$) and male students ($\overline{X} = 73.80$) students [t(45) = -1.83, p = .07]. In other words, after implementing the lesson plans with the activities prepared within the scope of the research, after the RPPAT post-test, the male students in the experimental group have no advantage over female students in terms of achievement scores. Considering the success of the control group students in the ratio-proportion and percentages in this process, it is concluded that the average success rate of both female and male students is significantly higher than the pre-test. Specifically, there is no significant difference between genders in the pretest and posttest, and there is a significant increase in the mean score of all students in the control group compared to the pretest ($\overline{X} = 20.10$) and posttest ($\overline{X} = 40.88$) [t(67) = -.41, p = .00]. This emerging situation is considered to be an expected result of the traditional education environment compared to the results obtained by the experimental group students.

Secondly, observed that there was no significant difference between the students in the experimental ($\overline{X} = 64.87$) and control ($\overline{X} = 66.10$) group students in the attitude score towards mathematics obtained as a result of the pretesting of SFASTM [t(113) = -0.53, p = .60]. Similarly, it is found that the difference between the mean scores of the experimental ($\bar{X}$ = 63.19) and control ($\bar{X}$ = 63.79) group students on attitude scores towards mathematics was not significant [t(113) = -0.22, p = .82]. In addition, there was no significant change in experimental group students' SFASTM pre-test and post-test scores according to both gender and all students. Similar results were seen where the total score mean for mathematics did not differ by gender, both pre-test and post-test separately. This showed that problem-based STEM activities, which lasted about two months, did not affect students' mathematics attitudes at the end of the application process.

Thirdly, to understand the effects of problem-based STEM activities on the students' math anxiety levels of students, the total anxiety mean scores of the experimental ($\bar{X}$ = 23.34) and control ($\bar{X}$ = 19.35) group students was analyzed by independent samples t-test and it is seen that this mean difference has significant in favor of the experimental group students [t (113) = 2.60, p = .01]. In other words, as a result of the pre-test, math anxiety levels of the experimental group students were significantly higher than the control group students. However, there was no statistically significant difference between the anxiety levels of the experimental ($\bar{X}$ = 23.60) and control ($\bar{X}$ = 22,56) group students from post-test of MASMSS [t (113) = 0.58, p =. 56]. The anxiety level of the experimental group students, which was high as a result of the pre-test, decreased or did not increase significantly in a way that did not make any difference comparing with the control group students. This shows that STEM activities applied in the research effectively lower students' math anxiety or eliminate the factors that will increase the students' math anxiety. When the data of MASMSS were analyzed by gender, it is found that the difference between the mean scores of male students and female students in both experimental and control group was not significant. In addition, when examining the MASMSS pre-test and post-test scores, it is found that there was no statistically significant change in the overall anxiety scores of the students in the experimental group with respect to either gender and as a whole. However, anxiety of both male and female students towards mathematics significantly increased in the control group of pre-test and post-test data. It is seen that the anxiety mean scores of the students in the control group did not show any significant difference in terms of gender in the pre-test and post-test, but the anxiety mean scores for all of the control group students were higher in the post-test and this difference was significant.

Fourthly, to understand the impact of problem-based STEM activities on students' self-efficacy perceptions of mathematics, the data obtained as a result of the application of SEPSMSS as a pre-test and a post-test were analyzed. Considering the data obtained from the pre-test, the total mean score for the self-efficacy perception of the control group ($\bar{X}$ = 52.59) students was significantly higher than the experimental group students [t(113) = -2.10, p = .038]. Given the data from the posttest and parallel to the result of the pretest, the mean of the total score of the experimental group ($\bar{X}$ = 51.01) for self-efficacy perception was higher than that of the students in the control group ($\bar{X}$ = 46.96), but this time this difference was not significant [t(113) = -1.87, p = .064]. We can say that the scores for self-efficacy decreased in both groups, but the scores for self-efficacy perception of the students of the control group concerning mathematics decreased more than those of the students of the experimental group. In addition, the mean scores of female students in the experimental group are statistically significantly lower [t(21) = 2.70, p = .01] in the post-test ($\bar{X}$ = 44.14) compared to the pretest ($\bar{X}$ = 49,00). The mean scores of male students, on the other hand, was higher in the post-test ($\bar{X}$ = 49.44) than the pre-test mean ($\bar{X}$ = 48.44) but this difference was not significant [t(24) = -0.46, p = .65]. This result showed that the problem-based STEM activities negatively affected the students' self-efficacy perceptions of mathematics and did not cause any change in male students. Also, there is no statistically significant difference in the pre-test ($\bar{X}$ = 48.70) and post-test ($\bar{X}$ = 46.96) self-efficacy mean scores of the students in the experimental group, both by gender and on the basis of all students [t(46) = -1.18; p = .24]. Considering the findings obtained from the results from the SEPSMSS of the control group students, the mean scores of the female students are in the pre-test ($\bar{X}$ = 53.00) and the post-test ($\bar{X}$ = 52.19) [t(42) = 0.70, p = .49] while the mean scores of the male students are in the pre-test ($\bar{X}$ = 51.88) and the post-test ($\bar{X}$ = 49.00) [t(24) = 1.20, p = .24]. These show that the pre-test and post-test mean differences of both genders was not significant (p > .05).

Fifthly, to understand the effects of problem-based STEM activities on the interests of students in professions in STEM fields, the data obtained as a result of the application of STEM-CIS to both experimental and control group students were analyzed. It was found that the total score of STEM-CIS from the pretest showed no significant difference between students in the experimental ($\bar{X}$ = 153.45) and control ($\bar{X}$ = 154.82) groups [t(113) = -0.35, p = .72].In parallel with this result, the interest levels of the experimental and control group students for the professions in mathematics, science, technology and engineering, which are subfields of the STEM, did not make a significant difference for each separately. This means that the interests of the experimental and control groups formed in the study for STEM occupations are at the same level, both overall and in comparison, to the sub-areas. In parallel with the pretest results, we saw that the total scores of STEM-CIS from the post-test did not create a significant difference between the experimental ($\bar{X}$ = 154.51) and control ($\bar{X}$ = 150.29) groups [t(113) = 0.90, p =

.37]. When we look at the scores related to the STEM subfields, it is concluded that the interest of the experimental and control group students in these fields does not make a significant mean difference compared to the post-test scores as in the pre-test results. Looking at the results of the analysis conducted to see how the students' interest in STEM professions changed depending on their gender in the pre-test and post-test, the analysis results show that the pre-test of the students in the experimental group by gender, based on the scores of the other sub-areas and the total score for the STEM areas, showed no significant mean difference as a result of the post-test. It is found that the post-test mean score ($\bar{X}$ = 44.72) regarding the interest of male students in the professions in technology was significantly higher than the pre-test score mean ($\bar{X}$ = 42.72) [t(24) = -2.21, p = .04]. Similarly, in the final test results of the STEM-CIS subtests show that only the technology scores of the male students ($\bar{X}$ = 44.72) are significantly higher than that of the female students ($\bar{X}$ = 37.86) [t(45) = -3.61, p = .00]. Moreover, the total interest mean score ($\bar{X}$ = 161.82) for the STEM professions of male students in the experimental group was somewhat higher than female students ($\bar{X}$ = 146.23) [t(45) = -2.21, p = .03]. When the scores of all female students and male students are compared, there is no significant difference between the total interest scores for the pre-test ($\bar{X}$ = 153.45) and post-test ($\bar{X}$ = 154.51) STEM professions [t(45) = -0.36; p = .72].

Lastly, when the mean scores of the control group students who continue their normal course process on the teaching ratio-proportion and percentages regarding STEM professions measured by STEM-CIS are examined, it was observed that only the mean score of female students decreased significantly in the post-test ($\bar{X}$ = 148.84) compared to the pre-test ($\bar{X}$ = 155.28) [t(42) = 2.39, p = .02]. Considering the interest in professions in STEM subfields, similarly, only the mean scores of female students in science and mathematics were statistically significant in the post-test compared to the pre-test. Furthermore, the findings regarding how the interest of the experimental group students in the sub-fields changed according to gender based on pre-test and post-test showed that the mean scores of female students in mathematics, science and engineering sub-fields were higher only in the pre-test compared to male students. When - look at the control group in general, the scores related to the professions in mathematics and science only decreased significantly in the post-test compared to the pre-test. The mean interest score of the control group with STEM-CIS also did not differ significantly with respect to gender in the pretest and posttest, but the mean score of the posttest ($\bar{X}$ = 150.29) based on all students was significantly lower than the mean score of the pretest ($\bar{X}$ = 154.82) [t(67) = -9.41; p = .00].

## Discussion and Conclusion

Proportional reasoning is defined as the heart of middle school mathematics and includes mathematical relationships in multiplicative state in nature (Ben-Chaim, Fey, Fitzgerald, Benedetto, & Miller, 1998). The ratio-proportion subject is crucial for school mathematics because of its connection with daily life and forming the basis of many subjects (Duatepe, Akkuş-Çıkla & Kayhan, 2005). So, we have chosen the topic of proportionality both because of its importance in mathematics education and because of its connection to daily life. According to NCTM (1989), the ability to reasoning in students develops proportionally from the fifth grade to the eighth grade, and the time and effort required to ensure the development of this ability are extremely important, and no matter how long it takes, students need to work to acquire this skill. The teaching process carried out by integrating STEM into science education contributed positively to students' academic achievements, scientific process skills, and engineering knowledge (Akdağ, 2017).

Similarly, the experimental group students of this study are more successful than the control group students in terms of ratio-proportion and percentages afterward the problem-based STEM activities. Moreover, according to the post-test results, both male students' and female students' scores increased more and statistically significant compared to the control group students. Factors affecting students' performance in mathematics consist of attitudes towards mathematics and the importance of developing these attitudes to improve students' achievements in mathematics (Mohamed & Waheed, 2011). McDonald (2016) states that involving students in fun, hands-on, and daily life-related activities will improve their attitudes toward STEM disciplines. STEM activities prepared in this framework are intended to provide students with a fun learning environment and to connect their subjects with daily life. Considering the definitions about attitude towards mathematics in the literature, the change of this affective feature in the individual depends on many factors such as family, teacher, social environment, age, intelligence, time etc. (Elçi, 2008; Kurbanoğlu, & Takunyacı, 2012; Yamak, Bulut & Dündar, 2014; Hacıömeroğlu, 2017; Aydın, Saka & Guzey, 2017). It is an expected result that the problem-based STEM activities, which last about two months, on the ratio-proportions and percentages do not cause any change in the students' attitudes towards the mathematics lesson. If these activities were kept longer and not limited to a specific subject or unit, one of the appropriate environments would allow students to develop a positive attitude towards the mathematics lesson.

Next, there are many studies on how math anxiety changes according to some variables such as gender, grade level, social environment, mathematics achievement (Dreger & Aiken, 1957; Aiken, 1974; Haladyna, Shaughnessy & Shaughnessy, 1983; Wigfield & Meece, 1988; Hembree, 1990; Randolph, 1998; Luo, Wang & Luo, 2009). When - looked at these studies, it is a common result that anxiety towards mathematics is among the factors that negatively affect mathematics achievement. In studies that investigate math anxiety by gender, it is observed that both students' math anxiety is higher than female students' and female students' math anxiety levels are higher than that of male students. Also, students' anxieties about mathematics are related to the students' expectations scores (Karjanto & Yong, 2013). This supports the view of Aiken (1974) in elementary and middle school years that male students had some more positive feelings about mathematics than female students, but there was no definite conclusion about whether there were gender differences in math anxiety among young students. As a result of the pre-test performed before the application, the mathematics anxiety of the experimental group students was significantly higher than the students in the control group. However, as a result of the post-test after the activities, this high level of anxiety has reached a level that is not statistically significant. This showed that problem-based STEM activities have an undeniable effect on reducing students' anxiety about mathematics.

Next, self-efficacy perception of mathematics is expressed as a situational or problem-specific assessment of an individual's confidence in the ability to perform a particular mathematical task or to successfully achieve a problem (Hackett & Betz, 1989). Bandura (1977) argues that a person's self-efficacy perception is an important factor that determines his belief in his ability to successfully perform a particular task or behavior in the face of obstacles faced by him, whether he will attempt to do a particular task, and how much effort he will make. At the same time, in terms of social learning theory, it is suggested that self-efficacy expectation is an important factor affecting mathematics education and career choices as well as attitude towards mathematics and mathematics performance and achievement (Bandura, 1977; 1986). In the study of Işıksal and Aşkar (2003), which included 7$^{th}$ and 8$^{th}$ grade students to investigate the relationship between perception of mathematics self-efficacy and computer self-efficacy, it was revealed that students' perceptions of mathematics self-efficacy did not change by their gender. Similarly, in Ayotola and Adedeji's (2009) study examining the relationship between middle school students' mathematics self-efficacy and their mathematics achievement, it was found that there was no significant difference between students' gender and their perception of mathematics self-efficacy. This is consistent with the results of the study among students in the overall control group and male students in the experimental group. In Pajares and Miller's (1994) study, which was designed to investigate the relationship between mathematics self-efficacy perceptions and mathematics achievement of high school students, it was found that students with high mathematics self-efficacy perceptions had higher mathematics achievement, and these perceptions were higher for male students than for female students. Similar to this result, Lent, Lopez and Bieschke (1991) concluded that male students at high school and university levels have higher self-confidence and self-efficacy perceptions in mathematics, science and technology than female students. The similarity with the results of Lent, Lopez and Bieschke (1991) because there were practices involving science, technology, engineering and mathematics in the activities, the self-efficacy perception scores of female students in the experimental group of the research were significantly lower in the post-test compared to the pre-test. These findings are similar with Pajares and Miller's (1994) study. Kalın (2010) stated that self-efficacy perceptions, which differ between studies, may be due to the qualifications of the researchers. In the context of the research, they tried to select subjects that might be of interest to both genders during the preparation of problem-based STEM activities, but it was clearly observed during the classroom practice those male students were more interested in these activities. Therefore, it can be said that the characteristics of the activities implemented cause this difference of female students. In addition, although the pre-test scores were significantly higher in favor of the control group students, the absence of this significance in the post-test results could mean that the STEM activities affected the students' perceptions of mathematics in the experimental group compared with the control group because there is a lot of research in the literature about a strong relationship between mathematics self-efficacy perception and mathematics achievement (Lent, Lopez and Bieschke, 1991; Bandura, 1995; Ayotola & Adedeji, 2009; Öztürk & Şahin, 2015; Keşan & Kaya, 2018 ). In other words, these activities have a positive effect on preventing students from deteriorating their perceptions, even though they do not directly increase students' self-efficacy perceptions in mathematics, since the mathematics performance of students in the experimental group is significantly higher than that of students in the control group, both proportionally and as a percentage. Fifthly, the fact that a philosophy that is in search of innovation is the basis of STEM education increases the importance of this education for economies day by day. In a rapidly changing, developing and the digitalizing world, a labor market that has the necessary training can meet the needs of the era and renew itself constantly is required for companies to take their place in economic competition (Vilorio, 2014; TÜSİAD, 2014). This situation causes an increase in the need for individuals who are trained in STEM fields, sectors of companies that want to have a voice in the global economy (TÜSİAD, 2017). According to TÜSİAD (2017), to lead the global economy where innovation and digitalization will give direction, studies and investments should be made to create employees with STEM skills and individuals should be educated in this way, starting from preschool. Students' interests and attitudes towards science, technology, engineering and mathematics develop negatively, especially in middle school years (Degenhart, Wingenbach, Dooley, Lindner, Mowen, & Johnson, 2007). To eliminate this situation and increase the interest of students in these areas, which are very important for today and the future, studies should be done especially in school education programs and the effectiveness of these studies should be investigated. As a result, it is observed that the interest scores of STEM professions of the experimental group students increased slightly in the post-test compared to the pre-test, while the scores of the control group students decreased in comparison to the pre-test. These differences were not significant for the experimental and control groups, but when the mean scores of these groups were examined separately, the interest of the control group students in STEM professions decreased significantly. In that case, the problem-based STEM activities contribute directly to the experimental group students in the professions in the STEM fields, but when the interest of the control group students decreases, they are positively contributed. Incorporating the skills of these occupations into the activities and providing information about them to students during the instructional phase is believed to be effective in this situation. In the study conducted by Wyss, Heulskamp, and Siebert (2012), they found that career choice occupies an important place in the middle school years. In this study, they examined the effect of providing accurate and detailed information about STEM careers during middle school. So, they expressed that video interviews with professionals in STEM fields have increased the students' interest in these professions and their desire to choose them in the future without any gender difference. This result supports the conclusion that obtaining information about the professions of the research increases the interest in STEM professions. As a result of the research in which the STEM education in the problem-based learning environment of Alıcı (2018) investigated the attitude of 5$^{th}$ grade students towards STEM disciplines, their perceptions of STEM career and their interest in STEM professions, they find that these characteristics of the students increased significantly. Finally, Hossain and Robinson (2012) stated that to be successful in STEM careers, it is necessary to be curious, think logically and creatively in problem-solving, have effective communication skills and work in teams. In this research, it is seen that the activities developed for the teaching process of the ratio-proportion and percentages contributed to the students acquiring and use these skills.

Finally, in the study to learn the opinions of students belonging to Şahin, Ayar and Adıgüzel (2014) about the activities they carried out about post-school STEM areas, they conducted these activities without any concern felt comfortable and enjoyed. Furthermore, students stated that these activities are very different from the normal lesson process, they make fun experiments and researches on mathematics and science, and finally they see the positive effects of learning with their friends. Not only are students learning 21st century skills such as teamwork and effective communication in these activities, but interest in STEM careers has also increased. In the study of Mohr - Schroeder, Jackson, Miller, Walcott, Little, Speler and Schroeder (2014), the mixed method was used as a post-test and STEM summer camps in which middle school students attend to increase their interest in various STEM fields and STEM professions. The effect of camps on students was investigated. The results indicated that students learned the subjects better because the camp and activities are very fun and they interact with the materials they have never seen before. According to the students, the fact that the activities addressed their interests provided both easier understanding and permanent learning. In addition, students' interest in STEM fields has increased and they want to do more activities in these fields. In the study defining STEM -integrated project-based learning by Afriana, Permanasari, and Fitriani (2016) and aimed at improving the science literacy of middle school students, they found that the development of science literacy of students in the experimental group after STEM -integrated project-based learning was more significant than that of students in the control group. In addition, student responses to the study showed that almost all students were excited about project-based STEM learning, had impressive experiences during learning and increased their learning motivations and interests.

In mathematics course, where many students from primary school to university have difficulties, different teaching methods accepted globally should be tried. In many studies STEM education has an important role in reducing students' fears of mathematics, contributing to self-efficacy perceptions and increasing mathematics achievement. STEM education will become an important part of mathematics education in addressing different intelligence types of students and bringing together different disciplines.

## Recommendations and Further Researches

With the widespread use of internet and social media networks, people can access information and experience anywhere in the world, which is expressed as globalization (Eser, 2014). With digitalization, which is a result of globalization, major changes have occurred in social, political, economic and cultural life. To keep up with these changes and have a say in the economic fields, countries need to have an education system suitable for the needs of the age. Involving students in STEM activities as in-school or out-of-school activities will assist students in gaining 21$^{st}$ century skills that are needed by the current century. First of all, prospective teachers should be trained in understanding STEM education and preparing a suitable lesson plan. In-service training for STEM education should be provided not only to prospective teachers, but also to existing teachers, but these training should be arranged so as not to be theoretical but practical. In addition, updating the mathematics curriculum accordingly, rearranging the textbooks to include more mathematical tasks that require students to think more and require interdisciplinary knowledge transfer, as well as effective communication skills, analytical and critical thinking, commenting, etc. are thought to be effective in gaining century skills. The impact of parents and social environment on students' preference for STEM fields in the choice of profession that will affect their future is very important. Parents should encourage students to research and participate in STEM camps and clubs that match their interests, not solve many questions, and contribute to their academic success in math and science and their interest in STEM fields and careers. This study examined the impact of STEM instruction for middle school students on variables related to mathematics instruction. Conducting a similar study at primary and high school levels will allow for more comprehensive results and comparison of the results of this study. Also, this research was carried out with students who did not know anything about STEM. Hence, conducting the research in an environment where students were exposed to STEM education for a longer period would probably produce different results. In addition, examining the effectiveness of the programs integrated into STEM, which takes mathematics courses and other disciplines as the center, can offer results to be taken into consideration in the training programs to raise individuals ready for Industry 4.0 and beyond.

## Acknowledgements or Notes

This study was produced from Yavuz Macun's master's thesis and was funded by the Erciyes University Scientific Research Projects Unit with the project code SYL-2019-8749.

## Author (s) Contribution Rate

The authors contributed equally to the article.

## Conflicts of Interest

Authors declare that they have no conflict of interest.

## Ethical Approval

Ethical permission 26.02.2019-18 was obtained from Erciyes University Social and Human Sciences Ethics Committee for this research.

## References

Afriana, J., Permanasari, A. & Fitriani, A. (2016). Project Based Learning Integrated to Stem to Enhance Elementary School's Students Scientific Literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261-267.

Aiken, L.R. (1974). Two scales of attitude toward mathematics. *Journal for Research in Mathematics Education*, *5*(2), 67-71.

Akdağ, F. T. (2017). *STEM Uygulamalarının Öğrencilerin Akademik Başarı, Bilimsel Süreç ve Yaşam Becerileri Üzerine Etkisi [Effect of STEM applications on academic achievement, scientific process and life skills].* Unpublished Doctoral Dissertation, Samsun: Ondokuz Mayıs University.

Alıcı, M. (2018). *Probleme dayalı öğrenme ortamında STEM eğitiminin tutum, kariyer algı ve meslek ilgisine etkisi ve öğrenci görüşleri [Effect of STEM applications on academic achievement, scientific process and life skills]*. Unpublished Master Thesis, Kırıkkale: Kırıkkale University.

Aydagül, B. & Terzioğlu, T. (2014). Bilim, teknoloji, mühendislik ve matematiğin önemi. [Importance of science, technology, engineering and mathematics]. *TÜSİAD Görüş Dergisi, 85*, 13-19.

Aydın, G., Saka, M. & Guzey, S. (2017). 4-8. sınıf öğrencilerinin fen, teknoloji, mühendislik, matematik (STEM=FETEMM) tutumlarının incelenmesi [Science, Technology, Engineering, Mathematic (STEM) Attitude Levels in Grades 4th - 8th]. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 13*(2), 787-802.

Ayotola, A. & Adedeji, T. (2009). The relationship between mathematics self-efficacy and achievement in mathematics. *Procedia-Social and Behavioral Sciences*, *1*(1), 953-957.

Balbağ. M. Z. & Yenilmez. K. (2016). Fen bilgisi ve ilköğretim matematik öğretmeni adaylarının STEM'e yönelik tutumları [The STEM attitudes of prospective science and middle school mathematics teachers]. *Eğitim ve Öğretim Araştırmaları Dergisi. 5*(4), 301-307.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191-21.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology, 4*(3), 359-373.

Bandura, A. (Ed.). (1995). *Self-efficacy in changing societie*s. Cambridge University Press.

Ben-Chaim, D., Fey, J. T., Fitzgerald, W. M., Benedetto, C. & Miller, J. (1998). Proportional reasoning among 7th grade students with different curricular experiences. *Educational Studies in Mathematics, 36*(3), 247-273.

Benešová, A. & Tupa, J. (2017). Requirements for Education and Qualification of People in Industry 4.0. *Procedia Manufacturing 11.* 2195 – 2202.

Bindak, R. (2005). İlköğretim Öğrencileri İçin Matematik Kaygı Ölçeği. *F. Ü. Fen ve Mühendislik Bilimleri Dergisi, 17*(2), 442-448.

Büyüköztürk, Ş., Çakmak, E., Akgün, Ö., Karadeniz, Ş. ve Demirel, F. (2013). *Bilimsel Araştırma Yöntemleri [Scientific Research Methods].* Ankara: Pegem Akademi Yayınları.

Bybee, R. W. (2010). *The teaching of science: 21st century perspectives.* NSTA press.

Çorlu, M. S., Capraro, R. M. & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Eğitim ve Bilim, 39*(171).

Çorlu, M. S. & Çallı, E. (2017). *STEM Kuram ve Uygulamalarıyla Fen, Teknoloji, Mühendislik ve Matematik Eğitimi, Öğretmenler İçin Temel Kılavuz [Science, Technology, Engineering and Mathematics Education with STEM Theories and Practices, Basic Guide for Teachers].* İstanbul: Pusula Yayıncılık.

Degenhart, S. H., Wingenbach, G. J., Dooley, K. E., Lindner, J. R., Mowen, D. L. & Johnson, L. (2007). Middle school students' attitudes toward pursuing careers in science, technology, engineering, and math. *NACTA Journal*, 52-59.

Delen. İ. & Uzun. S. (2018). Matematik öğretmen adaylarının FeTeMM temelli tasarladıkları öğrenme ortamlarının değerlendirilmesi [Evaluating STEM Based Learning Environments Created by Mathematics Pre-Service Teachers]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 33*(3), 617-630.

Doğanay, K. (2018). *Probleme Dayalı STEM Etkinlikleriyle Gerçekleştirilen Bilim Fuarlarının Ortaokul Öğrencilerinin Fen Bilimleri Dersi Akademik Başarılarına ve Fen Tutumlarına Etkisi [The effect of science festivals upon with problem-based STEM activities on the student's science attitudes and academic achievements].* Unpublished Master Thesis, Kastamonu: Kastamonu University.

Dreger, R. M. & Aiken, L. R. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology, 48*, 344-351.

Duatepe, A., Akkuş-Çıkla, O. & Kayhan, M. (2005). Orantısal akıl yürütme gerektiren sorularda öğrencilerin kullandıkları çözüm stratejilerinin soru türlerine göre değişiminin incelenmesi [An investigation on students' solution strategies for different proportional reasoning items]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 28*(1), 73- 81.

Elçi, A. N. (2008). *Öğrenme stillerine uygun olarak seçilen öğrenme yöntemlerinin öğrencinin başarısına, matematiğe yönelik tutumuna ve kaygısına etkileri [The effects of learning methods chosen in accordance to the learning styles on the achievements of the student,on his attitudes and his anxiety towards mathematics].* Unpublished Doctoral Dissertation, İzmir: Dokuz Eylül University.

Eser, E. (2014). Küreselleşme süreci ve eğitime etkisi [Globalization Process and Its Effects on Education]. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi, 2*(2), 211-224.

Fraenkel, J., R., & Wallen, N., E. (2010). *How to design and evaluate research in education.* (7th ed.). McGraw-Hill, New York: NY.

George, D. & Mallery, M. (2010). *SPSS for Windows Step by Step: A Simple Guide and Reference*, 17.0 update (10a ed.) Boston: Pearson.

Gökbayrak, S. & Karışan, D. (2017b). Altıncı Sınıf Öğrencilerinin FeTeMM Temelli Etkinlikler Hakkındaki Görüşlerinin İncelenmesi [Exploration of Sixth Grade Students' Views on STEMM Based Activities]. *Alan Eğitimi Araştırmaları Dergisi (ALEG) 3*(1), 25-40.

Gravetter, F. & Wallnau, L. (2014). *Essentials of Statistics for the Behavioral Sciences* (8thed.). Belmont, CA: Wadsworth.

Hacıömeroğlu, G. (2017). Matematiğe yönelik tutum ölçeği kısa formunun geçerlik ve güvenirlik çalışması [Reliability and Validity Study of the Attitude towards Mathematics Instruments Short Form]. *Journal of Computer and Education Research, 5*(9), 84-99.

Hackett, G. & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for research in Mathematics Education*, 261-273.

Haladyna, T., Shaughnessy, J. & Shaughnessy, J. M. (1983). A causal analysis of attitude toward mathematics. *Journal for Research in mathematics Education*, 19-29.

Hefty, L. J. (2015). STEM Gives Meaning to Mathematics. *Teaching Children Mathematics, 21*(7), 422-429.

Hembree, R. (1990). The nature, effects, relief of mathematics anxiety. *Journal for Research in Mathematics Education, 1*, 33–46.

Hossain, M. & Robinson, M. (2012). How to motivate US students to pursue STEM careers. *US-China Education Review A, 2*, 442–451.

IEA. (2015). *TIMSS 2015 International Results in Mathematics*. Retrieved August 20, 2018 from http://timss2015.org/timss-2015/mathematics/student-achievement/

Işıksal, M. & Aşkar, P. (2003). İlköğretim Öğrencileri İçin Matematik ve Bilgisayar Öz-Yeterlik Algısı Ölçekleri [The Scales of Perceived Mathematics and Computer Self-Efficacy for Elementary Students]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 25*, 109-118.

James, J. S. (2014). *Science, technology, engineering, and mathematics (STEM) curriculum and seventh grade mathematics and science achievement.* Retrieved October 11, 2018 from https://search.proquest.com/docview/1520011923?accountid=13014

Kalın, G. (2010). *İlköğretim Öğrencilerinin Matematik Tutumları, Öz yeterlikleri, Kaygıları ve Dersteki Başarılarının İncelenmesi* [The examination of Elementary Studets' Mathematics Attitudes, Self Efficiancy, Anxiety and Achievement]. Unpublished Master Thesis, Ankara: Başkent University.

Karjanto, N. & Yong, S. T. (2013). Test anxiety in mathematics among early undergraduate students in a British university in Malaysia. *European Journal of Engineering Education, 38*(1), 11-37.

Kennedy, T. J. & Odell, M. R. L. (2014). Engaging Students in STEM Education. *Science Education International*, *25*(3), 246-258.

Keşan, C. & Kaya, D. (2018). Mathematics and Science Self-Efficacy Resources as the Predictor of Academic Success. *International Online Journal of Educational Sciences, 10*(2), 45-58

Kier, M. W., Blanchard, M. R., Osborne, J. W. & Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). *Research in Science Education, 44*(3), 461-481.

Koyunlu Ünlü, Z., Dökme, İ. ve Ünlü, 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.

Kurbanoğlu, N. İ. & Takunyacı, M. (2012). Lise öğrencilerinin matematik dersine yönelik kaygı, tutum ve özyeterlik inançları bazı değişkenlere göre incelenmesi [An investigation of the attitudes, anxieties and self-efficacy beliefs towards mathematics lessons high school students in terms of gender, types of school, and students' grades]. *Uluslararası İnsan Bilimleri Dergisi, 9*(1), 110-130.

Lent, R.W., Lopez, F.G. & Bieschke, K.J. (1991). Mathematics self-efficacy: sources and relation to science-based career choice. *Journal of Counselling Psychology, 38*, 424-430.

Lim, S. Y. & Chapman, O. (2013). Development of a short form of the attitudes toward mathematics inventory. *Educational Studies in Mathematics, 82*, 145-164.

Luo, X., Wang, F. & Luo, Z. (2009). Investigation and analysis of mathematics anxiety in middle school students. *Journal of mathematics Education*, *2*(2), 12-19.

McBride, J. & Silverman, F.L. (1991). Integrating elementary/middle school science and mathematics. *School Science and Mathematics, 91*, 285-292.

McClain, M. L. (2015). *The effect of STEM education on mathematics achievement of fourth-grade underrepresented minority students.* Retrieved November 11, 2018 from https://search.proquest.com/docview/1728919094?accountid=13014

McDonald, C. V. (2016). STEM Education: A review of the contribution of the disciplines of STEM. *Science Education International*, *27*(4), 530-569.

Mohamed, L. & Waheed, H. (2011). Secondary students' attitude towards mathematics in a selected school of Maldives. *International Journal of Humanities and Social Science*, *1*(15), 277-281.

Mohr-Schroeder, M. J., Jackson, C., Miller, M., Walcott, B., Little, D. L., Speler, L. & Schroeder, D. C. (2014). Developing Middle School Students' Interests in STEM via Summer Learning Experiences: See Blue STEM Camp. *School Science and Mathematics*, *114*(6), 291-301.

MoNE. (2016). STEM Education Report. Retrieved from http://yegitek.meb.gov.tr/STEM_Egitimi_Raporu.pdf on July 26, 2018

MoNE. (2017). STEM Education Teacher's Handbook. Retrieved from http://scientix.meb.gov.tr/images/upload/Event_35/Gallery/STEM%20E%C4%9Fitimi%20%C3%96%C4%9Fretmen%20El%20Kitab%C4%B1.pdf on July 26, 2018

MoNE. (2018b). Mathematics Curriculum. Ankara.

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2004). *SPSS for introductory statistics: Use and interpretation*. Psychology Press.

National Council of Teachers of Mathematics (NCTM). (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA.: The Council.

Obama, B. (2009, November 23). *Remarks by the president on the "Education to Innovate" Campaign.* Retrieved July 22, 2018 from https://obamawhitehouse.archives.gov/photos-and-video/video/president-obama-kicks-educate-innovate#transcript

Öztürk, Y. A. & Şahin, Ç. (2015). Matematiğe ilişkin akademik başarı-özyeterlilik ve tutum arasındaki ilişkilerin belirlenmesi [Determining the Relationships between Academic Achievement, Self-Efficacy and Attitudes Towards Maths]. *International Journal of Social Science*, *31*, 343-366.

Pajares, F. & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. Journal of Educational Psychology, 86(2), 193.

Ramaley, J. A. (2007). *Facilitating change: Experience with the reform of STEM Education.* Retrieved January 19, 2019 from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.526.8592&rep=rep1&type=pdf

Randolph, T. (1998). *An assessment of mathematics anxiety in students from grades four through eight*. Cambridge, MA: Cambridge Information Group.

Rogers, C. & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education: Innovations & Research, 5.*

Sanders, M. (2009) STEM, STEM education, STEMmania. *The Technology Teacher, 68(*4), 20-26.

Şahin, A., Ayar, M. C. & Adıgüzel, T. (2014). STEM Related After-School Program Activities and Associated Outcomes on Student Learning. Educational Sciences: *Theory and Practice, 14*(1), 309-322.

Tapia, M. & Marsh, G. E., II. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*(2), 16-21.

TÜSİAD. (2014). *STEM alanında eğitim almış işgücüne yönelik talep ve beklentiler araştırması* [Demand and expectations research for the workforce trained in STEM]. Retrieved March 2, 2019 from https://tusiad.org/tr/yayinlar/raporlar/item/ download/7014_d28ffa2adda423c6d3852cc01c965993

TÜSİAD. (2017). *2023'e Doğru Türkiye'de STEM Gereksinimi* [STEM requirements towards 2023 in Turkey]. Retrieved March 2, 2019 from https://www.tusiadstem.org/images/raporlar/2017/STEM-Raporu-V7.pdf

Umay, A (2001). İlköğretim Matematik Öğretmenliği Programının Matematiğe Karşı Özyeterlik Algısına Etkisi [The Effect of The Primary School Mathematics Teaching Program on the Mathematics Self-Efficacy of Students]. *Journal of Qafqaz University*, 8 Fall, Bakü, Azerbaycan.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly, 58*(1), 2-12.

Wigfield, A. & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of educational Psychology*, *80*(2), 210.

Windschitl, M. (2009). *Cultivating 21st Century Skills in Science Learners: How Systems of Teacher Preparation and Professional Development Will Have to Evolve.* Paper commissioned by National Academy of Science's Committee on The Development of 21st Century Skills. Washington, DC.

Wyss, V. L., Heulskamp, D. & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International journal of environmental and science education*, *7*(4), 501-522.

Yamak, H., Bulut, N. & Dündar, S. (2014). 5. sınıf öğrencilerinin bilimsel süreç becerileri ile Fen'e karşı tutumlarına FeTeMM etkinliklerinin etkisi [The Impact of STEM Activities on 5th Grade Students' Scientific Process Skills and Their Attitudes Towards Science]. *Gazi Üniversitesi Eğitim Fakültesi Dergisi, 34*(2), 249-265.

Yıldırım, B. (2013). *Amerika, AB Ülkeleri ve Türkiye'de STEM Eğitimi [STEM Education in US, EU Countries and Turkey.].* 22. Ulusal Eğitim Bilimleri Kongresi. Eskişehir: Osmangazi Üniversitesi.

Yıldız, A. (2018). Endüstri 4.0 ve Akıllı Fabrikalar [Industry 4.0 and Smart Factories]. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 22*(2), 546-556.