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Effects of 5E Integrated STEM Based Activities on Middle School Students' Attitudes Towards Science, Science Anxiety and Perceptions of STEM Fields

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Abstract

The purpose of this study was to investigate the effects of using 5E integrated Science Technology Engineering Mathematics (STEM) based activities on 6th grades students' attitudes towards science, their science anxiety and their perceptions of STEM fields. Mixed research method was used for this purpose. The study was conducted with 28 6th grade students who live in Gaziantep city of Turkey. "Matter and Heat" science topic was taught using the 5E integrated STEM based activities. Questionnaires to test students' attitudes towards science, their science anxiety, and their perceptions of STEM fields were used as pre and post-tests before and after the implementation of the activities. While effect size difference (*r* score) and non-parametric Wilcoxon signed rank test were used for the quantitative data analyses, the qualitative data from the semi-constructed interviews were analyzed using thematic analysis. Before the implementation of the activities, female students' attitude levels were higher and their anxiety levels were lower than males. The results showed that the 5E integrated STEM-based activities had a positive effect on increasing students' attitudes towards science while decreasing their science anxiety. Although the effect on students' perceptions of individual STEM fields was relatively small, these activities positively increased their perceptions of each STEM field. The participants also found the activities very enjoyable, fun and like doing.

Key Words: STEM Based Activities, Attitude Towards Science, Science Anxiety

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INTRODUCTION

The global world has been facing serious issues related to public, environmental, economic and natural resources recently. In order to tackle with these issues, the advancement in science and technology play important roles. The curiosity and the unlimited needs of the humanity have filled their history with scientific and technological innovations. Today, the fast changing and increasing knowledge and technological innovations give directions to the needs of the 21st century. These needs become very important to have and to raise qualified individuals who answer and keep up with the changes of today's needs (Vennix et al., 2018). It is expected from this century's individuals to have critical and analytical thinking, investigation and questioning, creative thinking as well as decision making skills. The fields of science and mathematics, and educational activities in these fields play important roles in the gain of these expected skills (Yamak et al., 2018). This has led to many countries to priorities science and math education for improving the development and production of new knowledge and technologies, and to equip their citizens with these important skills that play important roles in the development of their economies. However, many studies highlight that students' motivation and involvement in the fields of Science, Technology, Engineering, and Mathematics (STEM) have been decreasing recently especially in developed nations (Thomas and Watters, 2015). Many developed and developing countries give high importance of students' interests and motivations in STEM fields, which it is expected to be shortages with these subjects related workforces in near future and this may influence global world issues negatively (Kelley and Knowles, 2016). Therefore, many countries are taking the necessary steps through improving and making changes by including STEM education in their existed educational systems and policies (Bybee, 2010).

Researchers propose various definitions and perspectives for STEM education (Lin et al., 2020). STEM education bases on the integration of science, technology, engineering and math knowledge and skills with engineering-based design teaching. It is an education approach that aims to improve research, creativity, effective communication, collaboration with other fields, analytic thinking, and problem-solving skills (Bybee, 2010).

STEM education has turned to be important matter in educational research recently. It is reported that it can provide many benefits to students all age. One of the most important purposes of STEM education is to improve students' motivation and interest in STEM fields, leading to increased career preferences in these areas (Hackman et al., 2021; Lin et al., 2020). It is suggested that STEM education increases children's attitudes and the selection of STEM related careers. The integration of STEM education and its applications to the real-world problem-solving situations can increase both students' attitudes and their career towards STEM fields (Toma and Greca, 2018). STEM education is an important approach that increases the interest, achievement and motivation of students through making them to involve in daily life problems (Honey et al., 2014). The process of solving daily life problems make students to engage with and use alternative solutions, enhancing their inquiry-based skills, expanding their higher order thinking and promoting cooperative learning skills (Buyruk and Korkmaz, 2014). While STEM education also helps students to develop their problem-solving and critical thinking skills, it prepares them to their future careers and jobs (Öztürk, 2017). It is reported that the STEM education approach has positively affected students' interests and learning in STEM fields (Becker and Park, 2011). STEM education approaches equip students with 21st century skills and positively increase their motivation and interest in STEM fields, and related job and career preferences in these fields (Fernandez-Cezar et al., 2020).

Problem solving skills, critical thinking, confidence, and creativity in using engineering knowledge and skills, and ability to understand and to explain the nature of technology are some of the benefits of STEM education for students (Morrison, 2006). It contributes to students to get interdisciplinary perspective, to improve their creativities with critical thinking, and to develop their engineering design skills. In addition, it is reported that students increase their knowledge and understanding by connecting them with their prior knowledge and experiences, learn their lesson without boring, and increase their higher order thinking (Yıldırım and Altun, 2015). Moreover, it

reported that math and science integration have effects on attitudes and interest towards school, learning motivation and achievement among students (Stohlmann et al., 2012).

STEM education has been prioritized due to positive effect on students' attitudes towards science and STEM related career preferences (Sanders, 2009). It is reported that students' attitudes, interest and motivations towards science are declining through their educational progresses. Although students have positive attitudes, interest and motivations towards science during their elementary education, those turn to decrease through middle and high school education due to their perceptions of science is irrelevant, boring and too hard to learn (Toma and Greca, 2018). These perceptions can be change using STEM based activities that involve students in active participation in their educational process (Savelsbergh et al., 2016).

Integration of 5E instructional model with STEM education can help student in more active participation in their educational process by applying STEM related daily life problems. 5E Instructional model that uses constructivist learning theory is generally used in science education practice. This model involves five cognitive stages which are engagement, exploration, explanation, extension and evaluation. It explained by Bybee (1997) "using this approach, students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment. Learners interpret objects and phenomena, and internalize those interpretations in terms of their current conceptual understanding" (p. 176) (cited by Duran and Duran, 2004). Science lessons and teaching plans can be developed according to the five stages of this model. Five stages of this model are described as the following:

Engagement: It is a motivational phase for students to capture their attentions, helps teachers to examine students' existed knowledge and any possible misconceptions about the given topic.

Exploration: Students explore the information through cooperative working, process skills, problem solving and inquiry-based learning. Teachers navigate students to explore the information.

Explanation: Students explain and discuss their understanding from the previous stage and ask questions to get better explanations. Teacher provides explanations and corrections about the information students explore.

Elaboration: Students apply the skills and the information they learn and expand their understanding with designing models or experiments. This stage helps students to expand their learning.

Evaluation: Students evaluate and test their understanding. Teacher evaluates students' works and gets their ideas about their learning (Duran and Duran, 2004).

Science and math should be integrated with engineering and technology for teacher to be able to use STEM based activities. This integration can be made with preparing teaching programs that include more than one individual STEM fields and use one of the teaching strategies (Ramaley, 2007). For this reason, the five steps of 5E Instructional model were adopted and used to design the 5E integrated STEM based activities used in this study. The purpose of this study was to investigate the effects of using 5E integrated Science Technology Engineering Mathematics (STEM) based activities on 6th grades students' attitudes towards science, their science anxiety and their perceptions of STEM fields. "Matter and Heat" science topic was selected and taught with these activities. The following research questions were answered:

Research Questions:

1. To what extent do the 5E integrated STEM based activities affect students' attitudes towards science, and what is the effect regarding gender?

2. What is the effect of the 5E integrated STEM based activities on students' science anxiety, and what is the effect regarding gender?

3. What are the effects of the 5E integrated STEM based activities on students' perceptions of STEM fields?

METHODS

The effects of using 5E integrated Science Technology Engineering Mathematics (STEM) based activities that include teaching activities of "Matter and Heat" science topic, on 6th grades students' attitudes towards science, their science anxiety and their perceptions of STEM fields were investigated. For this purpose, mixed research method was selected to be the most suitable research method for answering the research questions. Johnson and Onwuegbuzie (2004) defined mixed research method "as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p.17). Combining quantitative and qualitative research approaches provided best explanations for the research questions and eliminated any weaknesses of the used methods. One group pre and post-test experimental design was the most suited experimental research methods because of the researcher availability and easy access to the students. Qualitative research used to eliminate some of the limits of this experimental method and to provide more details about the effects of 5E integrated STEM based activities.

The lesson plans of this study prepared by integrating 5E educational model with STEM based activities. Questionnaires to test students' attitudes towards science, their science anxiety and their perceptions of STEM fields were used as pre and post-tests before and after the implementation of activities (Table 1).

Table 1. The experimental design of the study

Before the implementation (as pre-tests)	The implementation	After the implementation (as post-tests)
The attitudes towards science questionnaire The science anxiety questionnaire The perceptions of STEM fields questionnaire	5E integrated STEM based activities	The attitudes towards science questionnaire The science anxiety questionnaire The perceptions of STEM fields questionnaire Semi-constructed interviews

The 5E integrated STEM based activities were the independent variables while students' attitudes towards science, science anxiety and perceptions of STEM fields were the dependent variables of this study. The effects of the independent variables on the dependent variables were tested.

Participants

The study was conducted with 28 6th grade students who live in Gaziantep city of Turkey. 18 of these students were boys and 10 of them were girls. One of the researchers was the teacher of these students and the study mainly conducted by this teacher. The study was limited to this group because of the limited time and easy access to the participants.

Data collection tools

The attitudes towards science questionnaire used in this study developed by Oğuz (2002) and it was adopted to be used for measuring students' attitudes towards science. The questionnaire was 5 Likert type and containing 20 items. The reliability of this test was measured 0.85 through Cronbach alpha measurement. Science Anxiety questionnaire was used to measure students' science anxiety levels. This questionnaire developed by Uluçınar and Sağır (2014) was adopted and used in this study.

The questionnaire was also 5 Likert type containing 25 items and 5 factors. The reliability of this questionnaire was measured using Cronbach alpha analysis and the general Cronbach alpha value was 0.880. The perceptions of STEM fields questionnaire developed by Knezek and Christensen (2008), and translated to Turkish by Kızılay (2017) was adopted for measuring students' perceptions of STEM fields in this study. The questionnaire was also 5 Likert type containing 25 items and 5 sub-factors. The Cronbach alpha of this questionnaire was measured 0.820. The 5 sub-factors were the perceptions of Science, Maths, Engineering, Technology and Careers in STEM fields. The qualitative data of the study was collected using semi-structured interviews. The researcher developed 8 interview questions, but these questions reduced to 6 questions after some recommendations and the experts' reviews.

Lesson plans and development of the 5E integrated STEM based activities

The lesson plans used in this study were developed by the researchers according to the learning objectives from the 2018 National Science Education Program, 5E instructional model and the STEM education activities suggested in the literature. The "Heat and matter" science topic and its four learning objectives were selected from the 6th grade science lesson curriculum. Four hours lesson plans and the 5E integrated STEM based activities were designed according to each of the learning objectives. Additional handouts were prepared for each 5E integrated STEM based activities. Designing process of these activities and the lesson plans were as the following:

1. Researching the studies that used STEM education approach.
2. Selection of the student grade and the topic of science lesson.
3. Determining the learning objectives that suitable for STEM education.
4. Deciding to the 5E integrated STEM based activities to prepare suitable lesson plans.
5. Revising the activities and lesson plans according to the expert views.
6. Preparing the 5E integrated STEM based activities.
7. Giving the last format of the 5E integrated STEM based activities according the science education experts.

The 5E integrated STEM based activities and the selected learning objectives were shown in Table 2.

Table 2. The 5E integrated STEM based activities and the learning objectives

Learning Objectives	5E integrated STEM Based Activities
Students can classify matters according their heat conduction features	Which spoon heated?
Students can decide to the selection criteria of heat insulation materials that used in buildings.	My favourite house
Students can develop alternative heat insulation materials.	Which box becomes hotter?
Students can discuss the importance of using heat insulations in buildings regarding advantages for family and countries' economies, and effective uses of resources.	Which one more economic?

Implementation of the study and data collection process

The study was conducted with 6th grade 28 students who were attending to a private school in Gaziantep city of Turkey. The study took 4 weeks (16 lesson hours) time. Before implementing the activities, the students were pre tested with the quantitative data collection tools which were science attitudes, science anxiety and perceptions of STEM fields. After the pre-tests, the students were informed about the study through explaining STEM education, the 5E integrated STEM based activities, the activities handouts and other important matters such as participation, attendance etc.

"Matter and Heat" science topic was taught using the 5E integrated STEM based activities. After the study, the students were post tested and they were also questioned with semi-constructed interviews for the qualitative data of the study.

An example of the 5E integrated STEM based activity: "My Favorite House"

Engagement step: Before the activity, the students were separated to small study groups (4 or 5 students each). "My favorite house" activity handout that developed according "Students can classify matters according their heat conduction features" learning objective, were given to the students to direct their attention and interest to the topic. They were asked to read the problem situation (given below) in the given activity handout carefully and then it was read by the teacher loudly once more. Their ideas to the problem situation were taken by question-and-answer method. With this way, children's curiosity and awareness were directed to the topic and it was also aimed for the students to generate new ideas by using their prior experiences and knowledge.

Problem Situation: "*Contractor Mr. İbrahim, who owns a construction company, has been building and selling houses for about 5 years. However, he receives complaints about the houses he sells. The homeowners who buy the house say that their houses are very cold in the winter season, they do not get warmer, so they burn central heating at high temperatures and this leads to higher gas bill. In the summer, they complain that although they run air conditioners all day long, their homes are still too hot, and they pay high amounts of electricity bills. They say that they have a limited income that cannot afford the excess electricity and natural gas consumption. They want to return the houses they bought for such reasons. In the face of this situation, İbrahim told the owners that he will solve these problems in a short time and left them. When İbrahim realizes that he cannot solve this situation alone, he goes to his friend Mr. Ali, who is an engineer, and asks for help. He would be very happy with the ideas given by Ali and immediately set to work. Soon the homeowners' troubles resolved."*

Exploration step: The students were asked to find possible solutions to the answers about the problem situation. At the same time, students did research about possible solutions from the science book and other research materials. Students also undertook active roles to discuss their ideas with their peers.

Students asked to answer the following questions about the topic:

1. What do you think are the reasons why homes are too cold in winter and very hot in summer?

2. If you were engineer Ali, what kind of ideas would you give?

Explanation step: Students expressed and discussed their ideas and their own understandings with their peers. The researcher (was the teacher) presented the scientific and conceptual information about students' explanations and their ideas from the previous step. Clarifications for any possible misconceptions were also provided. Then, it moved on to next step in order to make the provided information more lasting in students minds. The following information provided to the students:

Heat Insulation:

In some cases, we want to preserve the heat and, in some cases, we want to be protected from its harmful effects. For example, we try to preserve the temperature of our house environment in winter, while we try to prevent it from heating in summer. In such cases, we use heat insulating materials with very little heat conduction. The purpose of thermal insulation is to prevent heat exchange. In other words, we try to prevent the inside heat to go out or the outside heat to come in. Heat insulation is achieved by covering the areas where the indoor and outdoor environments directly contact each other with heat insulating materials. For example, for heat insulation in buildings, the outer surfaces of buildings are covered with heat insulating materials.

Any process performed to protect the heat of the materials by preventing heat exchange is called heat insulation. Heat insulating materials used for heat insulation are called insulation materials. Insulation materials; It is made of heat insulating materials that do not conduct heat well. As insulation material, generally wood, plastic, glass wool, rock wool, plastic foam, tar, Bakelite, and air gap is used. The best example of the use of air gap is the air between double glazing.

Elaboration step: This was an important step for the integration of STEM based activities. It was aimed for the students to better understand the topic and to work the interdisciplinary connections with more active roles. The materials of the planned STEM based activities were handed to the small student groups by the teacher. The purposes of the activities for each STEM fields were as the followings:

- ***Science:*** The aims were to teach students about heat conduction and heat insulation, how to define and classify matters according their heat conduction features, and the criteria for selecting effective heat insulation materials.

- ***Mathematics****:* The aims were to encourage students to apply their knowledge and skills of mathematics to think logically and spatially, make decisions about the dimensions of the house using short and long sides, and measure temperatures.

- ***Technology****:* The aims of the activity were appropriate material selections, the use of materials and the importance of their usefulness. In addition to material features, the students were also expected to choose materials according their economic costs and utility.

- ***Engineering****:* The objectives of the activity were to use engineering design process and to be able to choose appropriate materials. Finally, students were asked to design and draw a house model from these STEM steps while explaining their material choices.

Evaluation step: The students were asked to answer the questions given to them in order to evaluate the effectiveness of the STEM based learning activities and to see how much students learned from these activities. The products that produced by the students from the STEM activities were also evaluated. In addition, the students were asked to develop a house model that they designed according STEM steps as a project assignment.

In this activity, assessment process took place from the beginning to the end of the lesson. In the introduction to the lesson, the teacher examined the students' prior knowledge and understandings about temperature, insulation and heat. The students designed home models and provided information about their products. In this way, the products and the learning process were evaluated.

Data analysis

The quantitative data from the questionnaires were analysed using SPSS and Microsoft Excel software. Effect size (r score) and non-parametric Wilcoxon signed rank test were calculated and used for the quantitative data analyses. Effect size calculated using $r = z/\sqrt{N}$ formula (z stands for z score and N is the total number of observed participants in the study) (Field, 2013). $0.10<r<0.30$ constitutes a small effect, $0.30<r<0.50$ constitutes medium effect and $r=0.50$ and higher score constitute a large effect (Field, 2013). The qualitative data from the semi-constructed interviews analyzed using thematic analyses.

RESULTS

This section explains the effect of the 5E integrated STEM based activities on students' science attitudes, their science anxiety and their perceptions of STEM fields. Due to using small sample size and not able to use random allocations, the effects on the dependent variables were

measured using effect size difference and non-parametric analysis by Wilcoxon Signed Ranks Test. Thematically analyzed qualitative data from the students' interviews were used to support the quantitative data and provide better understanding of the effects.

The effect on students' attitudes towards science

The effect of the 5E integrated STEM based activities on students' attitudes towards science was determined from pre- and post-test results difference from students' science attitudes scores. Table 3 demonstrated the descriptive statistic results, mean and median scores.

Table 3. The descriptive statistics results for the students' attitude scores

Gender	Test	N	Mean	Std. Dev. (SD)	Median
Boys	Pre-Test	18	74.44	16.56	78.00
	Post Test	18	90.05	9.62	94.00
Girls	Pre-Test	10	84.50	8.46	84.50
	Post Test	10	89.20	7.97	88.50
Total	Pre-Test	28	78.03	14.85	82.00
	Post-Test	28	89.75	8.92	93.00

In Table 3, pre-test median score was 82 and post-test median score was 93. The median scores from both tests were high, but post-test median score was considerably higher. Regarding gender, pre-test median score was 74.44 for boys and 84.50 for girls. Girls' pre-test median score was considerably higher than boys. Both boys' (Median=94.00) and girls' post-test median (Median=88.50) scores increased after the implementation.

Table 4 provided effect size and non-parametric Wilcoxon Signed Ranks Test results from students' attitudes towards science questionnaire.

Table 4. Effect sizes and Wilcoxon Signed Ranks Test results for students' attitude scores

Pre-Post Test		N	Mean Ranks	Sum of Ranks	z	p	Effect Size (*r*)
Boys	Negative Ranks	5	5.50	27.50	-2.529*	0.011	-0.421*
	Positive Ranks	13	11.04	143.50			
	Ties	0	-	-			
	Total	18					
Girls	Negative Ranks	4	11.70	117.00	-0.867*	0.386	-0.194*
	Positive Ranks	6	14.63	234.00			
	Ties	0	-	-			
	Total	10					
Total	Negative Ranks	9	9.89	89	-2.597*	0.009	-0.347*
	Positive Ranks	19	16.68	317			
	Ties	0	-	-			
	Total	28					

*Based on negative ranks

Table 4 showed that there was statistically significant difference between pre and post-test results ($z=-2.597$; $p<0.05$). Effect size was medium with $r=-0.347$. This can suggest that the effect of the 5E integrated STEM based activities on students' attitudes towards science was positively medium. The effect size and Wilcoxon signed ranks test results demonstrated that the 5E integrated STEM based activities can positively increase students' attitudes towards science.

Regarding gender, Table 4 demonstrated that there was statistically significant difference between pre- and post-test results of boys' science attitudes scores ($z=-2.529$; $p<0.05$), but the difference of girls' scores was not statistically significant ($z=-0.867$; $p>0.05$). However, regarding effect size, boys' science attitudes was positively medium with $r=-0.421$ ($0.30<r<0.50$) and effect size

of girls' scores was small with r=-0.194 (0.10<*r*<0.30). Although girls' science attitudes scores were higher than boys at the beginning, both girls' and boys' science attitudes scores increased after the 5E integrated STEM based activities, but boys' gains were noticeably higher than girls.

The qualitative data from students' interview also supported the quantitative results. Some of students' replies were:

S23:…I already like science lessons, but I even started to like it more because I had fun and I learned better with the activities.

S22:…These activities took my attention and contributed to like science.

S18:…The activities made science lesson more fun so I liked it.

S3:…science lessen were more fun and more effective. It made me to want more.

S19:…It contributed to like science lesson. It would be more difficult for me to understand this topic without these activities.

The effect on science anxiety

The effect of the 5E integrated STEM based activities on students' science anxiety was determined from pre- and post-test results' difference from students' science anxiety scores. Table 5 displayed some descriptive statistic results, mean and median scores.

Table 5. The descriptive statistics results for students' science anxiety scores

Gender	Test	N	Mean	Std. Dev.(SD)	Median
Boys	Pre-Test	18	62.72	15.51	65.00
	Post Test	18	44.94	13.84	36.50
Girls	Pre-Test	10	59.10	13.92	57.50
	Post Test	10	43.80	12.81	38.50
Total	Pre-Test	28	61.00	16.59	63.00
	Post-Test	28	41.96	14.51	36.50

In Table 5, total pre-test median score was 63.00 and total post-test median score was 36.50. Post-test median score was considerably lower than pre-test median score. Regarding gender, pre-test median score was 65.00 for boys and 57.50 for girls. Both boys' (Median=36.50) and girls' post-test (Median=38.50) median scores decreased after the implementation. Students' science anxiety significantly decreased after using the 5E integrated STEM based activities.

Table 6 showed effect sizes and non-parametric Wilcoxon Signed Ranks Test results from students' science anxiety test.

Table 6. Effect size and Wilcoxon Signed Ranks Test results for students' science anxiety scores

Pre-Post Test		N	Mean Ranks	Sum of Ranks	z	p	Effect Size (*r*)
Boys	Negative Ranks	15	9.50	142.50	-3.125*	0.002	-0.520*
	Positive Ranks	2	5.25	10.50			
	Ties	1	-	-			
	Total	18					
Girls	Negative Ranks	9	5.33	48.00	-2.091*	0.037	-0.467*
	Positive Ranks	1	7.00	7.00			
	Ties	0	-	-			
	Total	10					
Total	Negative Ranks	24	14.42	346	-3.773*	0.000	-0.504*
	Positive Ranks	3	10.67	32			
	Ties	1	-	-			
	Total	28					

*Based on negative ranks

Table 6 demonstrated that there were statistically significant differences between total pre and post-test results ($z=-3.773$; $p<0.05$). Effect size was large with $r=-0.504$. The effect size and Wilcoxon signed ranks test results can indicate that the effect of the STEM based activities on science anxiety was large and these activities could considerably decrease students' science anxiety.

Regarding gender, table 6 demonstrated that there was statistically significant difference between pre- and post-test results of both boys' ($z=-3.125$; $p<0.05$) and girls' science anxiety scores ($z=-2.091$; $p<0.05$). However, regarding effect size, boys' science attitudes was positively large with $r=-0.520$ ($0.50<r$) and effect size of girls' scores was medium with $r=-0.467$ ($0.30<r<0.50$). Both girls' and boys' science anxiety scores decreased significantly after using the 5E integrated STEM based activities.

The qualitative data from students' interview results supported these results. Some of students' replies were:

S23…I was not scared and did not get stressed. I had lot of fun.

S22…(stress, concern) did not happen. It makes me happier. It gave me the opportunities to more involve in the lesson and to be more responsible.

S18…I understood the topic better and this improved my motivation.

S13...I did not have any concerns because the lessons were very fun.

S3...I used to not understand science lessons very well and used to say what if I couldn't do it, but I do not say it anymore.

It can be seen from these results that most of the student enjoyed and had fun doing the activities. Since they enjoyed the activities and had fun doing them, their fears and worries decreased. This in turn could decrease their science anxiety.

The effect on students' perceptions of STEM fields

The effect of the 5E integrated STEM based activities on students' perceptions of STEM fields were determined from pre- and post-test results differences from students' perceptions of STEM fields mean scores. Table 7 demonstrated the descriptive statistic results, mean and median scores.

Table 7. The descriptive statistics results for students' perceptions of STEM fields scale

Subjects	Test	Mean	Std. Dev.(SD)	Median
Science	Pre-Test	5.60	0.89	5.80
	Post Test	6.06	1.02	6.20
Math	Pre-Test	5.30	1.60	5.70
	Post Test	5.90	1.28	6.40
Engineering	Pre-Test	5.30	1.07	5.50
	Post Test	5.86	1.29	6.40
Technology	Pre-Test	5.74	1.09	5.90
	Post Test	6.22	1.11	7.00
Career in STEM fields	Pre-Test	5.76	1.11	5.90
	Post Test	6.16	1.14	7.00
Total	Pre-Test	5.54	0.72	5.60
	Post Test	6.04	0.88	6.34

As seen in Table 7, students' perceptions of each STEM field median score increased positively. Median scores increased after implementing the STEM based activities for all STEM fields.

Table 8 demonstrated non-parametric Wilcoxon Signed Ranks Test results and effect size from students' perceptions towards STEM Fields test.

Table 8. Effect size and Wilcoxon Signed Ranks Test results students' perceptions of STEM fields scale

Subjects: Pre-Post Test		N	Mean Ranks	Sum of Ranks	z	p	Effect Size (*r*)
Science	Negative Ranks	6	11.42	68.50	-2.118*	0.034	-0.283*
	Positive Ranks	17	12.21	207.50			
	Ties	5					
	Total	28					
Math	Negative Ranks	10	11.70	117.00	-1.488*	0.137	-0.198*
	Positive Ranks	16	14.63	234.00			
	Ties	2					
	Total	28					
Engineering	Negative Ranks	9	12.67	114.00	-1.804*	0.071	-0.241*
	Positive Ranks	18	14.67	264.00			
	Ties	1					
	Total	28					
Technology	Negative Ranks	9	12.61	113.50	-1.320*	0.187	-0.176*
	Positive Ranks	16	13.22	211.50			
	Ties	3					
	Total	28					
Career in STEM Fields	Negative Ranks	8	14.50	116.00	-0.973*	0.331	-0.130*
	Positive Ranks	16	11.50	184.00			
	Ties	4					
	Total	28					
Total	Negative Ranks	10	11.30	113.00	-2.050*	0.040	-0.273*
	Positive Ranks	18	16.28	293.00			
	Ties	0					
	Total	28					

*Based on negative ranks

In table 8, it could be seen that there were statistically positive differences between pre and post-test results for students' perceptions of science ($z=-2.118$; $p<0.05$) and perceptions of STEM fields' total scores. ($z=-2.050$; $p<0.05$). However, the differences for Math ($z=-1.448$; $p>0.05$), Engineering ($z=-1.804$; $p>0.05$), Technology ($z=-1.320$; $p>0.05$) and Career in STEM fields ($z=-973$; $p>0.05$) were not statistically significant. However, the effect size for each individual field and total

scores were small (0.1<*r*<0.3). Although the differences for some fields were not significant, the effect size differences could suggest that there was positive small effect of the 5E integrated STEM based activities. These results could mean that the effect of the activities on students' perceptions of each STEM fields was positively small.

The qualitative data form students' answers to the interview questions demonstrated positive experiences regarding perceptions of STEM fields. Some of the replies from students were:

S18… (integrating technology, math and engineering with science lessons) was perfect. The lessons were what I needed for choosing a suitable career.

S22…I liked it. I think my science lesson and my engineering ability were improved.

S19…It was good, I felt like an architect and an engineer. I would like to learn human body systems topic like this.

S15…I think it was good. I liked the materials we did. I get some ideas about the topic at home and it was good.

S10…It was good. To become an engineer, you will need to study Science and Maths.

S16…I liked the STEM activities because I want to became an engineer.

Students' ideas about the 5E integrated STEM based activities

28 students interviewed after the implementation of the 5E integrated STEM based activities to get their ideas about these activities. The results from students' answers coded and the percentage of these codes were shown in Fig. 1. Almost all the students reported positive experiences regarding science related outcomes and the STEM based activities, but two students reported that they bored during the activities.

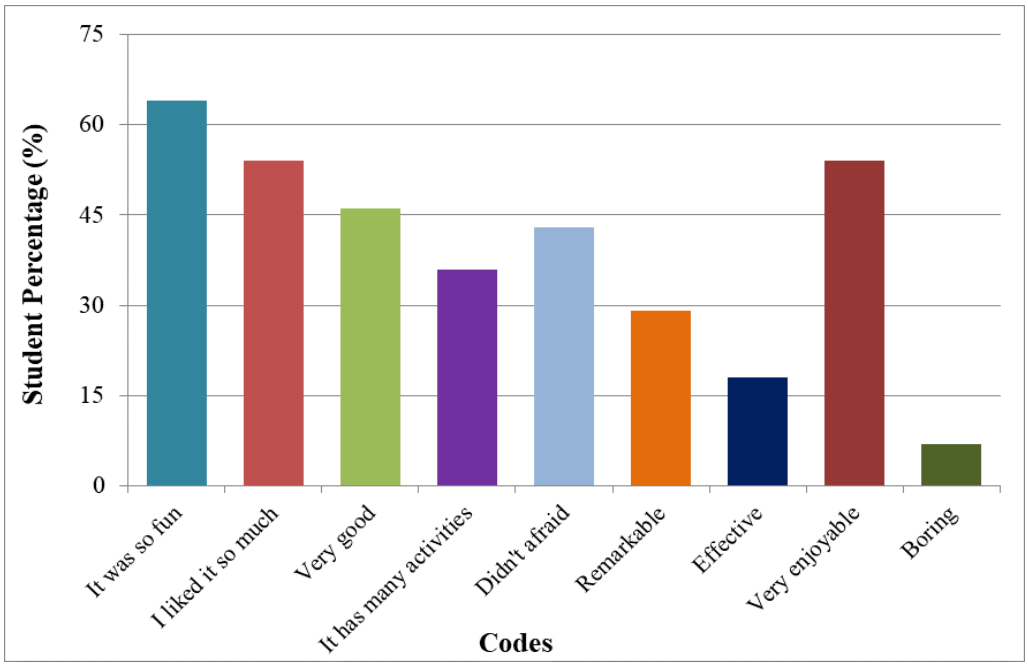

Figure 1. The percentage of coded replies from students' interviews

Most of the students found the activities to be very fun, enjoyable and like doing them. They stated that the STEM based activities supported them to produce different ideas in their lessons by

making them more active in their learning. These activities also helped them to decrease their fear, anxiety and worries about science lessons. The fear of "what if I become unsuccessful" turned to be having fun, being happy and learning effectively. This supported with one of the students reply as "*I didn't have any fear or worry, I understood and did the topic very well, which made me very happy*". The students also reported that they like doing the lessons with interdisciplinary activities. Some of the replies were "*doing the lesson with other subjects was fun (S2)*" and "i*t was fun doing math with science" (S4)*. In addition, some of the students stated that these activities changed their ideas about their career in STEM fields. They felt like being an architect or an engineer while doing the activities. "*It was good. I felt like an architect and engineer (S19)*", "*I liked the activities because I want to be an engineer (S10)"* and "*This kind of activities were exactly what I want for choosing a career (S18)*" were some of the replies from the students. In general, the students liked and enjoyed the 5E integrated STEM based activities through helping them to improve their different ideas, making them to be curious, improving their perspectives and making them to learn their lessons by being more active in their lessons.

DISCUSSIONS, CONCLUSIONS AND IMPLICATIONS

This study investigated the effects of using 5E integrated Science Technology Engineering Mathematics (STEM) based activities that include teaching activities of "Matter and Heat" science topic, on 6th grades students' attitudes towards science, their science anxiety and their perceptions of STEM fields. Discussions, conclusions and implications of this research were given below.

The quantitative and qualitative results of this study demonstrated that STEM integrated activities positively increased students' attitudes towards science. Although both boys and girls had prior positive attitudes towards science, their attitudes increased after doing the activities, but boys' attitudes substantially increased more than girls. The students stated that the 5E integrated STEM based activities improved their engineering and designing skills, made their learning more efficient, turned their lessons to be more fun, improved their interest towards engineering and helped them to better decide about their future careers. This result was consistent with some of the studies in the literature. Yamak et al., (2014) found that 5th grade students' attitudes towards science increased positively after participating to STEM integrated activities. Guzey et al., (2014) stated that there is positive influence of STEM education programs on middle school children attitudes towards science. Toma and Greca (2018) found that integrative STEM approach program increased children's attitudes towards science. Although Fernandez-Cezar et al., (2020) found small effect of STEM outreach program on students' attitudes towards science; they reported positive influence of STEM education programs on students' attitudes towards science. In another study, Şimşek (2019) reported that the integrated STEM activities had positive effect on students' attitudes towards science and the students liked and enjoyed doing the activities.

The 5E integrated STEM based activities positively decreased students' science anxiety. Both girls' and boys' science anxiety considerably decreased after doing the activities. The students also reported positive experiences regarding their science anxiety. Although there was no study in the literature examined the effect of STEM education on science anxiety, some studies reported positive effects of STEM education on math anxiety (Aosi et al., 2019). Aosi et al. (2019) studied STEM based learning to overcome math anxiety. They reported that STEM based learning helped to decrease students' math anxiety. Involving students in active, entertaining and interesting STEM activities may decrease their fear of doing science and this in turn could decrease their science anxiety.

Although the effect of the 5E integrated STEM based activities on students' perceptions of each STEM fields was small, these activities positively increased students' perceptions of each STEM fields. Some studies investigated the effect of STEM education on students' perceptions of STEM fields (Koyunlu et al., 2016; Gülhan and Şahin, 2016; Uğraş, 2018). Gülhan and Şahin (2016) investigated the effect of STEM integrated activities on 5th grade students' attitudes and perceptions towards STEM fields. They found that STEM integrated activities improved students' attitudes and their perceptions towards STEM fields. Knezek et al. (2013) reported environmental power monitoring

activities that used as project-based activities improved students' perceptions of STEM fields and career positively.

Education programs that included STEM integrated approaches can positively help students to improve their attitudes towards science, decrease their science anxiety and increase their perceptions of STEM fields and careers in STEM related subjects. Although the effects for students' perceptions of each STEM fields were small in this study, other studies suggested positive effect. These changes in middle school students' science related outcomes can follow with better academic achievement in science and more career preferences in STEM fields. Therefore, the following suggestions were made:

- Science lessons should be planned to involve more STEM based activities.
- Courses about how to effectively use STEM education should be provided to teachers and schools.
- Lessons plans should be prepared according STEM education.
- Studies with better methodological designs and with more participants should be conducted for both science and other subjects.

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