Universal Journal of Educational Research 7(5): 1275-1285, 2019 http://www.hrpub.org
DOI: 10.13189/ujer.2019.070513

The Effect of STEM-based Activities on 7th Grade Students' Academic Achievement in Force and Energy Unit and Students' Opinions about These Activities[i]

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Abstract In this research, it was aimed to investigate the effect of using STEM-based activities on 7th grade students' academic achievement and their opinions about these activities in the teaching of force and energy unit. The study was conducted with 52 students randomly selected from the 7th graders who were being educated in classrooms 7-D and 7-E in a middle school located in Kastamonu Province in 2016-2017 academic year. There were 26 students in experimental and control groups. This research utilized a mixed-methods design in which both quantitative and qualitative research designs are used together is used. A semi-experimental model with pre-test/post-test control group was used from the experimental models to determine to the students' academic achievement of STEM-based activities. The results of data analysis showed that attending lessons supported by STEM-based activities resulted in significantly greater academic achievement for the experimental group compared to that of the control group. In addition, content analysis of the data obtained from STEM Opinion Form (SOF) applied only to the experimental group students was made and the STEM-based activities were integrated according to the findings to reach the conclusion that the lesson was fun and active, the interest and motivation of the lesson increased for students of experimental group. Also, the subjects were better understood by experimental group students.

Keywords Science Education, STEM, Achievement, Interest and Motivation

1. Introduction

The global economic and technological landscape is rapidly changing. As a result, there exists an increasing need for a highly educated and skilled workforce [1]. The new workforce will have different demands as general proficiencies give way to more specialized competencies and requirements [2]. In particular, there is a growing need for science, technology, engineering, and mathematic (STEM) workers [3-4]. The reflections of the rapidly changing technology and the changes it brings about on education are inevitable. In this regard, all countries are updating their curricula to educate their citizens as individuals with qualifications and equipment required to meet the needs of the new age [5-8]. In many countries around the world, there has been an increasing emphasis on improving science education. Recent reform efforts in the USA call for teachers to integrate scientific and engineering applications into science teaching; for example, science teachers are asked to provide learning experiences for students that apply crosscutting concepts (e.g., patterns, scale) and increase understanding of disciplinary core ideas (e.g., physical science, earth science). Engineering applications and engineering design are essential elements of this new vision of science teaching and learning [9].

The concept of STEM was first introduced in 2001 by the director of National Science Foundation, Judith A. Ramaley, and spread rapidly among the countries of the world. Especially the USA is making reforms in this field within its education system. Considered to be the biggest educational movement in recent years, STEM education has begun to get the necessary attention in our country as well. The Ministry of National Education in Turkey (MoNE) issued an action report in its STEM Education Report, published in June 2016 [10]. In 2017, the science curriculum was updated, and STEM integration started by adding engineering and science applications as a subject area. STEM has been recognized as an approach that encompasses all levels of education from pre-primary education to university and incorporates different fields

[11]. STEM is an education process that brings together different fields of science to enable students to learn meaningfully, associate learned knowledge with everyday life, improve the skills required for life, and think on a high level and critically [12]. Another important purpose of STEM education is to ensure that students have the knowledge and skills to use the knowledge and experience they learned to meet the needs of the community and to offer necessary guidance. In addition, STEM education is also important in terms of ensuring the permanence of the learned knowledge and providing applications that will encourage students to learn.

Science education, intertwined with life and environment considering the issues it covers, is frequently subjected to updates in an attempt to offer a more quality education supported by various methods and techniques [13]. Having been updated again in 2018, the curriculum in Turkey requires individuals to have scientific literacy as well as basic literacy skills. Therefore, they should know how to think and consider scientifically, distinguish scientific situations, and use appropriate methods for this. They should be able to explain it scientifically when they encounter an event, a case or a situation. Also, the individual needs to possess production-oriented skills, think in a design-oriented way, and be innovative. In order to find a solution to an existing problem, it is necessary for the individual to distinguish between continuities and changes, identify the tools suitable for the objective, and recognize the laws in the universe [14]. Although education and teaching vary depending on the conditions in which the societies are involved, this leads to the emergence of different theories in education. Current approaches in education are emerging as a result of some changes and innovations in science education and teaching at schools. Science education is based on science and technology. In addition, science is a field in which individuals develop mentally and in terms of creativity and has a very important place in the development of countries [15, 16]. Recent research findings in science education demonstrate the necessity of utilizing engineering to develop science teaching [17]. Engineering provides a bridge between scientific and mathematical theory and the technology we use in our daily lives and combines the purpose of meeting social needs with the foundations of science and mathematics [18]. Considering these, STEM (Science, Technology, Engineering and Mathematics) education holds an important place in contemporary education.

Nowadays, it is important to integrate different disciplines such as science, technology, engineering and mathematics into education in order to reduce the problems encountered in education and training and to increase the achievement. Therefore, STEM activities are designed and used in science lessons will help the subjects to learn more easily, the information learned will be more permanent and students will be more actively involved in the lessons.

1.1. The Purpose of the Research

In order to solve the major problems of the 21st century, there is a need for technical and personal labor and STEM-literate individuals [19]. STEM-literate students approach issues through questioning, researching, and using problem-solving skills, collaborate, and improve their ability to invent by developing solutions. In education, the use of science and engineering applications by students has an important place in taking steps such as scientific research and technological development, socioeconomic development, and competitive power necessary for Turkey [20]. Global competition among countries has affected their education systems as well, especially in the teaching of science and mathematics. Findings from studies conducted in the field of science in recent years suggest that engineering applications as well as mathematics and technology should be utilized in science lessons so that science education can measure up to expectations [21]. Today, the integration of different disciplines such as science, technology, engineering and mathematics into education is important in reducing the problems in education and teaching and increase achievement levels. Therefore, the design and use of STEM activities in teaching, especially in science lessons, will undoubtedly make the subjects easier to learn and more permanent and promote more active participation of students in lessons.

This research aimed to investigate the effect of utilizing STEM-based activities in the teaching of force and energy unit, at 7th grade on the academic achievement levels of students and determine student opinions about STEM-based activities. As such, this study seeks answers to the following research questions:

1. *Is there a significant difference between the pre-test scores of students' academic achievement in the experimental and control groups before application?*
2. *Is there a significant difference between the post-test scores of students' academic achievement in the experimental and control groups after application?*
3. *Is there a significant difference between the pre-test/post-test scores of students' academic achievement in the control group before and after application?*
4. *Is there a significant difference between the pre-test/post-test scores of students' academic achievement in the experimental group before and after application?*
5. *What are the students' opinions in the experimental group about STEM-based activities after application?*

By answering these questions, student affairs professionals can gain better insight into STEM applications in order to develop new and imaginative programs that facilitate their academic success. As well, it will allow us to understand existing comparisons between lessons with STEM applications and their non-STEM applications concerning the quality of educational experiences and the types of sound educational activities that have the greatest impact on persistence and completion.

2. Methodology

2.1. Research Design

This research is both qualitative and quantitative. The research method in which both qualitative and quantitative research approaches are used together is defined as mixed type. According to [22], the combined use of qualitative and quantitative methods in mixed-methods research offers a better understanding of the research problem. A semi-experimental model with pre-test/post-test and control group was used to determine the effect of STEM-based activities on the academic achievement of the students. Experimental methods are used in studies to determine whether there are significant differences between pre-test and post-test data when statistical processes are applied to collect quantitative data [23]. For the qualitative data, the experimental group received SOF in which they were requested to write about their opinions regarding the STEM-based activities implemented within the scope of the unit. Students in the control group studied force and energy unit in accordance with the 2013 Science Curriculum, while the students in the experimental group studied the same subjects supported by additional STEM-based activities. The Force and Energy Unit Achievement Test (FEUAT) was applied to both groups as the pre-test before implementation. The same test was applied to both groups again as the post-test after six weeks of implementation. At the end of the study, the students in the experimental group filled in STEM Opinion Form (SOF) in order to get their opinions about STEM-based activities. The experimental model of the research is shown in Table 1.

Table 1. The experimental model of the research

Group	*Pre-test*	*Applications*	*Post-test*
Experimental	FEUAT	Supported by STEM-based activities	FEUAT, SOF
Control	FEUAT	In accordance with the 2013 Science Curriculum	FEUAT

2.2. Study Group

The study was carried out with 52 students in 7-D and 7-E branches randomly assigned in 7th grade of a middle school located in Kastamonu Province in 2016-2017 academic year. 21 of these students are female and 31 are male students. Table 2 shows the demographic characteristics of the students in the study group. 7-D (26 students) was assigned as the control group and 7-E (26 students) as the experimental group from these branches. This research was conducted in two different classes in the school. The classes of the treatment and comparison groups were decided by the simple random sampling method [24].

Table 2. The demographic characteristics of the students in the study group

Group	*Gender*			
	Female		*Male*	
	N	%	N	%
Experimental	11	42.31	15	57.69
Control	10	38.46	16	61.54

2.3. Data Collection Tools

In order to collect the data in the current study, two different data collection tools were used. A force and energy unit achievement test and STEM opinion form were developed.

2.3.1. Force and Energy Unit Achievement Test (FEUAT)

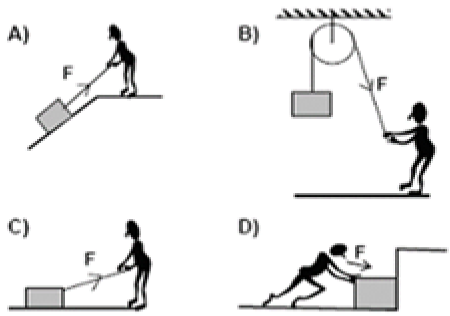
The achievement test was developed by the researchers based on gains of force and energy unit to determine whether the experimental practice led to a significant difference on the students' academic achievement. The test included questions from examinations administered by the Ministry of National Education (MoNE) in previous years and supplementary textbooks approved by MoNE and some were prepared by the researchers. The test was developed upon a consideration of the gains in force and energy unit and 25 multiple-choice questions were prepared initially based on them and care was taken to ensure that each of the prepared questions was related to unit gains. In order to ensure the content validity of the test, two expert physics teachers and three experienced science teachers were consulted. Some of the questions were removed considering the opinions and suggestions of the experts regarding the existence of similar questions measuring the same gain and to make it possible to administer the test within one lesson hour. Prepared in this way, the achievement test was applied to 195 students who had already studied this unit, were not included in the sample, and were studying in the 8th grade. The reliability coefficient of the test was calculated by Kuder-Richardson (KR-21) formula. Taking into account the results of item analysis, the number of questions were reduced from 25 to 22, and they were used in the final test. A few questions from the test are shown below.

In order to do work in physical sense;

Force should be applied,

The object that is under the influence of Force should travel.

Accordingly, no work can be done in any of the following.



The aim of this question is to learn the concept of physical work correctly. For students to learn correctly, the work sheet was prepared and made STEM-based activities by researchers as mentioned in procedure. Before application starts, number of students who answered this question correctly in experimental group is 8 (30.8%), in the control group is 6 (23.1%). After application, the number of students who answer the same question correctly in experimental group is 21 (80.8%), in the control group is 19 (73.1%).

Another question;


I-Floating man


II-Running man


III- Table hanging on the wall


IV- Plane on the ground

Which of the side have kinetic energy?
A) I and II
B) I, III and IV
C) II and III
D) II, III and IV

The aim of this question is to learn what kinetic energy depends on. For this, activities were carried out as described in the procedure. Before application starts, number of students who answered this question correctly in experimental group is 9 (34.6%), in the control group is 9 (34.6%). After application, the number of students who answer the same question correctly in experimental group is 24 (92.3%), in the control group is 16 (61.5%).

The reliability of the final form of the test was recalculated and the reliability (KR-21) value was found to be 0.75. Having a reliability value of 0.70 or above is considered to mean that the test is reliable [25]. According to these results, the test was taken as the final test and used in the research as the Force and Energy Unit Achievement Test (FEUAT).

2.3.2. STEM Opinion Form (SOF)

Consisting of two open-ended statements that students were asked to respond to in handwriting, SOF was used to determine the opinions of the students in the experimental group about the STEM-based activities that supported them while studying the subjects in the unit. The statements in this form were as follows.

Please write down your opinions about STEM-based activities in the science lesson.

1. Your Positive Opinions:
2. Your Negative Opinions:

Students' responses to this form were evaluated through percentage and frequency values based on the positive or negative themes.

2.4. Procedure

This research was conducted in order to investigate the effects of activities prepared according to STEM disciplines on 7th grade students' academic achievement in force and energy unit. In the control group, the lesson was taught according to the existing program by the teacher and in the experimental group the researcher supported the existing program with STEM-based activities. Prior to the research, activities and materials for STEM disciplines were designed in accordance with the gains of force and energy unit. A variety of teaching materials were developed for each discipline of STEM education, namely science, technology, engineering, and mathematics, in relation to the topic headings of the unit. Experiment sheets were prepared and experiments were carried out in consideration of unit gains. Various activities were carried out by using websites relevant to the lesson themes such as *http://www.morpakampus.com*, *http://www.phet.colorado.edu.tr* in order to better understand the subjects that students are challenged with and support the discipline of technology. In order to support the engineering discipline, they designed *equal arm scales*, *dynamometers*, and *catapults* using simple materials that were suitable for the unit content.

The researchers prepared worksheets on the subjects of mass and weight relationship, force and pressure relationship, force, work and energy relationship for mathematics, and used open-ended and multiple-choice questions from various sources for students' self-evaluation after they covered the subject. In addition, there were competitions and activities for the materials the students designed. STEM education is a model based on the principles of the constructivist approach and is integrated with the 5E learning model, which encapsulates many processes in learning scientific knowledge [16]. Therefore, the 5E learning model was utilized in the experimental group while teaching the subjects in force and energy unit. The instructional design developed for the unit subjects was implemented in the experimental group for a total of 24 hours, 6 weeks and 4 hours per week. Experimental group students received necessary information about STEM before intervention and what STEM-related tasks they will do within force and energy unit. The achievement test, which was prepared to measure the preliminary knowledge and readiness of control and experimental groups, was applied as pre-test.

2.4.1. Teaching in the Control Group

The lessons in the control group were taught by a subject-matter teacher within the frame of the annual plan prepared in accordance with the current 2013 Science Curriculum in Turkey. The textbook was used as a source and no intervention was made.

2.4.2. Teaching in the Experimental Group

In the experimental group, the researcher taught the subjects in Force and Energy unit by integrating activities and materials consistent with STEM disciplines within the frame of the annual plan prepared in accordance with the existing curriculum. STEM-based subjects and activities are presented below in weeks.

2.4.2.1. Teaching in Week One

The first topic of the first week was mass and weight relationship. Students often confuse these two concepts and find it difficult to understand them. Therefore, the plan was to use enjoyable and intriguing activities that could attract their attention before intervention. Here, the Engagement phase of the 5E model was taken into consideration. In this regard, students' preliminary knowledge was determined by asking them various questions and attracting their attention with examples from daily life indicating that the concepts of mass and weight are not synonyms. The aim here was to promote the students' motivation and create dilemmas about the concepts of mass and weight in their minds. At this stage, the science discipline of STEM education was utilized. Students received a worksheet on mass and weight relationship asking them to work together and find a solution to a problem, and they were asked to fill in the gaps in the worksheet. Here, the aim was for them to discover the two concepts. To this end, the Exploration phase of the 5E model was utilized. At this stage, students were allowed to work together without guidance from the teacher. Thus, the students made observations during the activity and took notes and discussed what they learned both within their groups and during whole-class discussions. In addition, since it was necessary to perform mathematical operations to fill the gaps in the worksheet, the aim was to make them utilize the Mathematics discipline in STEM education. At this stage, the researchers were in a guiding position facilitating group work and discussion.

The students were divided into groups and used the interactive board to make interactive activities related to the concepts of mass and weight on Morpa Kampus website. The aim here was to make the concepts of mass and weight, processes and skills become clear and understandable. For this purpose, the Explanation phase of the 5E model was utilized. At this stage, having attracted their attention, the researcher provided the students with a clear, simple, and scientific explanation of these two concepts and made the students in groups utilize scientific processing skills such as observing, measuring, classifying, predicting, and problem solving by filling in the gaps in the worksheets assigned to them. At this stage, the students made interactive activities to support the integration of the technology discipline of STEM education into teaching, and they learned the concepts better by utilizing them on these activities. Figure 1 demonstrates one of the interactive activities made by students to support the technology discipline. Making these activities, the students were able to see through visuals how the concepts of mass and weight are used and calculated in their environments by means of technology and the difference of mass.

Figure 1. Interactive activity on mass and weight relationship

The following activities about the mathematics and engineering disciplines were implemented in order for students to gain experience in the new concepts they learned and become knowledgeable about everyday applications. The aim here was to enable students to adapt the concepts they learned into new situations and utilize them. Therefore, the Elaboration phase of the 5E learning model was utilized. The students were divided into groups by the researcher and asked to make their own dynamometers and equal arm scales using the simple materials they were given.

The materials used for these activities are;

- Pipette,
- Styrofoam,
- Rubber,
- Rope,
- Two cardboards as scales,
- plastic injector,

Each group designed their own dynamometer to measure weight and equal arm scales to measure mass. Here, the focus was on the mathematics discipline of STEM education. Some of the examples of the materials designed by students are presented in Figures 2 and 3. At the end of the lesson, the students made activities about mathematical operations especially in comparing the concepts of mass and weight. Lastly, the students made predictions about the masses of objects by measuring them on the equal arm scales they designed and observing the balance levels of the scales.

Figure 2. The equal arm scale designed by the experimental group

Figure 3. The dynamometer designed by the experimental group

The experimental group received feedback from the researcher regarding areas they needed to improve on and answered open-ended and performance-based questions to evaluate the new concepts and skills they learned. The Evaluation phase of the 5E learning model was utilized for this purpose. Also, they graded the characteristics of their own designs by making in-class contests. The purpose was to integrate the Science and Mathematics disciplines of STEM education. The lesson was taught the same way as in week one in the following weeks, and some activities made by the students during this term are presented below (Figure 4 and 5).

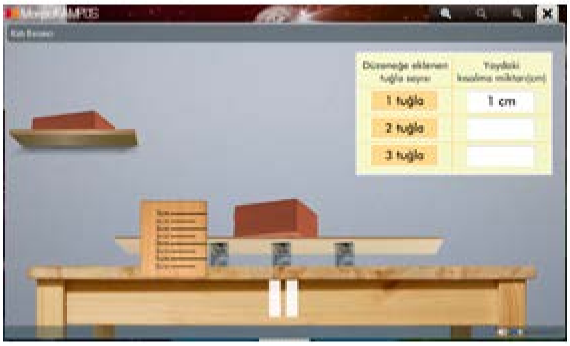


Figure 4. Interactive activity on force-solid pressure relationship

Figure 5. Interactive activity on liquid-gas pressure relationship

The students designed a poster for force-solid pressure relationship. Here, the students aimed at highlighting the Engineering discipline of STEM education through their designs. One image showing an example from the students' work on banners is presented in Figure 6.

Figure 6. The poster of pressure designed by the experimental group

One subject in force and energy unit, "force, work, and energy", was covered. Considering the outcomes of this subject, students made interactive activities aimed at recognizing the concept of work, understanding what the concept of work means, and understanding the concept of work is in direct proportion to the force applied and the amount of distance covered. They watched videos on this subject. One image from their activities is presented in Figure 7. Here, the aim was to focus more on the science and technology disciplines of STEM education.

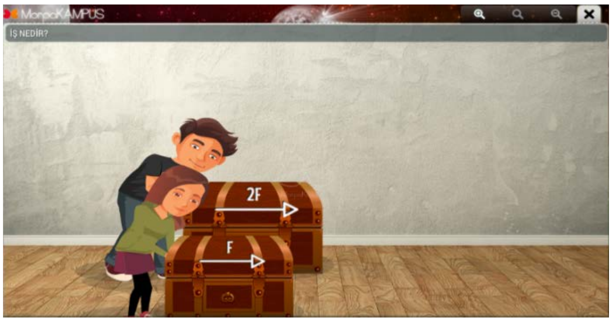


Figure 7. Interactive activity on the concept of work

Students received worksheets on another subject in the unit, "energy transformation", and answered questions. Also, they learned about one of the outcomes of this subject, "frictional force and its impact", through various activities. The aim of these activities was to integrate the Science and

Mathematics disciplines of STEM education. In addition to these activities, they made simulations on PhET website. Thus, there was a focus on the technology discipline of STEM education. Next, students in groups designed a catapult suitable for kinetic and potential energy transformation using simple materials they found themselves such as *tongue depressor, plastic bottle caps, rubber, thick wires, plastic spoon and silicon glue*. Here, the purpose was to focus on the engineering discipline of STEM education. There was a contest among groups based on the catapults they designed. One example from the catapults designed by the experimental group is presented in Figure 8.

Figure 8. The catapult designed by the experimental group

2.5. Analysis of the Data

This section presents an overview of the processes in analyzing the qualitative and quantitative data and the analysis methods used within these processes.

2.5.1. The Analysis of Quantitative Data

SPSS statistical package software was used in analyzing quantitative data. Firstly, it was checked whether the data from FEUAT were normally distributed and the results are presented in Table 3.

Table 3. Normality test results obtained from FEUAT pre-test and post-test

FEUAT	Groups	N	p
Pre-test	Control	26	0.413*
	Experimental	26	0.105*
Post-test	Control	26	0.213*
	Experimental	26	0.119*

*$p>0.05$

Table 3 shows that the data were normally distributed because $p>0.05$, and hence, parametric tests were used in analyzing the data collected from the control and experimental groups.

2.5.2. The Analysis of Qualitative Data

The data from SOF, administered to the experimental group, were categorized as positive, positive-negative, and negative, and their frequency and percentage values were calculated (Table 6).

3. Findings and Discussion

In this section, the findings of the research are presented under with the research questions.

3.1. The First and Second Research Questions

Is there a significant difference between the pre-test/post-test scores of students' academic achievement in the experimental and control groups before and after application? An independent samples t-test was used in analyzing the data collected from the experimental and control groups. Descriptive statistics of these data are presented in Table 4.

Table 4. The results of independent samples t-test of the experimental and control group students' academic achievement pre-test/post-test scores

Group	*N*	$\bar{X}$	*SS*	*t*	*p*
Experimental group pre-test	26	6.65	2.545	-.739	0.463
Control group pre-test	26	7.15	2.327		
Experimental group post-test	26	16.46	3.658	2.106	0.040
Control group post-test	26	13.92	4.939		

Table 4 shows that the experimental group had a mean score of $\bar{X}$=6.65 on the pre-test with a standard deviation of 2.545 before application. The control group had a mean score of $\bar{X}$=7.15 on the pre-test with a standard deviation of 2.327 before application. This shows that there was no significant difference between the two groups (t= -.739; $p>.05$). The experimental and control groups were similar in their preliminary knowledge of force and energy unit. As a result, this means that the research was well-established as the mean scores of both groups ($\bar{X}_{exp}$ =6.65; $\bar{X}_{cont}$ =7.15) were close to each other without a significant difference.

Also, Table 4 shows that the experimental group had a post-test mean score of $\bar{X}$=16.46 with a standard deviation of 3.658 whereas the control group had a post-test mean score of $\bar{X}$=13.92 with a standard deviation of 4.939 after application. There was a statistically significant difference between the post-test mean scores of the experimental and control groups (t=2.106; $p<.05$) As a result, it can be argued that the STEM-based activities utilized in the experimental group led to higher achievement levels compared to existing teaching method.

3.2. The Third and Fourth Research Questions

Is there a significant difference between the pre-test/post-test scores of students' academic achievement in the experimental and control groups before *and after application?* A dependent samples t-test was used to analyze the pre-test and post-test data of the experimental and control groups. Descriptive statistics for the data are presented in Table 5.

Table 5. The results of dependent samples t-test of the experimental and control group students' academic achievement pre-test and post-test scores

Group	*N*	$\bar{X}$	*SS*	*t*	*p*
Experimental group pre-test	26	6.65	2.545	-13.070	0.000
Experimental group post-test	26	16.46	3.658		
Control group pre-test	26	7.15	2.327	-6.984	0.000
Control group post-test	26	13.92	4.939		

Table 5 shows that there was a highly significant difference between the pre-test and post-test mean scores of the experimental groups. Whereas the experimental group had a pre-test mean score of $\bar{X}$=6.65, this score increased to $\bar{X}$=16.46 on the post-test. Also, there was a statistically significant difference between the pre-test and post-test mean scores of the experimental group (t= -13.070; p<.05). As a result, it can be argued that utilizing STEM-based activities in the given unit led to higher experimental group students' academic achievement.

Also, Table 5 shows that there was a significant difference between the pre-test and post-test mean scores of the control groups. Whereas the control group had a pre-test mean score of $\bar{X}$=7.15, this score increased to $\bar{X}$=13.92 on the post-test. Also, there was a statistically significant difference between the pre-test and post-test mean scores of the control group (t= -6.894; p<.05). As a result, learning takes place in every environment. Therefore, the 2013 Science Curriculum applied in the control group can be said to have a positive effect on academic achievement of control group students. However, the academic achievement of the students in the experimental group was higher.

3.3. The Fifth Research Question

What are the students' opinions in the experimental group about STEM-based activities after application? The comments on SOF, administered only to the students in the experimental group, were categorized as follows and the resulting frequency and percentage values are presented in Table 6.

Table 6 shows that 84.6% of the students in the experimental group stated that comments "*lesson more fun*" and 65.4% of them "*lessons better understood*" on the STEM-based activities used in the teaching of the unit. whereas no one made completely negative comments. 7.7% of the students mentioned "*it was a bit boring*" and "*homework was difficult*" from experiences they had during the applications. Some examples from the experimental group's responses in which they answered open-ended questions on STEM-based activities are presented in below (S1, S2 and S3 represent students).

Table 6. Frequency and percentage values of the experimental group students' opinions according to SOF

Opinions	*f*	*%*
better understanding of subject	17	65.4
lesson more fun	22	84.6
Activity as the catapult and equal-arm scales	3	11.5
I wish we could have our other lessons this way	1	3.8
According to me science lessons should be more	1	3.8
I would get bored if we didn't do the activities	4	15.4
I love science for the experiment we did	9	34.6
It takes too much time to prepare the experimental setups	2	7.7
A different method, does not mind	2	7.7
It was a bit boring	2	7.7
Homework was difficult	2	7.7

Positive opinions:

S1: "I learned more fun and more permanent. When you have a question in the exam, the observations we make in our experiments come to mind and I can do it more easily".

S2: "The activities we did at the events were very fun. These activities made us learn things better and easier for us. The subjects were more fun and enjoyable. I briefly understood the issues better".

S3: "I think it's different, a nice method, this method did not distract me".

Negative opinions:

S1: "We have spent a lot of time preparing experimental setups. Sometimes they could not see what was left behind because they were collected at the beginning of experiments".

S2: "We did too much activity. That's why I'm bored".

S3: "It was a bit boring, we could not have fun, the teacher gave some difficult homework".

4. Discussions and Conclusions

This research aimed to investigate the effect of STEM-based activities on 7th grade students' academic achievement in force and energy unit. Having collected both quantitative and qualitative data in a mixed-methods design, this research investigated the results from FEUAT, which measured students' academic achievement and SOF, in which the experimental group indicated their opinions regarding STEM. The FEUAT pre-test results, which aimed to measure the preliminary knowledge levels of the students in the experimental and control groups, showed that there was no statistically significant difference between the scores, and both groups were similar in their preliminary knowledge levels. The same test was administered as the post-test after intervention, and a significant difference was found between the mean scores, with the experimental group having greater scores. It was seen that learning took place at the end of this process in both groups, but compared with the control group, the experimental group students had higher academic achievement levels, suggesting an effect of the STEM applications.

This study contributes to the scholarly significance of understanding the effect of STEM activities on student achievement. We found positive growth rate in students' academic achievement. The relevant literature shows that similar studies also found that STEM applications were successful in enhancing students' academic achievement. [16] found that an instructional design based on STEM education was highly influential on the students' academic achievement. In an experimental research in which they investigated the effect of STEM education on elementary school students' scientific processing skills and science content knowledge, [26] maintained that the experimental group had improved significantly more in scientific processing skills and science content knowledge than the control group. In another research with pre-service science teachers, STEM applications in science laboratory lessons were found to enhance the learning levels and be effective in improving achievement [12]. In their studies on STEM applications and whole learning [27] concluded that STEM applications improved academic achievement. The research also investigated the effect of STEM applications and whole learning on motivation and attitudes towards science and inquiry-based learning skills. Similar studies in the literature support the conclusion of this research that STEM applications promote students' achievement levels.

In addition, content analysis of the data obtained from STEM Opinion Form (SOF), administered only to the students in the experimental group, indicated that the lessons supported by STEM-based activities were fun and active, enhanced students' motivation and interest in the lesson, made subjects more comprehensible, and made the learning of concepts concrete. The findings in SOF, administered to the experimental group, showed that 84.6% of the students in the experimental group stated that comments "*lesson more fun*" and 65.4% of them "*lessons better understood*" on the STEM-based activities used in the teaching of the unit. whereas no one made completely negative comments. 7.7% of the students mentioned "*it was a bit boring*" and "*homework was difficult*" from experiences they had during the applications. Experimental group students' positive comments included that the classes were enjoyable and active and the activities enhanced motivation and interest in the lesson and made the subjects easier to understand. In addition to these opinions, some students made negative comments because they had problems in meeting deadlines because they were not able to use their time and materials carefully during the activities. In a research in which they investigated the opinions of 6th grade students regarding STEM-based activities [28] maintained that the students had found STEM-based activities useful and favored their use in classes. Based on the content of student journals where the students noted their opinions of the work they did in class [29] found that students had developed more positive attitudes towards STEM education, found the applications enjoyable and tried them again at home. The qualitative and quantitative results of the research support each other.

The results obtained from this research indicated that attending lessons supported by STEM-based activities resulted in significantly greater academic achievement for the students in the experimental group compared to that the students in the control group. There are also various studies demonstrating that STEM-based activities positively influence students' cognitive and affective development and the results of this study and the results from other similar studies [30-35] support each other.

5. Implications and Recommendations

As stated above, this research shows that STEM-based activities improved students' academic achievement levels in the experimental group, made science lessons more enjoyable and active and enhanced students' interest in the lesson. The participants of this research were middle school students in 7th grade. STEM-based activities can also be implemented in students of different grades or levels. Lessons can be supported by extracurricular STEM-based activities and applications as well as in-school STEM activities. The number of outcomes for STEM education in the updated Science Curriculum can be increased. There can be a greater number of workshops within STEM-oriented lessons in faculties of education.

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[i] This study produced from master's thesis of the first author and a part of this study was presented as oral presentation in 17th International Classroom Teaching Education Symposium in Ankara, Turkey, April 11-14, 2018.