

# EFFECT OF THE STEM ACTIVITIES RELATED TO WORK-ENERGY TOPICS ON ACADEMIC ACHIEVEMENT AND PROSPECTIVE TEACHERS' OPINIONS ON STEM ACTIVITIES

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## Introduction

It is well known that most important factor that enables countries to become economically independent is production of technology. Technology production, which has a significant position in the economic development of countries, occurs through the combination of Science, Mathematics and Engineering fields. The importance of technological development is constantly increasing and in parallel, countries are developing innovative policies. Many developed and developing countries, being aware of these technological developments and having an interest in the future of technology production focus on these four fields. For this purpose, programs and projects have been initiated in the USA and EU countries in order to provide technical knowledge and skills, prepare students for modern business life (Akgunduz et al., 2015). One reform movement that focuses on approaches to the teaching of science was the National Research Society in USA, formed in 1996 (NRC, 1996). With this program, a step was taken regarding the future development of inquiry-based teaching. In Europe, a report published in 2007 (Science education now: A new pedagogy for the future of Europe) emphasized that the number of students' interest in mathematics, technology and science had decreased significantly. It also emphasized that the long-term innovative capacity of Europe will fall significantly unless there are effective action plans to counter this trend (Akgunduz et al., 2015). In this context, it is very significant to create new educational approaches so as to ensure individuals of the future are equipped with the required skills, in order to increase productivity and the potential of the labour force.

In recent years, STEM education has been among the most important innovative policies in the field of education. STEM education concentrates on the combination of skills and knowledge in engineering, mathematics, technology and science into an engineering education-oriented teaching. In addition, STEM education can be defined as an educational approach that aims to provide students with interdisciplinary cooperation, systematic thinking, open communication, ethical values, research, production, creativ-



JOURNAL  
OF BALTIC  
SCIENCE  
EDUCATION

ISSN 1648-3898 /Print/  
ISSN 2538-7138 /Online/

**Abstract.** *In this research, the effects of STEM (Science-Technology-Mathematics-Engineering) activities on academic achievement of prospective teachers were researched, their opinions on STEM activities were sought. The research was based on a semi-experimental model with pre-test and post-test control group. During the application phase, the topic of Work-Energy subject was taught through STEM based 5E model in the experimental group, while in the control group, the lessons were conducted using traditional teacher centred teaching. The research group is comprised of second-year students in Elementary Mathematics Education taking Physics I course at the Dokuz Eylul University in Turkey. A statistically significant difference was found in favour of the experimental group in terms of prospective teachers' academic achievement. In addition, the positive opinions of the prospective teachers from the experimental group on STEM activities were that STEM activities included encouraging group work, assisting students to produce original work, enabling them to do research, and ensuring that the information learned is permanent. The negative opinions of them on STEM activities were insufficient time for the application, the dominance of some students during the group work, and difficulties with noise levels in class.*

**Keywords:** *academic achievement, prospective teachers' opinions, STEM activities, work-energy.*

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ity and problem-solving ability (Ayar & Adiguzel, 2014; Bybee, 2010; Roberts, 2012; Sahin, Yildirim, & Altun, 2015).

STEM education emphasizes the importance of professions in engineering, mathematics, technology and science fields. As mentioned before, there is a growing need for qualified manpower in these four fields. In today's world, technology-based education means that inevitably, individuals are expected to become not only producers, but also inventors. It is seen as an important point that individuals can use their acquired knowledge in engineering, mathematics, technology and science fields in such a way as to demonstrate their productivity (Akgunduz et al., 2015). In order to meet current needs, it is important that individuals can think critically and creatively, investigate, question, find solutions, and make good decisions (Akaygun & Aslan-Tutak, 2016; Yamak, Bulut, & Dundar, 2014). For this reason, in order to meet the need for sufficiently qualified manpower, countries have placed STEM education approach at the centre of education programs. In addition, STEM education has been very significant with regard to allowing theoretical knowledge in these disciplines to be changed into applications and products (Corlu, 2013). Thus, it has become essential to encourage young people to choose a profession in STEM-related areas through STEM education. Increasing student interest in STEM is important not only for STEM literacy, but also for developing the related professions (Wyss, Heulskamp, & Siebert, 2012).

For teachers of STEM, field knowledge alone is not sufficient to produce well-qualified individuals (Corlu, Capraro, & Capraro, 2014); they should also have teaching knowledge and skills. The teachers using STEM education approach in courses should have the essential skills and knowledge, and it is essential that teachers should be capable of applying STEM education effectively in primary and secondary education to achieve successful results. When a preservice teacher is able to meet STEM education requirements, this is a great asset for future students. Thus, students studying with STEM applications will be more motivated and more successful in engineering, mathematics, technology and science fields. Therefore, it is very important to stress the importance of STEM applications to future teachers in the faculties of education. Campbell et al. (2012) have likewise proposed the development and dissemination of teacher training programs to increase STEM teachers' awareness.

It is generally known that students have difficulty with physics lessons and find them challenging. Students see physics lessons as both difficult (Olasimbo & Rotimi, 2012; Ornek, Robinson, & Haugan, 2008; Tekbiyik & Akdeniz, 2010; Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003) and uninteresting (Williams et al., 2003). Therefore, students tend not to participate in physics lesson effectively (Aktamis, Tanel & Ergin, 2004). Students' passivity in the course also causes major difficulties in understanding the topics (Duruhan, 2004). To overcome such difficulties, many different educational approaches and teaching models have been applied: The cooperative problem-solving approach, problem-based learning model, full studio model, and computer-based teaching approach. Researches related to these approaches and models have investigated the effects of the approach and the model on the students' success in physics, their attitudes to physics, and their conceptual understanding (Bodur, 2006; Ersoy, 2015; Madanoglu, 2015; Ozdemir, 2015; Yavuz, 2016; Yeryurek, 2013). It is seen that the approaches and models applied in many researches have had a positive effect. STEM education, an educational approach, allows students to be more active in the course; thus, studies in STEM applications in physics courses have the potential to contribute to the literature.

In recent years, STEM education research has increased considerably in the literature. Some studies have researched the effects of STEM education on student learning (Acar, Tertemiz & Tasdemir, 2018; Aydin-Gunbatar, Tarkin-Celikkiran, Kutucu & Ekiz-Kiran, 2018; Cevik, 2018; Guzey, Moore, Harwell & Moreno, 2016; Guven, Selvi & Benzer, 2018; Ince, Misir, Kupeli & Firat, 2018; Riskowski, Todd, Wee, Dark & Harbor, 2009; Sarican & Akgunduz, 2018; Yildirim & Selvi, 2017). Other studies have examined the teachers and prospective teachers' opinions about STEM education (Altan & Ucuncuoglu, 2018; Aydin-Gunbatar et al. 2018; Campbell, Lee, Kwon, & Park, 2012; Guder & Gurbuz, 2018; Kizilay, 2016; Ozbilen, 2018; Park, Byun, Sim, Han, & Baek, 2016; Thomas, 2014; Ugras, 2017; Ugras & Genc, 2018; Wang, 2012; Yildirim & Turk, 2018). Another group of studies has analysed the effects of STEM education on different variables, such as attitude, conceptual understanding, scientific process skills, and self-efficacy (Cotabish, Dailey, Robinson, & Hughes, 2013; Gokbayrak & Karisan, 2017; Gulhan & Sahin, 2016; Kecici, Alan, & Zengin, 2017; Ozyurt, Kayiran, & Basaran, 2018; Yildirim & Sidekli, 2018). A smaller number of researches have focused on the effect of STEM education approaches on prospective and practicing teachers applying STEM education (Akaygun & Aslan-Tutak, 2016; Delen & Uzun, 2018; Ugras, 2017; Yildirim & Altun, 2015; Yildirim & Sidekli, 2018). The introduction of STEM education practices to prospective teachers is increasingly seen as a necessity. Thus, the assessment of the effectiveness of STEM activities compared to traditional teacher centred teaching in Turkey plays an important role in determining future education policies. This practical introduction to STEM for prospective teachers will provide the necessary knowledge and experience for their careers (Tutak, Akaygun &



Tezsezen, 2017). One of the fundamental motivations for the current research is the lack of studies on STEM activities practices within prospective teacher education in the literature. In addition, it is important to research prospective teachers' academic achievement in STEM activities, specifically in physics courses, as a new strand in the literature. The main purpose of the research was, for that reason, to research the effects of STEM activities, a new educational approach, on students' academic achievement in physics learning. In addition, because the research group was composed of prospective teachers, the research also aimed to understand their opinions of STEM activities and gain insight into its applicability in the classroom.

The issues addressed in the research were expressed as follows.

- Is there a statistically significant difference between the STEM activities group and the traditional teacher centred teaching group in terms of their effects on academic achievement of prospective teachers on the topic of Work-Energy?
- Is there a statistically significant difference between the STEM activities group and the traditional teacher centred teaching group prospective teachers' academic achievement before the application?
- Is there a statistically significant difference between the STEM activities group and the traditional teacher centred teaching group prospective teachers' academic achievement before and after the application in their groups?
- Is there a statistically significant difference between the STEM activities group and the traditional teacher centred teaching group prospective teachers' academic achievement after the application?
- What are the prospective teachers' opinions on STEM activities?

## Research Methodology

### *Research Model*

In the research, a semi-experimental model with pre-test and post-test control group was used (Karasar, 2012, 102). During the application step of the research, the topic of Work-Energy was taught using STEM activities to the experimental group, while traditional teacher centred teaching was used with the control group. STEM based 5E model and traditional teacher centred teaching constitute the independent variables of the research, and academic achievement, the dependent variable. The duration of the research was equal in both groups. The research was carried on in 2017-2018 academic year (fall semester).

### *Sample of Research*

The research group was comprised of second-year students in Elementary Mathematics Education taking Physics I course at Dokuz Eylul University. In the department of Elementary Mathematics Education, there were two Physics I classes, A and B. Group A was randomly assigned as the experimental group (40 students: 28 female and 12 male) and group B as the control group (29 students: 21 female and 8 male). All students participated in the research as volunteers.

### *Data Collection Instrument*

In the research, data collection tool was "Work-Energy Achievement Test". The data collection tool was developed by Aydogmus (2008) and its reliability coefficient is 0.72. Furthermore, the opinions of the prospective teachers in the experimental group on STEM activities were gathered with 4 open-ended questions (STEM Activities Opinion Survey - SAOS). It is specifically stated that the survey form was anonymous to encourage students to express their thoughts freely. Firstly, student opinions were read, and the categories were determined based on the opinions of the students. In order to avoid confusion during the evaluation of student responses, survey forms were numbered. Then the student opinions were classified under the headings. The opinions of the students were evaluated also by another expert separately. The internal consistency in the Miles and Huberman models, which gives consensus between the coders, was calculated. According to the coding control that gives internal consistency, the inter-encoder consensus is expected to be at least 80% (From Miles & Huberman, 1994 quoted Baltaci, 2017). The fit between the two educators in terms of the categorising of data was 92.05%. Then, the two educators negotiated until all data were placed in categories.



### Data Analysis

First, Shapiro-Wilk normality test was performed to decide whether the data were distributed as normal and to determine which statistical analysis was appropriate. Then, paired and independent samples t-tests were used to determine the significance level of the difference between arithmetic mean, percentage, mean values and standard deviation of variables. Students missing either pre-test or post-test data were excluded from the statistical analysis. Analyses were carried out using the SPSS 22.0 statistical program.

The frequency values of the student opinions under the defined headings obtained from the SAOS are presented.

### Research Environment and Process

The application was carried out during the course hours in the normal course schedules for the Physics I course in November of the 2017-2018 academic year, fall semester (two weeks / 8 lessons in total). Since the time allocated to work-energy subject was limited to two weeks in the curriculum, the application was carried out in this time. There was simultaneous implementation of the subjects planned to be taught in the experimental process with group A and traditional teacher centred teaching with group B.

STEM teaching-learning models are 5E learning model, project-based learning and STEM SOS model (Cepni, 2017, 203). Bybee (2019) proposed the 5E instructional model to perform STEM activities. STEM course plans applied in the experimental group were prepared in accordance with the 5E model. The students in the experimental group were separated groups of 6 or fewer. As known, the 5E model stages are engage, explore, explain, elaborate and evaluate. During the *engage* phase, students were asked questions that promoted thinking about the subject and created a discussion environment. Then the work sheets prepared for each group were given. At the *explore* phase of the 5E model, a response time of approximately 10-15 minutes was allowed for each question. The students were allowed to use the source book and the internet on their devices. The groups then chose a spokesperson to report their responses to other groups. In the explanation phase, the teacher summarized the topic of work-energy after listening to the groups' answers for each question. During the *elaborate* phase, the groups were asked to design a product for subjects. They were allowed to use the resource books and the internet in the design stage. Each group was given a week to designing the product. During this period, they could ask the teacher for help if they deemed it necessary. At this stage, the teacher served as a guide. The groups presented their products to the rest of the class. During the *evaluation* phase, in order to determine whether there was any change in students' academic achievement, the Work-Energy Achievement Test was applied. Students' use smart phone and internet, STEM technology step, the solution of the questions in the worksheets; science and mathematics step, product design and production is the engineering step. In this process, the students created Roller-coaster systems, demonstrating energy transformations, by designing devices such as the winding simple wheel model, and energy conversion stations where potential energy is transformed into kinetic energy.

In the control group, the topic of Work-Energy was conveyed with traditional teacher centred teaching. The lectures were taught by the teacher. The work sheets for the experimental group were also given to the control group. The questions in the work sheets were solved by willing students on the board. All the courses were both carried out by the researcher, and in both groups, attention was paid to focusing on the specific subject content.

## Research Results

### Work-Energy Achievement Test Data Normality Analysis Results

Normality test was performed to determine whether the pre-test-post-test data of the experimental and control groups showed normal distribution and the results are given in Table 1.



**Table 1. According to Shapiro-Wilk test, experimental and control group pre-test and post-test normalization results for work-energy achievement test.**

Groups	Test	Statistics	df	p
Experimental Group	Pre-test	.987	39	.914
	Post-test	.964	39	.222
Control Group	Pre-test	.976	28	.717
	Post-test	.951	28	.196

\*= significant at .05 or less

According to Shapiro-Wilk test, it is seen that the data collected from the responses of the experimental and control group students to the pre-test and post-test shows a normal distribution ( $p > .05$ ).

*The Difference Between Experimental and Control Group Students' Academic Achievements Before Application*

The significance of the mean score difference between the pre-test scores of the experimental and control group students was calculated by independent t-test. The result of the analysis is given in Table 2.

**Table 2. Independent t-test results of work and energy achievement test of experimental and control groups before application.**

Groups	N	$\bar{X}$	S	SD	t	p
Experimental Group	40	9.82	4.14	67	2.18	.03*
Control Group	29	11.93	3.68			

According to Table 2, there was a statistically significant difference between the scores obtained from the experimental and control group students' work energy achievement test ( $t_{(67)} = 2.18, p < .05$ ). According to this result, the control group students ( $\bar{X} = 11.93$ ) were more successful than the experimental group students ( $\bar{X} = 9.82$ ).

*The Difference Between Experiment and Control Groups' Academic Achievements Before and After the Application*

The statistically significant difference of the academic achievements of the students in the experimental and control groups was calculated by paired samples t-test. Analysis results are given in Table 3.

**Table 3. The results of the paired samples t-test of the achievement test data of the experimental and control group students before and after the application.**

Groups	Achievement Test	N	$\bar{X}$	S	SD	t	p
Experimental Group	Pre-test	40	9.82	4.14	39	7.60	.0001
	Post-test	40	16.00	2.99			
Control Group	Pre-test	29	11.93	3.68	28	3.16	.0001
	Post-test	29	14.48	2.74			

According to Table 3, there was a statistically significant difference between the experimental group students' pre- and post-application academic achievement ( $t_{(39)} = 7.60, p < .05$ ). The average of academic achievement scores of the experimental group students before the application was  $\bar{X} = 9.82$ , increasing to  $\bar{X} = 16.00$  after application.



This finding showed that STEM activities have a significant difference on students' academic achievement.

There was a statistically significant difference between the control group students' pre- and post-application academic achievement ( $t_{(28)} = 3.16, p < .05$ ). The average of academic achievement scores of the control group students before the application was  $\bar{X}=11.93$ , increasing to  $\bar{X}=14.48$  after the application. This result showed that traditional teacher centred teaching has a significant difference on students' academic achievement.

*The Difference Between Experimental and Control Group Students' Academic Achievement After the Application*

A statistically significant difference was found between the experimental and control groups' pre-application academic achievement scores. Accordingly, so as to examine the effect of STEM based 5E model and the traditional teacher centred teaching, the academic achievement points of the groups was kept under control and a statistical analysis was conducted by using Single Factor Covariance Analysis (One Factor Ancova) (Buyukozturk, 2002).

In this context, a single factor covariance analysis was used to calculate whether there is a statistically significant difference between the experimental and control group students' academic achievement after the application. The analysis results are given in Table 4 and Table 5.

**Table 4. Descriptive statistics for the post test data of the work-energy achievement test.**

Group	N	Mean	Adjusted Mean
Experimental Group	40	16.00	16.02
Control Group	29	14.48	14.45

Table 4 shows that the corrected means of the post-test scores of the experimental and control group students in the work energy achievement test were calculated as  $\bar{X}=16.02$ ,  $\bar{X}=14.45$ , respectively. Table 5 gives the covariance analysis results on the significance of the difference between the two groups on adjusted mean scores for the work energy achievement test.

**Table 5. Results of covariance analysis of the work energy achievement test data of the experimental and control group students before and after the application.**

Source of Variance	Sum of Squares	SD	Sum of mean	F	p
Pre-test	.745	1	.745	0.088	.768
Method	38.856	1	38.856	4.575	.036*
Error	560.496	66	8.492		
Total	599.942	68			

According to Table 5, there was a statistically significant difference between the experimental STEM activities group and traditional teacher centred teaching control group ( $F_{(1-66)} = 4.575, p < .05$ ). According to this finding, compared to the traditional teacher centred teaching, STEM based 5E model is more efficient on students' academic achievement.

*Prospective Teachers' Opinions on STEM Activities*

The answers and frequency tables of each open-ended question in SAOS are presented below. There were 5 students in the experimental group who were not in pre-test or post-test measurements but since they participated in STEM activities, SAOS was applied to them. Thus, the data obtained from 45 students (32 female, 13 male) were examined.

The first SAOS question was, "What do you think STEM activities contribute to you and what are the positive aspects of STEM activities?". Table 6 shows the answers and their frequencies.



**Table 6. Frequency distribution of the responses to the first question.**

Responses	Student No	Number of Students (N=45)
STEM encouraged group work.	1, 4, 6, 9, 17, 20, 21, 28, 32, 39, 41, 45	12
STEM has led us to discover that we can produce something new.	1, 3, 17, 18, 19, 23, 26, 27, 28, 31, 35	11
STEM led me to do research.	4, 7, 15, 20, 22, 28, 30, 33, 34, 36, 44,	11
STEM made knowledge permanent	5, 6, 7, 9, 10, 16, 20, 22, 42, 43, 45	11
STEM offered the opportunity to practice what we learned.	8, 16, 18, 22, 31, 35, 36	7
STEM enabled us to be active in the course.	1, 3, 11, 18, 21, 34, 44	7
STEM made me think creatively.	24, 25, 28, 29, 39, 45	6
My confidence increased.	9, 17, 29, 33, 33, 37	6
STEM made courses more efficient.	24, 27	2
STEM made me think from different perspectives.	16, 33	2
STEM made lessons (more) enjoyable	14	1
STEM increased my interest in physics.	34	1

Table 6 shows that for STEM activities, the most common answers were "STEM encouraged group work." "STEM has led us to discover that we can produce something new." "STEM led me to do research." "STEM provided knowledge to be permanent." According to the answers given, prospective teachers reported that STEM encouraged working in groups, conducting research, playing an active role in the lessons and developing creative thinking skills.

The second SAOS question to the prospective teachers was "What are the negative aspects of STEM activities? Please indicate the difficulties you experienced during the application." Table 7 shows the answers and their frequencies.

**Table 7. Frequency distribution of the responses to the second question.**

Responses	Student No	Number of Students (N=45)
Time for practice was not enough.	1, 3, 4, 5, 6, 11, 17, 24, 32, 33, 34, 40, 43	13
Some students dominated the group work.	1, 8, 10, 11, 15, 18, 33, 36	8
I had difficulties in producing outputs. .	9, 14, 16, 23, 26	5
There was excessive noise in the classroom.	12, 14, 27, 28, 33	5
I had trouble finding the material for the product to be made.	17, 31, 32, 34, 45	5
The number of students in the groups was too large.	18, 20, 39, 43	4
It was an intensive and tiring approach.	3	1
I had difficulty adapting to the different approach.	7	1
Not applicable for every subject.	20	1
It is not an efficient approach to education.	38	1
My interest in class decreased.	13	1

Table 7 shows that the most commonly reported negative aspects of STEM are "Time for practice was not enough." "Some students came to the fore in group work." "I've had difficulties in producing something." "There was a lot of noise in the classroom." and "I had trouble finding the material for the product to be made."

The third SAOS question to the prospective teachers was "What are the interesting aspects of STEM activities?" Table 8 shows the answers and their frequencies.



**Table 8. Frequency distribution of the responses to third question.**

Responses	Student No	Number of Students (N=45)
Interesting products appeared.	4, 8, 10, 13, 15, 17, 28, 30, 31, 35, 38, 39, 40, 42, 43, 45	16
We discovered we can do something.	1, 23, 27, 31, 33, 39, 43, 45	8
I saw the applicability of the information we learned.	7, 11, 15, 16, 21, 24, 35, 36	8
There is no interesting aspect.	2, 6, 7, 12, 14, 18, 25, 44	8
It showed me I could learn physics.	13, 17	2
Good teacher-student communication	28, 34	2
The lessons were enjoyable.	13	1
Combination of internet and books to conduct research	20	1
It increased my interest in physics.	26	1

Table 8 shows that the most commonly reported interesting aspects of STEM were “Interesting products appeared.” “We’ve discovered we can do something.” “I have seen the applicability of the information we have learned.” and “There is no interesting aspect.”

The final SAOS question was “Will you use STEM activities in courses when you start working as a teacher?” Table 9 shows the answers and their frequencies.

**Table 9. Frequency distribution of the responses to fourth question.**

Responses	Student No	Number of Students (N=45)
I will use it.	1, 3, 4, 15, 16, 17, 18, 21, 24, 25, 27, 28, 29, 31, 32, 39, 45	17
I will not use it.	2, 8, 12, 19, 20, 22, 26, 30, 35, 36, 38, 44	12
I will use it for some subjects	5, 7, 9, 14, 23, 33, 34, 40	8
I will use it if the space and number of students is appropriate.	6, 10, 11, 41, 42, 43	6
I can use it in a different way.	13, 37	2

Table 9 shows that prospective teachers were willing to use STEM in their courses starting to work as a teacher. While the majority stated they would use it in most courses, some stated that they would only be able to use it with the appropriate number of students and the appropriate venue conditions, or with specific subjects. However, 12 expressed not being willing to use STEM activities at all.

## Discussion

### *Effect of The STEM Activities Related to Work-Energy Topics on Academic Achievement*

“Work-Energy Achievement Test” was implemented to groups as pre-test. Before the application, a statistically significant difference in academic success was found between the group averages in favour of the control group. In other words, it can be said that the control group was more knowledgeable about in the topic of work-energy than the experimental group. After the application, the “Work-Energy Achievement Test” was re- implemented as a post-test. According to the results, the academic achievement of work-energy subjects in both groups had increased statistically. This result shows that both STEM based 5E model and traditional teacher centred teaching had a positive effect on academic achievement. However, a comparison of the post-test results of the groups, showed a statistically significant difference in favour of the experimental group. At the pre-test the academic success average of the experimental group was lower, but after the application the experimental group was more successful than the control group. This result suggests that STEM based 5E model significantly increases academic achievement





compared to traditional teacher centred teaching on the topic of work-energy. This result also supports research findings that reported that STEM increased academic achievement. In their research on water resources with 8th grade students, Riskowski et al. (2009), have concluded that the engineering design process led to higher levels of academic achievement than the traditional lecture-based format. Studies by Guzey, Moore, Harwell and Moreno (2016) and Yildirim and Selvi (2017) both have concluded that STEM in science courses increased the academic achievement of 7th grade students. Similarly, Cevik (2018) has reported that STEM on the socio-economic significance of sustainable energy sources had a positive effect on academic achievement. Ince, Misir, Kupeli and Firat (2018) have found that, regarding crust mystery topic and group problem-solving skills, academic achievement was statistically significantly higher for a group involved in STEM approach-based activities compared to traditional teaching group. Acar, Tertemiz and Tasdemir (2018) have reported that STEM positively affects science and mathematics achievement. In addition, another research has shown that the design-based STEM course helped prospective teachers making their content knowledge deeper (Aydin-Gunbatar, et al.2018).

In contrast to the results of this research, it has previously found that unified STEM did not significantly improve success compared to constructivist teaching, although it provided positive contributions to academic achievement (Sarican & Akgunduz, 2018). Also, another research has noted no significant difference in academic achievement between students engaged in STEM activities compared to those in the traditional textbook group (Guyen, Selvi, & Benzer, 2018).

#### *Prospective Teachers' Opinions on STEM Activities*

The positive aspects of STEM activities included encouraging group work, assisting students to produce original work, enabling them to do research, and ensuring that the information learned is permanent. Similarly, there are researches reporting positive prospective and experience teachers' opinions on STEM in the literature (Bakirci & Kutlu, 2018; Campbell et al., 2012; Guder & Gurbuz, 2018; Aydin-Gunbatar et al.2018; Kizilay, 2016; Ozbilen, 2018; Park et al., 2016; Thomas, 2014; Ugras, 2017; Wang, 2012; Yildirim & Turk, 2018).

Among the positive aspects of STEM, prospective teachers were interested in the development of creativity, reporting that "STEM made me think creatively" and "STEM has led us to discover that we can produce something new", reflecting the findings of Yildirim and Turk (2018) and Bakirci and Kutlu (2018) who similarly have reported that prospective STEM teachers improved creativity. Another research finding that teachers commonly believed that STEM is necessary in the development of creativity is Campbell et al. (2012).

Regarding the negative aspects of STEM and the difficulties experienced during the implementation, prospective teachers highlighted three main points: insufficient time for the application, the dominance of some students during the group work, and difficulties with noise levels in class. In Park et al. (2016) and Wang (2012), teachers raised the issue of time limitations for the activities. However, students' negative statement 'I've had difficulties in producing something new' can in fact be perceived as a benefit for learning because it shows engagement in a labour-intensive process. A final problematic issue is that 8 pre-service teachers indicated that they would only use it for certain subjects, in line with Wang's (2012) finding that for some teachers, STEM may not be appropriate for certain subjects, such as matter.

Prospective teachers' responses on the interesting aspects of STEM activities were as follows: "Interesting products appeared", "We've discovered we can do something" "I have seen the applicability of the information we have learned", but also, "There is no interesting aspect". Finally, the majority of the prospective teachers mentioned that they were willing to use STEM in their future work, similar to the prospective teachers in a research by Ugras (2017).

#### **Conclusions**

In this research, it was revealed that STEM based 5E model on work-energy issues resulted in greater gains in academic achievement compared to traditional teacher centred teaching. The key reason is that a student-centred education approach directs the students to research and questioning, and most importantly, provides the opportunity to apply new learning through the design of the product, thus creating a sense of creativity and satisfaction. In addition, the current emphasis on environmental and energy issues is another factor increasing student interest in energy resources and energy transformations in daily life.

The opinions of the prospective teachers from the experimental group on STEM activities were found to be mainly positive. Prospective teachers agree that STEM practices encourage students to engage in group work and



also stated that they produced new outputs after doing research through STEM applications. Additionally, they considered that the knowledge learned through STEM applications was more deep-rooted. The prospective teachers' overall opinions about STEM activities clearly indicate the benefits of its more active use in the coming years.

Although there are plenty of researches examining the opinions of prospective teachers and teachers on STEM activities, there are limited researches examining the effect of STEM activities on different variables of teachers or prospective teachers. Therefore, the research done is closing a gap in the literature. In addition, it is thought that this research contributes to literature by examining the effects of STEM activities on the prospective teachers' academic achievement, especially in physics learning. Examining the opinions of prospective teachers on STEM activities is valuable in terms of comparison with the previous researches and enriches the literature. Such researches are also important for determining future education policies.

## Recommendations

STEM is recommended for educators and researchers for increasing the academic achievement of the students.

There are many studies which research different teaching methods for teaching physics subjects and the effect of the applied method on students' academic achievement. In these studies, generally, innovative teaching methods are compared with traditional teacher centred teaching. However, there should also be comparisons between STEM and other innovative teaching methods (cooperative teaching, problem-based teaching, etc.) in terms of student academic achievement.

In order for STEM activities to be used in education and education environments, prospective and practicing teachers should be informed about STEM through seminars.

Researchers should research the effect of STEM activities on academic achievement for a range of physics subjects, such as electricity, magnetism, optics, and waves.

## Note

This article was prepared from the master thesis of Mert Büyükdede at Dokuz Eylül University Institute of Educational Sciences under the supervision of Associate Professor Rabia Tanel.

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Received: February 26, 2019

Accepted: July 24, 2019

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