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BARRIERS AND NEEDS FOR SUCCESSFUL STEM IMPLEMENTATION IN PRIMARY SCHOOLS: A CASE STUDY WITH TURKISH PRIMARY SCHOOL TEACHERS

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ABSTRACT

This is a case study of the implementation of STEM (science, technology, engineering, and mathematics) education by teachers over the period of half a school term in Turkish primary schools. Given the growing interest in integrated STEM education in the world, it is necessary to identify the barriers and needs for successful STEM education at any level of the education systems of different countries. In this study, firstly, the barriers and needs for STEM implementations in the literature were revealed to handle the current situation in the world. Then, the teachers determined the Turkish case for the primary level and compared it with the existing literature. To this end, five primary school teachers planned and implemented integrated STEM activities in their own classrooms and asked them to express the barriers and needs that they experienced in the process. According to the teacher's experiences, there are barriers gathered under six main themes having sub-categories as school culture, curriculum, time, student, teacher, and material. The needs for successful STEM implementation at this level are also gathered under four main themes having sub-categories as school culture, curriculum, professional development, and material support themes. According to the findings, the Turkish case supports and is consistent with other studies in the literature. So, it can be said that STEM cannot be fully integrated into existing education systems yet and these barriers and needs will continue to exist. The study sheds light that there is a long way to go in, especially for Turkish primary schools. Additionally, it puts forth that the teachers may experience many new barriers to successful STEM implementations if precautions are not taken. The study sheds light on the current situation in schools from the teachers' viewpoint who are responsible for teaching at this level and serves as a springboard for further studies and concerned parties.

Keywords: Elementary STEM education, implementation, teachers' experiences, barriers, needs, case study.

INTRODUCTION

The term STEM education is now widely used in educational communities worldwide. It refers to the teaching of each discipline and its knowledge, skills, and beliefs within the 21st-century context. STEM education focuses on the disciplines' unique features by unifying them with integrative approaches. It covers every level of education from pre-school to higher education in both formal and informal settings (Gonzalez and Kuenzi, 2013). Integrating the four disciplines but not limited to these four of them. The pedagogical structure also covers other related disciplines (Bybee, 2010). STEM literacy is also defined as; (a) awareness of the roles of science, technology, engineering, and mathematics in modern society; (b) familiarity with at least some of the fundamental concepts from each area; and (c) a basic level of application fluency (e.g., the ability to critically evaluate the science or engineering content in a news report, conduct basic troubleshooting of common technologies, and perform basic mathematical operations relevant to daily life (National Research Council [NRC], 2012).

In order to train students as STEM literate, most countries are trying to be integrated STEM curriculum and pedagogy at every level of education nowadays. Turkey is one of these countries. In 2017 Turkish Ministry of National Education (TMNE) started the revisions to the school curriculums based on STEM education. In this context, there have been changes in the primary school curriculum. It is also one of the levels where integrated STEAM education is introduced and awareness begins (California Department of Education [CDE], 2014). All the reform actions Turkish primary school teachers are charged with building STEM literacy at this level. Because they are typically responsible for teaching all subjects, there is a unique opportunity for integrative approaches to teaching STEM pedagogy at the primary level (Becker and Park, 2011). Theoretical information and suggestions about how STEM should be applied are presented when looking at the relevant literature for K-12 education. On the other hand, it is seen that there are limited studies on the difficulties experienced by teachers and what they need through applied studies at this level. And, when it comes to the implementation, many problems and needs can be encountered even if changes for integration. Because while STEM is trying to enter primary schools, the existing structure of schools and programs do not overlap with each other (Wang, 2011). Since the primary level is a different level from other levels, sometimes something that happens, in theory, may not be realized in practice at this level. There are studies about the barriers and needs for successful STEM integration and implementation at any level in the literature. Teachers from different branches and different levels of schools have some barriers and needs according to the studies given in Table 1 and Table 2 down. Some of them (Bozan & Anagün, 2019; Estapa & Tank, 2017; Shernoff et al., 2017) are related to the primary school level. But no one of them was conducted with primary school teachers and only puts forth teachers' views about STEM implementation not the experiences of them. Therefore, it becomes important that we investigate what barriers and needs teachers experience in their classrooms in primary schools (Dugger, 2011). It is impossible to determine them without practising together with the teachers. Because Stenhouse (1975) stated that teachers are the people who will make the soundest judgments about the cases in the field of education.

This study aimed to put forth barriers and needs for successful STEM implementation at the Turkish primary schools based on teachers' implementation experiences over a half-term period rather than views. This is the central premise of the study that it is important to give voice to teachers who are responsible for implementing STEM at this level. It also aimed to get the opportunity to compare the findings from the teachers' experience and Turkish context with the existing literature.

Research Questions

The study investigates teachers' experience with STEM implementations at the primary level. It aims to identify barriers and needs for Turkish primary school teachers when they tried to implement STEM activities in their classrooms. To find out barriers and the needs for successful implementation at this level the following questions were used:

- What barriers do Turkish primary school teachers experience when using STEM pedagogy in their classrooms?
- What needs do Turkish primary school teachers feel for successful STEM implementation when in their classrooms?

Background

What is STEM Education?

STEM is an acronym for the integration of science, technology, engineering, mathematics and other related disciplines as a meta discipline. This means the "creation of a discipline based on the integration of other disciplinary knowledge into a new 'whole' rather than in bits and pieces (Ejiwale, 2013). It is an interdisciplinary educational approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning (Kelley & Knowles, 2016). Stohlmann et al. (2012) suggest that integrated STEM education is an effort to combine the STEM disciplines into one class but clarify that it can involve multiple classes and need not involve all four STEM disciplines. Bybee (2013) defined clearly that the overall purpose of STEM education is to further develop a STEM literate society and to create a skilled workforce for the 21st century. In this context, efforts are being made to integrate STEM into all levels of the classroom curriculums. The primary school level is the starting point for integration. Interdisciplinary STEM integration is complex and needs some requirements for successful implementation. It is therefore important to reveal what teachers think about the barriers and needs for successful STEM integration at this level.

STEM Education in Primary Schools

Students first have lessons from their teachers such as science and mathematics, which are the basic disciplines of STEM education at the primary school level. They gain an insight into what is done in these lessons and how these lessons are taught. For example; "In science lessons, is an experiment and something invented or solving tests for the exams?" According to the answers to the questions, the student's interest in the course or their orientation towards STEM fields changes and they may even withdraw from STEM careers throughout their education life.

According to Hom (2014), the studies aimed to raise awareness of STEM education at the primary school level and also aims to create awareness and interest in STEM fields and STEM-related professions. And the main focus is to attract students' interest in STEM education and to ensure the permanence of this interest in the future. It is also to link between in-school and out-of-school STEM practices. Therefore, provide a powerful environment for STEM implementation and learning (Estapa & Tank, 2017). When looking at the literature on STEM integration, there is not a single definition or conceptualization of what STEM integration is or should look like at the primary level (NRC, 2012). According to NRC (2007), students begin to develop their perceptions and knowledge about STEM fields in primary school and at earlier ages. Primary schools provide entry into STEM education and are also where STEM awareness begins (California Department of Education [CDE], 2014). Moreover, it can encourage students' innate interest in STEM fields (Maltese & Tai, 2010) and their further orientation towards STEM education in the coming years (NRC, 2011). These potential gains and impacts of STEM education at the primary school level provide a justification for activities to be carried out to increase teachers' competencies in STEM education (Nadelson et al., 2013). Alumbaugh (2015) stated that primary school is the stage of introducing STEM education, as well as focuses on raising STEM fields awareness and related professions at this level. The goal of STEM education is to direct students' interests to STEM-related fields (Hom, 2014). According to Ricks (2013), students' STEM experience at an early age contributes to their orientation to STEM fields. Because students believe that they will be successful in STEM fields thanks to their experiences and they are encouraged (Alumbaugh, 2015). DeJarnette (2012) also stated that there are studies (Bagiati et al., 2010; Bybee & Fuchs, 2006) showing that meeting STEM education at primary school age affects students' perceptions and tendencies positively. According to Daugherty et al. (2014) primary school level is the stage where students' interest in STEM careers and professions related to STEM fields are shaped. This level generally progresses to the end of primary school, which is the age range of 10-14, and the beginning of secondary school. During this period, students' career choices are not fully formed, it becomes more and more important to identify and encourage these interests and orientations of students (Archer et al., 2012). As a result, primary school and even kindergarten level have an important role in order to be successful in STEM education and to raise the individuals of the future. In short, the studies show that the primary school level is a very important level to attract students' interest in STEM fields and enable them to turn to these fields (DeJarnette, 2012). Harrison (2011) stated that the literature, it is generally emphasized that the primary level is very important for integrated STEM education but existing limited studies and much more things need to be done.

Barriers and Needs for STEM Education in Schools

Barriers to STEM Education in Schools

Although the importance of primary school level in STEM education is known, the following are some of the related barriers that have been identified to advancing STEM. For example, as an interdisciplinary study shows: (a) poor preparation and shortage in supply of qualified teachers, (b) lack of investment in teacher professional development (PD), (c) poor preparation and inspiration of students, (d) lack of connection with individual learners, (e) lack of support from the school system, (f) lack of research collaboration across STEM fields, (g) poor content preparation, (h) poor content delivery and methods of assessment, (i) poor conditions and facilities, and (j) lack of hands-on training for students are barriers for advancing STEM education (Ejiwale, 2013). The other studies in the literature on this subject are shown in Table 1.

Table 1. Barriers to STEM Education at The Primary Level According to Teachers

Author(s) (year)	Sample	Barriers
Dancy & Henderson, (2008)	faculty members	classroom layout, classroom size, departmental norms, expectations of content coverage, instructor time, student resistance, time structure.
Wang et al., (2011)	one math, physical science and engineering teachers who teach 5-8	digital technology devices, stem curriculum, technology integration.
Asghar et al., (2012)	biology, engineering, math, science, technology teachers	adequate team preparation time, discipline-based exams and graduation, education system, effective assessment standards, engaging in interdisciplinary, teamwork, pressure of curriculum, school structure, time.
Goodpaster et al., (2012)	STEM teachers	PD (insufficient mentoring, preparing for multiple classes, access to university resources), school factors (resistance to change, student performance, problem with administrators, salaries and benefits), strong interpersonal relationship and community ties (developing connections, maintaining boundaries, challenging public relations).
Bagiati & Evangelou, (2015)	a preschool teacher	attendance, scheduling constrains, teacher apprehension of engineering content, time constraints.
Neil-Burke, (2016)	middle school teachers	time constrains, materials.
Eroglu & Bektas, (2016)	middle school science teachers	time constrains, materials.
Byun et al., (2016)	primary, middle, and high school teachers	administrative support, financial support, time constrains, work load.
Estapa & Tank, (2017)	classroom teachers and candidates, engineering graduate students	implementation support, single definition of stem.
Shernoff et al., (2017)	elementary, middle and high school teachers	motivation, time, understanding stem and disciplinary content and standards, testing culture as competing value, school culture, teachers' resistance, technology, finance, administrative support, little researches for developing strategies.
Kurup et al., (2017)	primary school teacher candidates	confidence to implementation, confidence to preparation.
El-Deghaidy et al., (2017)	middle school science teachers	classroom size, confidence, curriculum density, interdisciplinary guide book, knowledge of different STEM disciplines, material availability, PD.

Shadle et al., (2017)	faculty or administrative staffs	instructional challenges, loss of autonomy, resistance to change, time constraints.
Goodpaster et al., (2012)	science teachers	insufficient mentoring, activity planning, accessing resources, resistance to change, student performances, administrator support.
Ozbilen, (2018)	middle school science, math and design teachers	collaboration with teachers, confidence to implementation, materials.
Bozan & Anagün, (2019)	primary school teachers	density of curriculum, financial opportunity, materials, time.
Madani, (2020)	science and math teachers	insufficient resources, exam-oriented system, insufficient time, lack of materials and large class sizes.

As can be seen from the studies that identify teachers' experiences in the Table 1, there are several barriers felt by teachers and candidates in the studies in literature for successful STEM implementation. They are external and internal barriers from the teachers' opinions.

All the studies above show that major barriers to successful STEM pedagogy are timing (Asghar et al., 2012; Bagiati and Evangelou, 2015; Bozan and Anagün, 2019; Dancy and Henderson, 2008; Eroglu and Bektas, 2016; Margot and Kettler, 2019; Neil-Burke, 2016; Shadle, Marker, and Earl, 2017; Shernoff et al., 2017), PD (El-Deghaidy et al., 2017; Goodpaster et al., 2012; Margot and Kettler, 2019), curriculum (Asghar et al., 2012; Bozan and Anagün, 2019; El-Deghaidy et al., 2017; Margot and Kettler, 2019; Wang et al., 2011), school structure (Asghar et al., 2012; Dancy and Henderson, 2008; Goodpaster et al., 2012; Margot and Kettler, 2019), support (Byun et al., 2016; Goodpaster et al., 2012; Margot and Kettler, 2019), materials (Bozan and Anagün, 2019; El-Deghaidy et al., 2017; Eroglu and Bektas, 2016; Neil-Burke, 2016; Ozbilen, 2018; Wang et al., 2011).

At the same time confidence in preparation and implementation (Kurup et al., 2017; El-Deghaidy et al., 2017; Ozbilen, 2018), financial support (Byun et al., 2016; Bozan and Anagün, 2019; Margot and Kettler, 2019), administrator support (Byun et al., 2016; Goodpaster et al., 2012; Margot and Kettler, 2019) are the other barriers that teachers expressed in the studies. student's resistance (Dancy and Henderson, 2008; El-Deghaidy et al., 2017), collaboration (Asghar et al., 2012; Goodpaster et al., 2012; Ozbilen, 2018), assessment (Asghar et al., 2012), strategies (Shernoff et al., 2017), understanding STEM pedagogy (Bagiati and Evangelou, 2015; El-Deghaidy et al., 2017; Shernoff et al., 2017), resistance to change (Goodpaster et al., 2012; Shadle et al., 2017) the other imported barriers that teachers experienced.

Needs for Successful STEM Implementations in Primary Schools

It is understood from the studies in the literature that teachers face many barriers to successful STEM implementations in classrooms. For this reason, these barriers also lead to the consequence that teachers have some needs in order to implement it. When we look at the studies on the need for the needs given in Table 2 below, it is seen that they are very closely related and parallel to the barriers. Teachers have needs in order to implement it successfully in their classrooms.

Table 2. Needs for Successful STEM Implementation in Primary Schools According to Teachers

Author(S) (year)	Sample	Needs
Stholman et. al., (2012)	middle school teachers	efficacy (content and pedagogical knowledge contribute to positive self-efficacy), materials (technology resources, broad view of technology, material kits for activities, room space and storage form materials, tables for group works), support (university partner, PD, collaboration time, curriculum company training and contacts), teaching (lesson planning and classroom practices).
Asghar et al., (2012)	biology, engineering, math, science, technology teachers	support.
Owens, (2014)	primary and secondary stem teachers	active support, leadership, PD opportunity.
Bruce-Davis et al., (2014)	high school teachers	PD.
Neil-Burke, (2016)	middle school teachers	administrator support, collaboration, curriculum support.
Kurup et al., (2017)	primary school teacher candidates	confidence, PD, professional preparation.
Shernoff et al., (2017)	primary, middle and high school teachers	additional resources, communication among all departments, community supports including parents, instructional time, integrated multidisciplinary approach, PD, resource support, supportive STEM culture, manageable class sizes, time for collaborative planning, teaching mentor, more classroom experience.
Owens, (2018)	primary, secondary science and math teachers	engineering design practices, instructional practices, interdisciplinary learning and instruction curriculum standards, PD, supporting classroom discourse.
Amran et al., (2021)	pre-school teachers	PD, mentoring, teaching and learning resources, financial support, sufficient time allocation.

It can be understood from the table that PD opportunity (Amran et al.,, 2021; Shernoff et al., 2017; Kurup et al., 2017; Owens 2014; Owens et al., 2018), collaboration (Asghar et al., 2012; Bruce-Davis et al., 2014; Herro and Quigley 2017; Neil-Burke 2016; Quigley 2017; Shernoff et al., 2017; Stholman et al., 2012; Wang et al., 2011; Van Haneghan et al., 2015), curriculum support (Asghar et al., 2012; Lehman et al., 2014; McMullin and Reeve 2014; Stholman et al., 2012), parent and college support (Asghar et al., 2012; Shernoff et al., 2017; Stholman et., al., 2012), instructional time (Shernoff et al., 2017; Stholman et al., 2012), active support (Asghar et al., 2012; Owens 2014), material support (Amran et al., 2021; Stholman et., al., 2012), administrator support (Neil-Burke 2016), financial support (Amran et al., 2021), engineering design and instructional practices (Owens et al., 2018; Stholman et al., 2012), lesson planning support (Stholman et al., 2012), additional resource support (Shernoff et al., 2017), communication (Shernoff et al., 2017), leadership (Owens 2014), broad view of technology (Stholman et al., 2012), and integration models (Shernoff et al., 2017) are the needs that teachers want for implementing STEM pedagogy successfully in their classrooms.

According to findings in the literature pd opportunity, collaboration, curriculum support and parent and college support are the major needs. Instructional time, active support, engineering design and instructional practices, material support, administrator support, lesson planning support, communication, additional resource support, leadership and integration models are the other important needs that teachers have experienced.

METHOD

This study was conducted to evaluate Turkish primary school teachers' implementation experiences of integrated STEM activities in their classrooms and compare it with the other cases in the literature. For this reason, the study was carried out in the case study design, which is one of the types of qualitative approach. It was aimed to determine in this way, the problems that the teachers experienced during the implementation of integrated STEM activities at the primary school level and to determine what kind of requirements they need in order to successfully implement the activities at this level. Creswell (2007) defines the case study as a qualitative research approach in which the researcher examines one or more limited situations in the process, and the situations and situational themes are defined. According to Yin (2014), a case study is examining a current real-life situation, since the boundaries between an event and context are not clear (Akar, 2016). The case study provided us with the opportunity to examine teachers' experiences in their classrooms in the context of STEM practices at the primary level. In this respect, the research is a holistic single case study within the scope of a single case study. They are the teachers who apply STEM activities in their classrooms in primary schools. Figure 1 shows the context, focus and limitation of the case.

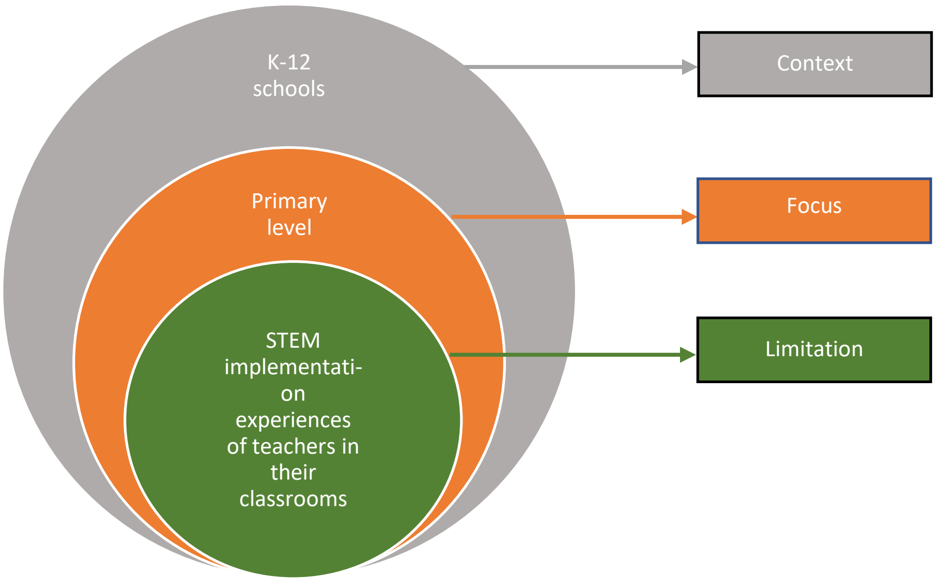

Figure 1. The Case Study

The Activities and Teachers

The present study was conducted at the primary school level, with teachers and their students as participants. It was conducted in the 2018-2019 school year in the province of Osmaniye, Turkey, in fourth-grade classes at state schools.

The participating teachers were two females and three males, a total of five teachers, from each school. A total of 153 fourth-grade students, aged 10-11, participated in the activities in groups of three or four. Teachers were selected from among 30 primary school teachers who attended a one-week STEM Trainer Training Programme held in the province and were willing to practise in their classes. They were preferred teachers who have different socioeconomic school profiles.

Table 3. Definition of The Teacher Cases

Teachers	STEM implementations	Grade	Age	Graduate	Seniority	Class size
Teacher S	Solar Cooking	4B	38	Bachelor	18	27
Teacher M	Pumping Rockets	4A	44	Master	21	25
Teacher Ş	Propellers are Racing	4K	40	Bachelor	18	32
Teacher T	Perfect Lighting	4D	45	Bachelor	23	25
Teacher H	Discovery of the Time	4C	37	Master	16	17

As seen in Table 3, the class sizes of teachers in five schools vary between 17 and 32 people. Only two of the teachers are graduates of postgraduate education. They are also between the ages of 37 and 45 and the years of service are between 16 and 23 years.

During the study process, the teachers prepared five activity plans and implemented them in their classrooms twice in a semester. The activities were carried out according to project-based learning in the form of group activities by creating homogeneous student groups. Each teacher implemented activities only his/her own classroom. No support was provided to the teachers in this process, and the process was followed only by participant observation. While preparing the activity plans, the teachers considered the fourth-grade science lesson themes.

Data Collection

In order to express the experiences in the process in the best way, the crystallization method described below was preferred, and more than one data collection method, from which we could obtain the best information, was preferred. Participatory observation, interview and researcher diary are the basic data collection methods used in the process. Every implementation of the teachers was followed by participant observation and teachers were interviewed before and after the implementation. Each practice of the teachers was followed by participant observation, and the teachers were interviewed before and after the practices, which ranged from 20 to 50 min in length. After all the first and second implementations, two focus group discussions were held with all the participating teachers, which lasted more than two hours. In its simplest definition, an interview is a conversation with relevant people for a specific purpose (Berg, 2001).

We utilized slightly different interview protocols for interviews and focus group meetings. We talked with teachers in the interviews about the barriers and challenges while implementing STEM in their classrooms. Then, what needs and supports do they need for successful implementation with their students at this level. In the focus group meeting, teachers shared and discussed their ideas and experiences on the subject in a democratic environment. They listened to the opinions of others and tried to come to a conclusion on the subject together. In the interviews with the teachers, it was tried to find out what kind of problems and what difficulties they experienced in the process in the context of the implementation of STEM activities beyond the casual problems experienced at school. They were asked what should be done in order to overcome them and what kind of needs they felt in this regard. In this way, beyond ordinary needs, teachers' specific needs and obstacles for a successful STEM application in primary school were determined. At the same time, we also followed the activities in the classes by participatory observation and took field notes to see the barriers and needs that teachers experienced. The purpose of participatory observation is to reveal what actually happens there (Merriam & Tisdel, 2015). The activity process and the student products obtained at the end of the process were also evaluated. In addition, all participating teachers kept personal diaries and recorded their ideas about the process in their diaries and had the opportunity to reflect during the interviews. According to Herry and Anderson (2005), autobiographical data such as interviews and diaries are used as data collection tools in qualitative research. Because the study process includes the individual's own practices and personal experiences. In short, the researcher and teacher worked on themselves while applying activities in their classrooms (Tenni et al., 2003).

Data Analysis

After the interview transcripts were made, they were subjected to content analysis as suggested in qualitative data analysis (Creswell 2007). Interview transcripts were shared between a random researcher and two other researchers experienced in qualitative data analysis. Content analyses were carried out at the end of the first and second implementations. Possible themes and sub-categories were determined after the first implementations and these categories and themes were finalized after the second implementations. Then, considering the participant observation notes, all the findings were integrated and the themes and categories were confirmed. All coders generated categories and discussed them. For example, it was revealed that teachers expected support from friends, administrators and parents after the first application, that STEM applications were required, and that the current structure of the schools was not yet suitable for the implementation of the activities. For this reason, the "*school culture*" theme was created in terms of needs and the sub-categories "*friend, parent and administrator support, STEM-oriented school environment*" were added to it. In addition to coding the data by the three researchers, focus group interviews with teachers and participant observation also played an important role in checking and finalizing themes and categories, especially from different data sources and coders. The triangulation method was used to ensure the consistency of the findings. Data were collected with more than one data collection tool and coded by more than one encoder and compared. Thirty per cent of the interview texts were coded by three coders to estimate inter-rater reliability. Inter-rater agreement was 90%, and Cohen's Kappa (which takes into account the rate of random agreement) was (.80), which is in the acceptable to good range. In addition, teacher practices were followed for a long time with participant observation in their classrooms. Practitioner teachers were included in the whole process and shared their ideas in a democratic way. Direct teachers' views were given in the study report and the characteristics of the typical situation were described. In addition, the categories and themes obtained for credibility were shared with the participating teachers both in the process and as a result of data analysis, and their opinions were received. Two participant teachers read the final study report and gave feedback.

FINDINGS

The teachers prepared activity plans and implemented them in their classrooms for a half school term period in the process. This way, they experienced the implementation of integrated STEM activities in primary schools with their students. They stated their experiences about the barriers and needs for successful implementation in the held interviews during the implementations. By monitoring the process with participatory observation, the barriers and needs that emerged in the context of teachers' practices in their schools and classrooms were defined.

Findings Regarding the Barriers Experienced by Teachers

First, the findings regarding the barriers experienced by the teachers are presented in Figure 2. The barriers experienced by the teachers were gathered under six main themes. These are a) school culture, b) curriculum, c) time, d) student, e) teacher and f) materials.

According to Figure 2 firstly, the teachers have barriers related to the category of school culture. Exam and instruction-oriented education, unsuitable physical conditions of the school and the classroom, and overcrowded classrooms are among these barriers. The physical conditions of the school and the classroom, specifically overcrowded classes, affect the successful implementation of STEM activities negatively. Teachers say that the nature of STEM and the current school culture do not fit together.

After the teachers carried out the activities in their classrooms, they stated their opinions during the interviews on the issue. In this regard, Teacher Ş stated that the high number of students in the class is both a disadvantage and a problem in the implementation of the activities. She said that since the activities are student-focused, effective instruction and close contact are required which is a problem in overcrowded classrooms. In overcrowded classrooms, the management of the activity, the active participation of the student and the classroom management are adversely affected, which hinders the successful realization of the activity. Another factor is the examination and instruction-based education in schools. One of the factors associated with school culture is that teachers take the current education in schools as an exam-based or test score-based system. They stated that an academic success-oriented education is carried out at the primary schools at the request of parents and school administration. They reported that there is a competition among themselves in terms of academic success and this environment makes it difficult to implement such activities. Implementing such a time-consuming activity while other classes are progressing with the curriculum has no value for parents and school administration. Because the exams are not held accordingly, which creates an element of pressure on teachers.

The experienced other barriers in the context of the curriculum result from a lack of a clear STEM and engineering curriculum for the primary school level and the current program load. The teachers planned the activities themselves in the process. In the current primary school curriculum, there is no program intended for STEM education, especially for engineering discipline from STEM disciplines. Although technology and engineering disciplines are among the basic STEM disciplines, there is no content in the programs on how to attain knowledge and skills specific to these disciplines at primary school level. For this reason, teachers cannot benefit from a guidebook or a program while preparing the activities. Teachers can only use their own experience and the knowledge they have learned in the one-week training they have received. In addition, as teachers implement these activities, the current program load becomes an obstacle. Since STEM education is not included in the curriculum, teachers prefer to apply the activities after the lessons or school, which raises many other problems.

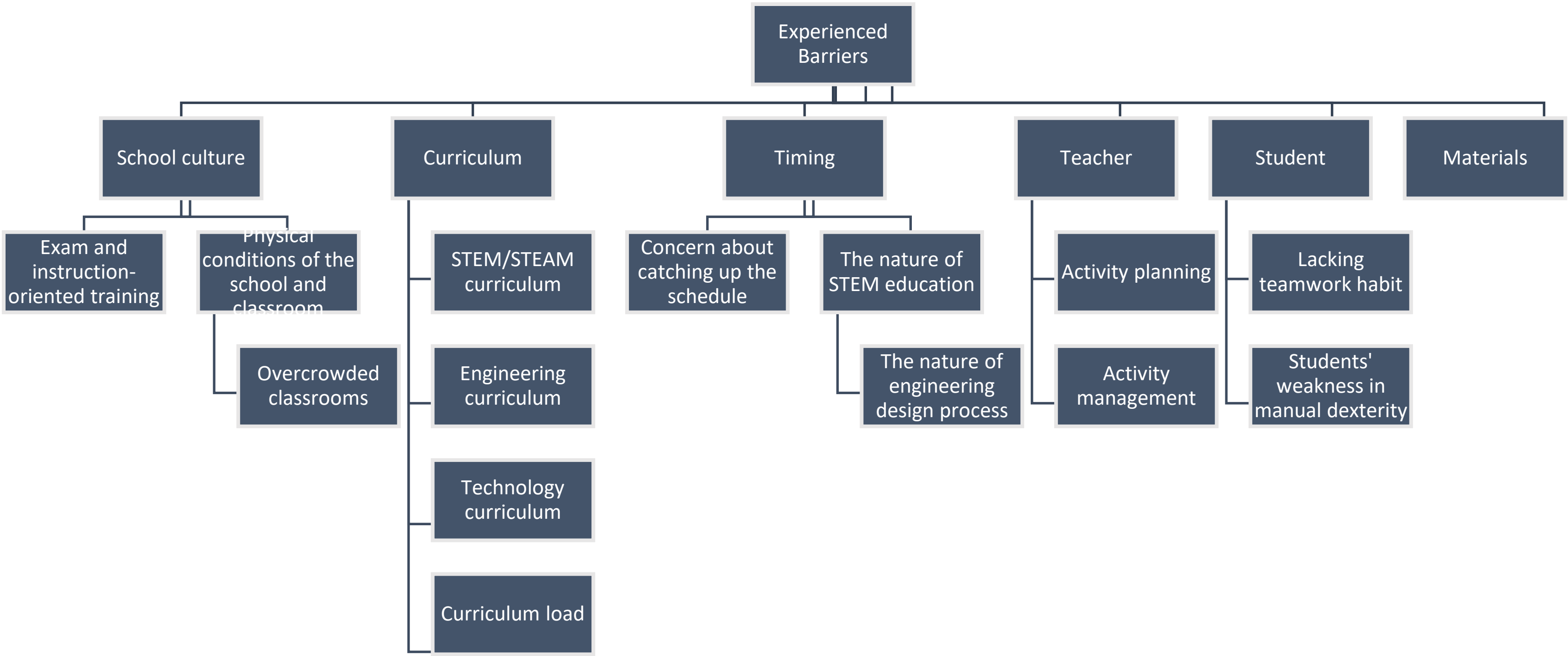

Figure 2. The Barriers Experienced by Teachers

The other category is the time category. In the category, the barriers experienced are the concern about catching up with the scheduled programs and the time-consuming nature of STEM education and engineering design process. Since the engineering design processes in the activities are applied and longitudinal processes, they need to take place over a long period of time. In the engineering design process, the presentation of real-life-based problem solutions, the decision of the solution proposal, and the progress of the product in the form of making, evaluating, testing, and re-doing the product cause it to stretch over a certain period. After students design their first products, they see what they should and should not have done and design their products again. This process continues until the optimum design is achieved. For example, in the Discovery of the Time activity, the sun was observed for 16-17 hours during the definition of the problem. As a result of these observations, the design of the product was decided on, and the construction phase of the sundial was started. After the product was designed by the students, its deficiencies were detected, and it was made again to make the necessary changes to make it aesthetic and more useful the next time. All these factors cause the problem of time.

The difficulty experienced from the teachers' perspective is the planning and management of the activity. First, teachers make a great effort to prepare the activity plan. Since STEM education promises interdisciplinary education, it is difficult to prepare an activity plan that includes the knowledge and skills of more than one discipline. In addition, teachers found that there was no clear source for the primary school level to help them, the programs were presented ready for them for many years, so it was very difficult for them to prepare the activity plans and the new concept.

Another problem for teachers is the management of the activity. Unlike standard activities, teachers' continuous active support in the process and the activity lasting three or four hours or a few days tire them a lot. It can be understood that teachers put more effort in these activities than standard activities and lessons, which makes it difficult to manage the activity. The lack of a curriculum or activity plans suitable for primary school level before, activities being different from a standard activity is tiring and makes it difficult to manage the activity successfully. The engineering process is also very difficult, because teaching engineering and technology disciplines is a new phenomenon for teachers. They have no experience in this subject.

The problems in the student theme, which is another difficulty encountered in the implementation of the activity at the primary school level, is that the students do not have the habit of working with the group and the weakness of the dexterity. In addition, activities not only are long-term, and but they also require. Students are expected to work with their groupmates in and harmony. However, teachers stated that our students were not used to this kind of activities because of the current education system.

Another problem is that the dexterity of the students is very weak. Teachers said that STEM activities generally required a product as a solution to the problem, and that they observed that students' dexterity was very weak during the design process of the product. Teachers reported that most of the students could not even cut a cardboard properly and draw a straight line, and that they could not use most of the tools and materials used in the activity properly.

Another theme was materials. Although the teachers stated that they were careful to use low-cost materials that students could easily access in the activities, not every student could provide every material. The fact that students are constantly asked for materials other than books and notebooks at school creates problems because of both the supply of materials and other factors. The supply and cost of equipment and materials becomes a big problem later in the process for the sustainability of the activities.

Table 4. Examples of Teacher Expressions About the Barriers

Main Theme	Subcategory	Examples of teachers' expressions in the interviews and diaries.
School Culture	Exam and instruction-oriented training	Teacher Ş: I implemented the activity for four class periods, trying to deal with all groups, but I still can't say that I could pay equal attention to all. The students bombarded me with questions and I just stood there then exhausted by the end of the activity. This is something very different from what we normally do. Teacher T: Program and lesson plans have come to us ready. But when we didn't have such a thing, I struggled with it for how many days. I don't remember ever trying so hard to prepare and plan for classes.
	Physical conditions of the school and classroom Overcrowded classrooms	Teacher M: I spent a month preparing an activity plan. Then I practiced in the classroom, sometimes lasting 4-5 hours and sometimes more, because I also give my students the opportunity to do it again. On the other hand, what I have in mind is to catch up with the program. What I understand from this experience is that these activities take a lot of time. So, I don't know how we can implement it in this case. Teacher S: For one thing, this is very different from regular classes. My students constantly ask questions, I visit groups, I give active support and instructions…. After going on like this for several hours, I found myself sitting at my desk, exhausted.
Curriculum	STEM/STEAM curriculum	Teacher H: There is only one theme in the science curriculum, but there is no clear information. It should not be a program that tells the teacher what to do in detail about STEM education, but it should still contain enough information to guide the teacher.
	Engineering curriculum Technology curriculum	Teacher Ş: There are lots of activity plans, but they don't fit our program. There are many problems when it comes to implementation. There is a shortage of programs and content, especially for the disciplines of technology and engineering. Using technological products in an event is considered technology, and making the product is considered engineering. But in fact, we have seen in applications that the technology and engineering dimensions are different.
	Curriculum load	Teacher Ş: While we are trying to implement our activities on the one hand, on the other hand, we have to do many things to be done in the program… Under normal conditions, STEM activities bring an extra workload, while the program cannot be completed.
Timing	Concern about catching up the schedule	Teacher M: It is clear that the activities are taking time… While trying a lot of preparation before implementation and then implementing it for at least four or five hours with my students, many curriculum tasks were in a corner of my mind.
	The nature of STEM education The nature of engineering design process	Teacher H: Defining the engineering problem in the activity, discussing and finding the best solution to the problem, designing the product as a solution to the problem, and the evaluation and testing process takes a lot of time. I see that the nature of STEM activities is very different from a regular lesson or activity. Teacher Ş: My students evaluate and test their propeller designs, propose changes, implement the change, and retest in the process...This process continues until the best solution the students decide on. This means an open-ended time frame instead of a certain time frame.

Teacher	Activity planning	Teacher H: My experience of preparing an event plan took a full month…There is no curriculum specifically related to technology and engineering disciplines. We must determine these ourselves according to the nature of technology and engineering. Teacher Ş: It was very difficult for me to plan the engineering and technology disciplines interdisciplinary in the activity.
	Activity management	Teacher T: I planned my activity and started to implement it in my class. Although I was in the role of a guide at the events, I spent a lot of effort to manage the event for a few hours. My students bombarded me with questions. I've been visiting groups all the time. Since my students were not used to teamwork, they tired me out during the activity.
Student	Lacking teamwork habit	Teacher S: While receiving feedback from the students at the end of the activity, most groups used expressions such as 'changing group mates', not arguing with group mates, getting along with friends better, being more respectful to each other' and 'listening to each other'. However, students do not have the luxury of saying that they do not want to work with anyone, and they should be accustomed to working with anyone in real life, including the people they do not want to work with.
	Students' weakness in manual dexterity	Teacher Ş: These are fourth graders, we shouldn't expect anything high-level, but they still need to be able to use some tools and materials properly, but I couldn't see that during the activity. They couldn't even cut a cardboard properly. It's like I just got to know my students. I'm shocked. We always provided everything ready, we helped them constantly, we shifted to theoretical training for exam success. We never focused on the motor-muscular skills of the students. We are also at fault in that.
Materials		Teacher M: Concrete materials other than books are required for the activities. There is no problem at the beginning, but when it is constant, you start to have problems with students due to factors such as lack of financial means or their availability. This is also a problem because you can afford the materials up to a point. Besides, we can't say anything to the parents. Everyone has their own fair share. Teacher Ş: Activities can also be done with low-cost materials, but if you are going to find solutions to real-life problems and do it all the time, then things start to change. In this case, asking students to bring these materials constantly is not sustainable.

Findings Regarding the Needs of Teachers

During the study process, the teachers applied the activities they planned for a semester in their classrooms, and both themselves and their students gained experience in this regard. Thus, the opportunity to determine what is needed for the successful implementation of STEM activities at the primary school level was taken. Teachers shared the needs and what they expected throughout the process.

The needs of teachers are presented in Figure 3. They have been categorized under four main themes. These themes are; a) school culture, b) curriculum, c) continuing PD, and d) material support.

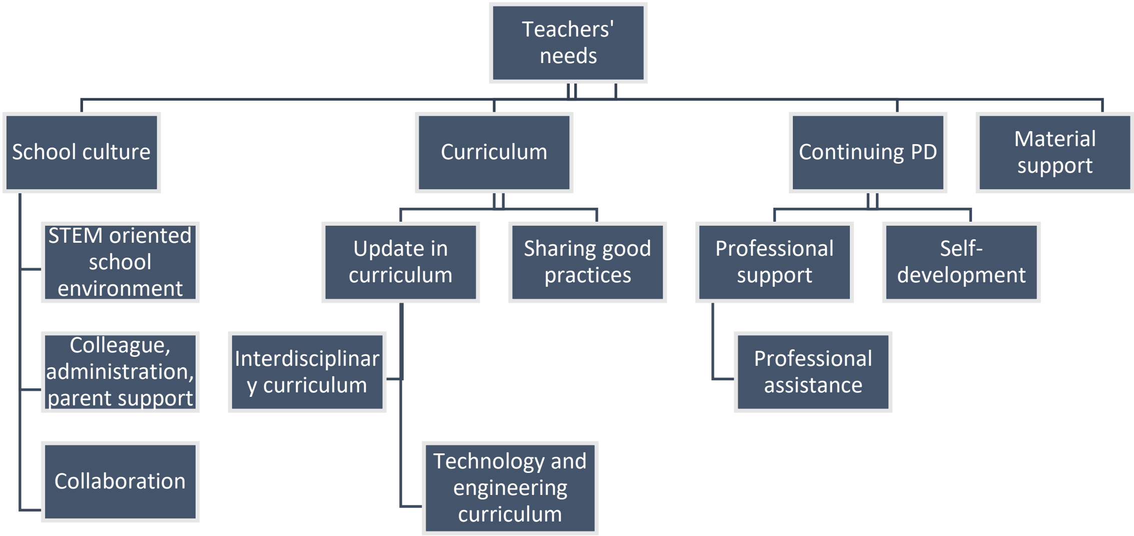

Figure 3. The Needs for Successful STEM Implementation

First, in the theme of school culture, it was found that teachers wanted a STEM-oriented school environment, colleague-manager-parent support, and collaboration. They have previously stated that the current school culture is not ready and suitable for the nature of STEM even if all integration efforts. They stated that it is impossible to implement activities constantly in their classrooms under these conditions and in this environment. For this reason, they stated that there should be a laboratory or a separate classroom where STEM activities can be implemented, or a completely STEM-oriented school. Another sub-category in this theme is colleague-manager-parent support. It was found that teachers who support and implement such activities expect to be appreciated (by colleagues and administration). Additionally, they stated that the attitude of the administrators is very important for a STEM-oriented school. In the current school environment, the teacher has a lot of workloads. School administration should support and encourage teachers in this regard. The lack of support from colleagues and managers affects them negatively and they have such an expectation. They stated that especially the support of parents motivates them, which they consider a must. Another category is the collaboration sub-category. They stated that a single teacher cannot completely deal with STEM at school, so teachers should cooperate with each other at school.

A second theme for the needs of teachers is the curriculum. Teachers stated that curricula should be revised in accordance with STEM education. Teachers need new curricula that enable interdisciplinary, integrative and are completely compatible with the nature of STEM. Although some updates have been made to the current curriculum, it can be said that not entirely suitable for STEM education. Moreover, teachers stated that this change was made only in the fourth-grade curriculum. They emphasized that no attainment they normally practice is included in existing curriculum. They stated that for this reason, they planned the activities themselves by allocating extra time and that they had to implement the program in an extra time to catch up with the scheduled program.

One of the most challenging barriers for teachers in the process is the preparation of activity plans. Teachers stated that they had barriers in terms of what should be done regarding the technology and engineering aspect of the activity, and what an interdisciplinary activity should be like, so they needed an interdisciplinary program for the primary school level, which also includes a technology and engineering program. They also stated that engineering and technology programs should be included in primary school curricula as an interdisciplinary theme and content. Interdisciplinary teaching programs are essential for successful implementation.

Sharing good and exemplary practices is another sub-category regarding the curriculum. The teachers emphasized that there are not many alternatives for their level, that there are many activities when they take a look the internet sites and other resources, but when examined in detail, none of them are completely suitable for their students. Teacher also reported that they were activities for experimentation or entertainment, and they realized that they were not suitable for the spirit of STEM. Teachers stated that for this reason, good and exemplary practices should be shared, otherwise there would be a lack of effectiveness.

Another theme for the needs of teachers is the theme of continuous PD. Teachers have demands for continuous PD for STEM education. This theme includes subcategories of "professional support (professional assistance)" and "self-development".

Teachers stated that their experience in this field increased by participating in the training and making applications in their classrooms. However, they stated in the interviews still need a professional support mechanism that will give feedback and cooperate with them while planning and implementing the activities. Teachers seek ongoing active support from experts in STEM education. For this, teachers want a support centre to be established on a school or provincial basis and experts in STEM education are assigned here. Teachers said that they should consult and exchange ideas about the activities at every stage. Another category is teachers' need for self-development. Teachers stated that they had certain ideas about STEM education in the process. However, they also stated that they realized that there is still much to learn and do in this regard. Teachers emphasized that there is still a lot of PD needs in STEM education for this reason. Teachers stated that they will move to different grade levels every year, so they should constantly improve themselves. In addition, they stated that not all colleagues are as lucky in this regard as they are, and if it is success, we want in STEM education in primary schools, all teachers should be trained.

The last theme expressed by the teachers is the theme of materials. STEM activities require some materials. Although teachers think that the materials related to STEM education will not cause a problem at the beginning, they think they will need material support to be provided in the future. Getting related materials and their cost appears as a problem in the continuing process according to teachers.

Table 5. Examples of Teachers' Expressions About The Needs

Main Theme	Subcategory	Examples of teachers' expressions
School culture	STEM oriented school environment	Teacher M: In school, we students and teachers have to deal with a lot besides STEM. For this reason, we can never fully devote to/ focus on activities. I think there should be STEM-oriented schools. We need to be familiar with these activities. Teacher Ş: A STEM lab or separate classroom is required for the event to be implemented regularly.
	Colleague, administration, parent support	Teacher S: I implemented activities here for a semester. We practiced in the garden, we tried our ovens with our students, but not even one of my colleagues or administrators did ask us what we were doing there. Even if they didn't help, it was enough they said, "take it easy" and offered good wishes. That's what you expect from people, but unfortunately…
	Collaboration	Teacher T: I realized that it is very difficult to plan and implement an activity alone. I have a robotic coding training, for example, I can help other colleagues in this regard. Some of my colleagues at school also have experience in Arduino and visual design. Together, we can plan and implement activities by collaborating. I don't think we need to know everything. This way, we can apply our activities in every classroom together with all our teachers in our school. Teacher H: …Teachers of all branches should all cooperate together... Teacher S: …While I was monitoring my colleague's activity for evaluation, they did the 'earnings piggy bank' activity. I really like this evaluation method. I decided to implement my colleague's brilliant idea. My colleague had asked me at the beginning of the event to present a real-life problem by drama. This way, we have successfully implemented our activities…
Curriculum	Update in curriculum *Interdisciplinary curriculum* *Technology and engineering curriculum*	Teacher M: We have always planned and implemented these activities ourselves. There is only one theme in the science curriculum, but there is no clear information. It should not be a curriculum that tells the teacher what to do in detail about STEM education, but it should still contain enough information to guide the teacher. Teacher H: Unfortunately, current curricula are far from achieving that. Teacher T: …We can teach most disciplines in primary school, but unfortunately, we do not have much experience in interdisciplinary teaching. Unfortunately, there is no program that guides us on how we can plan and implement the technology, engineering and even the art dimension of the event together with other disciplines (interdisciplinary). The technology and engineering program should be included in the primary school programs. I still do not know exactly what the attainments and skills at this level regarding technology and engineering are. Then interdisciplinary programs should be put into effect.
	Sharing good practices	Teacher M: I monitored Teacher S's activity. She presented the problem situation very well with the drama method. I asked her for help, to implement it in my classroom. From now on, I will use this method while doing my activities. Mustafa teacher showed the launch of the rocket on the smart board for his students. The children were so motivated by the process. They were very impressed. I liked the interventions regarding the technology dimension of the activity. I'm thinking of using these too.
	Sharing good practices	Teacher Ş: No matter how you take it, there are problems, not exactly like in my head. In theory, everyone says a lot. When I study resources for STEM activity plans, very different things come out. They are not suitable for my students, and they have named the experiment or recreational activities as STEM. It's all theoretical stuff. It doesn't work for us because it's not something that comes from experience. We need tried-and-tested practices
		Teacher H: None of us are perfect. We can be challenged on our own. No matter how sure we are, we sometimes need to ask, consult, and get approval while performing activities. There should be a place where we can consult. As we talk, new things come out, yet when we do something, we want to ask, get

		confirmation, to explore different solutions and perspectives. These should be followed up, just like the guidance teacher does.
Continuing PD	Professional support *Professional assistance*	Teacher T: An expert in STEM education should give us active support, especially for the technology and engineering dimension. Not every teacher in every school is at the same level. Most of them aren't even as good as us. Teacher H: We always need someone to ask, consult and discuss some ideas about STEM at this level.
	Self-development	Teacher S: At first, we were bad like our students, but we got better as time went on, but we still have a lot to learn. We need to improve ourselves in many other areas such as interdisciplinary teaching, technology and engineering dimension, integration of other disciplines into STEM, preparing activity plans and managing the activity.
		Teacher Ş: My students who will get to the next grade will move to a different level, so I have to constantly improve myself so that I can successfully apply these activities in this new level.
		Teacher S: Not everyone is as lucky as us. Most teachers are not competent at this. Therefore, PD opportunities should be offered to them.
Material support		Teacher M: STEM can be done with simple materials, but different materials are also required later. At the beginning, we provide the materials, the students do, but when you continue like this, you start to have problems with the parents. Moreover, I have students who do not have the financial means. On the other hand, finding some materials is also a problem. That's why material support is essential.
		Teacher H: The problem situation sometimes requires very different materials. Finding these materials is a problem, buying them is a problem… that's why material support is essential.

CONCLUSION and DISCUSSION

This case study process had the opportunity to present the Turkish primary school teachers' experiences of STEM implementations. The experiences of teachers show that there are barriers gathered under six main themes having sub-categories as school culture, curriculum, time, student, teacher, and material. And the needs for successful implementation at this level are also gathered under four main themes having sub-categories as school culture, curriculum, professional development, and material support themes in primary schools.

The Barriers Experienced by Teachers

According to findings, the first theme is the school culture theme in the experienced barriers. It is one of the six main barriers which have sub-categories as education based on exams and instruction, and the physical conditions of the schools and classrooms. Overcrowded classrooms are one of them, too. In the related literature, there are studies with findings revealing barriers originating from school culture (Asghar et al., 2012; Byun et al., 2016; Dancy and Henderson, 2008; El-Deghaidy et al., 2017; Goodpaster et al., 2012; Margot and Kettler, 2019), which are in agreement with the findings of the present study. Teachers feel that there is a mismatch between the current school culture and the nature of STEM education. In the curriculum theme, the integrated STEM program, engineering curriculum, technology curriculum and curriculum load are the barriers experienced by teachers. The current curriculum and program load at primary school level is one of the barriers for teachers. Moreover, the fact that engineering and technology education curriculum are not included in these curricula is a barrier for STEM. Although engineering education was previously given at the undergraduate level, it is now presented at the primary school level with STEM integration. At the end of primary school, it is expected that students' interest and awareness of engineering will reach the highest level (NRC, 2007). The primary school level has also started to play an important role in raising the engineers of the future. However, the teachers had neither an engineering nor a technology education as pre-service teachers, and there is no clear content at this level to help them. Teachers are trying to provide these trainings with their own efforts. There are studies in the literature with findings that are in line with the study findings (Asghar et al., 2012; Bozan and Anagün, 2019; El-Deghaidy et al., 2017; Margot and Kettler, 2019; Stholman et al., 2012; Wang et al., 2011). STEM education offers a certain degree of freedom to the teacher. But this does not mean that the teachers will do everything from planning to implementation on their own. In this regard, teachers should be provided with support, and clear STEM-oriented teaching programs should be put into effect that will be useful to teachers. Another main theme regarding the barriers is the theme of time. The barriers experienced are the teacher's concern about catching up with the scheduled program and the engineering and design processes taking time due to the nature of STEM education. These two factors seem to be completely contradicting each other and therefore cause time problems. Teachers also expressed their opinions about the time problem in other related studies in the literature (Asghar et al., 2012; Bagiati and Evangelou, 2015; Bozan and Anagün, 2019; Dancy and Henderson 2008; Eroglu and Bektas, 2016; Margot and Kettler, 2019; Neil-Burke, 2016; Shadle et al., 2017; Shernoff et al., 2017; Stholman et al., 2012). Teachers need time to plan and implement their activities, but it is not possible to create this time in the current system. The barriers experienced in the teacher theme are the barriers in planning the activities and the activity management. STEM practices are very different from standard activities. Therefore, its planning and implementation require different strategies and methods. There are other studies in the literature with similar findings (Kurup et al., 2017; El-Deghaidy et al., 2017; Ozbilen, 2018) showing that teachers have problems in planning the activity. The fact that the teachers do not have enough knowledge about teaching technology and engineering disciplines, that the lesson plans were provided ready for the teachers for a long time, real-life-based engineering problem, interdisciplinary teaching skills and integration approaches create problems in their planning and implementation of the activities. Most teachers reported that still do not fully understand STEM pedagogy (Bagiati and Evangelou, 2015; El-Deghaidy et al., 2017; Shernoff et al., 2017) and they need professional support in this respect (El-Deghaidy et al., 2017; Goodpaster et al., 2012; Margot and Kettler 2019). In the theme of the student dimension, barriers teachers perceive are that students are not accustomed to working in groups and they have poor dexterity. It was found that students at this level are not accustomed to such long-term activities that require and teamwork and dealing with concrete materials. Teachers see this situation as another barrier. In the literature, Dancy and Henderson (2008) and El-Deghaidy et al., (2017) mentioned similar problems experiences with students. In addition, it is stated in some studies that student's resistance is another barrier (Dancy and Henderson, 2008; El-Deghaidy et al., 2017). Finally, the materials theme is another difficulty experienced at this level. Unlike other activities, STEM requires certain materials. It is understood that finding materials suitable for the level of the student, supplying the material, and those materials coming with a certain cost pose a problem for the teachers further in the process. This affects the sustainability of STEM education. Studies in the literature with findings in line with our study (Bozan and Anagün 2019; El-Deghaidy et al., 2017; Eroglu and Bektas, 2016; Neil-Burke, 2016; Ozbilen, 2018; Wang et al., 2011) also show that material is one of the biggest barriers to STEM education. Teachers should be able to eliminate this material problem by receiving financial support (Byun et al., 2016; Bozan and Anagün, 2019; Margot and Kettler, 2019) instead of expecting materials from students or providing themselves.

Consequently, when compared with the existing findings in the literature, the Turkish teachers mostly experience the same barriers regarding school culture, curriculum, support, timing and materials. On the other hand, complaining weak manual dexterity of students is a different one apart from the literature. From this point of view, this situation seems to be unique to Turkish students only. At the same time apart from the teachers' experiences; lack of collaboration between the public and teachers, a standard definition of STEM, strategies, technology devices, financial support, administrative support and insufficient PD and salaries, resistance to change, loss of autonomy and confidence in preparation and implementation are seen as the other barriers existing in the literature.

The Needs for Successful Implementation

Teachers' needs for successful implementation have four main themes. First, in the context of school culture, teachers listed their needs as a STEM-oriented school environment, colleague-administrator-parent support and collaboration. According to the teachers, the current school culture and the nature of STEM education do not overlap. They expect the support of all parties (colleagues, parents, administrators) at the school and want a collaborative school culture. Again, in line with the findings of the present study, the related literature includes studies that reveal teachers' expectations of a STEM-oriented school culture (Asghar et al., 2012; Bruce-Davis et al., 2014; Neil-Burke, 2016; Owens, 2014; Shernoff et al., 2017; Stholman et al., 2012) and that school culture is very important for successful STEM practices (McMullin and Reeve, 2014). It was also mentioned by other studies that a supportive administrator or administrative team is important when teachers are implementing STEM pedagogy (Holstein and Keene, 2013; Park et al., 2016). Teachers believed instruction by and constant dialogue with administrators are needed in order to successfully utilize STEM programs (El-Deghaidy et al., 2017; Holstein and Keene, 2013; McMullin and Reeve, 2014). Another theme for the needs of teachers is the curriculum. They demand a curriculum completely suitable for the nature of STEM because of seeing the gap in this issue as one of the biggest barriers. Teachers also want good and exemplary practices related to STEM education to be shared. They especially want the technology and engineering curriculum, and interdisciplinary programs to be designed and put into effect as soon as possible. In line with these findings, there are studies in the related literature presenting teachers' demands for STEM-oriented programs (Neil-Burke, 2016; Owens, 2018; Shernoff et al., 2017; Stholman et. al., 2012). In addition, Herro and Quigley (2017) and Park et al. (2016) expressed that the K-12 curricular framework or scope and sequence should be restructured to allow for STEM programming. One of the other themes is PD. Within this theme, teachers stated that they want to receive continuous support from an expert in STEM education and even have ideas on certain issues, they still want to improve themselves on this subject. In short, they demand for continuous PD. No matter how much knowledge or experience they have, teachers have expectations of a mechanism where they can constantly get ideas, consult, and get help when necessary. Teachers want to improve themselves in technology and engineering education, interdisciplinary education, interdisciplinary integration approaches and many other subjects related to STEM education. In addition, most teachers have only awareness-level knowledge of STEM education. For this reason, PD is essential both to understand STEM and to deepen theoretical and applied knowledge on the subject. Teachers should be provided with active support through continuous PD opportunities (Asghar et al., 2012; Owens, 2014). Similar studies conducted with teachers in the literature also reveal a need continuous PD (Asghar et al., 2012; Kurup et al., 2017; Neil-Burke, 2016; Owens, 2014; Owens, 2018; Shernoff et al., 2017; Stholman et. al., 2012). The last theme regarding the demands of teachers is material support. Since teachers see material as a barrier to STEM education, they expressed material support as a need. Similarly, Stohlmann et al. (2012) stated that integrated STEM education often requires numerous materials and resources for students to investigate solutions to real-world problems through designing, expressing, testing, and revising their ideas. Teachers reported that they cannot constantly provide materials themselves or request materials related to STEM education from students. For this reason, they stated that material support is needed in the long term. There are also studies in the literature showing that teachers need material support (Neil-Burke, 2016; Shernoff et al., 2017; Stholman et. al 2012).

The research findings show that the teachers experience the needs under the four themes consistent with the literature as school culture, PD, timing and material support. It turned out that they did not specify any need differently from the existing literature. In addition, different from their experiences; communication, university partner support, additional research support, STEM lab, material storage, technology resource support, broad view of technology, financial support, and confidence in implementation are also defined in the other studies in the literature.

As STEM education becomes increasingly central to every level of education, it is important to understand the barriers and needs for successful implementation at any level in schools. The purpose of the present case study is to reveal what kind of barriers Turkish primary school teachers experience during their implementation of integrated STEM activities and what kind of needs they had for successful implementation at the primary school level and comparing it with the other cases in the literature. While similar studies have been done in the same direction as mentioned in the introduction, the study intended to take advantage of Turkish primary school teachers' own over a half school term period implementation experiences about the barriers and needs for successful implementation who are responsible for teaching at this level. In this respect, it differs from these studies and gets to obtain realistic knowledge involving the teachers' experiences in their classrooms and it also gives an opportunity to compare with the existing literature that was seized. According to findings, the teachers experienced some barriers and the need for successful implementation as in the literature. The barriers were gathered under six main themes having sub-categories as school culture, curriculum, time, student, teacher, and material. Turkish primary school teachers only complained about their students' poor dexterity apart from the literature. The needs for successful STEM implementation at this level were also gathered under four main themes having sub-categories as; school culture, curriculum, PD, and material support themes. The findings support and are consistent with other study cases in the literature. So, it can be said that STEM cannot be fully integrated into existing education systems yet and these barriers and needs will continue to exist. Since STEM education was introduced, many studies have been carried out mainly in the last ten years. However, the findings of these studies show that the main problems related to STEM education are still not solved, STEM cannot be integrated into the existing school system, and most issues are still at the theory level. It is understood that there is a long way to go in primary and other schools for successful implementations in any county. It can be said that teachers want a STEM-oriented school system instead of standard schools and active support for overcoming the related barriers and for meeting the needs. The study sheds light on the current situation in primary schools from the teachers' viewpoint who are responsible for teaching at this level and serves as a springboard for further studies and concerned parties.

RECOMMENDATIONS

This case study has findings according to the experiences of only five Turkish primary school teachers. The study shows that all teachers at any level of classroom, school and country have mostly common barriers and needs for successful STEM implementation. In this regard, a teacher who wants to implement STEM education may encounter the same or different barriers and have needs at any level of other schools. In line with the studies in the literature, the study findings show that the problems related to STEM education continue and there are many more to be done, especially at the primary school level. Although teachers overcome some of the barriers with their own efforts, there still are many barriers that they cannot overcome yet. The study confirms the current case in this regard. It shows that all teachers at any level of classroom, school and country have mostly common barriers and needs for successful STEM implementation. Additionally, it shows that there is an urgent need not theoretical but applied research that will provide useful and practical information and will directly meet the teachers' needs. Within the scope of the present study, teachers have experienced this much. If it continues in the current school system, it seems difficult to change this problem in the future. For this reason, a new STEM-oriented school culture, instead of standard schools can meet the teachers' needs. Otherwise, this burden will only remain on their shoulders, which is far from being sustainable. In this regard, it can be a basic starting point for the measures to be taken. In the light of these findings, interventions regarding the barriers expressed by the teachers can be made and their needs can be met. It seems urgent that continuous PD activities are carried out for teachers, the curriculum is updated, and measures are taken for many other problems and needs mentioned.

ETHICAL TEXT

In this article, the journal writing rules, publication principles, research and publication ethics, and journal ethical rules were followed. The responsibility belongs to the author for any violations that may arise regarding the article. And the data obtained from some interviews with teachers conducted in the author's doctoral thesis were also used. It was conducted in the 2018-2019 school year in the province of Osmaniye, Turkey, in fourth-grade classes at state schools.

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