



AN APPLICATION SAMPLE BASED ON THE STEM APPROACH WITH ENTREPRENEURSHIP: COLORS

Funda OKUŞLUK, Fatma YAZAR, Ayda GÖK, Fatih ÖZDEMİR, Ali ALBAYRAK

Abstract: In this research, Entrepreneurship and STEM (Science, Technology, Engineering, Mathematics) activity has been established to the gifted secondary school students and to show their applicability. Entrepreneurship and STEM will be shortened as E-STEM. The activity of Colors was implemented at İnönü University Scientific and Technological Research Center (ISTRIC) Laboratories and İnönü University Faculty of Fine Arts with gifted secondary school students. In the study, 14 gifted secondary school students were trained for a week based on the E-STEM approach. The students generated solutions to the problem statuses that were given to them using the components of science, technology, mathematics, engineering and entrepreneurship for a week. They developed products with a higher added-value by combining their imagination and creativity, and implemented studies to commercialize their products. The students designed their prototypes in three groups and then developed their designs by examining the dimensions of art and marketing. When examining the answers given by the students to open-ended questions in the activity evaluation form, it was determined that they thought that the E-STEM oriented activity developed their knowledge and skills in the areas of science, technology, mathematics, engineering, entrepreneurship and art.

Key words: E-STEM, E-STEM Education, Gifted students, STEM

1. Introduction

In our era where information and technology have changed rapidly, it is required for individuals to adapt to novelties. In this context, it is possible to state that individuals should have skills like investigating, questioning, creativity, critical and analytic thinking, decision making (Yamak, Bulut & Dündar, 2014). The necessity for students to have skills that can solve their daily problems and contribute to the needs of society is one of the important factors affecting the quality and standard of education (Danielson, 2002; Şahin, Ayar & Adıgüzel, 2014).

Being originally named Science, Technology, Engineering and Mathematics (STEM) this field is an integrated approach making students adopt creative problem solving techniques (Akgündüz & Ertepinar, 2015). STEM is an educational approach focusing on the integration of Science, Technology, Mathematics, and Engineering knowledge and skills into engineering and design-oriented teaching along with the interdisciplinary cooperation, systematic thinking, openness to the communication, research, production, creativity, and the ability to solve problems in the most appropriate way (Bybee, 2010b; Dugger, 2010; Rogers & Porstmore, 2004) and STEM also promote the Habits of Mind (Costa & Kallick, 2008). The National Research Council/CNC (2011) considers that Science, Technology, Engineering, and Mathematics (STEM) are "cultural achievements that reflect people's humanity, power the economy, and constitute fundamental aspects of our lives as citizens, workers, consumers, and parents". Providing and maintaining the leadership of a state in scientific and economic areas are associated with supporting STEM education and raising awareness of acquiring a profession in STEM areas (Anonymous, 2010; Şahin, Ayar & Adıgüzel, 2014; Smith, 2010).

Received April 2019.

Cite as: Okuşluk, F., Yazar, F., Gök, A., Özdemir, F., Albayrak, A. (2020). An Application Sample Based On The Stem Approach With Entrepreneurship: Colors. *Acta Didactica Napocensia*, 13(1), 138-153, <https://doi.org/10.24193/adn.13.1.13>

Composed of the initials of Science, Technology, Mathematics and Engineering; the concept of STEM is an integrated concept and the disciplines it contains coincide with one another. STEM education is a constantly developing area and there are many different views in this area. Abbreviations like ESTEM, STEAM, S-TEAM have recently been used instead of STEM. The letter “A” here is used as an abbreviation for “Art” comprising esthetics (Bequette & Bequette, 2012; Land, 2013). The letter “E” in ESTEM, on the other hand, represents the term “entrepreneurship” (Akgündüz, Aydeniz, Çakmakçı, et al., 2015).

STEM education grounds on an interdisciplinary approach and develops people’s competitiveness and STEM literacy. STEM education contributes to the global entrepreneurship and establishes connections between school, society and work. It also enables students to establish connections between the areas of science, technology, engineering and mathematics and implement these connections (Thomas, 2014; Eroğlu & Bektaş, 2016).

The literature offers two different program integration models in defining STEM; (a) content integration: combining more than one STEM disciplines in an activity, and (b) context integration: using different STEM contexts to make the content more meaningful (Moore, Stohlmann, Wang, et al., 2014; Baran, Bilici & Mesutoğlu, 2015). STEM education focuses on unique learning and production activities which concentrate on skills like investigating, designing, problem solving, team work and establishing an efficient communication rather than learning the aforementioned areas in an isolated way. Activities that may direct students toward the fields of science, technology, engineering and mathematics using the 21st century knowledge and skills are also included within the scope of STEM education activities (Akgündüz, Aydeniz, Çakmakçı, et al., 2015).

STEM education aims to enable students to (I) acquire STEM knowledge, identify STEM-oriented problems, generate solutions to these problems, (II) realize that STEM disciplines shape our physical, intellectual and cultural world, (III) and develop themselves in terms of producing new information for STEM disciplines (Akgündüz, Aydeniz, Çakmakçı, et al., 2015).

STEM education is tried to be expressed with four features:

- 1) Goals of STEM education,
- 2) Outcomes of STEM education,
- 3) Nature and extent of STEM education,
- 4) Application of STEM education (Figure 1) (Pekbay, 2017).

Entrepreneurs collaborate with experts to solve problems or satisfy needs, develop new products and deliver them to the economy and social life. Thus, they help to create new jobs and close the employment gap. As social needs are met and unemployment is reduced, the welfare level of individuals, consequently society and countries, is rising.

An entrepreneur is the person who brings together and manages services and/or manufacturing activities for profit. The entrepreneur can also be described as a person who is a dreamer, visionary, open to innovation, change agent and living in the future. The entrepreneur takes risks, innovates by starting a new business or producing new products; to this end he pursues changes and opportunities in the environment, tries to evaluate them.

Education has an important role in uncovering the hidden talents of individuals. Entrepreneurship education contributes to students in terms of improving the irability to be enterprising and problem solving.

Project-based or hands-on training for entrepreneurship supports learning. Research on entrepreneurship has shown that formal education and experiences increase students' self-confidence in entrepreneurship, which in turn has a positive relationship with entrepreneurial intention (Zhao, Seibert & Hills, 2005; Basu & Virick, 2008; Balaban & Özdemir, 2008; Cruz, Escuredo, Barahona, et al. 2009; Uygun & Güner, 2016). Research showed that with entrepreneurship courses and applications, students' self-sufficiency (Basu & Virick, 2008), motivation, courage increased, they

gained insight (Zhao, Seibert & Hills, 2005; Hecht, Werner, Raskar et al., 2014), at the same time their creativity, innovation, leadership (Doboli, Kamberova, Impagliazzo et al., 2010) characteristics improved.

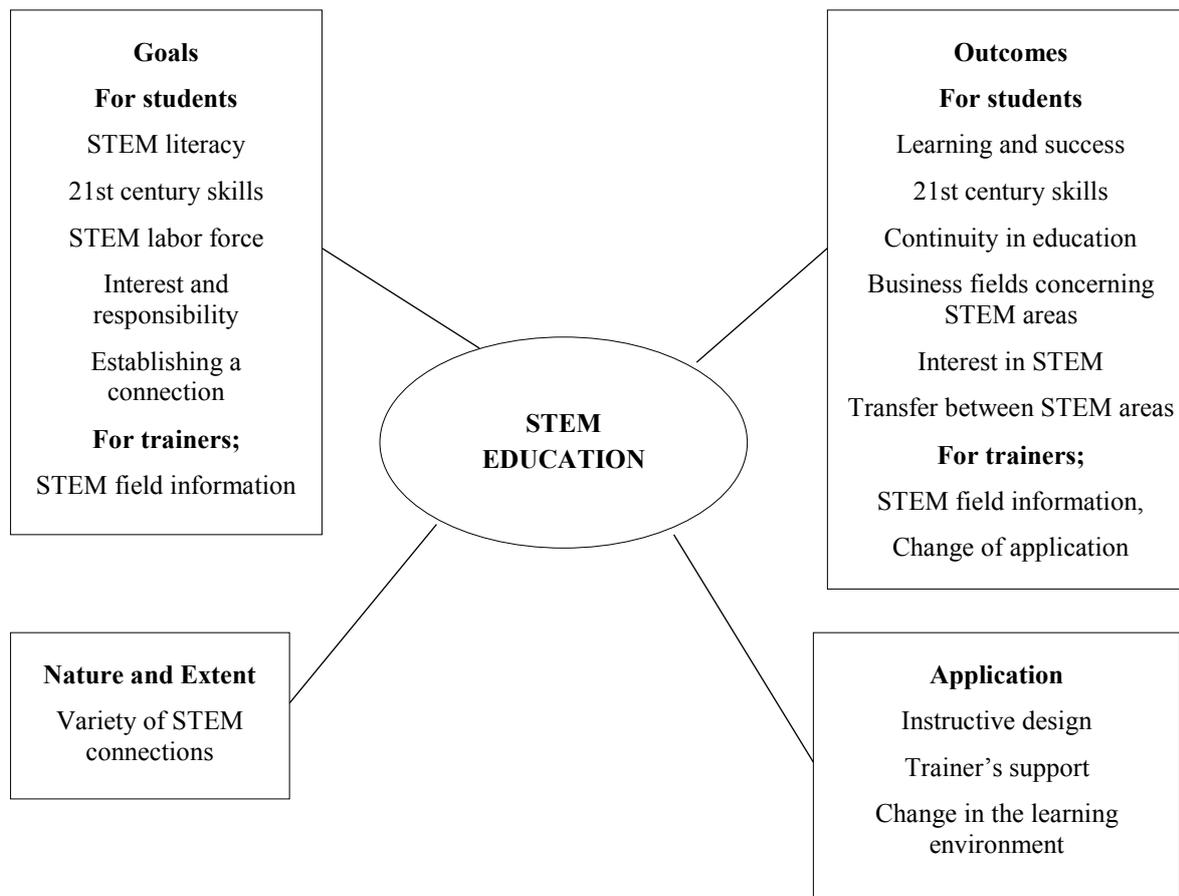


Figure 1. Theoretical Framework of STEM Education (Honey et al., 2014; Cited by: Pekbay, 2017)

In the activity of “Young Engineers’ Brain with STEM”, it was aimed for the students who participated in three applied activities for a week to; realize the importance of science, technology, engineering, mathematics, art and entrepreneurship education and to acquire necessary knowledge and skills, and it was also aimed to determine their E-STEM attitudes and their views about the project.

2. Method

Research Method

In the study, it was aimed to determine the views of the gifted secondary school students on E-STEM education. According to that goal, the study was conducted using the case study method, which is among qualitative research methods. Case study is a qualitative research approach that allows an in-depth study of a subject or situation within a given time frame (Cresswell, 2003)

Sample Group

The sample group of the study consisted of 14 gifted students receiving education at secondary schools within the body of Malatya Provincial Directorate for National Education. An activity of Young Engineers’ Brain with STEM was organized for a week at İnönü University Scientific and Technological Research Center (ISTRC) Laboratories between 29 January -3 February. 6 of these students are male and 8 are female, 57% of the participants are female, while 43% are male. The students not only participated in trainings, but also conducted E-STEM applications for a week.

Thus, the students were allowed to conduct STEM education applications, which have also been included in the national education program, in the academic environment and it was tried to bring a scientific point of view in them.

Data Collection Tools

In this research, "Product Development Book" and "Information Book" and "Personal Information Form" and "Student Diaries" developed by Çorlu (2017) and prepared according to the study were used as data collection tools.

Data Analysis

In this research, "Product Development Book" and "Information Book" and "Personal Information Form" and "Student Diaries" developed by Çorlu (2017) and prepared according to the study were used as data collection tools. The data obtained from the forms were subjected to content analysis. The data obtained from the forms are transcribed. This information is coded separately with the help of two experts. In this coding process, the parts with consensus and disagreement were determined. In this study, coder reliability was calculated with the formula $[(\text{Consensus} / (\text{Consensus} + \text{Disagreement})) \times 100]$ (Huberman & Miles, 1994).

Application Stages of the Study

The study was applied during the fall term holiday in the school year of 2017-2018. The implementation phase of the study was carried out for six days within the scope of the "Young Engineers' Brain with STEM" was organized for a week at İnönü University Scientific and Technological Research Center (ISTRC) Laboratories. The context integration model, which is one of the STEM integration program models, was taken as a basis in these applications. Context integration model involves teaching one of the STEM education contents to the center and teaching other disciplines around this centered content (Moore, Stohlmann, Wang, et al., 2014). Within the scope of this study, it was aimed to establish a connection between this content and other E-STEM disciplines by taking the color and color formation into the center. Thus realize the importance of science, technology, engineering, mathematics, art and entrepreneurship education and acquiring necessary knowledge and skills, and it was also aimed to determine their E-STEM attitudes and their views about the project.

The following steps were followed during the application;

1. The scenario given in Annex A were distributed and then explained to the students. In the scenario, the students were asked to not only generate non-cancerogenic textile products dyed with organic dyes, but also develop a project that would enable the wastes forming as a result of the process to be treated with environment friendly methods.

While designing their projects, they were asked to consider the trainings they had participated in and the activities they had done. The lesson was conducted in 6 stages as Introduction, Grouping and Business Plan, Supporting, Deepening, Experiment and Evaluation.

Problem: You work as an engineer in a textile factory. You have been chosen to develop a research project implemented by the World Health Organization (WHO). The organization demands you to develop a project that would enable you to not only generate non-cancerogenic organic dyes, but also prepare products colored with organic dyes. What kind of a project can you develop for this?

Disciplinary Acquisitions: In this activity, five different E-STEM disciplines are tried to be taught integrately.

**Science:* The student learns how to attain dyes from the plastids of plants. She or he learns how to treat wastes and detrimental substances using active carbon.

**Technology:* She or he designates how to treat using active carbon.

**Engineering:* She or he produces dyes, colors and designs an environment friendly treatment facility.

**Mathematics:* She or he learns weight measures and percentage calculations.

***Entrepreneurship:** She or he designs a product on which the acquired organic dyes can be used and also designs a brand name, brand sign (symbol), slogan and a package to market the product.

Materials: Ginger, Savoy Cabbage, Water, Mint, Ethanol, Beaker, Scoop, Dropper, Towel, Citric Acid, Glass Rod, Measure, Active Carbon, Filter Paper, Cone.

Limitations:

Only the specified materials should be used.

The product should be attained in a specified time.

Introduction to the Lesson:

It is seen that cancer risk has increased in our era. The studies suggest that especially young children have a higher risk of having cancer. It has been determined that artificial colorants used in food and textile sectors contain cancerogenic or cancer-triggering substances. Starting from this point of view; can you establish an environment friendly factory where textile products are colored with natural dyes?

The activity starts with the aforementioned text and the participants are asked to exchange opinions in relevant groups and conduct researches on the subject.

Grouping and Business Plan:

Each group is separated into groups of five people. The groups are given time to make discussions and brainstorm among themselves so that they can generate ideas. During that time, opinions and discussions of the groups are involved even for a moment in order for them to solve their problems.

Supporting:

The participants are informed about color concept, reason of seeing objects with colors, active-carbon and its area of utilization and methods of attaining natural dyes, and they are also asked to exchange opinions among themselves.

Experiment:

- Ethanol is added to ginger and the colorant attained with heating is filtered and it leaves the environment.
- Ethanol is also used for attaining a colorant from mint. The same processes are applied with ginger.
- Savoy cabbage is boiled in water to attain a colorant.
- After these processes, yellow, purple and green dyes will be formed.
- Dyes attained from plants are boiled in citric acid and will be used in dyeing white towels.
- The attained product will be washed and dried.
- Coloring wastes will be cleaned using active carbon.
- Conventional and modern colorings will be taught.
- They will develop a brand name, brand sign, slogan and a package to commercialize their organic dyes and fabrics.

Deepening:

They are asked to conduct researches and develop opinions about what else they can do concerning the concepts they learn and apply and how they can utilize these concepts.

Evaluation:

The students evaluate the products they attained with the help of a self-evaluation rubric.

2. The students were asked to have a division of labor within the group. The tasks of typer, researcher, designer and implementer were shared within the group for the purpose of creating a collaborative learning environment.
3. The trainers and counselors provided each group a computer with internet connection. The groups were asked to do research to find a solution to the problem and to fill in the Information Acquisition Books given in Annex B.
4. After collecting relevant information, a group discussion was made and they were asked to create their prototypes using certain materials and considering the limitations.
5. The students went to workshops within the body of Faculty of Fine Arts and took art, marketing and advertising classes there.
6. The students filled in Product Development Books depending on the prototypes they developed (Annex C). While filling in product books in this stage, the students were informed about the following factors to be paid attention to;
 - Product properties and introduction should be given clearly.
 - A brand name, brand sign, slogan and a package should be determined for the product.
 - A main assurance and its benefits should be emphasized clearly to commercialize the product.
7. An approval was received from the trainers and then they were enabled to finalize their products.
8. A project website, www.stemanadolu.com enabling an access to the project content and images was shared with the students so that they could contribute to the project of “Young Engineers’ Brain with STEM” and express their opinions.
9. The groups were informed about the self-evaluation form (Annex D) which they could use in evaluating themselves.
10. At the end of the activity, each group presented their products for 5 minutes.
11. The activity was terminated after the students filled in activity diaries including five open-ended questions (Annex E). These questions are as follows; (1) Which problems have you solved? (2) What has compelled you the most? (3) What has pleased you the most? (4) How did you feel to work as a team? (5) What have you learned?
12. The entire process was evaluated using the Evaluation Rubrics as shown in Annex F.

3. Results

In this section, there are comments of gifted students about their product designs, slogans and views of E-STEM fields and education within the framework of activity logs answered by students. Firstly, the answers given by the gifted children were examined and coded. Then these codes were collected under categories. The data acquired from the content analysis were supported using descriptive analysis. While presenting the data in the descriptive analysis, the participants were enumerated instead of person names (S1, S2,.....).

At the end of application steps, the students designed an energy capsule that could keep full for seven hours as a product. The product can be used in keeping full in cases where there is a limited possibility of eating or during busy shifts where a person is unable to eat.

The students developed a brand named “ASTRO-eat” for their energy capsule (Figure 2). Because it is planned to market the product abroad, the brand name is selected as English. “Astro” connotes astronomy and space, which is useful for attracting the attention of the target audience. It is emphasized that the product can be used by astronauts and thus, meets the needs of our era. The word “eat” is used in the brand name for the purpose of indicating that the product can keep full just like food and be consumed instead of food. The slogan that has been developed also emphasizes this condition: “When you can’t eat, ASTRO-eat”.

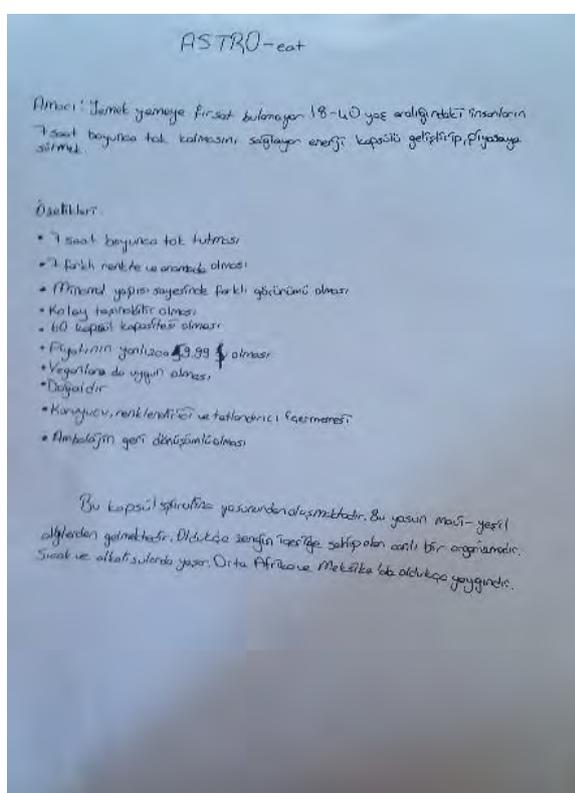


Figure 2. Energy capsule designed by students.

Energy capsules are circular and have a natural content. They are colored using seven different organic dyes and designed with seven different aroma contents. Primary package of the product is designed as round just like the energy capsule and looks like a planet. Thus, there is an integrity between the brand name, product form and package form in regard to the connotation of astronomy. This integrity makes it easier for the target market to keep the product and package in mind.

Because the capsules keep full for seven hours and are designed in seven different colors and aromas, the label on the package design emphasizes the number “seven (7)”, which has provided an integrity in terms of marketing communication. In order for marketing communication to succeed, it is important for activities like brand, package, advertisement and personal sales to give consistent messages supporting one another and aim the same goal. Messages repeated in each marketing communication activity create a permanent and powerful effect on the target customers.

The product package was designed in a recyclable way to protect the environment. The target customer mass was identified, benefits and properties of the product have been arrayed and the price was established to commercialize the product (Figure 3).



Aim: To develop an energy capsule that keeps people between the ages of 18-40, who have had no opportunity to eat, for 7 hours.

Properties:

- Steady for 7 hours
 - 7 different colors and flavors
- Having different view
- Easy to be portable
- Having capacity of 60 capsules
- 59.99 dollars for the price alone
- be natural
- no preservatives, sweeteners and colorants
- packaging recyclable

This capsule consists of spirulina algae. Spirulina comes from blue-green algae. It is a living organism with a very rich content. This type of algae lives in warm and alkaline waters. It is quite common in Central Africa and Mexico.

Figure 3. ASTRO-eat promotion brochure

Following are interpretations of the views of the gifted students on E-STEM areas and education within the frame of activity diaries answered by the sample group. Firstly, the answers given by the gifted children were examined and coded. Then these codes were collected under categories. The data acquired from the content analysis were supported using descriptive analysis. While presenting the data in the descriptive analysis, the participants were enumerated instead of person names (S1, S2,.....). Some of the students' worksheets are as follows (Figure 4 & Figure 5).

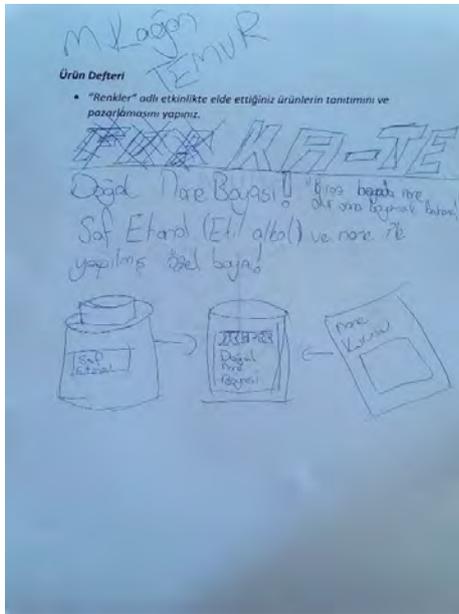


Figure 4. Student Product Book Example

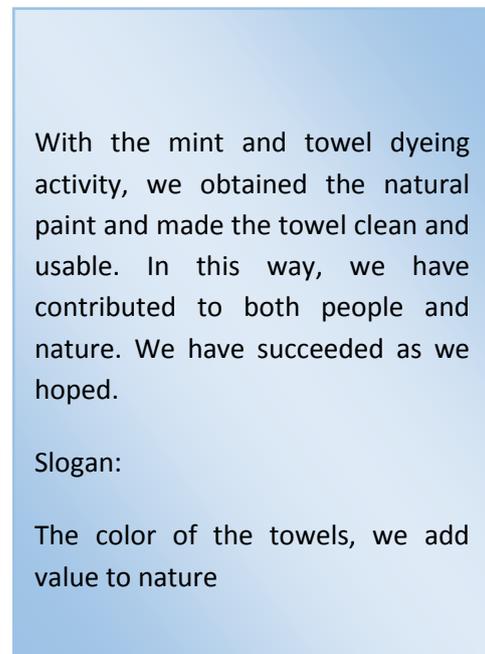
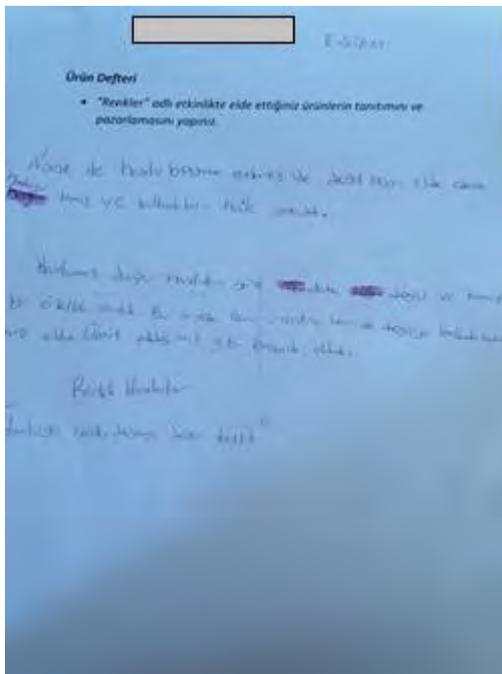


Figure 5. Student Product Book Example

The towels they designed with the paints prepared by the students are shown in Figure 6 and Figure 7.



Figure 6. Towel painted with organic paint



Figure 7. Towel painted with organic paint

The opinions of the gifted students about the positive and negative opinions they have after E-STEM applications and the relationship between the STEM disciplines are given in Table.

When examining Table, it was seen that the views of the gifted students on E-STEM education were collected under three titles. Accordingly, the students usually mentioned about the benefits of E-STEM education. In addition, 28% of the students indicated that the areas in E-STEM education were correlated, 21% indicated that the components completed one another and 50% stated that the disciplines were intertwined. While 28% of the students defined the process as difficult, 7% as boring, 50% as complicated, and 14% stated that working as a team was a negativity.

Following are the examples of the students' views on the activity of Colors.

"During the experiment, I had a difficulty in researching. I had the greatest joy while doing the experiment. Working as a team made me feel a sense of unity and solidarity. Today I learned a lot of things about dyes."S1

"Today was an exciting day at STEM. We moved from one laboratory to another all the time. We made natural dyes to remove the hazards of synthetic dyes. To be honest, I had no difficulty at all. I saw that a lot of substances like ethanol were colorants."S2

"I had a difficulty in chopping the beet. I had the greatest joy while draining the beet. It felt good to work as a team. I found out that natural dyes could be attained from natural materials."S3

"I had a difficulty in pressing the juice of the beet. I had the greatest joy while coloring the towel. I found out that working as a team provided a convenience and dyes could be attained not only chemically, but also from the roots of vegetables. Because we worked as a team, I got less tired and we were able to finish our work more quickly. By working in this project as a team, we were able to solve some problems in natural ways without polluting the environment." S4

Table : Views of the Gifted Students on the E-STEM Application

Categories	Codes	f	%
	Permanent Learning	12	85%
	Efficiency	13	92%
	Contribution to Comprehension	8	57%
	Learning by	9	64%

Benefit	Practicing-Experiencing			
	Developing a Sense of Creativity and Curiosity	10	71%	
	Artistic Thinking	12	85%	
	Design-Oriented Thinking	10	71%	
	Developing a design	12	85%	
	Problem Solving	8	57%	
	Developing the Communication Skill	11	78%	
	Developing a Sense of Taking Responsibility	10	71%	
	Critical/Creative Thinking	11	78%	
	Developing a Skill of Design/Imagination	12	85%	
	Acquiring a Skill of Empathy	7	50%	
	Mutual Interdisciplinary Relationship	Being Coordinated	4	28%
		Complementary	3	21%
Integrated		7	50%	
Negativities	Difficult	4	28%	
	Boring	1	7%	
	Complex	7	50%	
	Working as a team	2	14%	
Total		14	100%	

“I had an opportunity of asking some questions. I had great fun coloring the towel. I learned a lot of things in the fields of chemistry and art.”S5

“Today we made natural dye. I had a little difficulty in cutting the beet. I had the joy while submerging the towel in the beet juice. Working as a team strengthened solidarity and collaboration and increased self-confidence and happiness. I found out that lemon had a permanence and the color of the substance in the lemon would uncover better after boiling the water. I had a really fun day.”S6

“I had a great difficulty in filtering the mint after the process of boiling. I had great fun coloring the towel, which was the final stage of the study. I felt both proud and excited working as a team. I learned how to make madder and how to use it.”S7

“The project was obviously terrific. It was rational and mind developing. I liked working as a team and helping each other. We solved the problems together and did almost nothing personal. To be honest, instead of having difficulty in thinking, I got really nervous when the water filled with cabbage did not boil. Then, we found out that it didn't boil because we had added too little water and too much cabbage. After the water boiled, the process of filtering was really fun and I liked mixing and filtering active carbon and cabbage juice.”S8

“During the experiment, I had a difficulty in waiting for the water to boil. As a group, we had a lot of fun during the experiment. We worked as a team in harmony, which was great. I learned that natural madder could be attained only from vegetables/fruits.”S9

“We produced an alternative to cancerogenic dyes. It was difficult for me to work without any break. On the other hand, it was fun to watch the changes after adding carbon.”S10

“We found a solution to cancerogenic dyes. It was fun to work as a team. It felt so good to have people who would help and support me. I learned a lot of things about the properties of active carbon, polymers, effects of UV rays, and moisture meters.”S11

“I removed cancerogenic substances and cleaned the waste water. I had a difficulty in waiting because we had added too much cabbage to the water. It was a lot fun to color the towel. It felt so good to work as a team. I learned how to make madder and how to clean water.”S12

4. Conclusion

In this activity which was implemented as a team work, the students expressed their opinions about E-STEM activities through products that they designed providing an interdisciplinary integration. When examining the students’ activity diaries; it was observed that they developed attitudes and knowledge concerning the areas of science, engineering, technology, mathematics, and entrepreneurship. The four criteria presented in Annex-6 as content, product development, team work and responsibility, and time management were used in evaluating the products.

In their answers to open-ended questions in the activity diaries; the students indicated that the activity of Colors developed their problem solving and creative thinking skills, making collaboration within the group eased the process, and they learned while having fun and enjoyed the learning environment.

When the students were asked about what compelled them in the activity of Colors the most; they emphasized some problems in the process of working in collaboration, process of filtering, making researches and time limitation. In addition, the students indicated that they could use the knowledge and skills that they had learned at school.

In the study, the activity of Colors implemented within the scope of the project of Young Engineers’ Brain with STEM was carried out with an academic member who was specialized in the area of Chemistry and was responsible for the activity, an academic member who was specialized in the Faculty of Fine Arts and Design Department of Graphic Design, an academic member who was specialized in the area of production management and marketing, a STEM trainer, a graduate student studying in the area of science education and voluntary undergraduate students. Counselors and academic members who participated in the project were experienced in the processes of design and development. It is suggested to conduct relevant activities in collaboration with experts in different branches of the activity so as to meet the questions and demands of groups during studies. While creating the sample groups for students, it is suggested to evaluate their preparedness, knowledge and skills concerning the E-STEM and STEM compounds before the activity and include heterogeneous students with different knowledge and skills in the groups.

Changes in the students’ attitudes can be observed more clearly by extending the duration of activity. It is suggested to conduct activities with a larger sample group.

References

- Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Corlu, M. S., Öner, T. & Özdemir, S. (2015). STEM Eğitimi Türkiye raporu: Günün modası mı yoksa gereksinim mi? [A report on STEM Education in Turkey: A provisional agenda or a necessity?]. İstanbul, Turkey: Aydın Üniversitesi. Retrieved from: <http://www.aydin.edu.tr/belgeler/IAU-STEM-Egitimi-Turkiye-Raporu-2015>
- Anonymous, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/175406/CPTF_-_External_Report.pdf (Retrieved 08.04.2019).
- Balaban, Ö. & Özdemir, Y. (2008). Girişimcilik Eğitiminin Girişimcilik Eğilimi Üzerindeki Etkisi: Sakarya Üniversitesi Örneği [The Effect of Entrepreneurship Education on Entrepreneurship Tendency: The Case of Sakarya University]. *Girişimcilik ve Kalkınma Dergisi*, 3 (2), 134-148.
- Baran, E., Canbazoğlu-Bilici, S., & Mesutoğlu, C. (2015). Fen, teknoloji, mühendislik ve matematik (FeTeMM) spotu geliştirme etkinliği [Science, technology, engineering and mathematics (STEM) spot development activity]. *Araştırma Temelli Etkinlik Dergisi (ATED)*, 5(2), 60-69.
- Basu, A. & Virick, M. (2008). Assessing Entrepreneurial Intentions Amongst Students: A Comparative Study. In *12th Annual Meeting of the National Collegiate Inventors and Innovators Alliance*, Dallas, USA.

- Bequette J. W. & Bequette, M. B. (2012). A Place for Art and Design Education in the STEM Conversation. *Art Education*, 65(2), 40-47.
- Bruce, H., Werner, A. J., Raskar, R., Jouttenus, T. T., Khandbahale, S. S., Jouttenus, M. J., Bell, P. (2014), A Model for STEM Education and Social Entrepreneurship, *4th IEEE Integrated STEM Education Conference*, March 8, Princeton, NJ.
- Bybee, R. W. (2010a). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, 70(1), 30-35.
- Costa, A. L., Kallick, B. (2008). Learning and Leading with Habits of Mind: 16 Essential Characteristics for Success, ASCD.
- Creswell, J. W. (2003). Research design: Qualitative, quantitative, and mixed methods approaches (2nd ed.). Thousand Oaks, CA: Sage.
- Cruz, N. M., Escuredo, A. I. R., Barahona, J. H., & Leitao, F. S. (2009). The Effect of Entrepreneurship Education Programmes on Satisfaction with Innovation Behaviour and Performance. *Journal Of European Industrial Training*, 33, 198-214.
- Çorlu, M. S. (2017). STEM: Bütünleşik öğretmenlik çerçevesi [STEM: Integrated teaching framework]. In M. S. Corlu & E. Çallı (Eds.), *STEM Kuram ve Uygulamaları* (Pp. 1–10). İstanbul: Pusula.
- Danielson, C. (2002). *Policies and Practices Affecting Students In Enhancing Student Achievement*, Retrieved 31.03.2019. <http://www.ascd.org/publications/books/102109.aspx>
- Doboli, S., Kamberova, G. L., Impagliazzo, J., Fu, X., Currie, E. H. (2010). A Model of Entrepreneurship Education for Computer Science and Computer Engineering Students, *IEEE Frontiers in Education Conference*, Washington, DC, ABD.
- Dugger, W. (2010). Evolution of STEM in the United States. In *Technology Education Research Conference*. Queensland.
- Eroğlu, S., & Bektaş, O. (2016). STEM Eğitimi Almış Fen Bilimleri Öğretmenlerinin STEM Temelli Ders Etkinlikleri Hakkındaki Görüşleri [STEM-trained science teachers STEM-based opinions about lesson activities]. *Eğitimde Nitel Araştırmalar Dergisi*, 4(3),43-67. DOI:10.14689/issn.2148-2624.1.4c3s3m
- Huberman, A. M., & Miles, M. B. (1994). Data management and analysis methods. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (p. 428–444). Sage Publications, Inc.
- Land, M. H. (2013). Full STEAM Ahead: The Benefits of Integrating the Arts into STEM. *Procedia Computer Science* 20, 547 – 552.
- Moore, J.T., Stohlmann, M.S., Wang, H.H., Tank, K.M., Glancy, A.W., Roehrig, G.H. (2014). Implementation and integration of engineering in K-12 STEM education. In *Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices* (pp. 35-60). Purdue University Press.
- National Research Council (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics. Committee on Highly Successful Science Programs for K-12 Science Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education*. Washington, DC: The National Academies Press.
- Pekbay, C. (2017). *Fen, Teknoloji, Matematik ve Mühendislik Etkinliklerinin Ortaokul Öğrencileri Üzerindeki Etkileri [Effects of Science Technology Engineering and Mathematics Activities on Middle School Students]*. (Doctoral dissertation). Retrieved from <http://www.openaccess.hacettepe.edu.tr:8080/xmlui/handle/11655/3285>.
- Rogers, C. & Portsmore, M. (2004). Bringing engineering to elementary school. *Journal of STEM Education*, 5(3), 17-28.

Smith, E. (2010). Women into science and engineering? Gendered participation in higher education STEM subjects. *British Educational Research Journal*, 37(6), 993-1014.

Şahin, A., Ayar, M. C., & Adıgüzel, T. (2014). Fen, teknoloji, mühendislik ve matematik içerikli okul sonrası etkinlikler ve öğrenciler üzerindeki etkileri [Science, technology, engineering and mathematics content in after-school activities and its effects on students]. *Kuram ve Uygulamada Eğitim Bilimleri*, 14(1), 1-26. doi: 10.12738/estp.2014.1.18763.

Thomas, T. A. (2014). *Elementary teachers' receptivity to integrated science, technology, engineering, and mathematics (STEM) education in the elementary grades*. (Doctoral dissertation). Retrieved from Proquest. (3625770).

Uygun, M. & Güner, E. (2016). Girişimcilik Eğiliminin Gelişiminde Girişimcilik Eğitiminin Rolü [The Role of Entrepreneurship Education in the Development of Entrepreneurship Tendency], *Manas Sosyal Araştırmalar Dergisi*, Cilt: 5, Sayı: 5, 37-57.

Yamak, H., Bulut, N., & DüNDAR, S. (2014). 5. Sınıf Öğrencilerinin Bilimsel Süreç Becerileri ile Fene Karşı Tutumlarına FeTeMM Etkinliklerinin Etkisi [The Effect of STEM Activities on 5th Grade Students' Attitudes towards Science with Scientific Process Skills]. *Gazi Eğitim Fakültesi Dergisi*, 34(2), 249-265. DOI: dx.doi.org/10.17152/gefd.15192.

Zhao, H., Seibert, S. E. & Hills, G. E. (2005). The Mediating Role of Self-Efficacy in the Development of Entrepreneurial Intentions. *Journal of Applied Psychology*, 90(6), 1265-1272.

Authors

Funda OKUŞLUK, İnönü University, Faculty of Education, Malatya (Türkiye). E-mail: funda.gurer@inonu.edu.tr

Fatma YAZAR, İnönü University, Institute of Educational Sciences, Malatya (Türkiye). E-mail: yazar.fatma2016@gmail.com

Ayda GÖK, İnönü University, Faculty of Communication, Malatya (Türkiye). E-mail: ayda.gok@inonu.edu.tr

Fatih ÖZDEMİR, Nevşehir Hacı Bektaş Veli University/Faculty of Fine Arts Department of Visual Communication Design E-mail: mfatihozdemir@gmail.com

Ali ALBAYRAK, Bahçeşehir College, Malatya (Türkiye). E-mail: alialbayrak82@gmail.com

Acknowledgement

This research was supported by the Inonu University Scientific Research Projects Coordination Unit (SCD-2018-738 grant number).

ANNEX A. Scenario Given to the Students

Problem: You work as an engineer in a textile factory. You have been chosen to develop a research project implemented by the World Health Organization (WHO). The organization demands you to develop a project that would enable you to not only generate non-carcinogenic organic dyes, but also prepare products colored with organic dyes. What kind of a project can you develop for this?

Materials:

- | | |
|-----------------|----------------|
| - Ginger | - Filter Paper |
| - Savoy Cabbage | -Cone |
| - Water | - Scoop |
| - Dropper | - Mint |
| - Ethanol | - Towel |

- Citric Acid
- Measure
- Beaker
- Glass Rod
- Active Carbon

Limitations:

- Only the specified materials should be used.
- The product should be attained in a specified time.

ANNEX B. Information Books To Fill in Before the Activity**Information Books**

- What do you know about the subject and what are your preliminary information?
- What information do you need to have in order to conduct the study?
- What are the ways to follow and resources to use in the application?
- What have you learned?

ANNEX C. Product Development Books To Fill in During the Activity**Product Development Books**

- Draw a draft of your product.
- Test your product and report the results.
- What different properties can you add to your product and develop it?
- In what areas can you use the product that you have designed?

ANNEX D. Self-Evaluation Form**SELF-EVALUATION FORM**

Name Surname:

Class:

This form has been prepared for you to evaluate yourself. Please mark an option reflecting your activities the best (X).

SKILLS	RATINGS		
	Always	Sometimes	Never
I comprehended the problem accurately.			
I generated distinctive solutions the problem.			
I used an interdisciplinary point of view while solving the problem.			
I fulfilled my responsibilities within the group.			
I filled in my information and product books regularly and precisely.			
I used my time properly during my work.			
I acted according to my plan throughout the process of design.			
I have designed a product with such a functionality that it can solve the problem.			
My product is improvable and I prepare it as transformable to different forms.			
I paid a particular attention to developing a genuine, esthetical and practical product.			

The things I did the best during this activity and my other comments;

ANNEX E. Students' Activity Diaries



STUDENTS' ACTIVITY DIARIES



Name Surname:

Group:

How did you spend your day in the project of Young Engineers' Brain with STEM and what did you do today? Let's create a diary by following the clues.

- 1- Which problems have you solved?
- 2- What has compelled you the most?
- 3- What has pleased you the most?
- 4- How did it feel to work as a team?
- 5- What have you learned?

ANNEX F. Evaluation Rubric

	3	2	1	Total Score
CONTENT	<p>Comprehended the problem accurately,</p> <p>Used the limiters accurately,</p> <p>Expressed the information required to solve the problem precisely and accurately,</p> <p>The way followed and the information used were accurate and valid.</p>	<p>Comprehended the problem partially,</p> <p>Did not use all of the limiters,</p> <p>Did not classify the information required to solve the problem regularly.</p>	<p>Did not comprehend the problem accurately,</p> <p>Did not use the limiters accurately,</p> <p>Expressed the information required to solve the problem with deficiencies.</p>	
PRODUCT DEVELOPMENT	<p>The product; met the criteria and was genuine, improvable and practical in a way to solve the problem.</p> <p>The designed product reflected the student’s imagination and creativity.</p> <p>The students filled in the information and product development books carefully and precisely.</p>	<p>The designed product was formed with minimum deficiency to solve the problem to a large extent.</p> <p>The students filled in the information and product development books.</p>	<p>The product was not designed in a way to solve the problem.</p> <p>Some deficiencies were determined in the information and product development books.</p>	
TEAM WORK and RESPONSIBILITY	<p>Each student developed a sense of belonging to the group, adapted to collaborative work and fulfilled their task in the group precisely.</p> <p>All of the students took equal responsibilities in solving the problem and worked in collaboration.</p> <p>The students kept their activity diaries regularly.</p>	<p>It was observed that some of the students avoided responsibility and showed no interest at all.</p>	<p>It was observed that group members did not work in collaboration and they showed no interest at all.</p>	
TIME MANAGEMENT	<p>Solution offers were developed in a specified time and they were applied accurately and precisely.</p>	<p>Solution offers were developed in a specified time, but some inconveniences were encountered in practice.</p>	<p>No solution offer was developed in a specified time.</p>	