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EXAMINING PROJECT-BASED STEM TRAINING IN A PRIMARY SCHOOL

Research Article

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Abstract

This research primarily aims to examine project-based STEM training implemented in a state primary school in Turkey regarding teachers' and students' views. The phenomenological design, which is one of the qualitative research designs, was exclusively adopted in the study. The research sampling consisted of 18 students and 2 teachers working at a state primary school located in an Anatolian province during the 2017-2018 academic year. The research data were collected through interviews some of which were voice-recorded and analyzed through content analysis. Research findings revealed that successful implementation of STEM practices necessitates a systematic working plan consisting of preparation, implementation and evaluation stages. Besides, it was revealed that STEM training practices facilitate unearthing students' talents and developing their critical thinking and problem-solving skills as well as manual dexterity. The research findings also suggested that these practices increase cooperation among students, help them develop a positive attitude towards the lesson and behave more carefully during the classes. Nonetheless, various problems such as inadequate space, teaching materials and group-work driven problems were observed during STEM practices. Based on the research findings, it is suggested that STEM training should be separately implemented without being included in a single discipline.

Keywords: STEM, Science, Technology, Engineering, Mathematics

1. Introduction

21st century individuals are expected to have well-developed thinking and problem solving skills, to know when, how and where to use their knowledge, to be technologically literate, to make quick and accurate decisions, to work in groups, to establish effective communication, to have lifelong learning skills and to come up with a product (Akgündüz et al., 2015; Duban & Ay, 2016; Ministry of National Education [MoNE], 2018; Ocak, 2010). It is well-documented that STEM (Science, Technology, Engineering and Math) training plays an important role in training of individuals equipped with these skills (Duban & Ay, 2016). Therefore, the countries aiming to raise a generation equipped with high level skills adopt STEM training (Bybee, 2010). The idea that STEM training will be a solution to the current problems of the world makes this concept very popular and important (Labov, Reid, & Yamamoto, 2010).

Although the history of STEM training dates back to the 1990s (Bybee, 2010), it has been extensively investigated since 2001 (Breiner, Harkness, Johnson & Koehler, 2012). Furthermore, it has become one of the most debated issues in the international area (Kennedy & Odell, 2014; Labov et al., 2010). This is attributed the increasing popularity of the belief that science and technology will make significant contributions to solving the current problems such as climate change, population growth and the problems related to energy, water, health, agriculture and environment (Thomas & Watters, 2015). In addition, the fact that modern economic organizations need qualified researchers and technical staff is another factor that enables STEM training to be brought to the agenda in international context (Kennedy & Odell, 2014).

STEM education involves teaching the separate disciplines of science, mathematics, technology and engineering with an interdisciplinary approach and as one cohesive entity (Akgündüz et al., 2015; Breiner et. al., 2012; Gonzalez & Kuenzi, 2012). Instead of isolation of science, technology, engineering and mathematics from each other, STEM training emphasizes original production and learning activities by employing research, design, problem solving, teamwork and communication skills (Duban & Ay, 2016). It aims to realize learning from a holistic perspective by associating a unit or course with examples from real life problems (Bozkurt, 2014; Smith & Karr-Kidwell, 2000). It can be carried out in all educational processes from formal to informal learning environments, from kindergarten to doctorate (Altunel, 2018; Gonzalez & Kuenzi, 2012; MoNE, 2018). As a result, students can learn beyond memorization and put the acquired knowledge into real-life practices, improve their problem-solving skills, learn to work together, wonder and come up with products.

STEM education which is supported in many countries especially in the USA, Korea, China and the UK (Yıldırım, 2016) has gained significance in Turkey in recent years (Herdem & Ünal, 2018). Initial studies about STEM have been conducted by Hacettepe University and İstanbul Aydın University. Both universities founded their own STEM training centers (Akgündüz et al., 2015). Subsequently, many studies have been conducted with a focus on teacher training and program design related to STEM training at different universities (Kızılay, 2017). Besides, the MoNE General Directorate of Educational Innovation and Technology (YEĞİTEK) has been the representative of Scientix Project carried out by European Schoolnet (European Schoolnet) since 2014. Within the scope of the project, YEGITEK organizes STEM training workshops for teachers working in STEM branches in secondary and vocational and technical education schools to develop STEM projects and create an environment to share project ideas (MoNE, 2018). In addition to these initiatives, STEM centers have been established with the support of different universities and provincial directorates of MoNE. These centers provide the opportunity to extend STEM training and research in this field. At the same time, these centers can play an active role in teacher education, in-service teacher training and the integration of STEM subjects into the curriculum (Çepni, 2018).

Dugger (2010) advocates that STEM training is conducted in four ways. The first one involves teaching each discipline separately at school. This is defined as traditional STEM. In the second one, one or two disciplines are emphasized (SteM). The inability to meet the necessary standards for T and E of STEM has highlighted this method in STEM programs. Third, STEM is taught by integrating one STEM discipline into the other three (M; S-T-E). This is mostly in the form of integrating engineering into science, technology and mathematics courses with classroom engineering practices. In the fourth one, STEM training is conducted in an integrated manner by linking all four disciplines with an interdisciplinary approach. STEM schools established in the USA can be given as an example of this teaching method.

The review of the relevant literature indicates that STEM programs have been developed in different countries; however, it has resulted in diversity in practice since no consensus has been reached on the meaning of STEM (Akgündüz et al., 2015; Çepni, 2018). It is also seen that the studies have been mostly conducted on science and mathematics integration, and engineering practices and coding education (Çepni, 2018). In this context, the 2018 curriculum revision in Turkey has facilitated the integration of such new areas as coding and robotics into education (Ulutan, 2018). STEM issues were arranged as science, engineering and entrepreneurship practices in the 2018 Science Curriculum in Turkey. Accordingly, a small number of outcomes that require STEM training were integrated into the units across the curriculum (Seren & Veli, 2018). According to the instructions in the section of Science, Engineering and Entrepreneurship Practices, students are expected to carry out practices throughout the year and to exhibit their products during the science festival to be held at the end of the year (Bahar, Yener, Yılmaz, Emen & Gürer, 2018; MoNE, 2018). Although the 2018 Science Curriculum contains some explanations and outcomes regarding STEM, there are still uncertainties about STEM training (Bahar et al. 2018).

STEM training is essential for countries to become leaders in science and technology, to develop economically and to increase their competitiveness (MoNE, 2018; Lacey & Wright, 2009). It is believed that STEM training will increase the quality of individuals and education and meet the expectations of the business world (MoNE, 2016). Moreover, it is assumed that the need for qualified workforce to meet the capacity of innovation in the future will be met by educated individuals in the field of STEM (Turkish Industrialists' and Businessmen's Association [TÜSİAD], 2017). Therefore, conducting research on STEM education is necessary for the quality of STEM training.

Even though the number of the studies conducted on STEM training have been recently increasing at a rapid pace in Turkey, there is no consensus on what STEM is, its importance in the curriculum, how to implement it in the classroom, and how STEM-aided learning environment can be designed in various disciplines (Çepni, 2018; Delen & Uzun, 2018; Yılmaz, Yiğit Koyunkaya, Güler & Güzey, 2017). In Turkey, there have been many misconceptions about STEM training and some of non-STEM practices are perceived as STEM practices (Yıldırım, 2018a). This situation is reflected in the explanatory and binding nature of the 2018 Science curriculum. It seems unlikely for science teachers, who have not received STEM training at the undergraduate level and who attempt to carry out STEM practices with the in-service training programs they attended, to understand the defined outcomes and to make their students attain these outcomes Turkey (Bahar et al., 2018; Yıldırım, 2018b). Furthermore, the relevant literature shows that teachers want to implement STEM activities in their courses but they do not know how to implement them and they need a document that can guide them (MoNE, 2018). Therefore, this particular research attempts to explain the methods and processes followed by STEM training in the light of the obtained results, the encountered problems and practical implications and to provide a general framework for researchers, program designers, teachers, administrators and other practitioners. Thus, it is expected to provide data for future studies to be conducted on STEM training at home and abroad and to make a significant contribution to the determination of educational policies. Hence, the general purpose of this research is to examine the project-based STEM training implemented in a primary school in terms of process, outcomes and problems. For this purpose, the following research questions were raised.

1. What teaching practices do teachers perform in STEM training?
2. What are the reflections of STEM training on students?
3. What are the problems encountered in STEM training?
4. What should be done to make STEM training much more effective?

2. Methodology

2.1. Research Design

This research was conducted within the framework of the phenomenology design, one of the qualitative research designs. In the studies carried out in the phenomenology design, it is tried to reveal the experiences, perceptions and the meaning attributed by individuals to a case (Johnson & Christensen, 2004). In order to understand the examined phenomenon better, Patton (2014) emphasizes that the opinions of the primary and various individuals should be scrutinized in detail. Hence, the teachers and students' opinions were elicited and analyzed to gain a better insight into STEM in this research.

2.2. Participants

In phenomenological studies, the individuals who will explain the case should be directly related to the case and selected according to the purpose of the study (Creswell, 2016; Patton, 2014). In this research, the opinions of teachers and students who took part in the project were elicited in order to examine the STEM training in the context of process, results and encountered problems. The sampling consisted of 18 students and 2 teachers working in a state primary school located in an Anatolian province during the 2017-2018 academic year. The group in concern was formed based on the criteria of participation in the afore-mentioned project and voluntary participation in the research. For ethical consideration, codes were used instead of participants' names. While teachers (experts) were coded as "E1, E2", the students were coded as "S1….S18". E1 was a 40 year-old male teacher with 17 years of teaching experience who was teaching 4th graders at the time of data collection and who received STEM training before taking part in the project. E2 was a 49 year-old male teacher with 23 years of teaching experience who was teaching to 3rd graders at the time of the study and who received STEM training before participating in the project. 18 students also received STEM training within the scope of the project. Voluntary participation in the research was set as the first criterion to choose the students. Subsequently, a STEM test was administered to the volunteer students and a working group of 18 students was formed based on their achievement scores.

2.3. The Research Context

The research was carried out in the school where the project was implemented. The school in concern is located in the city center and in a neighborhood mostly settled by the parents with high socio-economic status. One classroom in the school was designed as STEM workshop room with the support of the Metropolitan Municipality. There were toy blocks, robotic materials, study desks and repair tools in the STEM room. There were also STEM activity sets for basic, advanced and expert levels, vehicles, blocks, preschool kit, STEM activity set-construction equipment, amusement park set, super cranes, mechanical and static systems, energy conversion systems, dynamic and power systems, cars and propulsion mechanisms, optics - observation and astronomy set in the room. Lastly, it contained energy conversion systems related to electrical and electronic engineering, compressed air systems, engineering set, robot competitions set, automation systems with robot arms, an introduction to robot set, robot txt discovery and type jumbo sets.

2.4. Data Collection and Analysis

The easiest and quickest way to learn about individuals' knowledge, emotions, attitudes and thoughts about an issue is to interview people about it. In social sciences, interview is a widely used technique to collect data (Creswell, 2016; Merriam, 2013; Patton, 2014). In this research, a chat-style interview was conducted in order to get participant teachers' opinions. Some parts of the interviews were recorded with the prior consent of the participants. Moreover, an interview form consisting of two parts developed by the researcher was used to collect data. The first part consists of questions to determine the demographic features of the participants (6 questions for teachers, 3 questions for students) and the second part consists of four open-ended questions to learn about the participants' opinions about STEM training. While preparing the interview form, the existing literature on STEM training was extensively reviewed and expert opinions were elicited from two faculty members with in-depth specialization in curriculum and instruction. The research data were collected in December, 2018 and analyzed through content analysis which requires an in-depth analysis of the data and identifying themes and codes based on the results. In content analysis, similar data are compiled within the framework of certain concepts and presented in a way that the reader can easily understand (Yıldırım & Şimşek, 2011, p. 227). In qualitative research, all stages of the research should be reported in detail and how the results were obtained should be explained in order to ensure the validity and reliability of the research (Yıldırım & Şimşek, 2011 p. 257). In that regard, all stages of the research and the data analysis process were explained in detail. The researcher created codes and themes by analyzing the data collected through interviews with teachers and students. Merriam (2013) suggested that the research should be presented to an expert to increase the validity and reliability of the study. Hence, this study was presented to an expert working at a state university in Turkey by the researcher. The themes and codes were formed and discussed in collaboration with the expert to reach a consensus (Silverman, 2005).

In order to ensure the validity and reliability of the qualitative data, the research findings were tabulated, direct excerpts from teacher and student opinions were taken, the participant confirmation was taken, and all data and stages of the study were stored in computer and file for confirmation.

3. Findings

3.1. Findings regarding Implementation of STEM Training

The first question of the research was motivated to find out what kind of teaching practices the teachers perform during the STEM training. The findings obtained from teachers' opinions revealed that STEM training was performed in three stages, as displayed in Table 1.

Table 1. *Teachers' practices during STEM training*

Theme	Codes
Preparing Activities	STEM training for teachers Identifying activities to do Designing the activities Preparing a guide book of activities Setting up STEM workshop room Preparing materials for activities Choosing among the volunteer students Creating student groups Creating work schedule / plan
Doing Activities	Creating a problem statement Enabling students to discover the problem Enabling students to decide on the product to design Enabling students to design the product Handing out the guide books to students Giving students time to do activities Revealing the relationships among the STEM courses through the activities Presenting the product
Evaluating the activities	Making presentation Writing report Organizing a competition Grading

As indicated in Table 1, the teachers' STEM practices consist of three stages: (i) preparation STEM activities, (ii) implementation STEM activities and (iii) evaluation of STEM activities. STEM activities start with the training of teachers in the preparation stage and continue with identifying the activities to do, designing the activities, preparing the activity plan as a guide book, creating a STEM class, creating the materials related to the activities, choosing the participant students, forming student groups and creating a work schedule/ making a plan, respectively. E2 states his/her opinion about the subject "*Within the scope of the STEM project, we conduct a draft project with the teachers before performing the activities. Then, we turn it into a guide book to hand out the students. We do the activities in groups*". As for the second stage of STEM training, teachers reported that they created a problem, encouraged the students to discover that particular problem, guided them to find and design the product, handed the guide books to the students, gave them time to do the activities, revealed the relationship among the STEM courses in the activities and guide the students to present the product, respectively. The following was taken from the interview with the first participant teacher to illustrate their opinion about the phase in concern.

> First of all, a problem likely to be encountered in daily life is identified. For example, floods in the Black Sea Region cause streams to overflow. The students are given relevant instructions and asked to design a bridge resistant to this natural disaster. They are expected to decide on the materials to use in order to perform the task, to draw (engineering) and to calculate structure of the materials, gravity and so on (will be associated with science), the cost and measurement (mathematics and technology), and to use all these disciplines in an integrated manner to solve the problem." (E1).

Table 1 also suggests that the last phase of the training involves making presentations, writing reports, organizing a competition and scoring the students' task performance. E2 expressed his opinion about the subject "*At the end of the activity, we deliver a presentation, write a report and evaluate the activities performed during the training.*" When activities are examined in STEM education, it is observed that the activities are related to daily life. E2 stated that "*I perform such activities as designing bridges, cars and scales, making cars from recycled materials and building a hunter tower*". Direct extracts of the students about the subject were given below.

> I drew a draft. We designed a barrier, a car, a jack, scales, an overhead bridge, cars from recycled materials and a hunter tower. We also made an oral presentation after performing these tasks (S13).
>
> Firstly, we drew a draft, STEM work, wrote a report paper and at the end we made presentation (S2).
>
> During the STEM training, I drew a draft, found the parts by looking through the book, assembled the parts, completed the project and presented it (S1).

3.2. Findings on the Reflections of STEM Education to Students

The second research question was intended to investigate the reflections of the STEM training on the students. In this context, the themes and codes obtained from the views of teachers and students are presented in Table 2.

Table 2. *Teachers and students' opinions about the reflections of STEM education on students*

Theme	Codes	Participants	
		Teacher	**Student**
Social contribution	Learning to work together	E1, E2	S1, S3, S6, S10, S11, S14, S15
	Improving friendships		S4, S7, S15
	Developing self-confidence	E1, E2	
	Being happy	E1	
Academic contribution	Increasing interest in the course		S12, S13, S16
	Gaining scientific knowledge		S4, S10
	Teaching learning by doing	E1	
	Bringing a different perspective to the lessons	E2	S12
	Increasing product creativity	E1	
Personal contribution	Developing manual skills	E2	S1, S2, S4, S7, S12, S13, S15, S17
	Discovering and developing the abilities	E2	S1, S4, S5, S7, S8, S9, S14, S18
	Gaining thinking skills	E2	S13, S17
	Developing problem-solving skills	E1	
	Learning to behave carefully		S3
	Improving the aesthetic aspect	E1	

As demonstrated in Table 2, the reflections of STEM training on students are classified into three groups as social contribution, academic contribution and personal contribution. It is observed that social contribution of STEM training covers enabling students to gain the habit of working together, to develop friendships, improving their self-confidence and making them happy. E1 stated that "*Team spirit was developed within the course of time*." *At first they had no idea about team work but they learned it during the activities…*" One of the interviewing students noted that they made new friends while performing the tasks together. Regarding self-esteem, E2 specified that "*We observed task sharing, improved self-confidence, and emergence and development of students' talents*". E1 expressed the students' happiness as " *…they obtain a kind of pleasure from creating their own design*".

The academic contribution of STEM training could be listed as increasing students' interest in the course, facilitating students' gaining scientific knowledge, teaching students learning by doing, bringing a different perspective to the courses and increasing students' product creativity. E1 remarks that "*It provides the students with the opportunity to learn by doing"* while one of the students highlights that he developed interest in engineering (S12).

Table 2 also shows that STEM training improves students' manual skills, unearths their talents, improves their thinking and problem-solving skills, teaches them to behave more carefully and improves their aesthetics taste. E1's states, "*Aesthetics and product are at the forefront, and most importantly such disciplines as science, engineering, mathematics and technology are employed together in the solution of a real-life problem. Students use mathematics to solve a problem they encounter in daily life rather than a mathematics class. This is the answer to the question of "How will we benefit from this knowledge in real life?* E2 mentioned his/her view on the subject as "*we also see that their ability to relate all courses and their analytical thinking skills have improved thanks to the practical solutions they found*." It is obviously seen that students had similar views about the subject; namely, they reported that *it improved their manual skills* (S12), *uncovered their hidden skills (*S9) and *helped improving their imagination* (S13). Concerning that STEM training taught them to behave carefully, S3 expressed his/her opinion "*I improved myself, I experienced team spirit, and I learned to behave carefully*".

3.3. Findings Related to Problems in STEM Training

The third research question was raised to identify the problems encountered during the STEM training. In this regard, the findings obtained from the views of teachers and students are displayed in Table 3.

Table 3. *Teachers' and students' opinions on the problems encountered during the STEM training*

Theme	Codes	Participants	
		Teacher	**Student**
Team Work	Not knowing task sharing	E1, E2	S1, S2, S12, S15, S17
	Exclusion of some students		S6, S11
	Communication problems among the groups		S18
	Crowded groups	E1	
	High number of groups	E1	
Individual	Low level of manual skills	E2	S1, S3 ,S4, S7, S8, S9
	Failure to recognize the parts		S3, S9, S12, S13, S18
Facilities	Lack of materials	E2	S3, S4, S5, S7, S12, S13, S14, S15, S16, S18
	Material incompatibility		S7, S8, S13, S14, S15, S17
	Inadequate space	E1	

As illustrated in Table 3, the problems faced in STEM training are grouped under the themes of team work, individual and facilities. The problems under the team work category are listed as task sharing, exclusion of some students, communication problems among the groups, crowded groups and presence of high number of groups. E1 expressed his opinions about team work, "*While assigning tasks, we divided our students into groups. The success of the project was positively correlated with the collaboration and cooperation among the group members. Individuality was at the forefront in the initial process. That was a problem. In addition, the implementation of these activities with crowded groups (design, product, presentation, evaluation) process was very slow.*" E2 stated, "*Initially there was a problem in team work. The students who acted individually at the beginning became accustomed to participating in group work over time.*"

The students expressed their opinions about group work as "*There was a dispute in the group*" (S12), "*My friends excluded me from the group*" (S6), and "*We couldn't manage the group work*" (S18). About the problems in the group, S18 complained "*We didn't have some parts and some groups didn't want to share them with us*." The participant students identified their low level of manual skills and failure to recognize the parts of training sets as the individual problems they were faced with. E2 stated his opinion, "*We had problems about supply and function of the parts. The students became more familiar with the parts as the activities were performed and they began to do the activities faster*." The following extracts are intended to exemplify students' opinions about the issue.

"*Failure to find the parts at first and failure to assemble the parts were the problems we had as a group in task sharing."* (S1)

"*Assembling the parts was problematic for us*." (S15)

"*Finding and fixing the parts were challenging."* (S14)

"*We had to ask our teacher for help since we had problems with assembling the parts."* (S4)

When the Table 3 is examined, it is also seen that there are problems with the infrastructure such as lack of materials, material incompatibility and inadequate space for STEM training. The following are the students' opinions about the problems in concern.

"*Some parts were missing and some parts didn't fit each other.*" (S7)

"*We had difficulty in finding and assembling the parts while performing some tasks*." (S13)

"*Many parts were missing.*" (S16)

"*The problems in team were missing parts and assembling them*." (S15)

3.4. Findings Related to Suggestions for Increasing Efficiency of STEM Training

The fourth research question scrutinized the suggestions to implement STEM training more effectively. In this scope, suggestions obtained from the opinions of teachers and students are provided in Table 4.

Table 4**.** *Suggestions of teachers and students to make STEM education more effective*

Theme	Codes	Participants	
		Teacher	**Student**
Suggestions for Administrators	Implementation in workshops rather than traditional classrooms	E1, E2	S2, S4, S7,S14, S13, S12
	Integrated into curriculum as a course		S1, S15, S13
	Exclusion from the course content	E1	
	Participation of all students	E2	
	Larger workshops	E1	
Suggestions for Practitioners	Product-oriented	E1	
	Associating with daily life	E1	
	Careful construction of the groups	E1	
	Presenting activities with OHP		S9, S14
	Organizing STEM courses		S5
	Equal distribution of tasks to students		S11

When Table 4 is examined, suggestions of teachers and students for the improvement of STEM training are gathered under two themes: (i) suggestions for administrators and (ii) suggestions for practitioners. The former includes implementation of STEM training in the workshops rather than classrooms. E2 stated, *"STEM workshop classrooms may be set up."* Students' opinions are "*Such workshop classes should be constructed in every school."* (S13), "*…STEM workshops should be set up on a corner in the classes*." (S4) S1 and S13 pointed out that STEM training should be integrated into the curriculum as a separate course rather than course content. S1 mentioned the necessity of implementation of STEM training independent from the other courses "*Course contents such as science, mathematics, engineering,* *technology, etc. should be associated with as much as possible. Besides, they should be functional, useful and independent of the textbooks and the classroom environment."*

E2 stated that all students should participate in the activities. As seen in Table 4, teachers and students suggested STEM training practitioners to perform product-oriented activities, to associate these activities with daily life, to form groups carefully, to present activities by using OHP, to organize STEM courses and to assign equal workloads to students. E1's notes, "*Creating original products should be encouraged. Number of students should not be more than five and the ideal group number is 3*." S9 who wants the activities to be projected stated "*There can be a big workshop classroom in the school, and the activities in STEM training can be projected in the classes."* S11 highlighted the significance of equal task sharing in STEM training.

4. Discussion, Conclusion and Suggestions

This study indicated that the STEM training was applied in an integrated way by interrelating the four subjects in accordance with Dugger's (2010) four-disciplinary approach. Based on the research findings, it is concluded that a systematic study consisting of preparation, implementation and evaluation steps should be performed in order to realize STEM practices successfully. This situation was emphasized in the work of YEĞİTEK in support of the present findings. It was stated that the cycle containing the steps of questioning, designing the product, testing the product, drawing conclusions, evaluating the product, sharing and reusing it, developing the product by re-thinking invention and product development with new questions should be realized after the completion of the infrastructure for STEM training (preparation) (MoNE, 2018). In this study, it was observed that the activities carried out within the scope of STEM training were in large agreement with the stages of the design-based learning model proposed by Penner, Giles, Lehrer and Schauble (1997). The process of performing STEM training is similar to that of Yamak, Bulut and Dündar (2014), and it is observed that the process in concern was in compatible with the roadmap suggested for integrated STEM teaching in Yıldırım (2018b).

As a result of the research, the activities of STEM training improved students' thinking, problem solving and manual skills. It was also indicated that cooperation between the students increased, that the students developed a positive attitude towards the course, that their self-confidence was increased and that they learned to behave more carefully.

The current research has yielded similar findings reported in the existing literature such as that STEM education developed students' thinking and problem solving skills and increased their self-confidence (Altunel, 2018; Bakırcı & Kutlu, 2018; Honey, Pearson & Schweingruber, 2014; Morrison, 2006; Yıldırım & Altun, 2015). The findings reported in this research also overlap with Altunel (2018), Yıldırım and Altun (2015) who previously informed that STEM training allows students to experience interdisciplinary thinking, inquiry-based learning, learning by doing, life-based learning, critical and alternative thinking and problem-based learning processes. The finding that the STEM training increases cooperation among the students is in line with Yasak (2017). Another finding of the study is that STEM activities helped the students have a positive attitude towards the course and increased their course achievement. This finding also perfectly fits with the relevant literature (Altunel, 2018; Baran, Bilici & Mesutoğlu, 2015; Fortus et al., 2004; Gencer, 2015; Gülhan & Şahin, 2016; Honey et al., 2014; MoNE, 2018; Şahin, Ayar & Adıgüzel, 2014; Yamak et al., 2014; Yasak, 2017; Wendell et al., 2010). One of the noteworthy findings of the study, which has not been reported in previous research, is that STEM training improves students' manual skills and teaches them to behave more carefully. This might be attributed to assigning students with various activities that help them develop their manual skills and act carefully to come up with products. In today's world, it is of great significance to educate cautious individuals with developed dexterity.

The study showed that the teachers and students encountered problems related to classrooms, lack of materials and students' working with the group during STEM training practices. This particular finding approves those reported in Yıldırım's (2018b) study with STEM teachers. However, Yıldırım (2018b) stated that students suffer from lack of interest in courses and fail to inter-relate the disciplines. The difference of the present finding might stem from the participation of a limited number of students in the project and the inclusion of volunteer students in the project through a test.

Wang, Moore, Roehring and Park (2011) emphasized that students should be interested in the activities in order to perform STEM training effectively. In this research, students' voluntary participation in the project may have increased the chances of success of the project. Baran et al. (2015) emphasized cooperation and disruptions in working processes, which is in line with the results of this study. Eroğlu and Bektaş (2016) stated that they suffered from lack of materials in STEM training, which is similar to the results of the present research. Morrison (2006) indicated that STEM classes for the students aged between 6-12 should be student-centered which encourages active participation of the students, which is suitable for innovation and invention, which is equipped with portable tools, recyclable materials, ventilation and computers with STEM software and which promotes the students' self-inquiry. The scholar also underlined that it should have furniture that can be easily changed to function and serve disabled students, as well.

A couple of practical implications were offered in the light of the findings reported in this research. First of all, it was concluded that STEM training make academic, social and personal contributions to the students. Therefore, it should be expanded as much as possible. Secondly, it was revealed that STEM training improved students' high-level thinking and manual skills. Hence, similar practices can be done in other schools and STEM workshops can be established in these schools. Third, it was found that the students had problems working in groups. In that regard, teachers are suggested to be rigorous when creating a group (number of people) and in the process (communication within the group and distribution of tasks) so that the students do not have such problems. More specifically, activities to develop students' manual skills can be held to minimize the problems they encounter. The research also revealed that the students encounter some problems arising from the lack of materials and failure to recognize the materials to perform the assigned tasks. Accordingly, the teachers are recommended to document and report the lack of materials for administrators to supply and to introduce the existing materials to the students during the initial days of STEM training. In addition, based on the participant teachers' and students' views, STEM training should be integrated into the curriculum as a course. Furthermore, Science and Math curricula could be revised to include STEM training. Another suggestion of the research might be the expansion of STEM training with the cooperation among MoNE, the Scientific and Technological Research Council of Turkey (TUBITAK), universities and municipalities. In-service teacher education programs and seminars on STEM training should be organized by MoNE. Lastly, students attending teacher training programs at faculties of education should be offered courses on STEM training.

5. Conflict of Interest

The author declares that there is no conflict of interest.

6. Ethics Committee Approval

The author confirms that the study does not need ethics committee approval according to the research integrity rules in their country.

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