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Association of Mechanical Clock Elements with STEM Disciplines and Energy Conversion

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Abstract: ***This research is intended for associating STEM disciplines and kinetic-potential energy conversion with the mechanical clock elements, with the purpose of informing 7th grade students about STEM and energy conversion. Throughout the qualitative research period, Mechanical clock components were visually presented to the students and they designed their own energy-conversion-operated mechanical clocks. In the end of the task, the students were asked for delivering their opinions about mechanical clock- STEM disciplines and mechanical clock-energy conversions which they observed during the process. The findings and the results obtained from the task are presented as tables and graphics. According to the Mechanical Clock-STEM (MCS) Association and Task Assessment Rubric (TAR), it has been observed that there were almost completely positive (90%) results for both of the associations mentioned above. When it came to associating Mechanical Clock with the Energy Conversion (MCEC), while some of the questions in the pretest were answered by none of the students, there was an increase about 50% in the posttest for all of those questions. In addition, the analysis of the interviews was shown that the task positively affected understanding Energy conversion and the relation between STEM disciplines.***

Keywords: Mechanical Clocks, Energy conversion, STEM, Science Education

1. Introduction

In recent years, one of the mostly studied educational subjects has been education of **S**cience, **T**echnology, **E**ngineering and **M**athematics (STEM) and its applications at schools [1], [2]. It is universally admitted that STEM disciplines are under the same roof [3] and interrelated as well as they are bridges for one another [4]. When we look into the studies in scientific literature in which the historical development and change of STEM have been investigated [5] we can easily understand that STEM education includes various fields from positive sciences to social sciences and from marketing to art [6]; because one of the main purposes of STEM is preparing the students to comprehend the real life problems by dealing with the needs of society [7].

Knowledge gathered from STEM applications contributes the students (and accordingly the community) to reaching higher life standards. However, the recent researches show that the students cannot reach proficiency levels especially in science and mathematics fields, from primary schools to universities, they keep themselves away STEM disciplines and have negative approaches to STEM [8]-[10]. This situation can be easily understood from PISA evaluations and OECD reports about the subject [11], [12]. Therefore, starting from primary levels, teaching STEM disciplines at school is of capital importance [13], [14].

Based on the idea that STEM and its applications require to be more attractive and interesting for the students, the mechanical clock in the Figure 1, which was related to the real life and including STEM disciplines, was used with the purpose of enabling students to concretely figurate Energy Conversion, a hardly understandable and abstract notion for students.

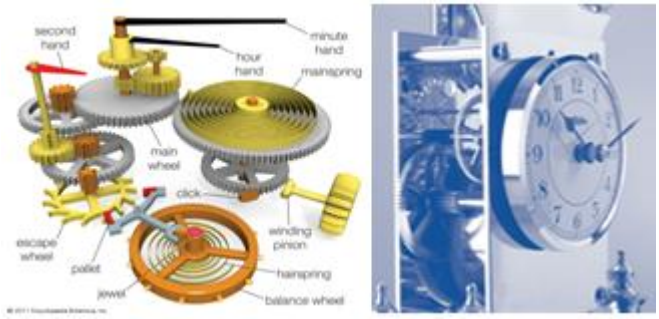


Figure 1: Clockwork with hairspring [15]

Although there have been a great number of studies upon STEM education in the scientific literature [16]-[24], there is lack of studies based on sample instrument like the mechanical clock which is exemplifying the conversion from potential into kinetic energy, widely used in daily life and associating STEM disciplines; because of which, we believe that our study will contribute much to the scientific literature.

1.1. Purpuse of the Study

The purpose of this study is providing 7th grade students with opportunities to learn about STEM and Energy conversion, through associating mechanical clock elements with kinetic-potential energy and STEM disciplines.

The research questions are guided as following:

1) How do the students associate mechanical clock elements with STEM disciplines?
2) How do the students associate mechanical clock elements with kinetic-potential energy conversion?

2. Methodology

Qualitative design is used in this study [25].

2.1. Participants

The universe of the research consisted of 40 students in two 7th grade in a public school in the province of İstanbul, Üsküdar. The classrooms were chosen randomly. The study lasted two weeks throughout the formal courses (8 hours) in addition to selective courses (4 hours). Before applying the task, the students were informed via in 4 hours of introductory courses. Among 40 students, 12 of them were chosen according to their interest scale points (high, medium and low). These students were encoded via pretest grades scores as high (SH), medium (SM) and lower (SL). The age average of research population was 13 while the numbers of male and female attendants were nearly equal.

2.2. Data Collection

The data of this research were qualitatively collected in the first semester of 2017-2018 academic year. But, in order to decide on 12 students, **S**TEM-**D**isciplines-**I**nterest-**S**urvey (STEM-DIS), which is developed by [19], was applied as pretest, and they (4 students for each of lower-medium-higher interest points) were chosen according to the results based on the 5 Likert type scale.

The data was gathered from **M**echanical **C**lock-**S**TEM-**E**nergy **C**onversion-**A**ssociation-**F**orm (MCSECAF) by applying open ended pretest and posttest; from **W**orksheets (W1 and W2) which were used during the activities and lastly from **T**ask-**A**ssessment-**R**ubric (TAR) and from **S**tudent-**I**nterview-**F**orm (SIF) in the end of practice.

The task that was implemented to different groups in different hours but on the same day and in the same length of time. In MCSECAF, there are 5 questions in **M**echanical **C**lock-**S**TEM (MCS) (A) and 9 questions in **M**echanical **C**lock-**E**nergy **C**onversion (MCEC) (B). In question preparation process, 3 science fields and a Turkish language expert were asked for professional consultation. Moreover, a pilot study was conducted on 15 students at another school than the real target-school, and the questions which caused hesitation were revised and applied for the real research group.

The worksheets which were used in the process were created according to 5E stages. There are 9 assessment criteria targeting 4 STEM disciplines in the TAR developed for evaluation of activities. Additionally, in SIF, there are 4 questions targeting the effect of Mechanical clock and STEM disciplines on understanding energy conversion.

2.3. Data Analysis

Descriptive and content analysis techniques were used in data analysis process. All the data gathered from MCSECAF, TAR and SIF were coded in accordance with the predetermined themes. The encodings, which were independently completed by the researcher and an expert, were organized in consequence of the themes and research questions.

3. Findings

3.1. Findings Related to the Association between Mechanical Clock and STEM Disciplines

In the research, 5 questions in MCS (A) and 9 criteria in TAR which were created with the purpose of answering the sub-question "How do the students associate mechanical clock elements with STEM disciplines?" are given below in Table 1.

Table 1: MCS (A) Questions and TAR Criteria According to STEM Disciplines

STEM diciplines	*MCS (A) Questions*	*TAR Criteria*
Common questions	**1.** What is STEM?	
	2.How can you associate mechanical clock with STEM?	
Science	**3.** What is the relationship between hairspring and STEM?	**1.** To be able to identify the problem **2.** To decide on the solution of the problem **3.** To be able to determine the depentdent, independent and control variables
Technology		**4.** To be able to convert gearwheel drafts into 3-dimensional images with the help of computer aided design technologies
Engineering	**4.** What is the relationship between gearwheels and STEM?	**5.** To be able to design a mechanical clock for the solution of the problem **6.** To be able to choose the suitable tools for the designed mechanical clock model **7.** To be able to use the tools suitably for the designed mechanical clock. **8.** To be able to combine the elements of mechanical clock model in convenience with the solution of the problem
Mathematic	**5.** What is the relationship between the numbers on clock and STEM?	**9.** To be able to define the relationship between the number of gears and the number of rotations of a gearwheel which provides the movement of the hour and minute hands of a mechanical clock.

MCS (A) and TAR data is given below. The findings for the opinions of students about STEM in MCS (A) is given in Table 2.

Table 2: Pre-posttest frequency of students' answers on STEM in MCS (A) and student codes

	MCS (A) Pretest		*MCS (A) Posttest*	
Answers	Students codes	f	Students codes	f
Education system	-	0	SH1, SH2 , SM5	3

Abbreviations of Science, Technology, Engineering and Mathematics	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SL10, SL11	9	SH1, SH2, SH3, SM6, SM8, SL10, SL11	6
Combination of all STEM disciplines	-	0	SH4, SM5, SM7, SL9, SL12	5
No idea	SM8, SL9, SL12	3	-	0

According to Table 2; there are 5 students defining STEM as a combination of all disciplines and 3 students specifying it as an education system.

The frequency values of pretest and posttest, which test the students' ability of relating Mechanical Clock to STEM, and the student' codes are given in Table 3.

Table 3: Pre-posttest frequancy of students' ability of relating Mechanical Clock to STEM in MCS (A) and students codes

	MCS (A) Pretest		*MCS (A) Posttest*	
STEM disciplines	Student codes	f	Student codes	f
Science	SH1, SH5, SH7, SL10	4	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SM8, SL9, SL10, SL11	11
Technology	SH4, SM5, SM7,SL11	4	SH1, SH2, SH4, SM5, SL10, SL11, SL12	7
Engineering	SH4, SL10	2	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SL9, SL10, SL11, SL12	11
Mathematic	SM5	1	SH1, SH2, SH4, SM5, SM6, SM7, SM8, SL9, SL10, SL11	10

According to Table 3; it is seen that the number of students who could establish a relationship between Mechanical Clock and STEM increased from 4 to 11 in Science; from 4 to 7 in Technology; from 2 to 11 in Engineering and from 1 to 10 in Math.

Based on the task assessment results of TAR, 12 students' level of understanding the relationship among STEM disciplines is stated in Table 4. The levels are coded as "A" for "adequate"; "PA" for "partially adequate".

Table 4: Results of TAR for students understanding the relationship among all STEM Disciplines and student codes

Student codes	*Science*	*Technology*	*Engineering*	*Math*
SH1	A	A	A	PA
SH2	A	A	A	A
SH3	A	A	A	PA
SH4	A	PA	PA	A
SM5	A	A	A	A
SM6	A	A	A	A
SM7	A	A	A	A
SM8	A	PA	A	PA
SL9	PA	A	A	A
SL10	PA	A	A	A
SL11	A	A	A	PA
SL12	A	PA	PA	A

According to Table 4; it is seen that SH2, SM5, SM6 and SM7 could understand the relationship among all STEM disciplines; SH1, SH3 and SL11 could understand the relationship among science, technology and engineering; SL9 and SL10 could understand the relationship among technology, engineering and math; SH4 and SL12 could understand the relationship between science and math; and PM8 could understand the relationship between science and engineering, in an adequate level.

The findings gathered from MCS (A) and TAR is given in Table 5.

Table 5: Student' codes and frequency of understand the relationship among all STEM disciplines sufficiently in MCS (A) posttest and TAR

	MCS (A) posttest		*TAR*	
STEM disciplines	Students codes	f	Students codes	f
Science	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SM8, SL9, SL10, SL11	11	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SM8, SL11, SL12	10
Teknology	SH1, SH2, SH4, SM5, SL10, SL11, SL 12	7	SH1, SH2, SH3, SM5, SM6, SM7, SL9, SL10, SL11	9
Engineering	SH1, SH2, SH3, SH4, SM5, SM6, SM7, SL9, SL10, SL11, SL12	11	SH1, SH2, SH3,SM5, SM6, SM7, SM8, SL9, SL10, SL11	10
Mathematic	SH1, SH2, SH4, SM5, SM6, SM7, SM8, SL9, SL10, SL11	10	SH2, SH4, SM5, SM6, SM7, SL9, SL10, SL11, SL12	9

According to Table 5; it is observed that the results of MCS (A) posttest and TAR is nearly equal to each other.

3.2. Findings for Understanding Energy Conversion (kinetic and potential)

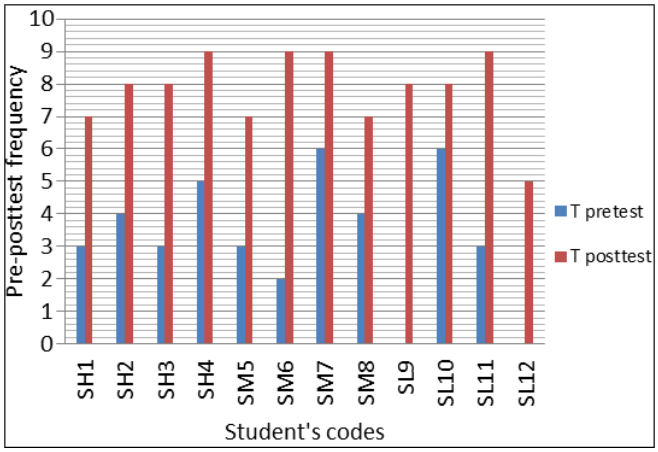
In the research, 9 questions about MCEC (B) and 4 questions related to SIF, in order to find an answer to the sub-problem "How do the students associate mechanical clock elements with kinetic-potential energy conversion ?" are presented in Table 6.

Table 6: MCEC (B) and SIF questions

MCEC (B) Questions	***SIF Questions***
1. What makes the hands in a mechanical clock move? **2.** Which type of energy occurs when the crown of a hairspring is rotated? **3.** Which type of energy does the hairspring have when it is compressed? **4.** What kind/kinds of energy emerge when the hairspring starts to unwind?	**1.** What have you learned about energy conversion during the task? **2.** Has the use of mechanical clock on the task contibuted you to understand the "energy

5. What kind of energy does the hairspring have when it is completely opened? **6.** In the hairspring- gearwheel sySTEM, what is the position of gearwheels when the hairspring is in a compressed position? **7.** What is the position of gearwheels when the hairspring starts to open? **8.** What is the position of gearwheels when the hairspring is completely opened? **9.** Which kinds of energy conversion occur due to hairspring- gearwheel system?	conversion" subject? **3.** What is the relationship between STEM and the mechanical clock used on the task? **4.** On this task, has principle of associating STEM disciplines contributed you to understand energy conversion subject?

The answers given to 9 questions in MCEC (B) are coded as (T) for True, (PT) for Partially True and (F) for False. Accordingly, the variation between the number of true questions in pretest and posttest is given in Graphic 1.



Graphic 1: Results of MSEC (B) for student's pre-posttest true answers frequency

According the Graphic 1; it is seen that there were 2 more true answers for SL10; 3 for SM7 and SM8; 4 for SH1, SH2, SH4 and SM5; 5 for SH3 and SL12; 6 for SL11 and 12 for SL9.

The findings gathered from SIF, which was aimed for assessing student's level of understanding the energy conversion, are given in Table 7.

Table 7: Themes, codes and examples of students' answers; which were gathered from SIF

Themes	*Codes*	*Examples of Students' Answers*
The subjects learned about energy conversion	Kinetic Energy Elastic Potential Energy Gravitational Potential Energy Energy conversion	*"The energy does not exist from nothing, nor does it disappear; I mean it is conserved.. I have learned that the energy convers from one form to another, I have also learned what increases and what decreases under what conditions."* (SH1) *"I have learned that there are two kinds of potential energy.I have also learned that elastic potential energy and gravitational potential energy can convers into kinetic energy."*(SM5) *"Energy convers from one form to another, but not disappears."* (SL11)
Use of Mechanical Clock	Working Mechanism of the Clock Energy Conversion Embodiment	"*Yes it happened, because, for example we have studied with rubber band and I have learned that elastic potential energy convers into motion energy."*(SH3) *"Yes it happened. I have apperently observed the energy conversion on the mechanical clock. For example, when we set the winding clock the gearswheels started to rotate."* (SM6) "Actually, i*t happened. It is a little bit confusing but once you see how the clock works, you can understand the issue"* (SL9)
Associating Mechanical Clock with STEM	Energy Conversion-Science Calculating the Number and Rotaion of Gearwheels and the Numbers-Maths Computer Aided Designing-Technology Combining the Elements of Clock-Engineering	"*For example, the clock conversed energy, it is about science. We made the wheels on the computer, I felt like an engineer when we designed that wheels. We have used both technology and design there and we have done mathematical calculations for the rotation of the wheels."* (SH3) *"The conversion in the hour is about science. The shape and structure of the clock is related to engineering"* (SM8) *"When I set the clock, the wheels turned and I think it's about science. The design of the wheels on the computer is about the technology. We combined the parts of the watch like the engineers."* (SL9)
Interrelating STEM disciplines	Science Technology Engineering Mathematic	"*Actually I can say that it happened..For example; we need to be good at maths.We have made some calculations like "how many wheels is required for the minute hand of a clock. In Science, we have designed a clock to provide energy conversion*." (SH2) "*We have benefitted from science and maths simultaneously; and such kind of things have naturally contributed me to understand the subject better.We have calculated the rotations of wheels and like an engineer, we combine the parts of the clock*." (SM7) "*Umm. I think, so. I mean it is actually hard to understand the energy conversions subject. We have observed the whole process in detail.We have made the rotation of gearwheels on a computer so we used the technology via using computer. I have understood it better after observing it*." (SL11)

According to Table 7; the codes gathered from SIF were; Potential Energy, Energy conversion, Energy conservation, Working Mechanism of the Clock, Energy Conversion, Embodiment, Energy Conversion-Science, Calculating the Number and Rotaion of Gearwheels and the Numbers-Maths, Computer Aided Designing- Technology, Combining the Elements of Clock-Engineering, Science, Technology, Engineering and Mathematic.

4. Discussion

4.1 The Results for Understanding the Relationship among STEM Disciplines and the Discussion

The discussion about the question "How do the students associate mechanical clock elements with STEM disciplines?" is given below. When the answers of students to the questions in Table 1 are evaluated in Table 2, it is understood that there is 41.6% increase in the number of students who evaluate STEM as a whole instead of separating it into disciplines; there is 25% increase in the number of students who evaluate STEM as an education (Table 2). Owing to these findings, it is thought that the students have knowledge about the definition of STEM. The positive change in the views of students about STEM can also be seen in various previous studies in the scientific literature [16], [17], [19], [26].

Due to the fact that there is an increase (58% for Science; 25% for Technology; 75 % for both Engineering and Math) in the number of the students who could associate the STEM disciplines with mechanical clock in MCS (A) posttest, it is understood that the students are in a better comprehension level than before the task (Table 3). Similarly, when the posttest activities are assessed through TAR, the students have benefitted from science, technology, engineering and math to design their own mechanical clocks; thanks to which it can be stated that the students could understand the interrelation of STEM disciplines (Table 4). According to the findings of TAR, the comprehension levels of students are 83.3% for Science and Engineering and 75% for Technology and Math respectively (Table 5); because of which it is arrived at the conclusion that the students have had knowledge about the subject.

It is observed that the findings, which are collected by both of the data collection tools (MCS (A) and TAR), support the conclusion that the students could understand the relationship among STEM disciplines better (Table 5). Studies, which indicate parallelism with the conclusion that the activities based on Integrated STEM Education could contribute the students to comprehend the relationship among STEM disciplines, are found in the literature [20], [23], [24].

4.2 The Results for Understanding Energy Conversion and the Discussion

The findings about the research question "How do the students associate mechanical clock elements with kinetic-potential energy conversion?" are discussed below. According to the results of 12 students participating the activity, there is an increase in the number of true answers of the students (2 more true answers for SH10; 3 for SM7 and SM8; 4 for SH1, SH2, SH4 and SM5; 5 for SH3 and SL12; 6 for SL11 and 12 more true answers for SL9); from which it can be understood that STEM activities have resulted in a completely positive way (Graphic 1). Although the students (SM7 and SL10) whose pretest results are good have accomplished better than others in the post test, the students without any correct answer in the pretest are observed having succeeded on the average in the post test. Therefore, we have arrived at the conclusion that the task has helped the students understand the energy conversion subject.

By observing the potential energy generated through compressing the hairspring; and observing the conversion of potential energy into kinetic energy due to slowly opening hairspring; and consequently, by observing the process during which gearwheels make the hands of the clock move, the students have created their own mechanical clocks; which indicates that they comprehend the energy conversion subject well. We think that the huge difference between the answers given after only observing energy conversion (the pretest) and the ones given after building their own mechanical clocks (the posttest) is resulted from experiential learning process. This apparently shows that observation and object teaching are more effective ways to teach STEM subjects. Similar point of views is supported by several studies in the literature [18], [22], [27]-[29].

It is understood from the interviews done with the students that they have gained information about energy and energy conversion thanks to the activity they have done. It is realized from the answers of the students that visualization of energy conversion thanks to mechanical clock mechanisms has facilitated their understandings. Studies on energy conversion in different activities in STEM applications are found in the previously literature [20], [21], [30].

5. Conclusion

Integrated STEM education is prepared in accordance with 5E stages. In the task of associating Mechanical Clock with STEM Disciplines, it is clearly seen from the students' answers that they have understood the subject well and that they have been able to associate the mechanical clock elements with STEM Disciplines; which is obviously shown in Table 2 and Table 3.

It is clearly understood from the results in Graphic 1, which consists of the students' answers for the questions in Table 6, that the students have perfectly comprehended the subject of energy and the relationship between Mechanical Clock and Energy Conversions (potential and kinetic).

The conclusion that the students have comprehended the subject of energy and the relationship between Mechanical Clock and Energy Coversions can be inferred from the students' own sentences in Table 7. Various activities and the findings of the study show how effective the visual,

experiential and applied learning is in this specific age group.

6. Recommendations

The suggestions developed in accordance with the results of this research are given below.

- By updating Science Education Program, STEM Education can be integrated into all units in the program.
- Abstract concepts such as energy transformations can be visualized within the scope of science lessons.
- STEM Disciplines can be explained with a simple current material and its prospective significance can be emphasized.
- By using different materials, STEM disciplines and science subjects can be taught to secondary school students

References

[1] J. Williams, "STEM education: Proceed with caution," Design and Technology Education: An International Journal, 16 (1), 2011.
[2] G. Siekmann, P. Korbel, " Defining "STEM" Skills: Review and Synthesis of the Literature," National Centre for Vocational Education Research (NCVER), Support Document 1, 2016.
[3] J. D. Basham, M. T. Marino, "Understanding STEM education and supporting students through universal design for learning," Teaching Exceptional Children, 45 (4), pp. 8-15, 2013.
[4] D. Vilorio, "STEM 101: Intro to tomorrow's jobs," Occupational Outlook Quarterly, 58 (1), pp. 2-12, 2014.
[5] D. W. White, "What is STEM education and why is it important," Florida Association of Teacher Educators Journal, 1 (14), pp. 1-9, 2014.
[6] R. W. Bybee, "Advancing STEM education: A 2020 vision," Technology and Engineering Teacher, 70 (1), pp. 30, 2010.
[7] B. Yıldırım, Y. Altun, "STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi," El-Cezeri Journal of Science and Engineering, 2 (2), 8-40, 2015.
[8] D. Goodrum, A. Druhan, J. Abbs, "The status and quality of year 11 and 12 science in Australian schools," Australian Academy of Science: Prepared for the Office of the Chief Scientist, 2012.
[9] S. Marginson, R. Tytler, B. Freeman, B., K. Roberts, K., "STEM: country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education," Final report, Australian Council of Learned Academies, Melbourne, Vic., 2013.
[10] S. Blackley, J. Howell, "A STEM Narrative: 15 Years in the Making,", Australian Journal of Teacher Education, 40 (7), p. 8, 2015.
[11] Organisation for Economic Co-operation and Development (OECD), "Education at a Glance 2017: OECD Indicators," OECD Publishing, 2017. doi: 10.1787/eag-2017-en
[12] Organisation for Economic Co-operation and Development (OECD), "PISA 2015 Results in Focus," Available: https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf . [Accessed: Jan. 30, 2018].
[13] J. Thomasian, "Building a Science, Technology, Engineering, and Math Education Agenda: An Update of State Actions," NGA Center for Best Practices, 2011.
[14] B. Yıldırım, M. Selvi, "STEM öğretme-öğrenme modelleri: 5E öğrenme modeli, proje tabanlı öğrenme yaklaşımı ve STEM SOS modeli," Pegem Atıf İndeksi, 205-241, 2018.
[15] Encyclopædia Britannica, Inc. "Typical components in a watch powered by a mainspring," 2011. Available:https://www.britannica.com/technology/clock/media/121951/110133. [Accessed: May. 10, 2018].
[16] G. Knezek, R. Christensen, T. Tyler-Wood, S. Periathiruvadi, "Impact of Environmental Power Monitoring Activities on Middle School Student Perceptions of STEM," Science Education International, 24 (1), pp. 98-123, 2013.
[17] S. Ceylan, "Ortaokul fen bilimleri dersindeki asitler ve bazlar konusunda fen, teknoloji, mühendislik ve matematik (fetemm) yaklaşımı ile öğretim tasarımı hazırlanmasına yönelik bir çalışma," Yayımlanmamış yüksek lisans tezi. Uludağ Üniversitesi Eğitim Bilimleri Enstitüsü, Bursa, 2014.
[18] S. Ercan, F. Şahin, "The Usage of Engineering Practices in Science Education: Effects of Design Based Science Learning on Students' Academic Achievement," Necatibey Faculty of Education Electronic Journal of Science & Mathematics Education, 9 (1), 2015.
[19] C. Pekbay, "Fen teknoloji mühendislik ve matematik etkinliklerinin ortaokul öğrenceleri üzerindeki etkileri," Yayımlanmamış doktora tezi, Hacettepe Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara, 2017.
[20] T. Tati, H. Firman, R. Riandi. "The effect of STEM learning through the project of designing boat model toward student STEM literacy," Journal of Physics: Conference Series. 895. No. 1. IOP Publishing, 2017.
[21] J. Krajcik, İ. Delen, "How to support learners in developing usable and lasting knowledge of STEM," International Journal of Education in Mathematics, Science and Technology, 5 (1), pp. 21-28, 2017.
[22] A. Yılmaz, C. Gülgün, A. Çağlar, "Teaching with STEM applications for 7th class students unit of" Force and Energy": Let's make a parachute, water jet, catapult, intelligent curtain and hydraulic work machine (bucket machine) activities," Journal of Current Researches on Educational Studies (JoCuRES), 7 (1), pp. 98-116, 2017.
[23] M. Çiftçi, "Geliştirilen stem etkinliklerinin ortaokul öğrencilerinin bilimsel yaratıcılık düzeylerine, stem disiplinlerini anlamalarına ve stem mesleklerini fark etmelerine etkisi," Yayımlanmamış yüksek lisans tezi, Recep Tayyip Erdoğan Üniversitesi, Rize, 2018.
[24] Y. Güder, R. Gürbüz, "Interdisciplinary Mathematical Modeling Activities as a Transitional Tool for STEM Education: Teacher and Student Opinions," Adıyaman University Journal of Educational Sciences, pp. 170-198, 2018.

[25] S. B. Merriam, Qualitative Research: a guide to design and interpretation. San Francisco: Jos-sey-Bass, 2009.
[26] F. Gülhan, F. Şahin, "Niçin STEM Eğitimi?: Ortaokul 5. Sınıf Öğrencilerinin STEM Alanlarındaki Kariyer Tercihlerinin İncelenmesi," Journal of STEAM Education, 1 (1), pp. 1-23, 2018.
[27] İ. Marulcu, K. M. Höbek, "Teaching Alternate Energy Sources to 8th Grades Students by Engineering Design Method," Middle Eastern & African Journal of Educational Research (MAJER), 9, 2014.
[28] P. Hudson, L. English, L. Dawes, D. King, S. Baker, "Exploring links between pedagogical knowledge practices and student outcomes in STEM education for primary schools," Australian Journal of Teacher Education (Online), 40 (6), p. 134, 2015.
[29] J. Krajcik, İ. Delen, "Engaging learners in STEM education," Eesti Haridusteaduste Ajakiri. Estonian Journal of Education, 5 (1), pp. 35-58, 2016.
[30] E. H. M. Shahali, L. Halim, M. S. Rasul, K. Osman, M. A. Zulkifeli, "STEM learning through engineering design: Impact on middle secondary students' interest towards STEM," EURASIA Journal of Mathematics, Science & Technology Education, 13 (5), pp. 1189-1211, 2017.

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