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Interpretation of an Energy Graph for a Mass-Spring System by Prospective Science and Mathematics Teachers: A Comparison

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Abstract

This study aimed at the investigation of skills of prospective science and mathematics teachers' reading of two parabolic line graphs related to simple harmonic motion of a mass attached to a spring. The participants were 31 prospective mathematics and 20 prospective science teachers taking the General Physics II course in the second term of the teacher training program. The participants were expected to determine the type, potential or kinetic, of energy and explain the variation of these energies in a written exam. Although harmonic motion is a phenomenon in science, findings showed that prospective teachers of mathematics performed better than prospective science teachers in general. The numbers of prospective science teachers' answers about the energy types represented by the curves were wrong but the energy changes of the curves were right, was higher than the number of corresponding prospective mathematics teachers, although the reverse was expected. It is concluded that a considerable number of prospective teachers' ability to read graphs was not at the desired level and need to be improved. This study showed that graph interpretation in physics was not just related to mathematics and a successful graph usage generally requires domain specific knowledge. It can be said that the use of graph interpretation questions in an assessment tool will contribute to determining the level of understanding the related subject in addition to the development of graph related skills of learners.

INTRODUCTION

Graphs are central to the representation in natural sciences, and graphing is a key component of high level thinking activities within mathematics and science education (Roth & Bowen, 2001). They are commonly used in textbooks and educational sources and can help students understand scientific concepts and data (Glazer, 2011; Lowe, 2000; Norman, 2012; Shah & Hoeffner, 2002). Drawing, reading and interpreting graphs are integral parts of experimentation (Mckenzie & Padilla, 1986; Susac, Bubic, Kazotti, Planinic & Palmovic, 2018). However, as many experienced teachers are aware, creating graphs and interpreting them are skills that are not easily acquired by most students (Padilla, McKenzie & Shaw, 1986) and that this issue has been a subject of several educational studies in physics (Beichner, 1994; Brassel & Rowe, 1993; McDermott et al., 1987). McDermott et al. (1987) reported that students have difficulties in discriminating the slope and height of a graph and interpreting changes in height and slope. Brassel and Rowe (1993) wrote that at least one fifth of the students had difficulties linking the graph to the verbal descriptions of a given event, and they did not understand graphs as a means of representing relationships among variables. Beichner (1994) pointed out that the most common mistakes students make with kinematics graphs are that they are thinking of a graph as a picture of the situation and confusing the meaning of the slope of the line with the height of a point on the line.

Graphs were first introduced into mathematics and then into other sciences. Both physics and mathematics require students to be able to extract various pieces of information from graphs. Physics, in addition, also requires an interpretation of the obtained information in the context of given physical situation (Planinic, Milin-Sipus, Katic, Susac & Ivanjek, 2012) via transferring knowledge between mathematics and physics (Planinic, Ivanjek, Susac & Milin-Sipus, 2013). In order to make such transfer to take place, it is necessary, but not always sufficient, for students to possess the underlying mathematical knowledge (Christensen & Thompson, 2012; Nguyen & Rebello, 2011). But students' problems with mathematics may not be the only or even the main reason for students' difficulties with graphs in physics. For example, Planinic et al. (2012) showed that many high school students successfully solved the mathematical questions but were unable to answer parallel physics questions, or used different strategies for solving analogous mathematics and physics problems contrary to the prevalent belief of physics teachers. The main source of student difficulties with the concept of line graph slope in physics was not their lack of mathematical knowledge, but rather their lack of ability to interpret the slope of line graphs in physics context. Similarly, in the work of Woolnough (2000), most secondary students, even those who do well in mathematics and physics, did not make substantial links between the two domains, and they continued to demonstrate a resistance to applying their mathematical knowledge to physics.

Purpose of Study

The ability to interpret graphs is considered one of the important outcomes of high school mathematics, physics, and university instructors assume that this ability of students is fully developed by the time they enroll at the university (Planinic et al., 2013). However, several studies in physics education showed that students at university level still have deficiencies in graph interpretation skills (Araujo, Veit & Moreira, 2008; Chabalengula, Mumba & Mbewe, 2012; Foster, 2004; Ivanjek, Planinic, Hopf & Susac, 2017; Harsh & Schmitt-Harsh, 2016; Planinic, Susac, Ivanjek & Šipuš, 2019) and science teachers rarely teach about graphical techniques needed in science (Aydın & Trakçı, 2018; Jarman et al. 2012; Lai et al., 2016). To help prospective teachers in developing these skills, science and mathematics teachers and educators need to foster graph drawing and interpreting in classroom activities (Bowen & Roth, 2005; Glazer, 2011), and more research needs to be done on graphical literacy in the context of science as well as in mathematics (Glazer, 2011; Keller, 2008). Research focusing on subject-specific graph work is generally on the subjects of force, motion (Yeltekin, 2020), kinematics (Aydın & Trakçı, 2018; Phage, Lemmer, & Hitge, 2017; Sokolowski, 2017; Uyanık, 2007), heat and temperature (Aydın, 2018). As is known, periodic motion is a special and relatively difficult type of motion, taking place at later chapters of coursebooks. A number of physical systems display mechanical, electrical or magnetic vibrations, some being harmonic and some inharmonic. The most common examples of mechanical vibrations are the pendulum and the mass attached to a spring. In this study the simplest system of mass and spring and the associated energy graphs are selected to investigate the skills of prospective science and mathematics teachers related to the given energy graphs.

METHOD

Study Design

This research employed the case study method incorporating an open-ended test involving graph interpretation questions. The participants of the study were 51 prospective teachers, 31 majoring in mathematics and 20 in science, who were taking the General Physics II course in the second academic term of the teacher training program. Prospective mathematics teachers (M_1, M_2, M_3,….M_{31}) previously took this course taught by another lecturer and were now repeating the course. Prospective science teachers (S_1, S_2, S_3….S_{20}) taking the course for the first time followed the lectures almost continuously unlike their mathematics counterparts. To examine prospective teachers' graph interpretations, three questions about the two curves of a graph including knowledge of both mathematics and physics were designed. The related graphs are included in standard elementary physics textbooks at university level (i.e. Serway & Beichner, 2000) and were explained by the instructor during course work.

Data Collection

To investigate the graph interpretations of prospective teachers, line graphs displaying the relationship between two continuous variables in pictorial form were chosen here for their importance in mathematics and science education (McKenzie & Padilla, 1986; Keller, 2008). Although the mechanical set up producing simple harmonic motion is simple, the related mathematical expressions and energy graphs are somewhat complicated. First of all, curved lines may seem more difficult to interpret than straight lines (Phage, Lemmer, & Hitge, 2017), secondly plotting the two curves with only limited segments without their asymptotic extensions may pose difficulty to assess that the curves are parabolic.

Because multiple-choice questions are not a valid measure of graphing abilities (Berg & Smith, 1994), the participants were expected to explain the graph (Figure1) showing the variation of potential and kinetic energy in written exam following the teaching of harmonic motion within the scope of General Physics II course.

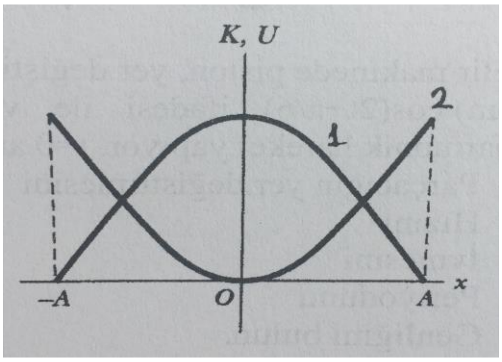

Figure 1. Graph of displacement-energy representing the harmonic motion of a mass *m* attached to a spring.

Prospective teachers should answer the following question:

a) Energy type represented by Curve 1………………….

b) Energy type represented by Curve 2 ……………………..

c) According to the graph, does the energy in a), i) increase, ii) decrease, iii) remain unchanged, as the mass moves from x= -A to x=0?

d) According to the graph, does the energy in b), i) increase, ii) decrease, iii) remain unchanged, as the mass moves from x= -A to x=0?

While the questions (a) and (b) are about the types of energy, (c) and (d) deal with the changes in these energies.

Data Analysis

The answers given by the students were analyzed according to the scale below, which was developed by Abraham et al. (1994):

0: Blank, repeats question; irrelevant or unclear response,
1: Scientifically incorrect responses containing illogical or incorrect information,
2: Responses containing some components of the scientifically accepted response,
3: Responses containing all components of the scientifically accepted response.

Then these scales were categorized in five levels as follows. The first two columns in each category show the scores from the items (a) and (b) and the second two columns show the scores from the items (c) and (d).

Table 1. Categorization of Answers of Prospective Teachers

Categories	A				B				C				D			
Score Type 1	3	3	3	3	3	3	3	1	1	1	3	3	1	1	1	1
Score Type 2					3	3	1	3					0	0	0	0
Score Type 3					3	3	1	1					1	1	3	1

Category A in which both energy types are expressed correctly and identification of the curves showing energy changes are correct
Category B in which energy types are expressed correctly but one or two identifications of the curves showing energy changes are incorrect.
Category C in which energy types are expressed incorrectly but identification of the curves showing energy changes are correct.
Category D in which both energy types are expressed incorrectly and identification of the curves showing energy changes are incorrect.
For the trustworthiness of the data collection tool, the opinions of an expert with a PhD degree were taken and conducted under the supervision of the course instructor. Although only one data collection instrument, the final exam, was used, it was assumed that the participants reflected their knowledge objectively.

FINDINGS

Table 2 shows findings obtained from the analysis of answers supplied by prospective teachers of science and mathematics.

Table 2. Categories of the answers given by prospective teachers

Prospective Science Teachers				Prospective Mathematics Teachers			
A	B	C	D	A	B	C	D
S_1, S_2 S_3, S_4 S_5, S_{20}	S_6 S_7 S_8	S_9, S_{10} S_{11}, S_{16} S_{18}	S_{12}, S_{13} S_{14}, S_{15} S_{17}, S_{18}	M_1, M_8, M_9, M_{10}, M_{12}, M_{14}, M_{18}, M_{20}, M_{21}, M_{22}, M_{24}, M_{28}, M_{31}	M_4, M_6, M_7, M_{13}, M_{15}, M_{23}, M_{30},	M_5, M_{16} M_{17}, M_{26}	M_2, M_3, M_{11}, M_{19}, M_{25}, M_{27} M_{29}
%30	%15	%25	%30	% 42	%23	%13	%22

*M: Prospective Mathematic Teachers; S: Prospective Science Teachers

According to the table, the number of prospective mathematics teachers at category A is higher than that of prospective science teachers. While nearly half of the prospective

mathematics teachers knew the graph showing the type and change of energies, the corresponding ratio is about 30% for science teachers.
When categories A and B are evaluated together, it is seen that 63% of prospective mathematics teachers and 45% of prospective science teachers correctly answered the type of energy shown in the graph.

In category B, in which energy types are expressed correctly but one or two of the curves showing energy changes are incorrect, the majority being in potential energy type. Six prospective teachers, M_4, M_{13}, M_{15}, M_{30}, S_6, and S_7, stated that as the mass moved from point -A to point 0 the potential energy increased even though it was approaching zero.

It is seen that the number of prospective science teachers in category C, in which energy types are expressed incorrectly but curves showing energy changes are given correctly, is higher than the number for mathematics teachers. Although the prospective teachers in this category did not answer the energy types correctly, they correctly expressed the changes indicated by the two curves of the graph.

Similarly, it is seen that the number of prospective science teachers in category D which represents prospective teachers who left the questions unanswered or gave wrong answers is higher than that of the prospective mathematics teacher.

CONCLUSIONS, DISCUSSION AND SUGGESTIONS

The purpose of this work was to examine the skills of prospective science and mathematics teachers in reading and understanding of two curves, combined in a single graph, related to simple harmonic motion. The comparison of the two disciplines showed some variations which permites the definition of four categories A, B, C and D. For example, although harmonic motion is a phenomenon in science, our findings about the categories A and B showed that the prospective teachers of mathematics were in general better in answering our questions than the prospective teachers of science, contrary to Dyke and White (2004) stating that prospective mathematics teachers had little willingness to use graphs as they required higher abstract thinking skills.

In category C, where the answers about the energy types represented by the curves are wrong but the energy changes represented are right, the number of prospective science teachers is higher than the number of prospective mathematics teachers, although the reverse is expected. While the prospective science teachers in this category were able to interpret the change in energy, they were not able to tell the type of energy represented by each curve. It seems that their lack of knowledge about velocity or acceleration at points A prevented them from identifying the curves representing two types of energy. This complies with the claims that although graphing is a generalizable skill used throughout many academic domains, successful graph interpretation generally requires domain specific knowledge (Boote, 2014) and the role of content knowledge on graph interpretation has largely been ignored in related research (Keller, 2008). Similarly, in some other studies (Woolnough, 2000; Ataide & Greca, 2013; Plannic et al. 2012; Plannic et al. 2013), it was expressed that the difficulties with graphs in physics were not just related to mathematics, but there at the same time were substantial links between the two domains.

The percentages of answers (15-23%) of the participants in category B in which energy types were expressed correctly but identifications of curves showing energy changes were incorrect pointed out that subject knowledge on harmonic motion did not guarantee successful graph interpretation, a result similar to that by Bowen and Roth (2005). Wrong answers in category B on the potential energy curve pointed to inadequacies in mathematical knowledge of prospective mathematics teachers.

The percentages (20-30%) of participants in category D suggest that prospective teachers need more experience in graph reading and interpretation practice in realistic applications (Roth, 1996; Bowen & Roth, 2005). It is concluded that a considerable number of prospective teachers' ability to read graphs was not at the desired level and need to be enhanced, as also emphasized in other studies (Gheith & Aljaberi, 2015). Although the prospective teachers of mathematics did not follow the Physics II course, they performed better graph reading than the prospective teachers of science who attended most of the lectures but, according to Table 2, displayed insufficient subject matter knowledge on harmonic motion of a mass-spring system. It can be said that the use of graph interpretation questions in an assessment tool will contribute to determining the level of understanding the related subject by learners in addition to the development of skills about graphs. Since graphs have generally been used in presenting the subject matter, their usage for assessment purposes has been insufficient or neglected (Gültekin & Nakipoğlu, 2015). In addition, many tests used for different examinations in the fields of science and mathematics employ graphs require skills of graph interpretation (Coleman et al., 2011). For this reason, the use of graph questions for assessment purposes is recommended to improve the awareness of student difficulties in graph handling and its importance in conceptual understanding of the subject. In this way, prospective teachers are expected to be engaged more effectively in graphical representations and relevant practices with their future students (Glazer, 2011; Marsh, 2020).

REFERENCES

Ataíde, A. R & Greca, I. M. (2013). Epistemic views of the relationship between physics and mathematics: Its influence on the approach of undergraduate students to problem solving. *Science & Education, 22*(6), 1405-1421.

Araujo, I. S., Veit, E. A. & Moreira, M. A. (2008). Physics students' performance using computational modelling activities to improve kinematics graphs interpretation. *Computers & Education, 50*(4), 1128-1140.

Aydın, N. (2018). Fen bilgisi öğretmen adaylarının ısı ve sıcaklık bilgilerine dayalı grafik anlama ve yorumlama düzeylerinin belirlenmesi, *Fen Bilimleri Öğretimi Dergisi, 6*(1), 20-36.

Aydın, A. & Tarakçı, F. (2018). Fen bilimleri öğretmen adaylarının grafik okuma, yorumlama ve çizme becerilerinin incelenmesi. *İlköğretim Online, 17*(1), 469-488.

Beichner, R. J. (1994). Testing student interpretation of kinematics graphs. *American Journal of Physics, 62*, 750–762.

Berg, C. A. & Smith, P. (1994). Assessing students' abilities to construct and interpret line graphs: Disparities between multiple-choice and free-response instruments. *Science Education, 78*(6), 527-554.

Boote, S.K. (2014). Assessing and understanding line graph interpretations using a scoring rubric of organized cited factors. *Journal of Science Teacher Education, 25*(3), 333-354.

Bowen, G.M. & Roth, W.M. (2005). Data and graph interpretation practices among preservice science teachers. *Journal of Research in Science Teaching, 42*(10), 1063-1088.

Brasell, H. M. & Rowe, B. M. (1993). Graphing skills among high school physics students. *School Science and Mathematics, 93*(2), 63-69.

Chabalengula, V. M., Mumba F. & Mbewe S., (2012). How Pre-service Teachers" Understand and Perform Science Process Skills, *Eurasia Journal of Mathematics, Science & Technology Education, 8*(3), 167-176.

Christensen, W. M. & Thompson, J. R. (2012). Investigating graphical representations of slope and derivative without a physics context. *Physical Review Special Topics-Physics Education Research, 8,* 023101.

Coleman, J. M., McTigue, E. M., & Smolkin, L. B. (2011). Elementary teachers' use of graphical representations in science teaching. *Journal of Science Teacher Education,* 22(7), 613-643.

Dyke, F. V., & White, A. (2004). Examining Students' Reluctance to Use Graphs. *Mathematics Teacher, 98*(2), 110-117.

Forster, P. A. (2004). Graphing in physics: Processes and sources of error in tertiary entrance examinations in Western Australia. *Research in Science Education*, *34*, 239-265.

Gheith, E. M. & Aljaberi, N. M. (2015). Pre-Service classroom teachers' attitudes toward graphs and their ability to read and interpret them. *International Journal of Humanities and Social Science, 5*(7), 113-124.

Glazer, N. (2011). Challenges with graph interpretation: a review of the literature. *Studies in Science Education, 47*(2), 183-210.

Gültekin, C & Nakipoğlu, C. (2015). Analysis of high school chemistry textbooks in terms of graphs and graph-related activities. *Dumlupınar University Journal of Social Sciences, 43,* 211-222.

Harsh, J. A., & Schmitt-Harsh, M. (2016). Instructional strategies to develop graphing skills in the college science classroom. The American Biology Teacher, *78*(1), 49-56.

Ivanjek, L. M. Planinic, M. Hopf, and A. Susac. (2017). Student difficulties with graphs in different contexts, in Cognitive and Affective Aspects in Science Education Research, Contributions from Science Education Research, edited by K. Hahl, K. Juuti, J. Lampiselkä, A. Uitto, and J. Lavonen, pp. 167–178. Springer International Publishing, London.

Jarman R, McClune B, Pyle E, & Braband G. (2012). The Critical reading of the images associated with science-related news reports: establishing a knowledge, skills, and attitudes framework. *International Journal of Science Education Part B Part B (2*), 103-129

Keller, S. K. (2008). Levels of line graph question interpretation with intermediate elementary students of varying scientific and mathematical knowledge and ability: A think aloud study Orlando University of Central Florida.

Lai, K., Cabrera, J., Vitale, J. M., Madhok, J., Tinker, R., & Linn, M. C. (2016). Measuring graph comprehension, critique, and construction in science. *Journal of Science Education and Technology, 25*(4), 665-681.

Lowe, R., (2000). Visual literacy and learning in science. *ERIC Digest.* ED463945.

McDermott, L. C., Rosenquist, M. L. & Van Zee, E. H. (1987). Student difficulties in connecting graphs and physics: Examples from kinematics. *American Journal of Physics, 55,* 503-513.

Mckenzie, D. L. & Padilla, M. J. (1986). The construction and validation of the test of graphing in science. *Journal of Research in Science Teaching, 23*(7), 571-579.

Nguyen, D. H. & Rebello, N. S. (2011). Students' understanding and application of the area under the curve concept in physics problems. *Physical Review Special Topics Physics Education Research,* 7, 010112.

Norman, R. R. (2012). Reading the graphics: what is the relationship between graphical reading processes and student comprehension? *Reading and Writing, 25*(3), 739-774.

Padilla M. J, McKenzie, D. L, & Shaw, E. L Jr. (1986). An examination of the line graphing ability of students in grades seven through twelve. *School Science and Mathematics, 86*(1), 20-26.

Phage, I. B., Lemmer, M., & Hitge, M. (2017). Probing factors influencing students' graph comprehension regarding four operations in kinematics graphs. African Journal of Research in Mathematics, *Science and Technology Education, 21*(2), 200-210.

Planinic, M., Milin-Sipus, Z., Katic, H., Susac A., & Ivanjek L. (2012). Comparison of student understanding of line graph slope in physics and mathematics. *International journal of science and mathematics education, 10*(6), 1393-1414.

Planinic, M., Ivanjek, L., Susac, A. & Milin-Sipus, Z. (2013). Comparison of university students' understanding of graphs in different contexts. *Physical Review Special Topics - Physics Education Research,* 9, 020103.

Planinić, M., Sušac, A., Ivanjek, L., & Milin-Šipuš, Ž. (2019). Comparing student understanding of graphs in physics and mathematics. In Mathematics in Physics Education, edited by G. Pospiech, M. Michelini & B. Eylon, pp 233-246, Springer, Cham.

Roth, W. M. (1996). Where is the context in contextual word problems? Mathematical practices and products in Grade 8 students' answers to story problems. *Cognition and Instruction, 14*(4), 487-527.

Roth, W. M., & Bowen, G. M. (2001). Professionals read graphs: A semiotic analysis. *Journal for Research in Mathematics Education,* 32(2), 159-194.

Serway, R.A. and R.J. Beichner, (2000). Physics for scientists and engineers, with modern physics. 5th ed., Fort Worth: Saunders College Publishing.

Susac, A., Bubic, A., Kazotti, E. Planinic, M. & Palmovic, M. (2018). Student understanding of graph slope and area under a graph: A comparison of physics and nonphysics students. *Physical Review Physic Education Research, 14,* 020109.

Shah, P., & Hoeffner, J. (2002). Review of graph comprehension research: Implications for Instruction. *Educational Psychology Review, 14*(1), 47-69.

Sokolowski, A. (2017). Graphs in kinematics—a need for adherence to principles of algebraic functions. *Physics Education, 52*(6), 065017.

Uyanık, F. (2007). *Ortaöğretim 10. sınıf öğrencilerinin grafik anlama ve yorumlamaları ile kinematik başarıları arasındaki ilişki.* Yüksek Lisans Tezi, Balıkesir Üniversitesi, Balıkesir.

Woolnough J. (2000). How do students learn to apply their mathematical knowledge to interpret graphs in physics? *Research in Science Education, 30*(3), 259-267.

Yeltekin, B.Ş. 2020. *Ortaöğretim öğrencilerinin kuvvet ve hareket konusuna yönelik grafik kullanma becerilerinin incelenmesi.* Yüksek Lisans Tezi, Hacettepe Üniversitesi, Ankara.

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Science, Engineering and Entrepreneurship Applications: Designing a Lighting Tool for Reducing the Light Pollution and Students' Views

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Abstract

In the study, it is aimed to explore how students find creative and innovative solutions to the given problems, develop products by transforming their solutions into a design and promoting their products by developing entrepreneurship strategies. In the study, the case study method was used. For the purpose of this research, an activity with 6 stages was conducted with 19 7th grade students. The data were collected from the interview forms and worksheets, and were analysed descriptively. In the study, it was seen that the students had some difficulties in transforming their designs into actual models. It was also observed that the students were happy with the entrepreneurship aspects of the activity and being completely free during the activity. The students completed the activity with high motivation and stated that these kinds of activities should be implemented within every science subject.

INTRODUCTION

In our era, international competition for innovation, manufacturing and value added products has been escalated. The countries desiring to catch up with the trends aim to raise individuals who are productive, creative, easily adaptable to the new situations, interested in science, able to solve problems and willing to life-long learning (MEB, 2018; OECD, 2019). The main reason behind this is the fact that the importance of enhancing the mental processes and value added production skills has been elevated in the modern era (Bybee, 2010). Therefore, the countries of different development levels have tried to find new methods and integrate the interdisciplinary STEM (science, technology, engineering and mathematics) approach that is inquisitive, focuses on research, makes people create new products, into their education systems (Kelley & Knowles, 2016; Kuenzi, 2008). STEM is an approach that focuses on producing and innovation in addition to knowing and learning by doing of classic education systems (Çorlu, 2017). Curricula give utmost importance to researching, designing, problem solving, teamwork and effective communication and especially focus on production activities via authentic learning (Flavell, 1976; Hogan, Dwyer, Harney, Noone & Conway, 2014; Lambert, 2019). In this regard, it can be seen that there has been a transition to STEM literacy based on scientific literacy (OECD, 2019; Zollman, 2012). The main difference between STEM literacy and scientific literacy is that STEM literacy aims that people gain an interdisciplinary perspective by improving competitive skills (Kelly & Knowles; 2016). STEM aims to raise students as individuals that are qualified in producing, creating new designs and solving problems (Guzey, Harwell & Moore, 2014). Moreover, one of the many purposes of STEM is to provide people with engineering skills and a multidisciplinary perspective in order to solve daily life problems. Many countries feature STEM in their strategic plans because of their education policies (Hernandez et al., 2014). Using produced information in a developing world has a great importance in terms of competitive capacity (Çorlu, Capraro & Capraro, 2014). STEM education is frequently addressed in the studies of developing and improving of both national and international education (Bozkurt Altan, 2017; Ercan, 2014; Karahan, 2017; MEB, 2017, 2018; NRC, 2011; Türkmen, Aydınlı & Türkmen, 2019). In Turkey, to develop an interdisciplinary educational system, the studies have begun with a curriculum revision in 2005. The joint learning outcomes, which the discussed subject contributes, are referred to when the programme mentioned above adopted the parallelism and holism law. Afterwards, in science curriculum, some changes and revisions have been implemented in different topics/learning areas in parallel with the requirements (Yaz, Yüzbaşıoğlu & Kurnaz, 2019). Within the process, the STEM education report was also published in 2016 (MEB, 2016). The report discussed the STEM approach in different ways and gave some suggestions on how to implement it in Turkey. At this point, it can be claimed that the report is the basis for a transition to STEM in Turkey. Following the developments, the science curriculum was revised in 2017, especially in terms of engineering, as aiming to provide students with STEM skills (MEB, 2017). With the latest updates, entrepreneurship was integrated into the curriculum and it led students to produce materials and present their products with entrepreneurialism throughout the year (MEB, 2018). Accordingly, students were expected to form strategies and use advertisement devices to market their products, which they produce for developing their own entrepreneurship skills. In order to make that happen, students were suggested that they prepare advertisements for newspapers, the Internet and TV or shoot a short promotional video (MEB, 2018).

Entrepreneurship is seen as individuals' positioning according to the opportunities and ideas (McCallum, Weicht, McMullan & Price, 2018; Obschonko et al., 2011). Although the concept of entrepreneurship has been used frequently in certain areas like economy and commerce, in recent years it is also used in curricula (MEB, 2018). The main purpose for the entrepreneurship skills being in the curriculum is to provide students to acquire knowledge, skills and attitudes related to entrepreneurship (Bartulović & Novosel, 2014). It is quite important to use activities that are able to draw students' attention and support and improve their skills (Ball & Beasley, 1998; Hassi, 2016). At the same time, when it comes to the purpose of STEM, individuals' marketing their products that they produce by using their entrepreneurship skills seems very crucial. The changes in the curriculum also support this argument (MEB, 2018). Even though there are lots of activities containing the STEM approach (Çilek, 2019; Tozlu, Gülseven & Tüysüz, 2019; Yılmaz, Gülgün & Çağlar, 2017; Yılmaz ve Yüzbaşıoğlu, 2019), an activity that contains the learning outcomes of the curriculum and can improve students' entrepreneurship skills together could not be found in the relevant literature. According to the studies, it is stated that teachers have some difficulties in preparing design problems containing STEM skills (Bozkurt Altan & Hacıoğlu, 2018). Students are asked to specify a problem in a daily life situation related to the subjects of the units under the section of Science, Engineering and Entrepreneurship from the curriculum and to find a solution by developing tools, objects or systems according to the problem. The criteria such as available materials, duration and cost should also be taken into consideration.

In addition, for entrepreneurship skills, students are expected to market their product/s by using several strategies (MEB, 2018). To execute the objectives of the science curriculum, it is vital that the activities containing science and engineering skills should be restructured to enable the use of the entrepreneurship skills. In this study, an activity on the topic "Light" was designed because it is a common topic both in students' daily life and on different class levels, and it is also suitable for the activities related to the science, engineering and entrepreneurship applications of the curriculum. The students were given a problematic situation, for which they could design a unique lighting device to reduce the light pollution and use their entrepreneurship skills. The students were expected to find creative and innovative solutions for the problematic situation, create products by transforming their solutions into designs and promote these products by developing entrepreneurship strategies. For this reason, the questions below were seek to be answered.

1- What ways do the students follow to solve the given problem for the solution of the problem?
2- What are the students' designs and products related to the problem?
3- What are the students' criteria for the materials they choose for their products?
4- What are the students' entrepreneurship strategies for marketing their products?
5- What are the lighting efficiencies of the students' models?
6- What are the students' opinions about the activity?

METHOD

During the development and implementation period of the activity, the students were given a problem that they could face in daily life to design a unique lighting device to reduce the light pollution. The study was conducted qualitatively because the students specified the problem, offered solutions and then gave their opinions. For the study, the case study method was used. This method enables to analyse a certain aspect of the problem thoroughly and in a short time (Çepni, 2018). The study focused on the students' specifying the problem and offering solutions, therefore, case method was selected.

Study Group

The study was conducted with 19 7th grade students from a state school in the Western Black Sea region in three course hours as part of the science class. In the study, criterion sampling method, one of the purposive sampling methods, was used as sampling method. There are preselected criteria in this sampling method (Yıldırım ve Şimşek, 2011). When the science curriculum is analyzed (MEB, 2018), it is seen that the learning outcomes related to the problem are completed in the 7th grade. In this sense, the study group was formed with the 7th grade students who had completed the learning outcomes mentioned above.

Data Collection and Analysis

An interview form with four open-ended questions and a worksheet presented in Annex-1 were used for taking the students' opinions about the activities. To ensure the validity of the study, two experts were consulted for the suitability of the problem, context of the activity and the interview questions. Then the data collection tool was revised accordingly. The students' answers to the questions about the activity were discussed based on the questions, and analysed descriptively (Çepni, 2018).

The Activity's Context and Implementation Steps

The activity contained science and engineering skills listed in the curriculum. Besides, a different dimension was added to the activity, considering developing individuals' entrepreneurship skills from special learning outcomes of the science curriculum (MEB, 2018). Accordingly, students were asked to form a strategy to market their products which they designed in order to improve their entrepreneurship skills and use different devices to advertise them. The activity consisted of six stages.

At the first stage, a questioning process was initiated by giving students' a problematic daily life situation. In line with this objective, it was questioned which ways students would follow against the problem.

At the second stage, the students were to plan their solutions against the problem. For this reason, the students were asked to design and explain their solutions before putting them into practice. The students' designs and solutions against the problem were classified by similarities.

At the third stage, the groups were asked to reach a consensus on designs and select the materials they would use. After that, the groups were expected to determine and choose the materials they needed.

The materials for the activity:

-Construction paper	-Connection wire	-Silicon gun
-Cardboard	-Socket	-Screwdriver
-Straw	-Lightbulb	-Scissor
-Photocopy paper	-Battery holder	-Liquid adhesive
-Pencil	-Battery	-Clear tape
-Luxmeter	-Switch	

At the fourth stage, the groups created their model products and explained the reasons why they chose the materials they used.

At the fifth stage, the groups developed strategies in order to market their products.

At the last stage, the efficiencies of the products were tested and the groups promoted their models by using their entrepreneurship skills.

FINDINGS

The findings of the study are presented in this section.

The Findings of the First Research Question

In the study, the ways students used in order to find a solution for high efficiency and accurate lighting were explored. For that, students were given a daily life problem:

"*The school board wants to renew the lighting system because it is getting dark early and the school's lighting system is insufficient. The school board wants to solve the problem efficiently and accurately with the students. They ask students to come up with different ideas on what kind of lightbulbs should be used and to do that, they organize a project contest."*

Later on, students were expected to create solutions, and the question below was asked;

"*You want to join the project contest. What kind of path would you follow in the contest?".*

The students' answers were analysed separately and it was seen that the answers could be gathered under two sections. The students' answers are presented in Table 1.

Table 1. The path followed in the project process

	f
Researching	10
Individual Solution	9

According to Table 1, when students encountered a problem, ten students tended to do research by using the Internet and books and asking people. Sample answers are as follows:

S1. "*I talk to my mother and my friends and to solve the problem I try harder. I find dark places."*

S2. "At first, I consult. I do research on the Net. I choose the most reasonable choice and execute it. If my first choice doesn't work, I move onto the next one."

S17. "In the beginning, I ask my family members or consult my teacher and my friends. Lastly, I use books."

On the other hand, nine students decided to use their own knowledge to create a solution. Sample answers are as follows:

S3. "*I begin with brainstorming. After that, I purchase the materials I need and design."*

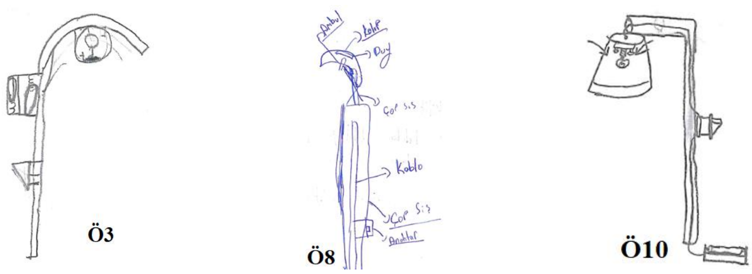
S4. "I try to create a solution on my own."

S10. "First of all, I prepare a draft by utilizing my own experience and knowledge and determine which materials I should use. I come up with different solution without any distraction and observe my project with the help of different perspectives."

The Findings of the Second Research Question

The drafts that students prepared related to the models for the problem's solutions and their final products were specified. At the second and third stage of the activity, several questions were posed to the students.

At the second stage, the students were expected to design solutions over the problem and answer the question "*Design your product and explain it."*. Figure 1 presents the samples of the students' drafts.



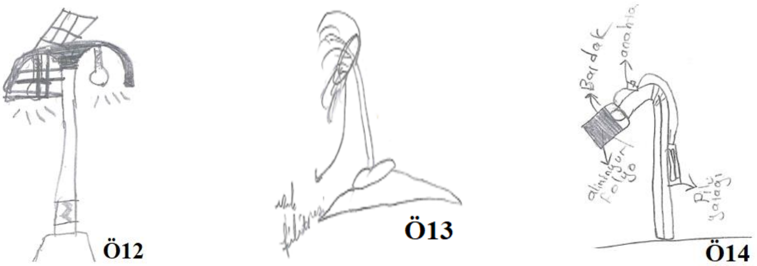


Figure 1. Sample drafts

After this stage, the students' drafts and solution offers were examined. The students offering similar solutions worked in the same group and there were eight groups in total.

At the third stage, the students in groups were asked to reach a consensus and specify the necessary materials for their models. The students decided on the materials they needed on their own. The groups were given 40 minutes for creating their models. Figure 2 presents the images of the students' models.

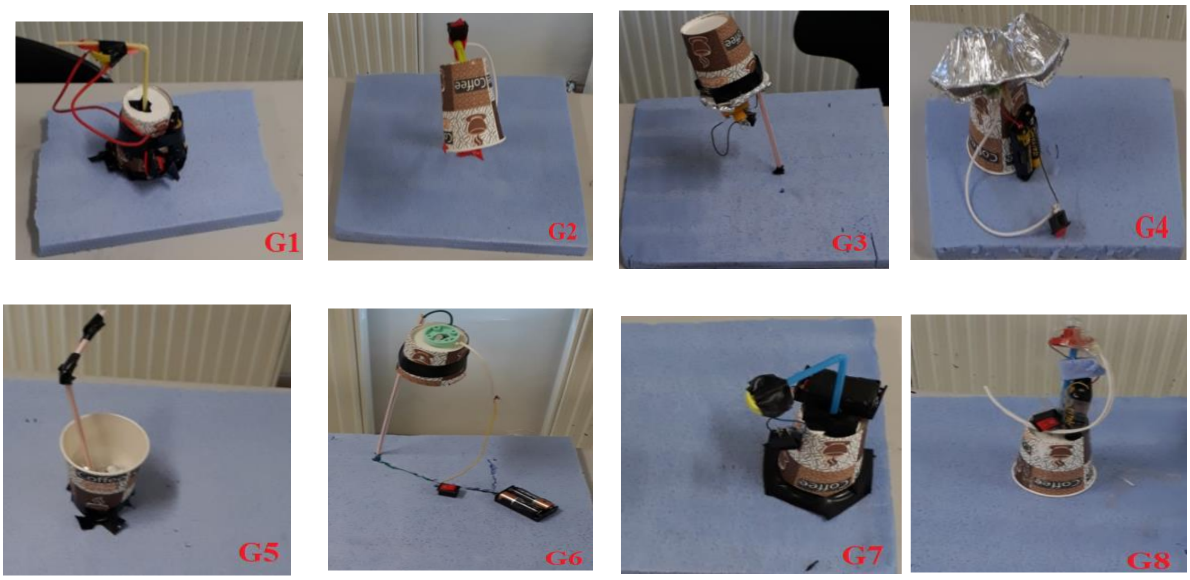


Figure 2. Sample designs

When the designed models were examined, it was seen that each group offered a different solution. Especially, the solution offering to prevent the light from radiating and to design an efficient lighting device are different.

The Findings of the Third Research Question

The reasons why the students chose the certain materials for creating their models were investigated. To that end, at the fourth stage, the groups were asked why they chose the materials for their models. The findings are presented in Table 2.

Table 2. The groups' reasons for material selection

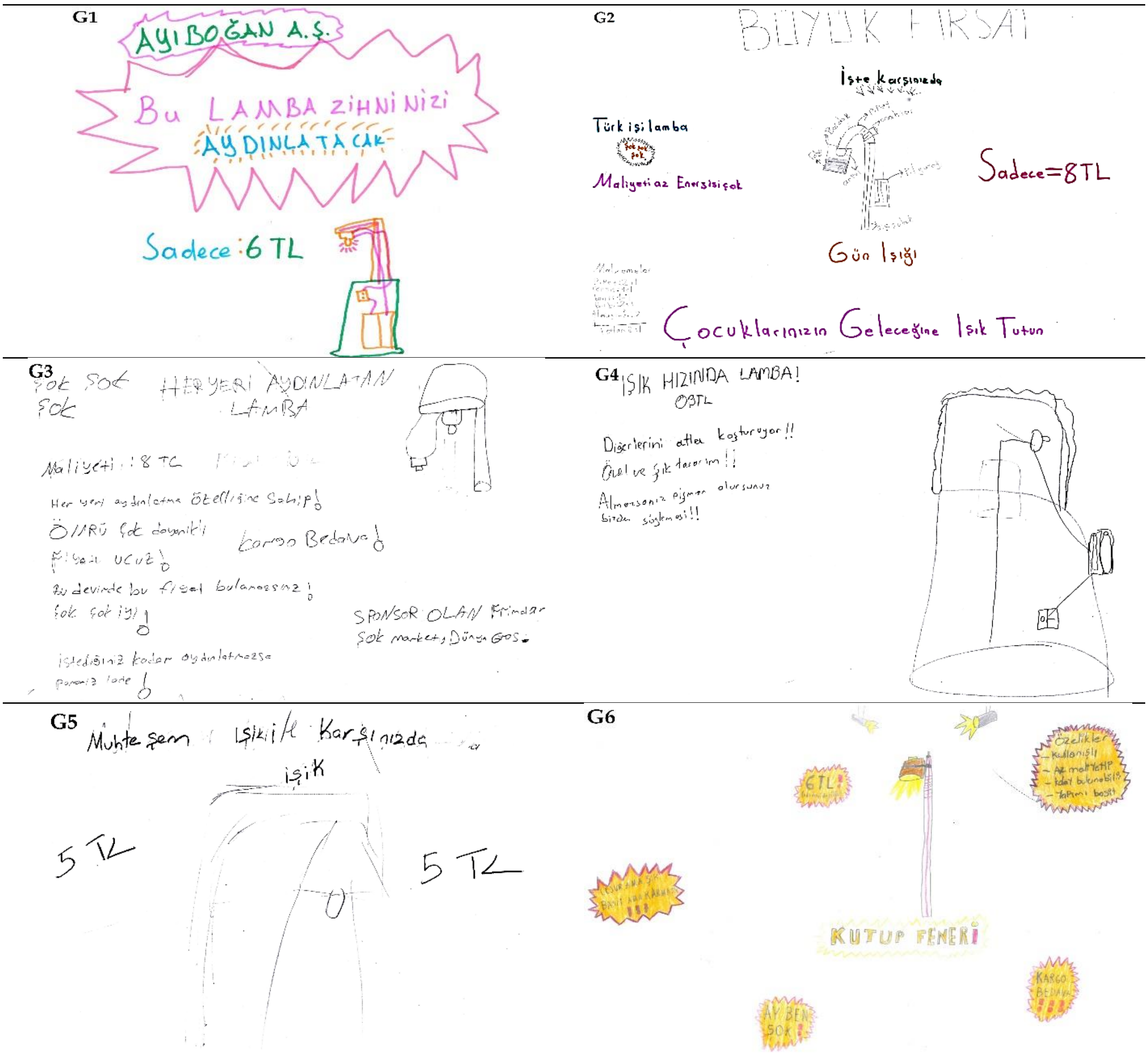
Groups	Reasons		
	Cost	Practicality	Appearance
1	+		
2	+	+	
3		+	+

4		+	+
5		+	
6	+		
7	+		+
8	+		+
Total	5	4	4

When Table 2 is examined, it is seen that the groups chose certain materials depending on their costs. It is followed by practicality and appearance.

The Findings of the Fourth Research Question

At the fifth stage, the groups were asked to make presentations to introduce their products in order to improve their entrepreneurship skills. Figure 3 presents tools students create for promoting their products.



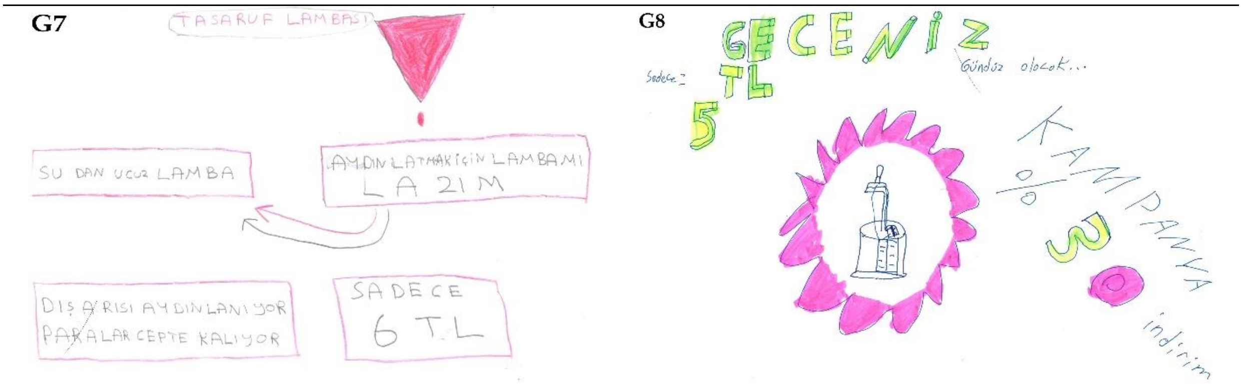


Figure 3. Groups marketing devices

All of the groups prepared posters for marketing. It is seen that the groups used slogans and images on their posters. Also, they promoted their products by using their models and posters as well as making presentations.

The Findings of the Fifth Research Question

The lighting efficiencies of the students' models were presented. For this reason, at the sixth and last stage, the effectiveness of the products was tested and the models' lighting levels were measured with a luxmeter. The findings are presented in Table 3.

Table3. Lighting values

Group	Lighting Values
1	13
2	80
3	235
4	185
5	210
6	46
7	45
8	19

In Table 3, the lighting values of the devices can be seen. The third group had the highest lighting value, whereas the lowest lighting value belonged to the first group.

The Findings of the Sixth Research Question

After the activity, students were asked four questions in order to find out their opinions. According to the answers given by the students, the findings are presented respectively.

The students' answers to the question "1- *What deductions did you make from your products and results?"* are presented in Table 4.

Table 4. The students' deductions from the activity

Reducing the light pollution	Efficient lighting methods	Irrelevant
f	f	f
9	2	8

According to Table 4, nine students deduced that light pollution could be reduced by taking the necessary precautions. Two students stated that they saw how a lighting device could be efficiently designed. Eight students, on the other hand, gave irrelevant answers or no answer.

The students' answers to the question "2-*What is your favourite part/s of the activity?"* are presented in Table 5.

Table 5. The students' favourite part/s of the activity

Designing the model	Running the products	Installing the circuit	Preparing a poster
f	f	f	f
7	5	4	3

According to Table 5, seven students said that their favourite part of the activity was being completely free and finding their own solutions for the problem. Five students said they liked the part that they designed the products most. Four students liked using the circuits and three students liked the poster making part.

The students' answers to the question "3-*In which part/s do you have difficulties?"* are presented in Table 6.

Table 6. The parts students have difficulties.

Designing the model	Installing the circuit	I did not have any difficulties
f	f	f
10	7	2

According to Table 6, ten students stated that the designing the model was the most difficult part. It is revealed that these students also had difficulties in turning their designs into the models. Seven students said that they had difficulties in installing the circuit and two students did not have any difficulties.

The students' answers to the question "4-*What is your opinion on the activity?"* are presented in Table 7.

Table 7. The students' opinions on the activity

We should activities like this one	The activity is rather difficult	The activity is instructive	No answer
f	f	f	f
11	3	2	3

According to Table 7, eleven students expressed their positive feelings towards the activity and stated that they wanted to do activities similar to this one again. Three students found the activity quite hard. Two students thought that the activity was informative and three students do not give any opinions.

DISCUSSION, CONCLUSION AND SUGGESTIONS

Raising students with high entrepreneurship skills in science class is vital for countries. Students are expected to find solutions for daily life problems, turn their solutions into products, search for ways of marketing their products and the activity contains very important qualifications on raising future individuals. This study is very important because it contains the learning outcomes that the students must acquire (MEB, 2018) and it is also directly related to the STEM approach (English, 2017; Hallström & Schönborn, 2019; NRC, 2011). At this point, the designed activity focuses on the learning outcomes *"To create solutions in order to reduce light pollution"* and "*To design a unique lighting device"* and match up with the aim "To *market the products which students produce by using their entrepreneurship skills"* of science (MEB, 2018). The students' taking precautions against light pollution and designing lighting devices correspond with STEM's goals of finding solutions for the problems by using theoretical knowledge (Bybee, 2010). Connecting the learning outcomes such as light pollution and designing lighting devices provides an opportunity to the students for using their knowledge for daily life problems. In addition, it leads to meaningful learning (Gencer, 2015; Yıldırım & Altun, 2015). Teachers should relate the designs which are produced for practicing STEM activities in the learning environment to daily life and use at least one of the disciplines like science, technology, engineering and maths (Bozkurt Altan, Yamak & Buluş Kırıkkaya, 2016). This study makes a significant contribution to this matter. In the study, the students used their knowledge of how to reduce light pollution and designed a lighting device for a daily life problem and offered solutions. Thanks to that, students were provided with an opportunity through which the knowledge they acquire becomes permanent. In literature, when the effect of practises of STEM education on academic success is examined, it is concluded that this kind of activities enhance students' success (Ceylan & Öztürk, 2015; Yıldırım & Selvi, 2017). The students need their teachers' guidance in order to relate the knowledge they acquire to daily life problems and be successful (Aslam, Adefila & Bagiya, 2018; King & English, 2016; So, Zhan, Chow & Leung, 2018). Because of this, it is considered that the teachers should use this kind of activities more in the classroom environment for both making the knowledge permanent for the students and enhancing their academic success.

In the present study, most of the students stated that at first, they conducted research for the problem they faced. They also added that they consulted their family, friends, teachers and the Internet for finding a solution. This finding is a justification for the study of Şahin, Mertol, Arcagök & Kayapınar (2014). Other students taking part in the activity said that they used their existing knowledge for solving the problem.

In the study, the groups were completely free during designing their models. The students decided freely on which materials they used. It provides students to create their products as unique and freely as possible. It is revealed that primarily, the groups take the material costs into consideration, after that they think about practicality and appearance. It can be the reason that the students want their products to be liked.

As part of the study, the groups designed their posters to promote their products. It was seen that the groups used slogans and images on their posters. Also, they promoted their products by using their models and posters and making verbal presentations. It is considered that thanks to these kinds of activities, the students use different types of marketing strategies.

One of the most remarkable opinions is that the students stated that they did not participate in an activity in which they market their own products before. The entrepreneurship part of the activity is found different and appreciated by the students. The students fulfilled their part in the activity with high motivation and said that this kind of activity should be repeated on a more frequent basis. This result shows that entrepreneurship education has positive sides on the students and the students have positive attitudes towards the education (Deveci, Zengin & Çepni, 2015; Ortaakarsu & Can, 2019). It is considered very important that for science curriculum to reach its aim of the entrepreneurship dimension (MEB, 2018), these kinds of activities should be executed more often. The students stated that the most difficult part of the activity was where they turned their designs into actual products. The reason behind this could be the fact that the students do not have enough opportunities to join these kinds of activities. At the end of the activity, it is pointed out that the students make the deductions that the light pollution can be reduced if the necessary precautions are taken and efficient lighting systems can be made if the necessary designs are prepared.

The participants of this study are 7^{th} grade students. To fulfill the entrepreneurship objectives of the science curriculum (MEB, 2018), it is clear that this kind of activities should be included beginning from 5^{th} grade. In literature, it is seen that the 5^{th} grade students show remarkable enthusiasm about entrepreneurship education (Deveci, 2018; Ortaakarsu & Can, 2019). Thus, individuals find a chance to acquire these skills from the early ages. According to the developing science, engineering and entrepreneurship skills objectives of the science curriculum (MEB, 2018), it is suggested that these kinds of activities containing these skills should be implemented by teachers. Besides, for improving students' science, engineering and entrepreneurship skills, it is also suggested that these kinds of activities should be developed and used in lower grades more.

REFERENCES

Aslam, F., Adefila, A., & Bagiya, Y. (2018). STEM outreach activities: An approach to teachers' professional development. *Journal of Education for Teaching, 44*(1), 58-70.

Ball, R. W., & Beasley, F. M. (1998). Entrepreneurship awareness education: An example in an elementary school. *Journal of Small Business Strategy, 9*(1), 26-38.

Bartulović, P., & Novosel, D. (2014). Entrepreneurial competencies in elementary schools. *Education for Entrepreneurship - E4E : International Journal of Education for Entrepreneurship*, *4*(1), 83-87.

Bozkurt Altan, E., Yamak, H., & Buluş Kırıkkaya, E. (2016). FeTeMM eğitim yaklaşımının öğretmen eğitiminde uygulanmasına yönelik bir öneri: Tasarım temelli fen eğitimi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 6*(2), 212-232.

Bozkurt Altan, E. (2017). Disipliner yapıdaki derslerde STEM eğitimi: Tasarım temelli öğrenme ve probleme dayalı STEM uygulamaları. S.Çepni (Ed.). *Kuramdan uygulamaya STEAM eğitimi içinde (ss. 165-202). Ankara: Pegem Akademi.*

Bozkurt Altan, E., & Hacıoğlu, Y. (2018). Fen bilimleri öğretmenlerinin derslerinde STEM odaklı etkinlikler gerçekleştirmek üzere geliştirdikleri problem durumlarının incelenmesi. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 12*(2), 487-507.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and engineering teacher, 70*(1), 30-35.

Çepni, S. (2018). *Araştırma ve proje çalışmalarına giriş.* Trabzon: Celepler Matbaacılık.

Ceylan, S., & Özdilek, Z. (2015). Improving a sample lesson plan for secondary science courses within the STEM education. *Procedia-Social and Behavioral Sciences, 177*, 223-228.

Çilek, E. (2019). Effect of gases in temperature change in the atmosphere: A STEM activity. *Journal of Inquiry Based Activities, 9*(2), 109-131.

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

Çorlu, M. S. (2017). STEM: bütünleşik öğretmenlik çerçevesi. M. S. Corlu & E. Çallı (Eds.), *STEM kuram ve uygulamaları* içinde (ss. 1-10). Ankara: Pusula Yayıncılık.

Deveci, İ. (2018). Ortaokul öğrencilerinin fen tabanlı girişimcilik eğilimlerinin incelenmesi. *Journal of Science, Mathematics, Entrepreneurship and Technology Education, 1*(1), 19-47.

Deveci, İ., Zengin, M.N., & Çepni, S. (2015). Fen tabanlı girişimcilik eğitimi modüllerinin geliştirilmesi, uygulanması ve değerlendirilmesi. *Eğitim Bilimleri ve Uygulama (EBULİNE), 14*(27), 59-80.

English, L.D. (2017). Advancing Elementary and Middle School STEM Education. *Int J of Sci and Math Educ* 15, 5–24.

Ercan, S. (2014). *Fen eğitiminde mühendislik uygulamalarının kullanımı: Tasarım temelli fen eğitimi.* Yayımlanmamış doktora tezi, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. L. B. Resnick (Ed.) içinde, *The nature of intelligence* (s. 231-235). Hillsdale, NJ: Erlbaum.

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

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

Hallström, J., & Schönborn, K.J. (2019). Models and modelling for authentic STEM education: reinforcing the argument. *IJ STEM Ed* 6, 22.

Hassi, A. (2016). Effectiveness of early entrepreneurship education at the primary school level: Evidence from a field research in Morocco. *Citizenship, Social and Economics Education, 15*(2), 83-103.

Hernandez, P. R., Bodin, R., Elliott, J. W., Ibrahim, B., Rambo-Hernandez, K. E., Chen, T. W. & de Miranda, M. A. (2014). Connecting the STEM dots: measuring the effect of an integrated engineering design intervention. *International journal of Technology and design Education, 24(*1), 107-120.

Hogan, M., Dwyer, C., Harney , O., Noone, C. & Conway, R. (2014). Metacognitive skill development and applied systems science: a framework of metacognitive skills, self-regulatory functions and real-world applications. A. Peña-Ayala (Ed.) içinde, *Metacognition: fundamentals, applications, and trends* (s. 75-106). London: Springer.

Karahan, E. (2017). STEM eğitim merkezleri. S. Çepni (Ed.), *Kuramdan uygulamaya Stem+A+E eğitimi* içinde (ss. 93-113). Ankara: Pegem Akademi.

Kelley, T. R., & Knowles, G. J. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(11), 1-11.

King, D., & English, L. (2016). Designing an optical instrument: A culminating STEM activity for a primary science light unit. *Teaching Science, 62*(4), 15.

Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action* (CRS report for Congress). Retrieved from http://www.fas.org/sgp/crs/misc/RL33434.pdf

Lambert, A. (2019). Developing skills through creative problem-solving. *Childhood Education, 95*(4), 24-29.

McCallum, E., Weicht, R., McMullan, L. & Price, A. (2018). *EntreComp into action-get inspired, make it happen: A user guide to the European entrepreneurship competence framework* . Luxemburg: Office for Official Publications of the European Union.

Milli Eğitim Bakanlığı (MEB). (2016). STEM eğitimi raporu. Retrieved from: http://yegitek.meb.gov.tr/STEM_Egitimi_Raporu.pdf

Milli Eğitim Bakanlığı (MEB). (2017). *İlköğretim kurumları fen bilimleri dersi öğretim programı* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Milli Eğitim Bakanlığı (MEB). (2018). *Fen bilimleri dersi öğretim programi.* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

National Research Council [NRC]. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics.* Washington: National Academies Press.

Obschonka, M., Silbereisen, R. K., Schmitt-Rodermund, E., & Stuetzer, M. (2011). Nascent entrepreneurship and the developing individual: Early entrepreneurial competence in adolescence and venture creation success during the career. *Journal of Vocational Behavior, 79*(1), 121-133.

OECD. (2019). *Education at a Glance 2019: OECD Indicators.* Paris: OECD Publishing.

Ortaakarsu, F. & Can, Ş. (2019). Ortaokul öğrencilerinin fen tabanlı girişimcilik eğilimlerinin araştırılması. *Eğitim Kuram ve Uygulama Araştırmaları Dergisi, 5*(3), 361-369.

Tozlu, İ., Gülseven, E., & Tüysüz, M. (2019). FeTeMM eğitimine yönelik etkinlik uygulaması: kuvvet ve enerji örneği. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 16*(1), 869-896.

Türkmen, S, Aydınlı, B, & Türkmen, Ş. (2019). Pre-school teachers' views about lifting force of water. *Social Scientific Centered Issues,* 1 (2), 52-58.

So, W. W. M., Zhan, Y., Chow, S. C. F., & Leung, C. F. (2018). Analysis of STEM activities in primary students' science projects in an informal learning environment. *International Journal of Science and Mathematics Education*, *16*(6), 1003-1023.

Şahin, Ç., Mertol, H., Arcagök, S., & Kayapınar, E. (2014). Üstün zekâli öğrenciler ile İlkögretim Ögrencilerinin Girişimcilik Algılarının Karşılaştırılması. *Journal of Educational Science, 2*(3), 32-41.

Yaz, Ö. V, Yüzbaşıoğlu, M. K., & Kurnaz, M. A. (2019). Fen bilimleri dersi 2000 yılı ve sonrası öğretim programlarının konu/öğrenme alanlarının değişimlerinin karşılaştırmalı incelenmesi, *Uluslararası Fen, Matematik, Girişimcilik ve Teknoloji Eğitimi Kongresi*, 12-14 Nisan, İzmir.

Yıldırım, B., & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi. *El-Cezerî Fen ve Mühendislik Dergisi*, *2*(2), 28-40.

Yıldırım, B., & Selvi, M. (2017). STEM uygulamaları ve tam öğrenmenin etkileri üzerine deneysel bir çalışma. *Eğitimde Kuram ve Uygulama, 13*(2), 183-210.

Yıldırım, A., & Şimşek, H. (2011). *Sosyal bilimlerde araştırma yöntemleri.* Ankara: Seçkin Yayınları.

Yılmaz, A., Gülgün, C., & Çağlar, A. (2017). 7. sınıf öğrencilerine "Kuvvet ve Enerji" ünitesinin STEM uygulamaları ile öğretimi: Paraşüt, su jeti, mancınık, akıllı perde ve hidrolik iş makinası (kepçe) yapalım etkinliği. *Journal of Current Researches on Educational Studies, 7*(1), 97-116.

Yılmaz, A., & Yüzbaşıoğlu, M. K. (2019). 5. sınıf fen bilimleri canlılar dünyası ünitesinde bulunan mantarlar konusuna yönelik STEM etkinliği tasarımı. G. Kalkan, H. Göksu (Eds.), *Strateji odakli akademik değerlendirmeler içinde* Lithuanian: Strategic Researches Academy.

Zollman, A. (2012). Learning for stem literacy: stem literacy for learning. *School Science and Mathematics, 112(*1), 12-19.

Addition-1

The school management wants to renew the lighting system because it gets dark in the early hours and the existing lighting is insufficient to light the school garden. The school administration, which wants to illuminate the school garden with the highest efficiency and in the right way, wants to solve this problem together with the students. Students at the school are asked to find ideas about how the lighting system should be replaced with lamps and a project competition is organized.

1- You want to participate in the project competition organized by the school administration. What kind of path do you follow during the project process? Explain.
2- Draw the product you aim to present and explain your drawing.
3- What is your reason for choosing the materials you use in the model you designed? Explain.
4- Develop strategies to introduce the product you have created to the school administration.