MOJES MALAYSIAN ONLINE JOURNAL OF EDUCATIONAL SCIENCES JANUARY 2021, 9 (1)

THE EFFECTS OF STEM APPLICATIONS ON THE ENVIRONMENTAL ATTITUDES OF THE 8TH YEAR STUDENTS, SCIENTIFIC CREATIVITY AND SCIENCE ACHIEVEMENTS

Sinan Çalışıcı
Ministry of National Education

Semra Benzer
*Department of Science Education, Gazi University
**sbenzer@gazi.edu.tr*

ABSTRACT

The aim of this study is to investigate the effects of science, technology, mathematics, engineering (STEM) applications and STEM based teaching on 8th grade students 'environmental attitudes, scientific creativity, problem solving skills and science achievement and to get students' opinions about STEM practices. Two groups were used in the research, one of which was the control (22 students) and the other was the experimental group (22 students). Experimental design with pretest-posttest control group, one of the quantitative research approaches, was used in the study. In the study, the subjects in the Organisms and Energy Relations unit, which is the 6th unit of the 8th grade science course, were taught to the students in the experimental group in accordance with STEM acquisitions and disciplines and by focusing on STEM practices. The data of the study were collected by using "Environmental Attitude Scale", "Problem Solving Skills Perception Scale of Primary School Students", "Scientific Creativity Scale", "Science and Technology Course Achievement Test" and "Student Opinion Questionnaire on STEM Applications". Considering the results of the analysis, it was observed that STEM applications contributed positively to 8th grade students' environmental attitudes, problem solving skills and science achievements.

Keywords: STEM Education, STEM, Organisms and Energy Relations, Academic achievement

INTRODUCTION

The developments in the field of science, technology and engineering which are constantly increasing in our renewed and developing era, affect our entire life. In order for the countries to become better economically and not to stay away from the information and informatics era, it is necessary to train creative individuals who have achieved the age of creative, informatics and technology and will be innovative. Education is at the forefront of the most important elements that will raise individuals in these characteristics. One of the main objectives of our education system is to raise qualified individuals who can keep up with developing and changing technology. To achieve this goal, teaching should be planned in accordance with today's needs and student level.

Science and technology are today the most important factors affecting the development of a country. Technological progress and research and development activities are of great importance for countries. The need for engineers and scientists who will work in these fields and conduct research has increased with the increasing importance of these fields. The place of science education is very important in

primary education, where the need for qualified manpower is increasing, in the children of the age group 06-14, and which includes the compulsory education period (Korkmaz, 2002). Technology provides solutions to real problems by accessing new information in order to change the world and to meet our needs (Sanders, 1999). This shows that science and technology are connected in a holistic way (Bybee, 2000).

Engineers have created technological products using science and mathematics knowledge to understand, design and implement solutions to problems (Burghardt & Hacker, 2009). Most of the modern technology we have now is a product of science, mathematics and engineering. Recent science education research findings suggest that an engineering design-based approach is needed to improve science teaching (Kelly, 2010). Science, Technology, Engineering and Mathematics (STEM) education integrates science, technology, and engineering to integrate the foundations of these sciences. STEM education is a multidisciplinary approach that aims to educate students as a whole in terms of these disciplines by opposing the learning of science, technology, engineering and mathematics in an isolated way. In this approach, teaching is carried out by using four disciplines together and simultaneously in real life situations, not on different subjects. STEM education allows students to find creative and effective solutions to problems encountered in daily life and likely to be encountered in the future by increasing their knowledge in science, technology, mathematics and engineering disciplines (Hom, 2014).

In literature; there are studies for primary and secondary school students to use STEM activities (Cho & Lee, 2013; Gottfried, 2015; Kim & Chae, 2015; Yıldırım & Selvi, 2017; Karabulut, 2017; Güven, Selvi & Benzer, 2018; Akkaya & Benzer, 2020; Kurt & Benzer, 2020). In addition, it is observed that there is an increase in the number of studies examining the experiences of candidate teachers in order to use STEM activities effectively in teaching (Adams, Miller, Saul, & Pegg, 2014; Corlu, Capraro, & Çorlu, 2015; Blackley, Sheffield, Maynard, Koul, & Walker, 2017).

The STEM education, which aims to provide individuals with a different perspective, knowledge and skills to problems, is considered important for scientific development and economic development (Lacey & Wright, 2009). In this regard, ensuring the progress and continuity of a country in scientific and economic fields is associated with the importance of STEM education and awareness raising in the STEM fields. As STEM education is an innovation-oriented education approach, it can be said that it contributes to situations such as technological development and orientation to students' career planning, 21st century skills development. As a result of these thoughts, it was aimed to investigate the effect of STEM applications and STEM based education on the environmental attitudes, problem solving skills, scientific creativity and science achievements of the 8th grade students and to get students' opinions about STEM applications. For this purpose, the answer sought for the following research questions.

1. Is there a statistically significant difference between the environmental attitudes of the experimental group students who applied the STEM acquisitions of the subjects in the 6th unit of the 8th grade science lesson and the environmental attitudes of the control group students who applied the constructivist approach before and after the study.
2. Is there a statistically significant difference between the scientific creativity skills of the experimental group students and the scientific creativity skills of the control group students before and after the study?
3. Is there a statistically significant difference between the problem solving skills of the experimental group students and the problem solving skills of the control group students before and after the study?
4. Is there a statistically significant difference between the science achievement of the experimental group students and the science achievement of the control group students before and after the study?

METHODOLOGY

Study Design

In the study, according to the current science education program and the education with constructivist approach supported by national education achievements, the students were examined in terms of some variables. These variables are: Students' opinion on STEM application, science achievements, problem solving skills, environmental attitudes and scientific creativity. In order to determine whether there is a difference in the variables to be measured, pretest-posttest controlled group design was employed as a quasi-experimental research design (Büyüköztürk, Çakmak, Akgün, Karadeniz, & Demirel, 2016).

Sample

Two groups were used in the research, one of which was the control (22 students) and the other was the experimental group (22 students) in a private school of the interior of Anatolia of Turkey. In the study group, pre-test scores of the groups were determined and the data were transferred to the SPSS package program. As a result of these tests, it was determined that there were no significant differences between the two groups.

Data Collection Process and Tools

In this research, the data were collected by using "Environmental Attitude Scale" (EAS) (Uzun & Sağlam, 2006), "Problem Solving Skills Perception Scale of Primary School Students" (PSS) (Ekici & Balim, 2013), "Scientific Creativity Scale" (SCS) (Çeliker & Balim, 2012), "Science and Technology Course Achievement Test" (SCA) and "Student Opinion Questionnaire on STEM Applications".

The EAS scale consists of a 5 point Likert-type question with 27 items and a Cronbach alpha value of 0.80. The PPS scale consists of a 22 item 5 point Likert-type question and the Cronbach alpha value is 0.88. SCS scale consists of 7 items open ended question and Cronbach alpha value is 0.86. SCA scale consists of 8 questions related to 8th class living organism and energy relations unit. The Cronbach alpha value of the test was found to be 0.895. "Student Opinion Questionnaire on STEM Applications" questionnaire on STEM applications consists of 2 open ended questions prepared by examining the literature (Ceylan, 2014; Çelikkıran & Günbatar, 2017).

Stages of Application

In this study; two separate 8th grade were selected. One of the classes was determined as the experimental group and the other as the control group. Teaching in the control group was supported by teaching practices based on the current Science education curriculum. Applications, pre-tests and post-tests applied to the control and experimental group are given in Table 1.

Table 1
Applications and tests used in study

Groups	Pre-test	Application	Post-test
Control	EAS, PSS, SCS, SCA	Constructivist system applications focused on MEB achievements	EAS, PSS, SCS, SCA
Experiment	EAS, PSS, SCS, SCA	STEM activities and applications focused on STEM gains	EAS, PSS, SCS, SCA

MEB: Ministry of Education

In the study, the process was planned for the control group based on the 8th grade Science and Technology textbook and the achievements in the current science education program. The activities and

experiments in the Science and Technology textbook were completed in 6 weeks and 24 hours in total, which were considered sufficient for the subject acquisitions (Table 2).

Table 2
Schedule of Activities and Experiments Applied to the Control and Experiment Group

	Activities and Experiments Applied to the Control Group	Activities and Experiments Applied to the Experiment Group
Week 1	Let's Create a Food Chain Activity	Let's Create a Food Chain Activity
Week 2	Photosynthesis and Light Efficiency	1. Photosynthesis Internet Experiment 2. Publisher Program Poster Event
Week 3	Photosynthesis and Light Efficiency	Elodea Experiment
Week 4	"When Do Plants Breathe?" Activity	"When Do Plants Breathe?" Activity
Week 5	"Why the balloon is swollen?" Activity	Photosynthesis and Oxygen Respiratory Experiment 1. Photoelectric Cells Activity
Week 6	Let's Make Paper Event	2. Publisher Program Poster Event 3. Waste Burial Test

It was aimed to determine the difference between the environmental attitudes of the experimental group students who applied the practices that included the STEM acquisitions of the subjects in the 6th unit of the 8th grade science textbook and the environmental attitudes of the control group students, who were supported by current science teaching practices, before and after the study. Examples from students' activities that have been produced during implementation using the STEM approach in class are shown in Figure 1.

Data Analysis

Data were analysed by SPSS package program. The normality assumption was tested with Shapiro - Wilk before the analysis of group data. Since the data for the statistical procedures between the experimental and control groups were normally distributed in the analysis of the research data, parametric tests were used. The relationship between the groups' environmental attitudes, problem solving skills, scientific creativity scale and science achievement test pre-test and post-test mean scores were tested by unrelated sample t test. At the end of the study, students' opinions about the study were analysed and their responses were categorized.

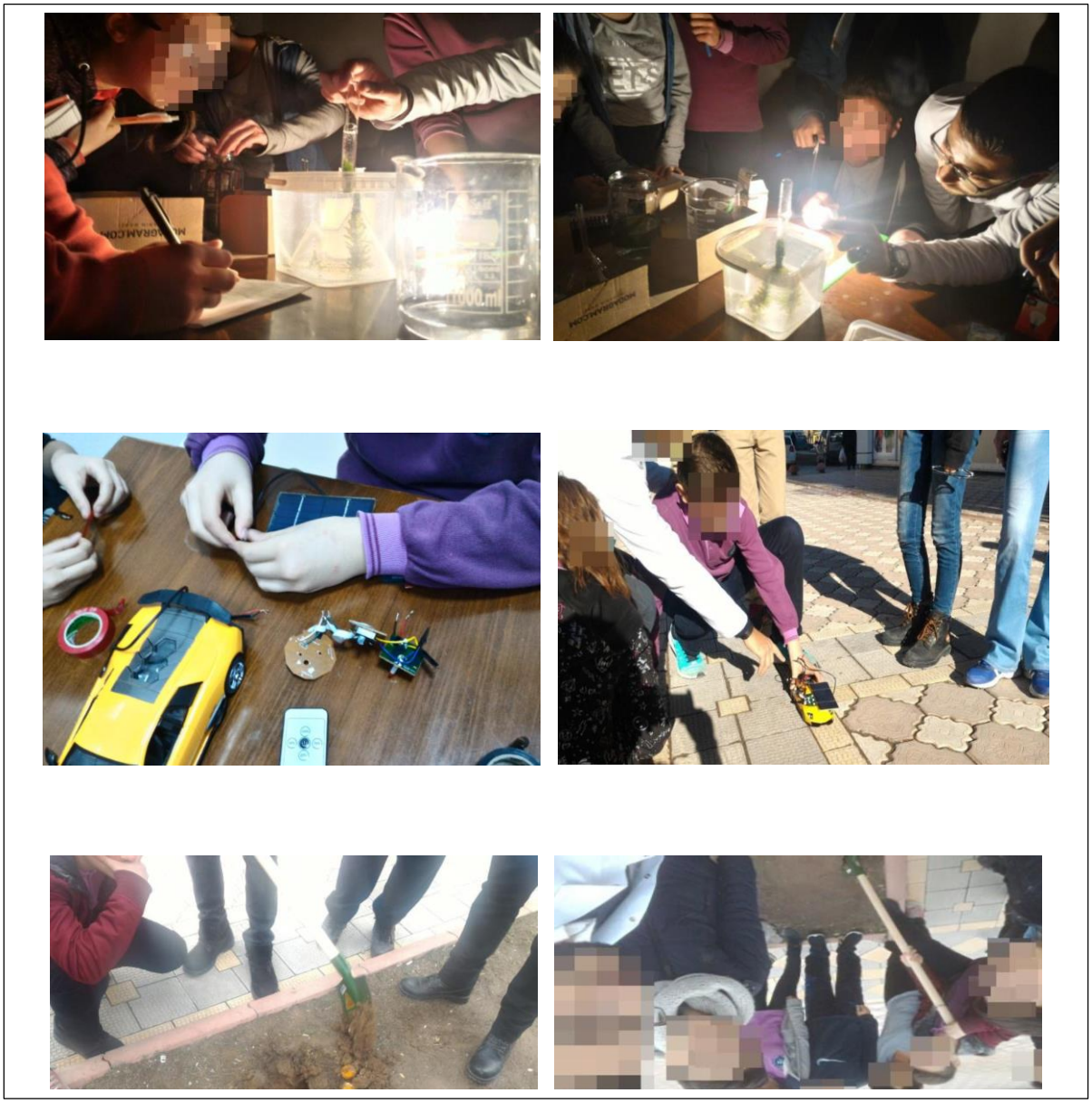

Figure 1. Examples from Students' Activities of Developed in This Study

FINDINGS

Students' Environmental Attitude

In this study, Environmental Attitude Scale was used as a pre-test and post-test to determine whether there was a significant difference between the experimental and control group students before and after the study. Arithmetic averages and standard deviations of the scores obtained from the scale were calculated and the data were analysed by t-test for independent samples. The results obtained are shown in Table 3 and Table 4.

Table 3
Pre-test Results of Environmental Attitude Scale Scores According to Groups

Groups	N	$\bar{X}$	SD	t	p
Control	22	90.36	12.58	0.822	0.416
Experiment	22	86.86	15.52		

It is seen that the mean scores of the Environmental Attitude Scale of the students in the experimental group were 86.86 and the standard deviation was 15.52 when Table 3 is examined. In the control group, the mean score of the pre-test mean scores of the Environmental Attitude Scale was 12.58. The pre-test results of the Environmental Attitude Scale were applied to both groups at the beginning of the study, it was seen that there was no significant difference between the experimental and control groups as p> 0.05. According to these findings, it can be said that the environmental attitudes of the students in the experimental and control groups are close to each other (Table 3).

Table 4
Post-test Results of Environmental Attitude Scale Scores According to Groups

Groups	N	$\bar{X}$	SD	t	p
Control	22	92.91	15.74	3.493	0.001
Experiment	22	107.36	11.30		

It is seen that the mean scores of the Environmental Attitude Scale of the students in the experimental group are 107.36 and the standard deviation is 11.30 when the results of Table 4 are examined. In the control group, it was observed that the mean scores of the Environmental Attitude Scale of the students in the control group were 92.91 standard deviations 15.74. It was found that there was a statistically significant difference between the experimental and control group mean scores when the final test results of the Environmental Attitude Scale were examined. This significant difference was in favour of the experimental group. As a result of the findings in the table, it can be said that the skills of the environmental attitudes of the experimental group students using STEM applications are higher than the control group students who are applied according to the existing science program (Table 4).

Second Sub-Problem Findings

In the research, "Scientific Creativity Scale" was applied to students in both groups as pre-test and post-test to determine whether there is a significant difference between the students in the experimental and control groups before and after the research. In order to determine whether there is a statistically significant difference between the scores obtained from the applied scale, t-test was conducted for independent samples and the results found are shown in Table 5 and Table 6.

Table 5
Pre-test Results of Scientific Creativity Scale Scores According to Groups

Groups	N	$\bar{X}$	SD	t	p
Control	22	19.00	2.02	1.530	0.134
Experiment	22	20.54	4.28		

It is seen that the pre-test mean scores of the students in the experimental group are 20.54 and the standard deviation is 4.28. Scientific creativity scale pre-test mean score of the students in the control group is 2.02. It was seen that there was no significant difference between the experimental and control groups when the pre-test results of the Scientific Creativity Scale were examined. According to these

findings, it can be said that the scientific creativity of the students in the experimental and control groups is equivalent (Table 5).

Table 6
Post-test Results of Scientific Creativity Scale Scores According to Groups

Groups	N	$\overline{X}$	SD	t	p
Control	22	22.36	1.59	1.887	0.066
Experiment	22	23.64	2.73		

It is seen that the results of Scientific Creativity Scale post-test mean score of the students in the experimental group is 23.64 and the standard deviation value is 2.73. The results of the Scientific Creativity Scale post-test mean scores of the students in the control group were 22.36 and the standard deviation was 1.59. When the pre-test and post-test results of the Scientific Creativity Scale data were considered, the average score value of the scale increased from 20.54 to 23.64 when the scores of the students in the experimental group were taken into consideration. At the same time, when the pre and post test results of the students in the control group were examined, the mean score from the scale increased from 19.00 to 22.36. However, since the significance level ($p = 0.066$) in the last test results was $p > 0.05$, it can be said that the applied method did not make a significant difference in terms of scientific creativity variable between the two groups (Table 6).

Third Sub-Problem Findings

In the research, "Problem Solving Skills Perception Scale of Primary School Students" was applied to students in both groups as pre-test and post-test to determine whether there is a significant difference between the students in the experimental and students in control groups before and after the research. In order to determine whether there is a statistically significant difference between the scores obtained from the applied scale, t-test was conducted for independent samples and the results were shown in Table 7 and Table 8.

Table 7
Pre-test Test Results of the Problem Solving Skills Perception Scale of Primary School Students Scores According to Groups

Groups	N	$\overline{X}$	SD	t	p
Control	22	83.55	16.49	0.393	0.696
Experiment	22	81.86	11.44		

It is seen that the pre-test mean scores of the students in the experimental group are 81.86 and the standard deviation is 11.44. In the control group, the students' pre-test mean scores of the Problem Solving Skills Scale were 83.45 and 16.49, respectively. When the pre-test results of the Problem Solving Skills Scale were examined, it was seen that there was no significant difference between the experimental and control groups. According to these findings, the problem solving skills of the students in the experimental and control groups are similar (Table 7).

Table 8
Post-test Test Results of the Problem Solving Skills Perception Scale of Primary School Students Scores According to Groups

Groups	N	$\overline{X}$	SD	t	p
Control	22	88.00	12.16	3.414	0.002
Experiment	22	99.05	9.08		

It is seen that the average of the problem solving skills of the students in the experimental group is 99.05 and the standard deviation is 9.08. In the control group, the mean score of Problem Solving Skills Perception Scale of Primary School Students Scores is 88.1 standard deviation of 12.16. The statistically significant difference was found between the mean scores of the experimental and control groups when the final test results of the Problem Solving Skills Perception Scale of Primary School Students Scores were $p < 0.05$. This significant difference was in favour of the experimental group. As a result of these findings, it can be said that the problem solving skills of the experimental group students using STEM applications are higher than the control group students who are applied based on the existing science program (Table 8).

Fourth Sub-Problem Findings

In the research, "Science and Technology Achievement Test" was applied to students in both groups as pre-test and post-test to determine whether there is a significant difference between the students in the experimental and control groups before and after the research. In order to determine whether there is a statistically significant difference between the scores obtained from the applied scale, t-test was conducted for independent samples and the results are shown in Table 9 and Table 10.

Table 9
Pre-Test Results of Achievement Test Scores by Groups

Groups	N	$\overline{X}$	SD	t	p
Control	22	19.77	4.25	1.521	0.136
Experiment	22	22.09	5.75		

It is seen that the average of the achievement test pre-test scores of students in the experimental group is 22.09 and the standard deviation value is 5.75. Success test pre-test mean scores of the students in the control group were 19.77 and the standard deviation was 4.25. According to the pre-test results of the achievement test data, there was no significant difference between the experimental and control groups as $p > 0.05$. According to these findings, it can be said that the success of the students in the experimental and control groups is similar (Table 9).

Table 10
Post-Test Results of Achievement Test Scores by Groups

Groups	N	$\overline{X}$	SD	t	p
Control	22	22.13	6.76	3.142	0.003
Experiment	22	27.86	5.24		

It is seen that the average point of achievement test of students in the experimental group is 27.86 and the standard deviation is 5.24. In the control group, it is seen that the achievement test score of the post-test mean score 22.13 is 6.76. The statistically significant difference was found between the mean of the experimental and control group when the final test results of the achievement test data were p

<0.05. This significant difference was in favour of the experimental group. As a result of these findings, it can be said that the experimental group students who applied STEM applications have higher level of success in terms of living things and energy relations than the control group students who applied in the current science program (Table 10).

Students' Opinion On STEM Application Findings

In order to refer to the students' views in the classroom where lessons were applied with STEM education, a "Science and Technology Course Archievement Test" and "Student Opinion Questionnaire on STEM Applications", consisting of two open-ended questions, was applied to the students. The first question in the questionnaire is "What are your opinions about the application and the contributions it provides to you?". This question in the questionnaire was examined by the responses of each student about the application and the contributions they provided, and these answers were analysed and interpreted through the content analysis method. The frequency and percentage values of the students for their opinions about the application and the floors provided are shown in Table 11.

Table 11
Concepts of Student Opinion Analysis

Concepts	Participants	Frequency	Percent (%)
Academic success	P2, P6, P7, P8, P13, P15	6	27
Direction of catchiness	P1, P4, P6, P8, P9, P10, P11, P12, P13, P14, P16, P17, P18, P19, P21, P22	16	72
Research awareness	P15	1	4
Active participation in the course	P1, P8, P11	3	13
Sensitivity to nature	P1, P4, P5, P13, P15, P17, P19, P22	8	36
Effective learning	P3, P4, P5, P6, P7, P8, P20, P21	8	36
Positive attitude towards science	P1, P4, P6, P7, P9, P10, P11, P12, P13, P14, P18, P19, P20	13	59
Visual memory development	P2, P3, P8, P13, P14, P16, P21	7	32
Associating with daily life	P1, P10	2	9
Social interaction	P5, P6, P12, P20	4	18
Technological awareness	P9, P13, P17, P19	4	18
Learning by doing and living	P1, P3, P7, P8, P10, P12, P14, P15, P20, P22	10	45

It can be said that the biggest contribution of STEM applications to students is in the direction of catchiness as stated by 72% of students. This view is then followed by the idea of creating a positive attitude towards science course with a rate of 59% (Table 11).

Considering the analysis results of the study, it was observed that STEM applications contributed positively to environmental attitudes, problem solving skills and science achievement of 8th grade students. At the same time, according to the results of the student opinion survey; STEM applications have helped to increase students' academic success and to develop positive attitudes towards science

course. It is concluded that the most important aspect of the students' attention is the experiments and activities in the course.

The answers given to the question "What are the aspects of the applications that draw your attention most?" were examined. Students' views were analysed. The students 'interest attracted the attention of the students' experiments and activities on the topics, evaluation questions at the end of the topics, the method of the lesson, establishing relationships with the daily life of the subjects, conducting group studies, the course with the participation of students, the use of technological materials while the subjects were being processed. The results of the analysis, it was seen that the most striking aspect in the application was the experiments and activities carried out in the course with a 64% participation rate of the students.

DISCUSSION

The research was conducted in a limited way with a total of 44 students in the experimental and control groups studying in the 8th grade and subjects in the "Living and Energy Relations" unit. As a result of the data obtained from the "Environmental Attitude Scale" has been determined that it has a statistically significant difference in favour of the experimental group. It was determined that there was no significant difference in "Problem Solving Skills Perception Scale of Primary School Students", "Scientific Creativity Scale" and "Science and Technology Course Archievement Test".

In line with the answers received within the scope of "Student Opinion Questionnaire on STEM Applications" has been concluded that academic achievements have increased, subjects and concepts are more memorable, research awareness about the subjects of the course has increased, active participation in the course has increased, sensitivity to nature has increased, effective learning has been realized, positive attitudes towards science lesson have developed, contributed to the development of visual memory, association with daily life has increased, social interactions increased, their technological awareness increased and they reached learning by living.

STEM aims to create conscious, environmentally and socially conscious communities. Our long-term well-being depends on students who are affected by environmental education and who are sensitive to the environment. STEM helps students understand concepts and study real life issues. It is known that it prepares students to become citizens who can evaluate these issues from various perspectives and make informed decisions. However, it is not possible to leave students in libraries and wait for them to become environmentally literate individuals by learning the information on this subject. New generation science standards and common core state standards are in natural harmony with the environmental literacy plan. Environmental literate individuals are more flexible and more willing to conduct in-depth research in these areas by addressing real-world problems. Environmental education and environmental sensitivity prepare the ground for teachers to use basic teaching practices that depend on student interest and success (Ritz & Stephen, 2012). STEM education courses are similar to the results of Gottfried (2015), in which students have an influence on their choice of advanced mathematics and science courses, their attitudes and motivations towards the environment.

In these results, it has been determined that 8th grade students contribute to the development of problem solving skills and the lessons applied to the study group within the framework of the applications and achievements of the STEM. STEM education increases children's curiosity towards what is happening around them and the world. It is also possible to provide children with basic problem solving skills and to develop logic skills. Since the problems encountered are solved by trying, students can learn not to be afraid of making mistakes and develop their skills of reasoning without fear while trying new ways. Thus, as children approach problems and problems, they will develop the ability to apply the most appropriate solution for each situation by trying different ways instead of staying in fixed patterns (Innolab, 2018). STEM education is an integrated approach that adopts creative problem solving techniques to students who will be the innovators of the future (Roberts, 2012). STEM education aims to provide students with an interdisciplinary perspective and gain knowledge and skills (Şahin, Ayar, & Adıgüzel, 2014).

The aim of STEM schools and STEM applications is to increase students' interest levels in STEM areas, to increase their academic success in this field and to increase the number of people in occupations in STEM (Atkinson & Merrilea, 2010; Corlu, Capraro, & Capraro, 2014).

STEM disciplines increase students' academic achievement levels in science and mathematics by building a relationship between mathematics and science by integrating the knowledge they learn through their own experiences and integrating their knowledge in these courses (NAE & NRC, 2009).

Ceylan (2014) states that the application of instructional design prepared on the basis of science, technology, engineering and mathematics (STEM) education about the acids and bases of the 8th grade students of the middle school is positively related to their academic success, creativity and problem solving skills. Yıldırım and Selvi (2017) state that STEM applications and full learning have positive and statistically significant impact on academic achievement of secondary school students, their perceptions of questioning learning skills for science, their motivation for science, their attitudes towards STEM and the permanence of knowledge. Çelikkıran and Günbatar (2017), in their study, concluded that the applications of STEM education, which were applied to prospective teachers, provided significant contributions to gain an interdisciplinary perspective and to recall / learn the knowledge of chemistry. Although the study group in this research does not overlap with the study group and course subjects in our study, it is consistent with the recall and success of the study. The results of Ceylan (2014), Yildirim and Selvi (2017) and Celikkiran and Gunbatar (2017), which are included in the literature in the literature, correlate with the results of the study and conclude the results related to the academic achievement and STEM relationship.

CONCLUSIONS

Considering the results of the analysis in the research, it was observed that STEM applications contributed positively to 8th grade students' environmental attitudes, problem solving skills and science achievements. At the same time, according to the results of the student opinions survey; STEM practices helped to increase students' academic success and to develop positive attitudes towards science lessons. It was concluded that the aspects of the application that attracted the students' attention the most were the experiments and activities conducted in the course.

The research was carried out with a total of 44 students in the experimental and control groups who were studying in the 8th grade and limited to the subjects in the organisms and energy relations unit. In order to reach more valid and reliable results, it is recommended to conduct more than one experiment and control group in different subjects and different grade levels and conduct research.

ACKNOWLEDGEMENT

This study was presented as an oral presentation at 3rd International Eurasian Educational Research Congres (EJER-2016), Turkey. This study was produced from Sinan Çalışıcı's Master Thesis.

REFERENCES

Adams, A. E., Miller, B. G., Saul, M., & Pegg, J. (2014). Supporting elementary pre-service teachers to teach stem through place-based teaching and learning experiences. *Electronic Journal of Science Education*, *18*(5), 1-22.

Akkaya, M. M., & Benzer, S. (2020). The effect of STEM practices on academic achievement and attitudes of sixth grade students an application on the unit of force and motion. *Malaysian Online Journal of Educational Sciences: MOJES, 8*(2), 36-47.

Atkinson, R. D., & Merrilea, M. (2010). Refueling the U.S. Innovation Economy: Fresh Approaches to STEM Education. *The Information Technology and Innovation Foundation*, 1-178.

Blackley, S., Sheffield, R., Maynard, N., Koul, R., & Walker, R. (2017). Makerspace and reflective practice: Advancing pre-service teachers in STEM education. *Australian Journal of Teacher Education*, *42*(3). https://doi.org/10.14221/ajte.2017v42n3.2

Burghardt, D., & Hacker, M. (2009). *Perspectives on K-12 engineering.* http://www.hofstra.edu/academics/colleges/seas/ctl/ctl_k12engr.html.

Büyüköztürk, Ş., Çakmak, E. B., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2016). *Bilimsel Araştırma Yöntemleri [Scientific Research Methods]*. Pegem.

Bybee, R. W. (2000). Achieving technological literacy: A national imperative. *The Technology Teacher*, *60*(1), 23-28.

Ceylan, S. (2014). *A study for preparing an instructional design based on science, technology, engineering and mathematics (STEM) approach on the topic of acids and bases at secondary school science course.* [Unpublished Master Dissertation, Uludağ University, Bursa, Turkey].

Cho, B., & Lee, J. (2013). The effects of creativity and flow on learning through the STEAM education on elementary school contexts. *International Conference of Educational Technology*, *1,* 206-210.

Corlu, S., Capraro, R. M., & Çorlu, M. A. (2015). Investigating the mental readiness of pre-service teachers for integrated teaching. *International Online Journal of Educational Sciences*, *7*(1), 17-28.

Çeliker, D. H., & Balım, A. G. (2012). Adaptation of scientific creativity test to Turkish and it's assessment criterias. *Uşak University Journal of Social Sciences*, *5*(2), 1-21.

Çelikkıran, A., & Günbatar, S. (2017). Investigation of pre-service chemistry teachers' opinions about activities based on STEM approach. *YYU Journal Of Education Faculty, 14*(1), 1624-1656.

Çorlu, M. S., Capraro, M., & Capraro, M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Education and Science*, *39(*171), 74-85.

Ekici, Y., & Balım, D. (2013). Problem solving skills perception scale for secondary students: A study of validity and reliability. *YYU Journal Of Education Faculty*, *10*(1), 67-86.

Gottfried, M. A. (2015). The influence of applied STEM coursetaking on advanced mathematics and science coursetaking. *Journal of Educational Research*, *108*(5), 382-389.

Güven, Ç., Selvi, M., & Benzer, S. (2018). Teaching applications xx based on 7e learning model centered STEM activity effect on academic achievement, *Journal of Social Sciences of Mus Alparslan University*, *6*(STEMES'18), 73–80.

Hom, E. J. (2014). *What is STEM education. Live science contributor.* http://www.livescience.com/43296-what-is-stem-education.html

Innolab, A. (2018). Robotik Ve Kodlama Eğitimi Çocuklara Ne Vadediyor? [*What does robotics and coding education offer to children*?] http://abainnolab.com/robotik-kodlama-egitimi-cocuklara-ne-vadediyor.

Karabulut, G. (2017). Yerel bazlı STEM etkinliklerinin öğrencilerin problem çözme becerilerine etkilerinin incelenmesi. [*Examining the effects of local-based STEM activities on students' problem solving skills]*. https://prezi.com/ywokofxr5z-d/yerel-bazl-stem-etkinliklerinin-ogrencilerin-problem-cozme

Kelly, T. (2010). Staking the claim for the "T" in STEM. *Journal of Technology Studies*, *36*(1), 2-11.

Kim, H., & Chae, D. H. (2015). The development and application of a STEAM program based on traditional korean culture. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(7), 1925-1936.

Korkmaz, H. (2002). The effects of project-based learning on elementary school students' academic achievement, academic self concepts and study time in science education. *Eurasia Journal of Mathematics, Science and Technology Education, 11(*3), 469-477.

Kurt, M., & Benzer, S. (2020). An investigation on the effect of STEM practices on sixth grade students academic achievement problem solving skills and attitudes towards STEM. *Journal of Science Learning, 3*(2), 79-88.

Lacey, T. A., & Wright, B. (2009). *Occupational employment projections to 2018*. Monthly Labor Review, November, 82-109.

National Academy of Engineering and National Research Council [NAE & NRC]. (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. National Academies Press.

Ritz, S. (2012). A teacher growing green in the South Bronx. TED.com. http://www.ted.com/talks/stephen_ritz_a_teacher_growing_green_in_the_south_bronx.html

Roberts, A. (2012). A justification for STEM education. *Technology and Engineering Teacher*, *74*(8), 1-5.

Sanders, M. E. (1999). Technology education in the middle level school: Its role and purpose. *NASSP Bulletin*, *83*(608), 34-44.

Şahin, A., Ayar, M., & Adıgüzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning*. Educational Sciences: Theory & Practice*, *14*(1), 297-322.

Uzun, N., & Sağlam, N. (2006). Development and validation of an environmental attitudes scale for high school students. *Hacettepe Journal of Education, 30*, 240-250.

Yıldırım, B., & Selvi, M. (2017). An experimental research on effects of STEM applications and mastery learning. *Journal of Theory and Practice in Education*, *13*(2), 183-210.