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Serdar İnal
Ministry of National Education, Türkiye

Yusuf Ergen
Kahramanmaraş Sütçü İmam University, Türkiye

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Serdar İnal, Yusuf Ergen

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Abstract

In this study STEM activities created with the 5E learning model were applied to 4th grade primary school students and the effects of these activities on the students' mathematics problem solving-skills and attitudes towards mathematics were examined. A quasi-experimental design with a pre-test-post-test control group was used in the study. The sample of the study was 42 students studying at a primary school in the Mamak district of Ankara in the 2022-2023 academic year. The appropriate sampling method was used in the study. The data of the study were collected with the Attitude Towards Mathematics Scale and the Problem-Solving Achievement Test developed by the researcher. Independent sample and dependent sample t- tests were used in the analysis of the data. According to the research results; It was determined that there was no statistically significant difference between the pre- test-posttest problem-solving success scores of the experimental group students, but the pre-test-posttest scores of the attitude towards mathematics were statistically significant in favor of the posttest. It was determined that there was no statistically significant difference between the attitude towards mathematics and problem-solving success posttest scores of the experimental and control groups. Suggestions were made in line with the research results.

Introduction

The needs of the 21st century have caused policy changes in the field of education as in every field (Karakaya et al., 2019). Raising individuals with 21st century skills who think creatively and critically, have problem-solving and scientific process skills, and can work collaboratively as a team is one of the needs that necessitate policy change in education (Akgündüz et al., 2015; Karakaya et al., 2019). One of the approaches that will respond to these needs and ensure the education of individuals with 21st century skills is the STEM approach (Karakaya et al., 2018). Fioriello (2010) defined STEM as an educational approach that enables the search for solutions by integrating science, technology, engineering and mathematics with learning approaches to solve a problem. STEM is an educational approach that aims to find solutions to problems by using the sense of interest and curiosity intensively, which encourages individuals to use their creative thinking skills that exist in the early years of childhood and to encourage problem-solving-centered thinking (Guide, 2013). Problem-solving is also a mental, emotional and behavioral adaptation skill that an individual demonstrates in order to adapt to daily life and continue his/her life (Shewchuk et al., 2000). This adaptation skill is important for children as well as adults and

is used in problem-solving (Yücesan, 2017). Children who learn problem-solving skills at an early age can provide active learning and contribute to the shaping of their lives with the knowledge, skills and experiences they acquire (Casey, 1990). Zembat and Unutkan (2005) also emphasized the importance of teaching problem-solving at an early age as it is a learnable skill that will enable children to acquire new skills beyond experiences and live in harmony with the environment. It has been stated that children who take an active role in problem-solving processes are more successful in generating solutions to problems, establishing cause and effect relationships, trying ideas for solutions, and that solving the problem helps them gain self-confidence (Şanlı, 2005). This may affect children's attitudes towards mathematics.

Believing that mathematics is in life, that it is necessary at every moment of life and under all circumstances, and internalizing the importance of mathematics can contribute to the individual as well as the society to have a positive attitude towards mathematics (Işık, 2018). Raising individuals who produce creative ideas to solve real-life problems that make us feel the presence of mathematics in real life and who can look at problems from different perspectives may be possible by introducing interdisciplinary studies into our education system (Çevik & Özgünay, 2018). This interdisciplinary approach is the STEM approach that enables students to produce solutions to real-life problems presented to students by bringing together different disciplines (Labov et al., 2010; Sanders, 2009). STEM education has an important role in looking at problems from different angles, producing solutions and developing problem-solving skills (Öztürk, 2018; Tezel, 2017). In many studies, it has been stated that STEM education contributes to the development of problem-solving skills (Acar, 2018; Alnıak & Bekiroğlu, 2019; Cooper & Heaverlo, 2013; Çalışıcı, 2018; Çorlu & Aydın, 2016; İnce et al., 2018; Köngül, 2019; Saleh, 2016; Topsakal, 2018). According to Moore et al. (2014), STEM education contributes to students to produce solutions to daily life problems by combining the disciplines within it. It can be said that this approach is of great importance for problem-solving skills, as the individual can find the solution to a problem with STEM education that combines different disciplines (Topsakal, 2018). STEM education can provide designs related to the real-life problem and the solution of this problem and the acquisition of the achievements of different disciplines at the same time in this design creation process (Çorlu & Çallı, 2017). Primary school is a critical period in which there are significant changes in children's cognitive development. In this period, children acquire skills such as classification, critical and versatile thinking, and problem-solving through concrete experiences (Deniz-Yöndem & Taylı, 2019). Primary school children can solve problems based on concrete experiences in this period when their observation skills are intense (Keklik, 2019). It has been stated in many studies that problem-solving skills should be acquired from an early age and that this skill benefits cognitive development (Aydoğan, 2021; Bingham, 2004; Gelbal, 1991, Senemoğlu, 2015). The education to be given to children in the primary school period should ensure that the skills gained are practical (Bacanlı, 2021). In this period, children should be given the opportunity to develop skills such as critical and analytical thinking, decision-making, and research (Yamak et al., 2014; Arıkan, 2018). Therefore, many countries have turned to STEM education based on research and production in order to become one of the developed countries by providing students with the skills of the 21st century (critical and analytical thinking, decision making, research, problem solving, creative thinking, etc.) (Turner, 2013; Pehlivan & Uluyol, 2019). In many studies, it has been stated that STEM education should be taken from an early age (Taşdemir et al., 2019; Acar, 2018). Students who receive STEM education at an early age can understand the relationship between the fields of mathematics, engineering, technology, and science and can make it easier

to experience (MEB, 2018). In addition, STEM education in the primary school period can increase students' learning skills and interest in the lesson (Kaya, 2019).

In this study, answers to the following questions were sought in order to examine the effect of STEM activities created with the 5E learning model on problem-solving skills and attitude towards mathematics.

1. Is there a significant difference between the pre-test and post-test scores of the problem-solving skills of the experimental group in which STEM activities created with the 5E Learning model were applied?
2. Is there a significant difference between attitude towards mathematics pre-test and post-test scores of the experimental group in which STEM activities created with 5E learning model were applied?
3. Is there a significant difference between the pre-test and post-test scores of problem-solving skills of the control group continuing with the current MEB curriculum?
4. Is there a significant difference between the pre-test and post-test scores of attitudes towards mathematics of the control group continuing with the current MoNE curriculum?
5. Is there a significant difference between the post-test scores of problem-solving skills of the experimental group in which STEM activities created with the 5E learning model were applied and the control group that continued with the current MEB curriculum?
6. Is there a difference between the post-test scores of the attitude towards mathematics of the experimental group in which STEM activities created with the 5E learning model were applied and the control group that continued with the current MoNE curriculum?

Method

Research Model

Research is a planned and systematic investigation shaped by certain principles in order to understand, develop and produce scientific knowledge about a phenomenon or event, and is a process that involves collecting, analyzing and interpreting data and reporting and announcing the results. In research, the most appropriate method to be used to determine the cause-effect relationships between variables by examining an event, phenomenon and factor, and to compare and measure the results is the experimental model (Ekiz, 2020). The most preferred experimental model in educational research to determine the cause and effect relationship between dependent and independent variables is the quasi-experimental model (Cohen et al., 2000; Robson, 2002).

Since it is difficult to create a new class and assign students to the new class when selecting the experimental and control groups in the field of education, the experimental and control groups are determined by making measurements instead of random selection by using the quasi-experimental model (Frankfort- Nachmias & Nachmias, 1996; Cohen et al., 2000; Robson, 2002). In this study, instead of assigning students to new groups, a quasi-experimental model was used by selecting experimental and control groups from existing groups according to certain criteria. In this study, the effects of STEM activities created with the 5E learning model on problem-solving skills and attitude towards mathematics were examined. This research was conducted with an experimental group and a control group. Which measurement tool was used at which stage in this study is shown in Table 1.

Table 1. Research Design

Groups	Pre-test	Application	Final test
Experimental Group	Problem-solving Achievement Test Attitude Scale towards Mathematics	Teaching Mathematics with STEM-based lesson plans created with 5E learning model	Problem-solving Achievement Test Attitude Scale towards Mathematics
Control Group	Problem-solving Achievement Test Attitude Scale towards Mathematics	Current MoNE Curriculum	Problem-solving Achievement Test Attitude Scale towards Mathematics

Population and Sample of the Study

The target population of the research consists of primary school 4th grade students in Turkey. The accessible population consists of primary school 4th grade students in Mamak district of Ankara province. The sample of the study consists of 42 students studying in the 4th grade of a primary school in Mamak district of Ankara province in the 2022-2023 academic year. Considering that the researcher is a 4th grade teacher, the sample was selected from 4th grade students. In this study, the convenience sampling method, which is included in non-random sampling, was chosen, considering that it would be efficient in terms of easy access to the existing sample, ease of application and speed. In this study, which was conducted with a quasi-experimental design, a pre-test was applied to all 4th graders in the school where the researcher worked to determine the experimental and control groups. According to the results of the pre-test, the groups in which there was no significant difference between the averages were determined. Among these groups, the class where the researcher was working was determined as the experimental group in terms of ease of experimental application. Another class, which was randomly selected and there was no significant difference between the class in which the researcher worked and the class in which the researcher worked according to the pre-test results, was determined as the control group.

Data Collection Tools

The "Problem-solving Achievement Test" developed by the researcher and the "Attitude Towards Mathematics Scale", which was first developed by Tapia and Marsch (2004), then adapted by Lim and Chapman (2013), validity and reliability study was conducted by Hacıömeroğlu (2017) and a short form was created, were used as pre-test and post-test data collection tools.

Attitude Scale towards Mathematics

In this study, in order to see the effect of STEM activities created with the 5E education model on students' attitudes towards mathematics, the "Attitude Scale towards Mathematics", which was developed by Tapia and Marsch (2004) and later adapted by Lim and Chapman (2013), and whose short form was created by Hacıömeroğlu (2017) after a validity and reliability study, was applied to the experimental and control groups as

a pretest and posttest. There are a total of 17 items in this scale. There are 12 positive and 5 negative items in the scale with a 5-point rating system. The answers to the items were expressed as Strongly Disagree, Disagree, Undecided, Agree, and Strongly Agree. Hacıömeroğlu (2017) calculated the reliability coefficient (Cronbach Alpha) of the scale as 0.84. In this study, the reliability coefficient (Cronbach Alpha) was found to be 0.82. The calculated Cronbach's alpha reliability coefficient above 0.70 can be considered reliable (Field, 2005).

Mathematics Problem-Solving Achievement Test

The problem-solving achievement test developed and applied by the researcher was prepared based on the gains in the primary school fourth grade mathematics program. A specification table was prepared for the gains and multiple-choice questions were prepared with at least two questions for each gain. The problem-solving achievement test was developed since it was necessary to have a suitable achievement test that would provide content validity in accordance with the STEM-based lesson plans prepared in this research and the gains related to the primary school fourth grade mathematics program and that would measure the gains related to problem solving. For the achievement test to be developed, a literature review was conducted according to the qualities to be measured. Primary school 4th grade mathematics textbooks, activities and studies were examined. The aim of this test is to measure the academic achievement of 4th grade primary school students in problem-solving for mathematics course and to what extent the achievements are achieved. Question items were prepared for the problem-solving outcomes in the 4th grade mathematics curriculum of MEB (2018) and content validity was tried to be ensured. The 45-item problem-solving achievement test was edited and the achievement test was finalized. In order to create the final achievement test from the trial achievement test, item difficulty indices and item discrimination indices were calculated according to the answers given by the students in the test. After the statistical analyses of the trial problem-solving achievement test, the final problem-solving achievement test was formed by giving the final form to the test. The final problem-solving achievement test consists of 23 questions. The KR-20 reliability coefficient of the developed problem-solving achievement test was found to be 0.86.

Analyzing the Data

As a result of the analysis performed for the normality test of the data, the skewness and kurtosis (Skewness and Kurtosis) of the scale and its sub-dimensions were found to be within the range of +2-(-2) and it was assumed that the normality assumption was accepted. If the skewness and kurtosis values are within the range of +2-(-2), it can be accepted that the data are normally distributed (George & Mallery, 2010; Almquist, Ashir & Brännström, 2019).

Dependent and independent sample t-tests were used for the pre-test and post-test comparisons of the information collected from the participants and the scales. Independent sample t-test was used for the pre-test and post-test comparisons of the control and experimental groups; dependent sample t-test was used to determine the significant differences in the pre-test and post-test scores of the participants.

In all analyses, the significance (p) value was taken as 0.05. In the results of the tests applied, when $p<0.05$, the

difference was considered statistically significant, and when p>0.05, the differences were considered statistically insignificant. In this context, the analyses related to the Attitude Scale towards Mathematics and Achievement Test collected from the participants will be examined.

Table 2. Mathematics Attitude Scale Skewness Kurtosis Values

Tests	Groups	N	$\bar{X}$	Skewness	kurtosis
Front	Experiment	22	3.1934	-1.074	1.413
Test	Control	20	3.1963	-.628	-.258
Last	Experiment	22	3.5626	.077	-.929
Test	Control	20	3.1014	.102	-.065

Table 3. Skewness Kurtosis Values of Problem-Solving Achievement Test

Tests	Groups	N	$\bar{X}$	Skewness	kurtosis
Front	Experiment	22	.4881	.303	-.199
Test	Control	20	.5152	.093	-.973
Last	Experiment	22	.3992	.750	-.217
Test	Control	20	.4283	.691	1.238

The skewness and kurtosis values of the variables subject to the research are given above. According to George and Mallery (2010), normality assumption can be accepted if skewness and kurtosis values are in the range of -2 and +2. Accordingly, it is seen that the data belonging to the variables of the research show normal distribution. Accordingly, parametric tests were used in the analysis of the research data.

Table 4. Pre-test Comparison of Attitude Towards Mathematics Scale

	Group	N	Average	S	t	sd	p
Attitude towards	Control	20	3.1963	.47065			
Mathematics	Experiment	22	3.1934	.38323	.022	40	.983

According to the results of the t-test comparing the pre-test scores of the control and experimental groups who participated in the research in the pre-test, there was no statistically significant difference between the pre-test scores of the attitude towards mathematics of the experimental and control groups (p>.05). The fact that there were no statistical differences shows that the control and experimental groups started the research under equal conditions in terms of their attitudes towards mathematics before the intervention.

Table 5. Problem-solving Achievement Test Pre-Test Comparison

	Group	N	Average	S	t	sd	p
Problem Solving	Control	20	.5152	.22975	.405	40	.688
Achievement Test	Experiment	22	.4881	.20390			

According to the results of the t-test comparing the achievement test scores of the control and experimental groups participating in the research in the pretest, there is no statistically significant difference (p>.05). The fact that there were no statistically significant differences in the pre-test shows that the control and experimental groups started the research under equal conditions in terms of problem-solving achievements before the intervention.

Results

The results of the analyses of the pre-test and post-test applications of the problem-solving achievement test and attitude towards mathematics scale pre-test and post-test applications conducted to determine the effect of STEM activities created with the 5E learning model on problem-solving skills and attitudes towards mathematics are included. The findings obtained from the analysis of quantitative data collected within the framework of the sub-objectives of the study are included. The findings obtained are given as headings in the order appropriate to the sub objectives of the study.

Comparison of Problem-solving Skills Pre-test and Post-test Scores of the Experimental Group in which STEM Activities Created with 5E Learning Model were Applied

Dependent sample t-test analysis was performed to determine whether there was a significant difference between the pre-test and post-test problem-solving skills achievement scores of the experimental group students to whom STEM activities created with the 5E learning model were applied.

Table 6. Pre-test-post-test Comparison of the Scores obtained by the Experimental Group from the Problem-solving Achievement Test

	Group	N	Average	S	t	sd	p
Problem Solving	Pre-Test	22	.4881	.20390	1.821	21	.083
Achievement Test	Final Test	22	.3992	.23687			

According to the results of the dependent sample t-test in which the difference between the achievement scores of the experimental group between the pre-test and post-test was analyzed; there was a decrease in the mean score of the experimental group from the pre-test ($\bar{X}$=.4881) to the post-test ($\bar{X}$=.3992). This decrease was not statistically significant (p>.05).

Comparison of Attitude towards Mathematics Pre-test and Post-test Scores of the Experimental Group in which STEM Activities Created with 5E Learning model were Applied

Dependent sample t-test analysis was performed to determine whether there was a significant difference between the pre-test and post-test attitude towards mathematics scores of the experimental group students to whom STEM activities created with the 5E learning model were applied. According to the results of the dependent sample t-test, which examined the difference between the pre-test and post-test scores of the experimental group's attitudes towards mathematics, there was an increase in the mean score of the experimental group from the pre-test

($\bar{X}$=3.1934) to the post-test ($\bar{X}$=3.5626). It was determined that this increase was statistically significant in favor of the post-test (p<.05).

Table 7. Experimental Group Attitude towards Mathematics Scale Pre-test-post-test

	Group	N	Average	S	t	sd	p
Attitude towards	Pre-Test	22	3.1934	.38323	- 2.700	21	.013
Mathematics	Final Test	22	3.5626	.65160			

Comparison of Problem-solving Skills Pre-test and post-test Scores of the Control Group continuing with the Current MoNE Curriculum

Dependent sample t-test analysis was performed to determine whether there was a significant difference between the pre-test and post-test problem-solving achievement scores of the control group students.

Table 8. Control Group Problem-solving Achievement Test Pre-test-post-test

	Group	N	Average	S	t	sd	p
Problem Solving	Pre-Test	20	.5152	.22975	2.251	19	.036
Achievement Test	Final Test	20	.4283	.15789			

According to the results of the dependent sample t-test in which the difference between the pre-test and post-test achievement scores of the control group was analyzed; there was a decrease in the mean score of the control group from the pre-test ($\bar{X}$=.5152) to the post-test ($\bar{X}$=.4283). This decrease was statistically significant in favor of the pre-test (p<.05).

Comparison of Attitude towards Mathematics Pre-test and post-test Scores of the Control Group continuing with the Current MoNE Curriculum

Dependent sample t-test analysis was performed to determine whether there was a significant difference between the pre-test and post-test attitude towards mathematics scores of the control group students.

Table 9. Control Group Attitude towards Mathematics Scale Pre-test-post-test

	Group	N	Average	S	t	sd	p
Attitude towards	Pre-Test	20	3.1963	.47065	.344	19	.735
Mathematics	Final Test	20	3.1014	.99083			

According to the results of the dependent sample t-test in which the difference between the pre-test and post-test scores of the attitude towards mathematics of the control group was examined; a decrease was observed in the mean scores from the pre-test ($\bar{X}$=3.1963) to the post-test ($\bar{X}$=3.1014). However, this decrease was not statistically significant (p>.05).

Comparison of Problem-solving Skills Post-test Scores of the Experimental Group in which STEM Activities created with the 5E Learning Model were Applied and the Control Group continuing with the Current MoNE Curriculum

Independent sample t-test analysis was performed to determine whether there was a significant difference between the experimental group post-test and control group post-test problem-solving achievement scores.

Table 10. Experimental and Control Groups Problem-solving Achievement Test Post-test

	Group	N	Average	S	t	sd	p
Problem-solving	Control	20	.4283	.15789	.471	36.822	.640
Achievement Test	Experiment	22	.3992	.23687			

According to the t-test results comparing the achievement test post-test scores of the control and experimental groups participating in the research in the post-test; there is no statistically significant difference between the post-test scores of the experimental and control groups (p>.05).

Comparison of Attitude towards Mathematics Post-test Scores of the Experimental Group in which STEM Activities Created with the 5E Learning Model were Applied and the Control Group continuing with the Current MoNE Curriculum

Independent sample t-test analysis was performed to determine whether there was a significant difference between the post-test attitude towards mathematics scores of the experimental group and the control group.

Table 11. Experimental and Control Groups Attitude towards Mathematics Scale Post-test

	Group	N	Average	S	t	sd	p
Attitude	Control	20	3.1014	.99083	- 1.798	40	.080
towards Mathematics	Experiment	22	3.5626	.65160			

According to the t-test results comparing the post-test scores of the control and experimental groups who participated in the study in the post-test, there is no statistically significant difference between the post-test scores of the experimental and control groups (p>.05).

Discussion

The Effect of STEM Activities Created with 5E Learning Model on Problem-solving Skills of the Experimental Group

In the first sub-objective of the study, it was investigated whether there was a significant difference between the pre-test and post-test findings of the experimental group students who learnt the mathematics course outcomes with STEM activities created with the 5E learning model with the problem-solving achievement test prepared by the researcher. For the data of this sub-objective, pre-test was applied before the implementation of STEM-based

activities and post-test was applied after 10 weeks of experimental study. When the data obtained as a result of the statistical analyses were examined, it was seen that there was no significant difference between the pre-test and post-test scores of the students.

There are studies in literature that support the findings of this research. For example, Nağaç (2018) examined the effect of STEM education on students' problem-solving skills in his study with sixth grade students. At the end of the study, he concluded that STEM education did not contribute to students' problem-solving skills. Elliot et al. (2001) examined the effect of STEM education on the problem-solving skills of university students. At the end of the research, it was determined that STEM education did not contribute to students' problem-solving skills.

Durmuş (2019), in his study with pre-service primary school teachers, found that the STEM education-based laboratory course increased the problem-solving skills of students, but this increase was not statistically significant. Asığığan (2019) examined the effect of STEM education on students' problem-solving skills in his study with primary school students. As a result of the study, it was concluded that STEM education had no effect on problem-solving skills. When the studies are examined, the results that STEM education does not contribute to problem-solving skills can be explained by reasons such as students' difficulty in developing opinions and material selection, students' not having encountered STEM education in the education system before, and students' resistance to remain passive in activities.

When the literature is examined, it is seen that there are studies in the opposite direction of the findings in this study (Adanır & Hacıoğlu, 2021; Akar & Yadigaroğlu, 2021; Alatas & Yakin, 2021; Baumberger, 2005; Buyuran, 2021; Çakır & Yalçın, 2021; Kurt & Benzer, 2020; Lin et al, 2020; Özkızılcık & Cebesoy 2020; Robyn Cooper & Heaverlo, 2013; Septimawati et al. 2022; Villarta et al., 2021; Yurtseven et al., 2021). Bal (2018) concluded that STEM activities improved the problem-solving skills of 48-72-month-old children. Ceylan (2014) conducted a study with eighth grade students on the preparation of instructional design with STEM approach in science course and concluded that teaching based on STEM education improved students' problem-solving skills. Morrison (2006), in his study on the qualities of STEM, emphasized that students raised with STEM education are good problem solvers. Pekbay (2017) investigated the effects of STEM activities on secondary school students and concluded that STEM activities were effective in the development of students' problem-solving skills. In the study conducted by Çalışıcı (2018) with eighth grade students, it was determined that STEM applications contributed to the development of students' problem-solving skills. İnce et al. (2018) examined the effect of STEM-based applications on students' problem-solving and academic achievement in the science course of fifth grade students. As a result of the study, it was determined that STEM-based applications contributed to students' problem-solving skills. Öztürk (2018) conducted a study on the effect of STEM activities on problem-solving skills with pre-service science teachers and found that STEM activities had a positive effect on pre-service teachers' problem-solving skills. Acar (2018) examined the effect of STEM education on the problem-solving skills of primary school fourth grade students and concluded that STEM education contributed to students' problem-solving skills at a high level. Kim and Chae (2016) conducted a study with high school students on the development and implementation of a STEAM program suitable for Korean culture and found that STEAM activities have an approach suitable for improving students' problem-solving skills. Cho and Lee (2013) developed

a STEAM education lesson plan and applied these plans to see the effect of these plans on the problem-solving skills of primary school students. As a result of the study, it was determined that lesson plans positively affected students' problem-solving skills. Cooper and Heaverlo (2013) investigated the relationship between girls' interest in problem-solving and their interest in STEM fields. As a result of the study, it was determined that students who were interested in problem-solving were also interested in STEM fields. Gwon- Suk and Sun Young (2012) investigated the effect of STEAM education on problem-solving skills of fourth grade primary school students. At the end of the study, it was determined that STEAM education contributed positively to students' problem-solving skills. In the literature review, it is noteworthy that there are many studies in which STEM education contributes positively to problem-solving skills.

The Effect of STEM Activities Created with 5E Learning Model on the Experimental Group's Attitude Towards Mathematics

In the second sub-objective of the study, the "Attitude Towards Mathematics Scale", which was developed by Tapia and Marsch (2004) and later adapted by Lim and Chapman (2013), and whose short form was created by Hacıömeroğlu (2017) after a validity and reliability study, was applied to the experimental group in which STEM activities were applied at pre-test and post-test times. It was investigated whether there was a significant difference in the attitudes of the experimental group students towards mathematics. As a result of the analyses, a statistically significant difference was found in favor of the post-test attitude towards mathematics.

When the literature is examined, it is seen that there are studies supporting the findings of this study (Akın, 2019; Alıcı, 2018; Hill, 2002; Kavacık, 2019; Keçeci, Alan & Kirbağ-Zengin, 2017; Sümen & Çalisici, 2016; Thomas, 2013; Yamak et al., 2014; Yıldırım, 2016). Ceylan and Karahan (2021) examined the effect of STEM education on eleventh grade students' attitude towards mathematics. As a result of the study, there was a positive increase in students' attitude towards mathematics with STEM education. Şireci (2021) examined the effect of STEM applications in mathematics course on students' attitude towards mathematics in a study with sixth grade students. At the end of the study, it was concluded that STEM applications had a positive effect on students' attitude towards mathematics. Bircan and Çalışıcı (2022) examined the attitude of STEM activities towards STEM disciplines in their study with primary school students and found that their attitudes towards science, technology, engineering and mathematics changed positively. Koçyiğit (2019) also examined the effect of STEM education on students' attitudes towards mathematics and concluded that students' attitudes towards mathematics increased.

There are also studies in the opposite direction of the findings in this study. Macun (2019) examined the effect of STEM activities on attitudes towards mathematics in his study with 7th grade students. As a result of the study, he found that STEM activities did not change their attitudes towards mathematics. Ersoy (2023), in his study with high school students, found that STEM-based teaching did not have an effect on students' attitudes towards mathematics. Erçetin (2021) examined the effect of STEM-oriented mathematics teaching on attitude towards mathematics in a study with seventh grade students. As a result of the study, the effect of STEM-oriented mathematics teaching on students' attitude towards mathematics was not statistically significant. Wendell and Rogers (2013) concluded that the effect of engineering designs on attitude towards science was not significant

between experimental and control groups. Kocayusuf (2014), in his study with sixth grade students, found that the effect of the application with the whole learning strategy supported by real life scenarios on attitude towards mathematics was not significant. There are many studies in the literature that overlap with the findings of this study (Anuar, et al., 2020; Gündüz & Çelik, 2016; Elçi, 2008; Özgen & Alkan, 2014; Rojas, 2020; Sirmaci, 2010). Burghardt et al. (2010) concluded that the effect of STEM-based mathematics teaching on secondary school students' attitude towards mathematics was not statistically significant.

Control Group Pre-Test Post-Test Problem-solving Achievement Test

In the fifth sub-objective of the research, it was investigated whether there was a significant difference between the problem-solving achievement test prepared by the researcher and the pre-test and post-test findings of the students in the control group who continued their lessons with the current MEB curriculum for the 4th grade mathematics course acquisitions. When the data obtained as a result of the analyses are examined, there is a statistically significant difference between the problem-solving achievement test scores applied to the control group students in the pre-test and post-test periods in favor of the pre-test.

Control Group Pre-Test Post-Test Attitude towards Mathematics

In the sixth sub-objective of the study, the "Attitude Towards Mathematics Scale", which was developed by Tapia and Marsch (2004) and later adapted by Lim and Chapman (2013), and whose short form was created by Hacıömeroğlu (2017) after a validity and reliability study, was applied to the control group using the current MEB curriculum as pre-test and post-test. According to the data obtained, no significant difference was found between the pre-test and post-test scores of the control group in the whole attitude towards mathematics scale. Accordingly, it can be said that the current MEB curriculum does not contribute positively to the students' attitudes towards mathematics. There are studies supporting this in the literature. In his study, Özçelik (2015) found that there was no significant difference in the attitude towards mathematics score in the control group who taught according to the curriculum. Similarly, Özkaya (2016) concluded that there was no significant change in the attitudes towards mathematics of the control group students who studied with the MEB curriculum. There are also studies in the literature in the opposite direction of the findings in the study. Bıldırcın (2012) and Kaylak (2014) concluded in their study that the experimental group did not differ significantly from the control group studying with the current MEB curriculum, and the experimental group studying with different teaching method did not differ from the control group in the attitude towards mathematics score.

Experimental Group and Control Group Posttest Problem-solving Achievement Test

In the third sub-objective of the study, with the problem-solving achievement test prepared by the researcher, it was investigated whether there was a significant difference between the post-test problem-solving achievement test scores of the experimental group students who learned the mathematics outcomes with STEM activities created with the 5E learning model and the post-test problem-solving achievement test scores of the control group students who learned with the current MEB curriculum. It was determined that there was no statistically significant

difference between the post-tests of problem-solving skills of the experimental and control groups.

Similarly, in the experimental study conducted by Elliott, Oty, McArtur, and Clark (2001), problem-solving skills were not significant in favor of the experimental group. STEM activities have a very flexible structure and can be organized in many different formats. The reason for this situation may be the functioning of the STEM activity format used in the study. Güven (2022) examined the problem-solving skills of secondary school students in STEM activities. At the end of the study, it was found that the problem-solving skills of the students were significant in favor of the experimental group. The abundance of studies in the opposite direction of the result of this study draws attention (Pekbay, 2017; Ceylan, 2014; Alan, 2017; Demir, 2018). In the literature, a limited number of studies similar to the results of this study stand out.

Experimental Group and Control Group Posttest Attitude towards Mathematics

In the fourth sub-objective of the study, it was investigated whether there was a significant difference between the attitude towards mathematics post-test scores of the experimental group and the attitude towards mathematics post-test scores of the control group with the "Attitude Towards Mathematics Scale" developed by Tapia and Marsch (2004) and later adapted by Lim and Chapman (2013) and the validity and reliability study was conducted by Hacıömeroğlu (2017). As a result of the analyses, no statistically significant difference was found between the attitude towards mathematics posttest scores of the experimental group and the control group.

Similar results with the results of this study are seen in the literature. For example, in the study conducted by Kong and Huo (2014) with primary school students, STEM activities did not yield significant results in favor of the experimental group in students' attitude towards mathematics. Similar results are also seen in the study conducted by Alinak-Bozkurt (2018). In the study, the effect of engineering design-based STEM activities on attitude towards mathematics did not show a significant difference in favor of the experimental group. Gülhan and Şahin (2016) concluded that the effect of STEM activities on the experimental group students' attitude towards mathematics was not significant in their study with fifth grade students.

There are also studies in the literature in the opposite direction of the findings in this study. Erçetin (2021) examined students' attitudes towards mathematics in STEM-oriented mathematics teaching with seventh grade students. According to the results of the study, two sub-dimensions of students' attitudes towards mathematics were significant in favor of the experimental group. Şireci (2021) examined the effect of STEM applications in mathematics lesson on attitude towards mathematics. According to the results of the study, it is significant in favor of the experimental group in attitudes towards mathematics.

Conclusion

In this study, the effects of STEM activities created with the 5E learning model on problem-solving skills and attitude towards mathematics were examined. In this direction, STEM activities were prepared and implemented for the experimental group students according to the acquisitions in the MEB mathematics curriculum. As a result

of the research, no statistically significant difference was found between the pre-test and post-test scores of the problem-solving achievement test of the experimental group, which was taught with STEM activities created with the 5E learning model. There was a statistically significant difference between the pre-test and post-test scores of the attitude towards mathematics of the experimental group in favor of the post-test. There was no statistically significant difference between the attitude towards mathematics post-test scores of the experimental group and the control group. There was no statistically significant difference between the problem-solving post- test scores of the experimental and control groups.

As a result, according to the findings of this study, there was no significant difference between the experimental and control groups in terms of problem-solving skills and attitudes towards mathematics. The attitude towards mathematics pre-test and post-test scores of the experimental group were significant in favor of the post-test. However, the problem-solving achievement test scores of the experimental group were not significant in favor of the post-test.

Recommendations

At the end of the study, a series of recommendations were made as a guide for teachers who will implement STEM activities, field researchers who will benefit from the study and decision makers in the field of education. In the study, it was determined that there was no statistically significant difference between the problem-solving skills post-tests of the experimental and control groups. Accordingly, it can be suggested that STEM activity plans should include sections aimed at increasing mathematics problem-solving skills.

In the study, it was determined that there was no statistically significant difference between the attitude towards mathematics post-tests of the experimental and control groups. Accordingly, it can be suggested that STEM activities should be organized in a way to emphasize mathematics more and to develop more positive attitudes towards mathematics than the MEB curriculum. Since STEM activity plans have a flexible structure, it may be recommended to conduct a similar experimental study with formats other than the STEM activity plan format used in this study. Research can be conducted on the relationship between STEM and other variables and methods at the primary school level.

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Notes

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Author Information

Serdar İnal

https://orcid.org/0000-0002-4949-9936

Ministry of National Education

Turkiye

Yusuf Ergen

https://orcid.org/0000-0003-4313-5354

Kahramanmaraş Sütçü İmam University

Turkiye

Contact e-mail: *yergen22@gmail.com*