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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 7^{th} 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 7^{th} 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."*

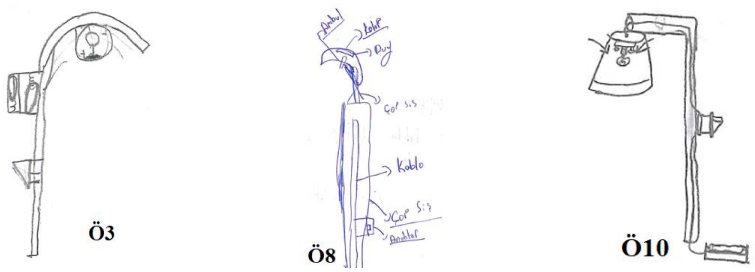
S4. "I try to create a solution on my own."

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.



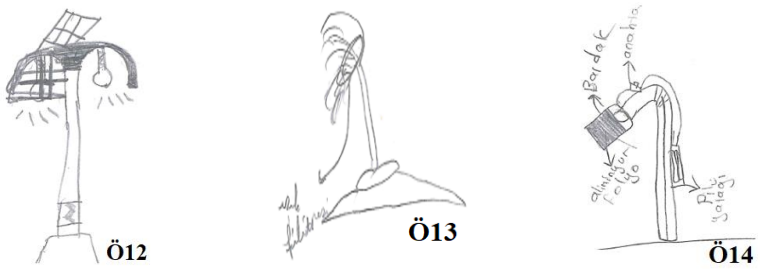


Figure 1. Sample drafts

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.

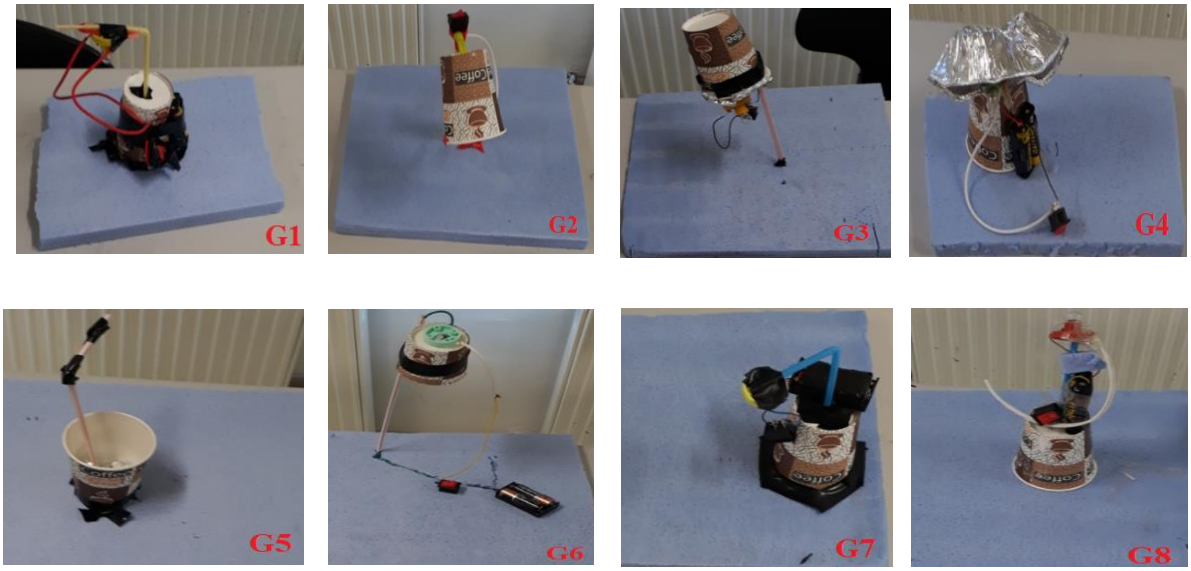


Figure 2. Sample designs

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.

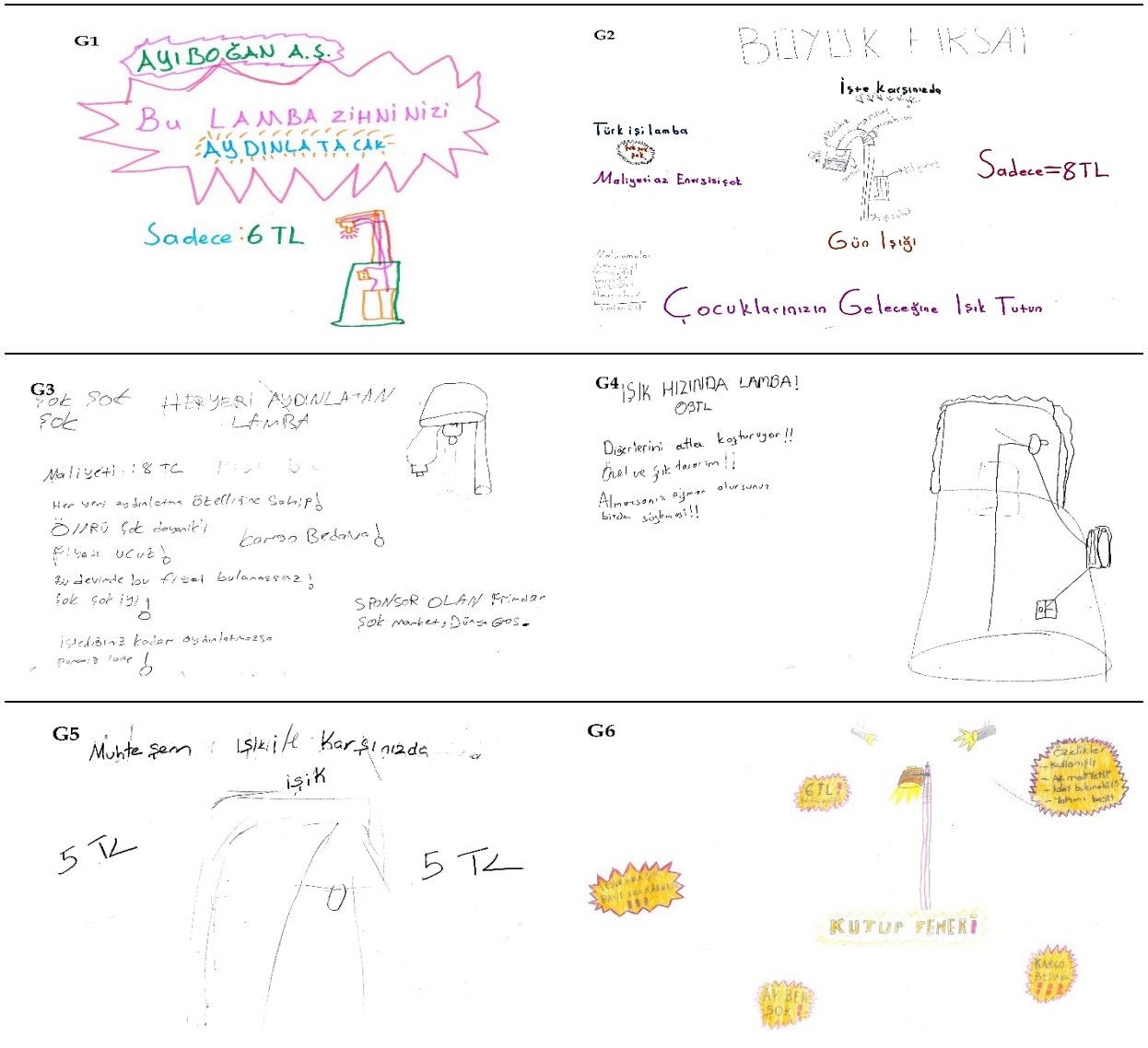


Figure 3. Groups marketing devices

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 7th 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 5th grade. In literature, it is seen that the 5th 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.

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Appendix-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.