Karakaya, F., Alabaş, Z.E., Akpınar, A., & Yılmaz M. (2020). Determination of middle school students' views about stem activities. *International Online Journal of Education and Teaching (IOJET), 7*(2), 537-551.

http://iojet.org/index.php/IOJET/article/view/662

Received: 10.06.2019
Received in revised form: 22.02.2020
Accepted: 28.03.2020

DETERMINATION OF MIDDLE SCHOOL STUDENTS' VIEWS ABOUT STEM ACTIVITIES

Research article

Ferhat Karakaya
Yozgat Bozok University
ferhatk26@gmail.com

Ali Akpınar
Ankara Keçiören Sınav College
akpinar232@gmail.com

Zeynep Ebru Alabaş
Ankara Keçiören Sınav College
aalabas5406@gmail.com

Mehmet Yılmaz
Gazi University
fbmyilmaz@gmail.com

Ferhat Karakaya is working as a research assistant in Yozgat Bozok University and having his PhD at Gazi University. He is interested in studies related STEM education and environmental education.

Teacher Zeynep Ebru Alabas graduated from Sakarya University at 2002 in Sakarya. She works at Private Keçiören Sınav Collage in Ankara. Her research interests are STEM education and Project Based Learning.

Teacher Ali Akpinar graduated from Middle East Technical University at 2015 in Ankara. He works at Private Keçiören Sınav Collage in Ankara. His research interests are STEM education and Project Based Learning.

Professor Mehmet Yilmaz is in the Department of Secondary Science and Mathematics Education at Gazi University, His research interest includes biology teaching methods and environmental education.

DETERMINATION OF MIDDLE SCHOOL STUDENTS' VIEWS ABOUT STEM ACTIVITIES

Ferhat Karakaya

ferhatk26@gmail.com

Zeynep Ebru Alabaş

aalabas5406@gmail.com

Ali Akpınar

akpinar232@gmail.com

Mehmet Yılmaz

fbmyilmaz@gmail.com

Abstract

In this research, it is aimed to determine the opinions of middle school students about STEM activities. The research, which used case study from qualitative research designs, was conducted in 2018-2019 academic year. The research working group is composed of 27 middle school students studying in a private school in Turkey. In the data collection, semi-structured interview forms prepared by the researchers were used. The data were analyzed in accordance with the descriptive analysis. According to the findings of the research, it was determined that STEM activities were related to daily life problems, and that students' lessons, occupational preferences and communication skills were affected. In addition, lack of time and material and lack of information have been found to have problems in the realization of STEM activities.

Keywords: STEM education, STEM activity, middle school students

1. Introduction

Developments in science and technology have changed the needs of the age, social structure, and the change in economics and educational policies of countries. In order to increase the competitiveness of the countries in the international dimension and to have a voice, qualified individuals should be trained (Karakaya, Avgın & Yılmaz, 2018a; Tekerek & Karakaya, 2018). At this point, the strategic importance of STEM training is enormous (Çorlu, Capraro & Capraro, 2014). STEM is the abbreviation of the initials of science, technology, engineering and mathematics (Gonzalez & Kuenzi, 2012; Yıldırım & Selvi, 2015). STEM is an educational approach that aims to gain interdisciplinary cooperation, openness to communication, ethical values, problem-solving skills using research, production and creativity by focusing on the engineering design of science and technology-engineering and mathematics knowledge and skills (Buyruk & Korkmaz, 2016; Karakaya, Avgın & Yılmaz, 2018a).

The interdisciplinary approach STEM (Eroğlu & Bektaş, 2016) includes 21st century skills that will enable students to look at life through different windows (Baran, Canbazoglu Bilici & Mesutoğlu, 2016). The use of STEM programs within the education system will enable students to develop skills in science-technology-mathematics and engineering disciplines (MacFarlane, 2016) and increase their readiness (Thomasian, 2011). According to Honey, Pearson and Schweingruber (2014), STEM education aims to improve students' skills in preparing for STEM workforce, training as STEM literate and linking their discipline to students. In Turkey this context, the Ministry of National Education (MEB) by from 4th published in Science Curriculum in 2017, "Science and Engineering and Entrepreneurship applications," says the subject field is added (Karakaya, Unal, Çimen & Yılmaz, 2018b). The subject area of Science, Engineering and Entrepreneurship applications aims to enable students to establish the connection between engineering and science, to understand the interdisciplinary interaction and to develop worldview by making them experience and experiencing what they have learned (MEB, 2018).

Turkey's scientific research and technological development capacity, to improve the socio-economic development and competitiveness is important updates students to experience science and engineering applications (MEB, 2018). From an early age, it is necessary to develop learning environments and activities that will improve students' thinking skills and develop knowledge levels that they will use to solve their life problems (Akbıyık & Kalkan-Ay, 2014).

When the literature on the subject is examined, it is determined that there are different studies. For example, Savran Gencer, Doğan, and Bilen (2020) aimed to develop an integrated biomimicry STEM activity about the unit of Living Things World at grade five. Karakaya, Yantırı, Yılmaz and Yılmaz (2019) have determined the opinions of the primary school students about STEM activities. In the research conducted by Özcan and Koca (2019), it was determined that the effect of a teaching module on the topic of pressure, developed with STEM approach, on the academic achievements of the students as well as on their attitudes towards STEM. In the research conducted by Retnowati, Riyadi and Subanti (2020), the effect of the developed rectangular module with the STEM approach students' critical thinking skills was determined.

It is important to develop STEM focused activities in order to improve the experience and to increase the persistence in learning. STEM activities enable students to be active in the education process (Bransford, Brown & Cocking, 2000). In addition, STEM focused activities allow students to find solutions to their real life problems and to test hypotheses they develop (Sanders, 2008). However, in order to determine the suitability, quality, success, contribution of students to the purpose of the prepared activities and the problems that have occurred, students' opinions should be taken. It is thought that this research will contribute to the literature. The aim of this study was to determine the views of middle school students on STEM activities.

2. Method

2.1. Research model

In this study, a case study of qualitative research designs was used. The case study refers to the elaboration of the situation or events in a system (Creswell, 2003). The case study enables the study of the subject to be investigated in different dimensions.

2.2. Study group of the research

The study, which used case study from qualitative research designs, was conducted in 2018-2019 academic year. The research working group is composed of 27 middle school students studying in a private school in Turkey. The students in the study group of the research were selected from STEM activity club members in the 2018-2019 academic years. Demographic information of the study group is given in Table 1.

Table 1. *Demographic information of the study group*

Demographic information		**f**	**%**
Gender	Female	15	55.6
	Male	12	44.4
Grade level	5th grade	3	11.1
	6th grade	6	22.2
	7th grade	11	40.8
	8th grade	7	25.9

2.3. Data collection tool

The data were collected through the semi-structured opinion form prepared by the researchers. For the validity of the semi-structured opinion form, two different experts from STEM field were consulted and the final form was given. The opinion form consists of five questions. The questions in the data collection tool are given below:

a. Do you think team work is important in STEM activities? Explain briefly with the reasons.

b. Do you think that STEM activities contribute to your lessons? Explain briefly with reasons.

c. Do you think STEM activities are related to daily life? Explain briefly with the reasons.

d. What do you think is the most important problem for STEM activities? Explain briefly with the reasons.

e. Do you think that STEM activities are effective in your future career choices? Briefly explain reasons.

2.4. Collection of data

Within the scope of the study, 27 primary school students carried out STEM-oriented applications for 6 weeks (3 hours per week) during the 2018-2019 academic years. The program content related to STEM oriented applications performed presents in Table 2.

Table 2. *Program content related to STEM oriented applications*

Week	Content
1st	The definition of STEM, its importance and theoretical knowledge about how it emerged
2nd	How can STEM focused events be performed? Theoretical knowledge on engineering design process
3rd	Workshop 1: Greenhouse design activity
4th	Workshop 2: Bridge design activity
5th	Workshop 3: Energy transformations design efficiency
6th	Giving student opinions about theoretical information and workshops

In the implementation of the activities, engineering design process steps (ask, imagine, plan, create, and improve) developed by EiE (Engineering is Elementary) were used (Cunningham & Hester, 2007). The engineering design process is given in Figure 1. The applications of students in the engineering design process are given in Table 3.

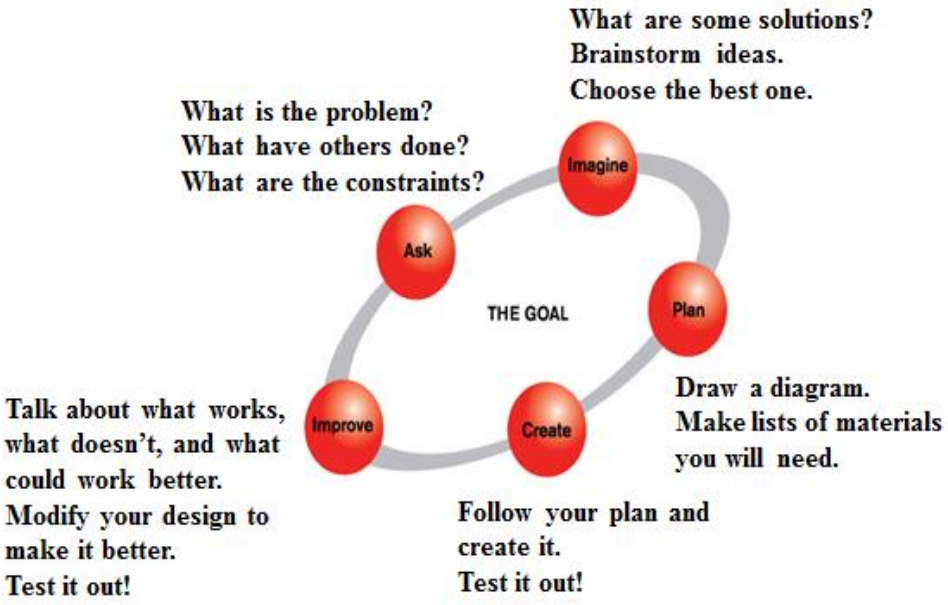


Figure 1. The Engineering Design Process (Cunningham & Hester, 2007).

Table 3. The applications of students in the engineering design process

EiE Process	Student application
Ask	The students determined the problems and limitations in the given scenario.
Image	Students made different suggestions about the solution of the problem. Then, they chose the most suitable solution proposal.
Plan	The students determined the plan suitable for the solution proposal. They made drawings. They also identified the necessary materials.
Create	Students followed the plan. Students made their design products.
Improve	Students; They completed the project by making tests and improvements.

Problem scenarios have been given to teams (groups) formed by researchers. The students evaluated the problem scenarios with their teammates and developed solution suggestions according to the conditions given in the problem content. The groups decided on the most appropriate form of their proposals and formed the drawing, material selection and implementation plans. Then, the students formed their designs for solving the problem by bringing together the materials they chose. The designs have been tested and found to be incomplete, if there are faulty directions, and the designs have been finalized. The same steps were performed for the other activity. Researchers, in the process of the documents (student opinions, activity photos, such as student drawings) have realized the collection. Sample drawings and products of the students are given in the figure.

Figure 2. Tinkercad drawings and models of the students

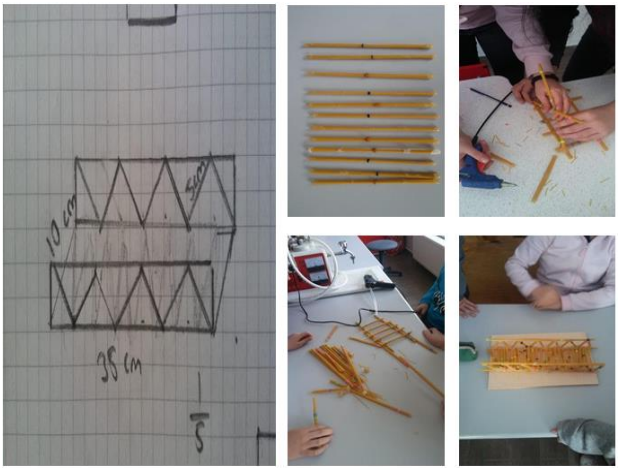


Figure 3. Bridge design of the students

2.4. Analysis of data

In the analysis of the data, the answers given by the students to the semi-structured opinion form were examined separately by two experts. In the analysis of the data, student opinion forms were read and coded by two different researchers. To determine whether there is consistency between the researchers after this coding, Miles and Huberman (2015) formulated the formula (Reliability=Consensus/All opinions). As a result of the calculation, reliability was calculated as 0.81.

3. Results

In this section, the findings of the research are presented. "Do you think team work is important in STEM activities? Explain briefly about the reasons". The results are given in Table 4.

Table 4. *Findings related to the importance of team work in STEM activities*

Codes	f	%	Sample student opinions
Yes, because	26	96.3	*S-1: We can finish things more easily.* *S-2: Important for us to do group work in the future.* *S-4: Everyone is knowledgeable about different subjects and adds value to work.* *S-8: We cannot do any work on our own.* *S-13: Exchange of ideas in such studies is important.* *S-18: We can easily and successfully carry out our works with team work.* *S-25: The group members interact with each other and the lessons are consolidated.*
No, because	1	3.7	*S-16: It is difficult to gather and work with the team.*

S: Student

When the data in Table 4 were analyzed, 96.3% of the students (f = 26) stated that group work was important in STEM activities and 3.7% (f = 1) stated that it was not important.

In the research "Do you think that STEM activities contribute to your lessons? Explain briefly about the reasons". The results are given in Table 5.

Table 5. *Findings about the contribution of STEM activities to the lesson*

Codes	f	%	Sample student opinions
Yes, Because	25	92.6	*S-1: It makes me objective in the lessons.* *S-2: It allows me to use my knowledge of science and mathematics.* *S-5: Our activities enable me to understand the topics.* *S-6: I can use my different course information together.* *S-7: I can focus my attention on lessons.* *S-10: I can interpret the long questions in LGS tests.* *S-13: It makes me think analytically.* *S-15: I am learning new information during activities.* *S-24: We learn different information and change our perspective.* *S-27: Our activities reinforce our lessons.*
No, Because	2	7.4	*S-12: There is no lecture about the lessons.* *S-22: We do not use the subjects that we have learned in the course.*

S: Student

When the data in Table 5 were examined, 92.6% of the students (f = 25) stated that they contributed to STEM activities and they did not contribute to 7.4% (f = 2).

In the research "Do you think STEM activities are related to daily life? Explain briefly with the reasons". The results are given in Table 6.

Table 6. *Findings about the relationship of STEM activities with daily life*

Codes	f	%	Sample student opinions
Yes, Because	25	92.6	*S-1: I think the problems in the places I go and find solutions.* *S-2: We use information obtained from most professions in daily life.* *S-5: Studies in daily life are also encountered.* *S-6: Activities include problems in our lives.* *S-12: It helps us to raise awareness about the subjects.* *S-15: Our activities are based on real-life problems.* *S-18: We are trying to find solutions to the problems of people with projects.* *S-19: It can be seen all over our lives.* *S-20: We are experiencing the same things in real life.*
No, Because	2	7.4	S-9: I don't know. S-16: We don't do construction or engineering in daily life.

S: Student

When the data in Table 6 were examined, 92.6% of the students (f = 25) stated that STEM activities were related to daily life and 7.4% (f = 2) stated that they were not related to daily life.

In the research "What do you think is the most important problem for STEM activities? Explain briefly with the reasons". The results are given in Table 7.

Table 7. *Findings for the most important problem in STEM activities*

Codes	f	%	Sample student opinions
Shortage of time	12	44.4	*S-2: Not enough time for activities.* *S-5: Time is limited.* *S-20: Time shortage.*
Material shortage	11	40.8	*S-1: Inadequate materials for prepared projects.* *S-6: Inadequate materials for activities.* *S-9: Inadequacy of opportunities.* *S-22: Lack of materials.* *S-25: Lack of materials for our ideas.*
Lack of information.	4	14.8	*S-10: We do not have enough knowledge about the courses.* *S-11: Personally inadequate.* *S-13: We do not have enough information about the problem encountered.* *S-16: Failure to find solutions to problems.* *S-23: The information in the lessons cannot be related to each other.*

S: Student

When the data in Table 7 were examined, 44.4% (f = 12) of the students who participated in the research were experiencing lack of time, 40.8% (f = 11) of material deficiency and 14.8% (f = 4) of the lack of knowledge of STEM activities have stated that it will be a major problem.

In the research "Do you think that STEM activities are effective in your future career choices? Briefly explain reasons". The results are given in Table 8.

Table 8. *Findings about the effects of STEM activities on occupational preferences*

Codes	f	%	Sample student opinions
Yes, Because	24	88.9	*S-2: After the events, I realized that I had to choose a profession related to science or mathematics.* *S-6: I realized that I should become an engineer in the future.* *S-7: I saw the contribution of being an engineer to life.* *S-8: The fun of STEM activities showed that I should be happy in my profession.* *S-10: The happiness of connecting lives by bridge is good.* *S-13: STEM studies have improved my ability to solve problems. I want to be an engineer.* *S-15: My problem solving skills have increased.* *S-18: I saw the importance of knowledge.* *S-20: Events showed which course I was interested in.*
No, Because	3	11.1	*S-9: I didn't decide on my job.* *S-11: No, it was not very effective.* *S-16: I want to be a musician. Therefore, it was not effective.*

S: Student

When the data in Table 8 were analyzed, 89.9% (f = 24) of the students who participated in the study stated that STEM activities were effective in their job choices, while 11.1% (f = 3) stated that STEM activities were not effective in their job choices.

4. Discussion and Conclusion

The aim of this study was to determine the views of middle school students on STEM activities. The students who participated in the research conducted STEM focused activities prepared by the researchers for 6 weeks. In the research, it was determined that team work was important in STEM activities according to student opinions. When the research findings are examined, the primary school students stated that team work is important in STEM activities. The students stated that they could complete the works more easily by performing STEM activities with team work and they could share information with different perspectives. According to these results, it can be said that it is important that students work together in order to realize STEM activities more actively and efficiently. When the researches on the subject are examined, it is seen that there are researches showing that STEM activities encourage collaborative learning (Çınar, Pırasa & Sadoğlu, 2016; Uğraş & Genç, 2018). In addition, as a result of some researches in the literature, STEM activities have been developed to develop creativity, cooperation and communication skills that will enable students to learn lifelong (Altan & Üçüncüoğlu; 2018; Eroğlu & Bektaş; 2016; Şahin, Ayar & Adıgüzel; 2016; Yıldırım & Selvi, 2018). STEM education programs enable the gathering of students and researchers from different countries, group work and communication skills (Choi & Hong, 2013; Kim, Ko & Han, 2014).

In the research, it was determined that the STEM activities contributed to the lessons. Primary school students stated that STEM activities contributed to their attitudes, behaviors and academic success. According to this result, it can be said that the use of STEM activities is effective in students' positive attitudes and behaviors towards lessons. Eroğlu and Bektaş (2016) stated that the use of STEM activities in science courses has benefited teachers in different subjects such as recognition, addendum and effective teaching. In addition, the use of STEM activities in science courses has been found to benefit students in terms of motivation, interest, achievement, responsibility and development of scientific process skills (Eroğlu & Bektaş, 2016). In the research conducted by Gülhan and Şahin (2018), it was determined that STEAM activities contributed positively to the students' academic achievement and attitudes towards the courses. Gökbayrak and Karışan (2017) found that STEM activities developed for science prospective teachers constitute a statistical difference in scientific process skills of teacher candidates. In the studies conducted by Strong (2013) and Sullivan (2008), it was determined that the STEM-oriented activities that were prepared provided the development of scientific process skills. When the literature is examined, it is seen that the researches which focus on engineering applications (Bozkurt, 2014; Sungur-Gül & Marulcu, 2014) are effective in the scientific process skills and science achievement of prospective teachers. STEM activities have a positive effect on the scientific process skills and attitudes of the 5th grade students towards science course (Yamak, Bulut & Dündar, 2014). STEM activities increase the academic success of the students due to the development of cognitive, affective and psychomotor skills (Acar, Tertemiz & Taşdemir, 2018; Çavaş, Bulut, Holbrook & Rannikmae, 2013; Yıldırım & Selvi, 2018). These results are consistent with the findings of the result.

In the research, whether or not STEM activities are related to daily life was determined according to student opinions. As a result of STEM activities conducted in the research, students stated that they realized their abilities, knowledge, skills to be oriented towards professions and happiness of problems they solved with very similar problems in their daily lives. According to the research findings, it can be said that students associate STEM activities with daily life. In a study conducted by Damar, Durmaz and Onder (2018), it was determined that middle school students were very happy at STEM activities and they were able to develop projects by doing scientific research. Timur and İnançlı (2018) concluded that

STEM education is a solution-oriented approach centering on the life of individuals. In the research conducted by Uğraş (2017), it was determined that STEM activities of preschool teachers included daily life problems. These results coincide with the findings of the study.

In the research, the problems that may occur in the realization of STEM activities are determined according to the views of the students. According to the students, lack of time, lack of material and lack of knowledge are defined as the most important problems to be experienced in the realization of STEM activities. In order for STEM training to be carried out for its purpose and without any problems, it is necessary to have different materials, technological equipment and classes designed for activities (Morrison, 2006). When the literature on the subject is examined, there are studies that overlap with the findings of the research (Eroğlu & Bektaş, 2016; Geng, Jong & Chai, 2019; Kurtuluş, Akçay & Karahan, 2017; Siew, Amir & Chong, 2015; Timur & İnançlı, 2018). In researches (Eroğlu & Bektaş, 2016; Siew, Amir and Chong, 2015), it has been determined that there are negativities about STEM-based lesson activities such as time, material shortage, lack of knowledge about the subject. According to preschool teachers and teacher candidates, STEM is experiencing problems in the realization of applications, lack of education for the service, lack of adequate information for the disciplines and costly practices (Park, Dimitrov, Patterson & Park, 2017; Uğraş & Genç, 2018). According to Yıldırım (2018), time management and pedagogical knowledge are very important for effective STEM education. In a study by Baran, Canbazoglu Bilici, Mesutoglu and Ocak (2016), it was suggested that time, material and information sources should be increased in order to increase activities in STEM education programs.

In the research, it was determined whether STEM activities were effective in the career choices of the students. STEM activities are effective when students become aware of their talents, knowledge, skills they need to address and the happiness they solve. Therefore, it was determined that STEM activities were effective in students' career choices in the future. According to these results, STEM activities can be said to be a factor that influences the future professional preferences of the students. According to Gencer (2017), career awareness and knowledge levels of students in STEM activities are increasing. In the study conducted by In the study conducted by Özçelik and Akgündüz (2018), it was determined that STEM activities provided an increase in the students' vocational tendencies towards STEM. The research conducted by Dieker, Grillo and Ramlakhan (2012) found that the STEM summer camp, which they conducted with technology focus, had a significant impact on students' career preferences. According to Guzey, Harwell and Moore (2014), STEM-oriented schools provide positive developments in STEM career attitudes towards students. Baran et al. (2016) determined that STEM activities increased the awareness of the 6th grade students towards the occupations. Christensen, Knezek and Tyler Wood (2015) stated that STEM activities are effective in career choice of students at different levels of education. These results support the findings of the study.

STEM activities are the right process for students to improve their problem solving skills, choose engineering and work in teams. Therefore, more STEM activities are recommended in schools. In addition, the necessary time, material and information infrastructure should be provided to the students in order to achieve the purpose of the activities. According to the research findings, it is also recommended that STEM activities problem scenarios be associated with daily life.

References

Acar, D., Tertemiz, N., & Taşdemir, A. (2018). The Effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training. *International Electronic Journal of Elementary Education, 10*(4), 505-513.

Akbıyık, C., & Kalkan-Ay, G. (2014). Perceptions of pre-school administrators and teachers on thinking skills instruction: a case study. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 29*(1), 1-18.

Altan, E.B., & Üçüncüoğlu, İ. (2018). Fen bilimleri öğretmen adayları için STEM odaklı laboratuvar uygulamaları etkinliği: sağlıklı yaşam modülü'ne yönelik değerlendirmeler. *Uluslararası Beşeri Bilimler ve Eğitim Dergisi, 4*(9), 329-347.

Baran, E., Canbazoglu Bilici, S., Mesutoglu, C., & Ocak, C. (2016). Moving STEM beyond schools: Students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics, Science and Technology, 4*(1), 9-19.

Bozkurt, E. (2014). *Mühendislik tasarım temelli fen eğitiminin fen bilgisi öğretmen adaylarının karar verme becerisi, bilimsel süreç becerileri ve sürece yönelik algılarına etkisi.* (Doktora Tezi). Ankara, Gazi Üniversitesi.

Bransford, J. D., Brown, A., & Cocking, R. (2000). *How people learn: Mind, brain, experience and school, expanded edition.* Washington, DC: National Academy Press.

Buyruk, B. & Korkmaz, Ö. (2016). FeTeMM farkındalık ölçeği (FFÖ): Geçerlik ve güvenirlik çalışması. *Türk Fen Eğitimi Dergisi, 13*(2), 61-76.

Çavaş, B., Bulut, Ç., Holbrook, J., & Rannikmae, M. (2013). Fen eğitimine mühendislik odaklı bir yaklaşım: ENGINEER projesi ve uygulamaları. *Fen Bilimleri Öğretimi Dergisi, 1*(1), 12-22.

Choi, Y., & Hong, S.H. (2013). The Development and application effects of steam program about 'world of small organisms' unit in elementary science. *Elementary Science Education, 32*(3), 361-377.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of hands-on STEM engagement activities with positive STEM dispositions in secondary school students. *Journal of Science Education and Technology, 24*(6), 898-909.

Çınar, S., Pırasa, N., & Sadoğlu, G.P. (2016). Views of science and mathematics preservice teachers regarding STEM. *Universal Journal of Educational Research, 4*(6), 1479-1487.

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

Creswell, J.W. (2003). Research design: Qualitative, quantitative, and mixed methods approaches. Thousand Oaks, CA: Sage.

Cunningham, C.M., & Hester, K. (2007). Engineering is Elementary: An engineering and technology curriculum for children. Presented at the ASEE Annual Conference and Exposition, Honolulu, HI. Retrieved from: http://eie.org/eie-curriculum/research/articles/engineeringelementaryengineering-and-technology-curriculum

Damar, A., Durmaz, C., & Önder, İ. (2018). Ortaokul öğrencilerinin fetemm uygulamalarına yönelik tutumları ve bu uygulamalara ilişkin görüşleri. *Journal of Multidisciplinary Studies in Education, 1*(1), 47-65.

Dieker, L., Grillo, K., & Ramlakhan, N. (2012). The use of virtual and stimulated teaching and learning environments: Inviting gifted students into science, technology, engineering, and mathematics careers (STEM) through summer partnerships. *Gifted Education International, 28*(1), 96-106.

Eroğlu, S., & Bektaş, O. (2016). STEM eğitimi almış fen bilimleri öğretmenlerinin STEM temelli ders etkinlikleri hakkındaki görüşleri. *Eğitimde Nitel Araştırmalar Dergisi, 4*(3), 43-67.

Gencer, A. S. (2015). Fen eğitiminde bilim ve mühendislik uygulaması: Fırıldak etkinliği. *Araştırma Temelli Etkinlik Dergisi, 5*(1), 1-19.

Geng, J., Jong, M.S.Y., & Chai, C. S. (2019). Hong Kong Teachers' Self-efficacy and Concerns About STEM Education. *The Asia-Pacific Education Researcher, 28*(1), 35-45.

Gökbayrak, S., & Karışan, D. (2017). STEM etkinliklerinin fen bilgisi öğretmen adaylarının bilimsel süreç becerilerine etkisi. *Batı Anadolu Eğitim Bilimleri Dergisi, 8*(2), 63-84.

Gonzalez, H.B. & Kuenzi, J.J. (2012). Science, technology, engineering, and mathematics (STEM) education: A primer. Congressional Research Service, Library of Congress.

Gülhan, F., & Şahin, F. (2018). STEAM (STEM+Sanat) etkinliklerinin 7. sınıf öğrencilerinin akademik başarı, STEAM tutum ve bilimsel yaratıcılıklarına etkisi. *Journal of Human Sciences, 15*(3), 1675-1699.

Guzey, S. S., Harwell, M., & Moore, T. (2014). Development of an instrument toassess attitudes toward science, technology, engineering, and mathematics (STEM). *School Science and Mathematics, 114*(6), 271–279.

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research* (p. 180). Washington, DC: National Academies Press.

Karakaya, F., Avgın, S.S., & Yılmaz, M. (2018a). Ortaokul öğrencilerinin fen-teknolojimühendislik-matematik (FeTeMM) mesleklerine olan ilgileri. *Ihlara Eğitim Araştırmaları Dergisi, 3*(1), 36-53.

Karakaya, F., Ünal, A., Çimen, O., & Yılmaz, M. (2018b). Fen Bilimleri öğretmenlerinin STEM yaklaşımına yönelik farkındalıkları. *Eğitim ve Toplum Araştırmaları Dergisi, 5*(1), 124-138.

Karakaya, F., Yantırı, H., Yılmaz, G., & Yılmaz, M. (2019). Ilkokul öğrencilerinin STEM etkinlikleri hakkinda görüşlerinin belirlenmesi: 4. sınıf örneği. *Uluslararası Türk Eğitim Bilimleri Dergisi, 7*(13), 1-14.

Kim, D.H., Ko, D.G., & Han, M.J. (2014). The Effects of science lessons applying steam education program on the creativity and interest levels of elementary students. *Journal of the Korean Association for Science Education, 34*(1), 43-54

Kızılay, E. (2016). Fen bilgisi öğretmen adaylarının FETEMM alanları ve eğitimi hakkındaki görüşleri. *The Journal of Academic Social Science Studies*, 47, 403-417.

Kurtuluş, A., Akçay, A.O., & Karahan, E. (2017) Ortaokul matematik derslerinde STEM uygulamalarına yönelik öğretmen görüşleri. *Journal of Research in Education and Teaching, 6*(4), 354-360.

MacFarlane, B. (2016). Infrastructure of comprehensive STEM programming for advanced learners. In B. MacFarlane (Ed.), *STEM Education for High-Ability Learners Designing and Implementing Programming* (pp. 139–160). Waco, TX: Prufrock Press.

MEB (2018). *İlkokul ve Ortaokul Fen Bilimleri Dersi (3., 4., 5., 6., 7., ve 8. sınıf) öğretim programı.* Ankara: MEB Yayınevi.

Miles, M.B., & Huberman, A.M. (2015). *Nitel veri analizi*. (1.baskı) (Ed. S. Altun Akbaba ve A. Ersoy). Ankara: Pegem Akademi.

Özcan, H., & Koca, E. (2019). The impact of teaching the subject "pressure" with STEM approach on the academic achievements of the secondary school 7th grade students and their attitudes towards STEM. *Education and Science, 44*(198), 201-227.

Özçelik, A., & Akgündüz, D. (2018). Üstün/özel yetenekli öğrencilerle yapılan okul dışı STEM eğitiminin değerlendirilmesi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 8*(2), 334-351.

Park, M., Dimitrov, D.M., Patterson, L.G., & Park, D. (2017). Early childhood teachers' beliefs about readiness for teaching science, technology, engineering, and mathematics. *Journal of Early Childhood Research, 15*(3), 275–291.

Retnowati, S., Riyadi, & Subanti, S. (2020). The STEM approach: The development of rectangular module to improve critical thinking skill. *International Online Journal of Education and Teaching (IOJET), 7*(1), 2-15.

Şahin, A., Ayar, M.C., & Adıguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences: Theory & Practice, 14*(1), 309-322.

Sanders, M.E.(2008). Stem, stemeducation, stemmania. Retrieved from: https://vtechworks.lib.vt.edu/bitstream/handle/10919/51616/STEMmania.pdf?sequence=1&isAllowedy.

Savran Gencer, A., Doğan, H., & Bilen, K., (2020). Developing biomimicry STEM activity by querying the relationship between structure and function in organisms. *Turkish Journal of Education, 9*(1), 64-105.

Siew, N. M., Amir, N., & Chong, C. L. (2015). The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science. *SpringerPlus, 4*(8), 1-20.

Strong, M. G. (2013). Developing elementary math and science process skills through engineering design instruction. Hofstra University.

Sullivan, F.R. (2008). Robotics and science literacy: Thinking skills, science process skills and systems understanding. *Journal of Research in Science Teaching, 45*(3), 373–394.

Sungur Gül, K., & Marulcu, İ. (2014). Yöntem olarak mühendislik-dizayna ve ders materyali olarak legolara öğretmen ile öğretmen adaylarının bakış açılarının incelenmesi. *Electronic Turkish Studies, 9*(2), 761-786.

Tekerek, B., & Karakaya, F. (2018). STEM education awareness of pre-service science teachers. *International Online Journal of Education and Teaching (IOJET), 5*(2), 348-359.

Thomasian, J. (2011). *Building a science, technology, engineering and math education agenda.* US: National Governors Association.

Timur, B., & İnançlı, E. (2018). Fen bilimleri öğretmen ve öğretmen adaylarının STEM eğitimi hakkındaki görüşleri. *Uluslararası Bilim ve Eğitim Dergisi, 1*(1), 48-68.

Uğraş, M. (2017). Okul öncesi öğretmenlerinin STEM uygulamalarına yönelik görüşleri. *The Journal of New Trends in Educational Science, 1*(1), 39-54.

Uğraş, M., & Genç, Z. (2018). Pre-School teacher candidates' views about STEM education. *Bartın Üniversitesi Eğitim Fakültesi Dergisi, 7*(2), 724-744.

Yamak, H., Bulut, N., & Dündar, S. (2014). 5. sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTeMM etkinliklerinin etkisi. *Gazi Eğitim Fakültesi Dergisi, 34*(2), 249-265.

Yıldırım, B. (2018). STEM uygulamalarına yönelik öğretmen görüşlerinin incelenmesi. *Eğitim Kuram ve Uygulama Araştırmaları Dergisi, 4*(1), 42-53.

Yıldırım, B., & Selvi, M. (2015). Adaptation of STEM attitude scale to Turkish. *Turkish Studies, 10*(3), 1107- 1120.

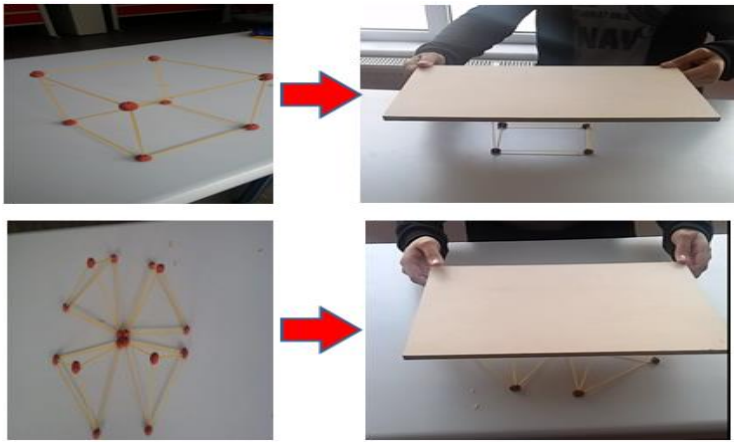
Yıldırım, B., & Selvi, M. (2018). Ortaokul öğrencilerinin STEM uygulamalarına yönelik görüşlerinin incelenmesi. *Anemon Muş Alparslan Üniversitesi Sosyal Bilimler Dergisi, 6*(STEMES'18), 47-54.

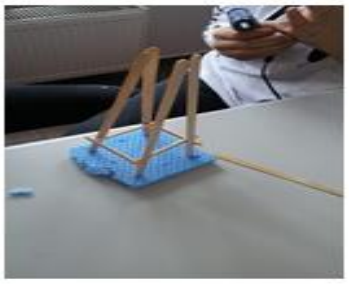
APPENDIX

Workshop 2: Bridge Design Activity

Problem scenario

Turkey is a country where different seismic zone. Therefore, engineers in construction projects in Turkey, it will take into account this situation. Istanbul Metropolitan Municipality wants to build a bridge over the Marmara Sea. However, the ground on which the feet of the bridge will be located is located above the earthquake zone. For this reason, Istanbul Metropolitan Municipality does not want to make mistakes in bridge construction. Istanbul Metropolitan Municipality launched an earthquake-resistant bridge project, the first of which will be determined by the votes of the people. If you were an engineer who wanted to participate in this competition, what kind of a bridge would you make?

Students first explored how to improve the durability of the materials.	
Students played games on the digital platform to learn how to build bridges.	
Students have investigated the effect of geometric shape on durability.	

Students have prepared bridge legs.	   
The students tested the earthquake resistance of the bridge legs.	 
The students drew the designs of their bridges and made their bridges.