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Preschool STEM Activities: Preschool Teachers' Preparation and Views

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Abstract

The aim of this study was to determine preschool teachers' STEM training, STEM classroom activities, lesson planning processes, problems, and evaluation strategies and methods during activities. The study sample consisted of 20 preschool teachers. Participants were recruited using criterion sampling, which is a purposive sampling method. This was a case study, which is a qualitative research method. Data were collected using a semi-structured interview form. Qualitative data were analyzed inductive content analysis. Themes, categories, and codes were developed according to the content analysis results in line with the research purpose. Content analysis results showed that participants implemented different preschool STEM activities and used different strategies, methods, and techniques while implementing those activities. They also stated that they faced various problems during those activities. They stated that the STEM training helped them to develop professional competence. However, they had difficulty planning lessons in line with STEM education, due to lack of content knowledge.

Keywords Preschool · Teacher · STEM education · Teacher views

Introduction

Advances in science and technology have changed states' expectations of their citizens. States have revised their education systems and focused on new educational approaches to meet the need for people equipped with the skills necessary to survive in a competitive world. One of those approaches is STEM, which integrates the disciplines of science, technology, engineering and mathematics and relates them to everyday life.

STEM is used in many countries at all levels, from preschool to higher education, to stimulate preschoolers' interest and awareness of STEM fields and to teach them STEM concepts. The preschool period is critical because if children do not develop basic skills and learn concepts during this period, they will have difficulties during later stages of life. Additionally, this is a time in which children begin to identify what subjects they like, what fields they are good at, and what career path they would like to pursue from preschool to higher education. For example, half of students lose interest in science, mathematics, and engineering before they reach the eighth grade (Allen 2016), preventing them from pursuing a career in those areas (Brophy et al. 2008). Therefore, all students should be taught STEM subjects beginning at an early age, in order to increase their interest in these fields and to provide information about related career options. Preschool STEM education helps children to develop positive attitudes towards STEM fields (Gonzalez and Freyer 2014).

In early childhood, children are curious and inquisitive learners who ask questions and establish understandings of cause-effect relationships. They are, therefore, defined as potential scientists who are capable of solving problems creatively (Torres-Crospe et al. 2014). In other words, children in early childhood already possess the twenty-first century skills that STEM education is supposed to help them develop. Preschool STEM education is of paramount importance (Allen 2016; Moomaw and Davis 2010) because it stimulates children's curiosity (Soylu 2016), helps them to develop cognitive, affective, and psychomotor skills (Clements and Sarama 2016; Moomaw and Davis 2010; Torres-Crospe et al. 2014), teaches them STEM concepts (Sullivan and Bers 2016), affects their academic achievement (Becker and Kyungsuk 2011; Milford and Tippet 2015), and encourages them to challenge common misconceptions about gender norms (Kazakoff et al. 2013).

Teachers play a key role in the education system, and therefore, are primarily responsible for preschool STEM

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education and student learning (Türk et al. 2018). Teachers play an important role in classroom this education (Timur and Inancli 2018) because students' academic achievement depends on teachers who are qualified enough to provide appropriate STEM education. Only teachers who have a sound grasp of STEM content can successfully integrate and implement it (Pang and Good 2000). However, preschool teachers typically know less about STEM fields than middle and high school teachers, because the former often learn less about this than the latter in their academic preparation (DeJarnette 2018).

Preschool teachers often have negative attitudes towards STEM education because they know little about STEM fields (Jamil et al. 2018). For example, preschool teachers with low self-perceived competence have difficulty teaching science and mathematics (Timur 2012). For preschool teachers to provide STEM education, they must first be competent in this area. Nugent et al. (2010) reported that increasing preschool teachers' knowledge of engineering increased their self-efficacy and helped them to integrate engineering in classes.

Strategies and methods used by teachers have a significant effect on student interest and attitudes towards STEM fields (Okur Akçay 2015; Ünal and Akman 2006) because they help them learn topics easily and allow them to enjoy learning and develop positive attitudes (Conezio and French 2002). Lesson plans are another factor that helps substantiate STEM knowledge. Lesson plans help teachers deliver lectures and carry out classroom activities systematically and comprehensively (Kablan 2012). Teachers who teach children should, therefore, have competence in STEM education. Research shows that the vast majority of teachers feel incompetent in preschool STEM education, although it is of paramount significance (Yıldırım 2018). What is more, teachers are typically not offered a STEM education program to help them develop STEM skills (National Research Council 2011). Notably, preschool teachers often lack the types of high-quality training that would meet their STEM education needs and help them develop STEM-related professional skills (DeJarnette 2018).

This study provided an 80-h STEM teacher professional development program (STEM-TPDP) for participants to enable them to develop STEM-related professional skills, and then, elicited their views of the program. This study is important because we believe that the STEM-TPDP will be a foundation for STEM education that will be provided to preschool teachers in the future. It is important also because research focuses mostly on primary, secondary, and high school teachers' views of STEM education (Lee et al. 2013; Türk et al. 2018; Wang et al. 2011; Yıldırım 2018), but there are very few studies that investigate preschool teachers' views of STEM education after providing them with initial STEM training (Uğraş and Genç 2018; Park et al. 2016; Uğraş 2017). However, this study provided participants with a professional development program, allowed them to perform classroom activities, and then asked about their views. This is what distinguishes this study from others. The aim of this study was to determine preschool teachers' STEM classroom activities, classroom observations, lesson planning processes, problems, and evaluation strategies and methods that were used during class. In this context, the main research question was: "What do preschool teachers think about STEM activities?".

Methods

Design

Case study design, which is a qualitative research method, was used to validly and reliably determine the effects of the STEM-TPDP on preschool teachers' STEM classroom activities. Case study allows researchers to holistically analyze and interpret an event within its reality (Merriam 2009). The aim of this study was to determine and interpret preschool teachers' views of the STEM-TPDP on their STEM classroom activities. Therefore, each participant was regarded as a case.

Participants

Participants were recruited using criteria sampling, which is a purposive sampling method. Criteria sampling involves the selection of a sample that meets a predetermined set of criteria (Yıldırım and Şimşek 2011). Criteria sampling is a time- and cost-efficient method by which researchers select participants most suited to the research purpose (Platton 2002). Participants were recruited from those who enrolled in trainings and met the specified research criteria. The inclusion criteria were as follows:

1. Having attended the STEM-TPDP training
2. Having performed STEM activities during class
3. Having agreed to be interviewed
4. Teaching students 60 to 66 months of age in kindergartens

The study sample consisted of 20 preschool teachers (16 female, 4 male) who met the inclusion criteria. Eight participants had 1 to 10 years of work experience while the remaining 12 had 11 to 20 years of work experience. Participants were assigned pseudonyms (Ali, Fatma, Buket etc.) in order to assure anonymity.

Instruments

Preschool Teachers Interview Form (PTIF)

Semi-structured interviews were conducted to determine participants' views of STEM activities during class. The 10-item Preschool Teachers Interview Form (PTIF) was developed for interviews (See Appendix 1). It was made sure that the PTIF items were open-ended and easy to understand. The PTIF was sent to two experts, one of whom had published studies and received a PhD degree in the field of STEM education while the other had a PhD in the field of preschool education. The PTIF was revised based on their feedback. A pilot study was conducted with three teachers. The PTIF was finalized based on their feedback.

Data Analysis

Qualitative data were collected through face-to-face interviews. Each interview lasted 20 to 25 min. Data were analyzed using content analysis to develop related themes, categories, and codes, from which findings were derived. The process was completed after the findings were interpreted. Two experts developed the themes, categories, and codes separately. The parts on which they agreed and disagreed during coding were identified. Disagreements were resolved through discussion. Afterwards, interrater reliability was calculated using the formula [Reliability = (number of agreements)/(number of agreements + number of disagreements) × 100] suggested by Miles and Huberman (1994). The interrater reliability in this study was ((119/119 + 20) × 100) = 85.61%, indicating acceptable reliability.

Process

STEM-TPDP for Preschool Teachers

This design process consisted of four stages: (1) design, (2) training, (3) classroom activities, and (4) receiving feedback. The design stage involved the preparation of the STEM-TPDP training. The training stage involved providing participants with the STEM-TPDP training. The classroom activities stage consisted of STEM activities performed by participants in their classes after the STEM-TPDP training. The feedback stage involved eliciting participants' views of the STEM-TPDP training and STEM classroom activities. Based on their feedback, the design stage was revised. Figure 1 shows the process.

Design Process

The STEM-TPDP design process consisted of three steps:

Determining Needs: Preschool teachers' needs were determined using needs analysis, and then, content was revised accordingly.

Determining Objectives: Teaching preschool teachers the pedagogical basis of STEM education to enable them to put it into practice during class.

Determining Content: Preschool teachers were provided with STEM pedagogical content knowledge (STEM-PCK) based on their needs. The STEM PCK consisted of five subscales: content knowledge, pedagogical knowledge, context knowledge, integration knowledge and twenty-first century skill knowledge. The content was based on those subscales:

Content Knowledge: Knowledge related to content was provided to participants. The concepts specified in the preschool curriculum, and the needs analysis results were taken into consideration to determine the concepts to be taught. Participants were taught the concepts of science,

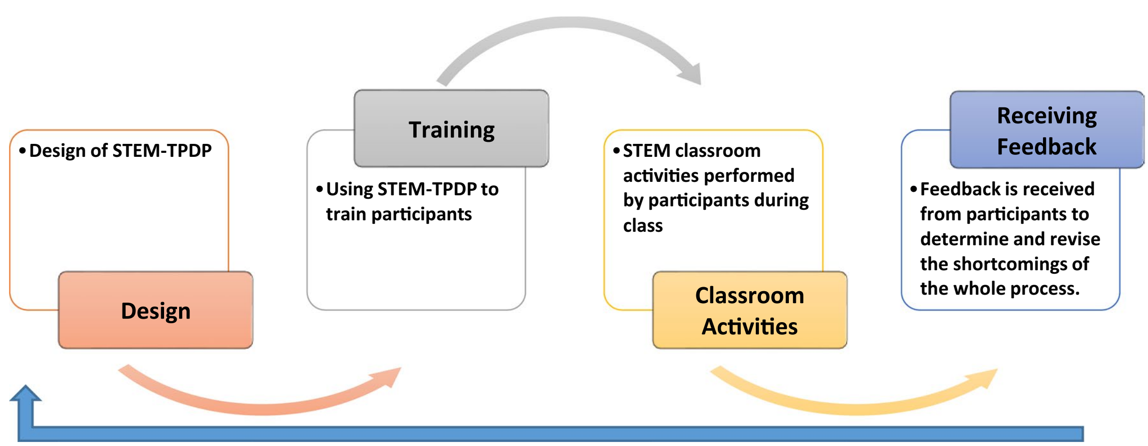

Fig. 1 STEM-TPDP process

mathematics, engineering, and technology, as well as engineering design concepts.

1. *Pedagogical Knowledge* is information on teaching–learning processes, assessment-evaluation, and classroom management.
2. *Context Knowledge* concerns the skills necessary to evaluate STEM education in terms of family, individual and society.
3. *Twenty-First Century Skill Knowledge* contains information on twenty-first century skills.
4. *Integration Knowledge* contains information that participants need to use to be able to integrate STEM education in their classes.

Evaluation: The design process was completed after being reviewed based on participants' needs.

Training Process

The STEM-TPDP training consisted of three steps: (1) theoretical teaching, (2) sample STEM activities, and (3) lesson planning.

Theoretical Teaching: Participants were taught the specified theoretical content.

Sample STEM Activities: Participants were shown sample STEM activities designed for students aged 60 to 65 months. Four STEM activities were presented:

1. Astronomy topics—Rocket Design
2. Living and non-living things—Making innovation inspired by nature
3. Patterns—Bridge design
4. Geometric figures—Home designs

Lesson Planning: Participants developed lesson plans to determine what classroom activities to use and how to use them.

Classroom Activities

Participants put what they learned from the STEM-TPDP training into practice in their classes to reinforce the new information.

Receiving Feedback

After the classroom activities, participants were interviewed to identify their views of STEM education. We then went back to the design step and made corrections based on their feedback.

Results

The themes, categories, and codes are presented as tables. Direct quotations were used to provide an accurate and coherent picture of participants' views and to allow readers to easily analyze and interpret the findings.

The Importance of Preschool STEM Education

The first research question addressed participants' views of the importance of STEM education (Table 1).

Participants' views of the importance of STEM education were grouped under the categories of "skills," "career choice," and "teaching of concepts" consisting of a total of 12 codes. Participants stated that STEM education helped students develop critical thinking, problem-solving, and creativity skills, increased their interest in STEM-related professions and taught them the basic concepts of STEM fields.

Target Skills of STEM Activities

The second research question addressed participants' views of the target skills of preschool STEM activities (Table 2).

Participants' views of the target skills of STEM activities were grouped under four categories consisting of ten codes. Participants stated that they would like to use STEM activities to help their students develop "problem-solving," "creativity and innovation," "entrepreneurship and self-direction," "technology literacy," "scientific process," and "observation skills," which are some of the twenty-first century skills.

Challenges of Lesson Planning

The third research question addressed what kind of problems participants faced during lesson planning (Table 3).

Participants' views of the challenges of lesson planning were grouped under four categories consisting of nine codes. They stated that they had difficulty preparing lesson plans due to different reasons, such as a lack of content knowledge, materials, and resources.

What to Consider When Preparing a Lesson Plan

The fourth research question addressed what factors participants took into consideration for lesson planning (Table 4).

Participants stated that they took four factors into consideration for lesson planning. They stated that they made

Table 1 Participants' views of the importance of STEM education

Theme	Category	Code	Quotations
Importance of STEM education	Skills	Critical thinking skills (n = 5)	It is important because it turns children into inquisitive individuals. (Buket)
		Creativity (n = 3)	It is important because it makes children more creative. (Ayşe)
		Problem-solving skills (n = 3)	It allows children to experience real life and solve potential life problems. (Merve)
		Communication skills (n = 1)	It can help students present their designs and so develop communication skills. (Emine)
		Cooperation skills (n = 1)	I think it allows students to learn to cooperate. (Ali)
		Developing scientific process skills (n = 1)	It helps children develop and use scientific process skills and actively use those skills in the future. (Beyza)
	Career choice	Increasing interest in STEM-related professions (n = 5)	Preschoolers should be given STEM education to increase their interest in the jobs of the future and to prepare them for them. (Fatma)
		Discovering talents (n = 1)	STEM activities play a key role in discovering the potential in every child. (Feyza)
	Teaching of concepts	Teaching the concepts of technology (n = 2)	I think that it is important because it helps children learn about basic technology needed to keep up with technology. (Ayça)
		Teaching the concepts of engineering (n = 2)	STEM activities are important because they allow students to test their designs and teach them the concepts of engineering during design. (Emine)
		Teaching the concepts of mathematics (n = 2)	I think it is important because preschool period is when children learn about basic mathematics. (Ryan)
		Teaching the concepts of science (n = 2)	Students used to focus only on one concept (temperature, coldness, fast-slow, etc.) but now they get to learn different concepts with STEM activities. (Hamza)

sure that their lessons plans were interesting, applicable, compatible with STEM fields, and suitable for students' levels.

Preschool STEM Activities

The fifth research question addressed participants' views of preschool STEM activities (Table 5).

Participants stated that they employed different STEM activities such as robot design, biomimicry, computerless coding, and design from waste materials.

Challenges of STEM Activities

The sixth research question addressed what kind of problems participants faced during STEM activities (Table 6).

Participants stated that they faced various difficulties during STEM activities such as poor time management, easily distracted students, and lack of material.

Strategies, Methods and Techniques for STEM Activities

The seventh research question investigated what strategies, methods, and techniques participants used during STEM activities (Table 7).

Participants stated that they used different strategies, methods, and techniques during STEM activities. They mostly used presentation and learning through research and inquiry strategies; design-based, project-based, and play-way method of learning methods; and experiment and brain storming techniques.

Table 2 Target skills of preschool STEM activities

Theme	Subtheme	Category	Code	Quotations
Target skills	Twenty-first century skills	Learning and innovation skills	Problem-solving skills (n = 9)	Finding different solutions to everyday problems (Beyza)
			Creativity and innovation (n = 9)	People with innovation and productivity skills who use science and technological knowledge (Feyza)
			Cooperation (n = 7)	I think they help children develop cooperation skills to solve problems. (Ali)
			Critical thinking (n = 7)	STEM education should help children develop critical thinking skills, which are some of the most important basic skills. (Fatma)
			Communication (n = 6)	They help children develop communication skills in particular. (Büşra)
		Life and career skills	Entrepreneurship and self-direction (n = 4)	This is a critical period because it allows children to present their activities and share them with their classmates. (Hamza)
			Leadership and responsibility(n = 2)	Preschool STEM activities should help children develop a sense of responsibility (Ayça)
			Social and intercultural skills (n = 1)	Preschool STEM activities can be used to encourage children to interact. (Feyza)
		Information, media, and technology skills	Technology literacy (n = 1)	Preschool STEM activities can teach children about basic technology and help them develop technology skills. (Emine)
	Scientific process skills	Basic skills	Observation (n = 1)	Preschool STEM activities allow children to develop scientific process skills and help them observe living and non-living things and thus develop observation skills. (Hatice)

Methods of Measurement and Evaluation Employed during STEM Activities

The eighth research question addressed the instruments of measurement and evaluation used by participants during STEM activities (Table 8).

Participants' views were grouped under two categories consisting of seven codes. They stated that they mostly used rubrics as an alternative measurement and evaluation method while they used the question–answer method as a conventional measurement and evaluation method.

The Effect of STEM-TPDP Training on Teacher Professional Competence

The ninth research question addressed the effect of the STEM-TPDP training on participants' professional competence (Table 9).

Participants stated that the STEM-TPDP training improved their professional competence in numerous ways such as "content knowledge," "planning education and training," "managing the teaching–learning process," and "personal and professional development."

Table 3 Challenges of lesson planning

Theme	Category	Code	Quotations
Challenges of lesson planning	Content knowledge	Lack of engineering knowledge (n = 3)	I have a hard time aligning engineering content with the subject matter because I think that I know less than I should about how to do it. (Buket)
		Lack of mathematics knowledge (n = 2)	I have difficulty integrating math with other content. It is only addition and subtraction. (Feyza)
		Challenges of ensuring interdisciplinary integration (n = 2)	I have a hard time making interdisciplinary connections. (Ayça)
		Lack of technology knowledge (n = 1)	I find it difficult to integrate technology with other content. (Ayşe)
		Lack of science knowledge (n = 1)	It is hard to integrate every content with science. (Beyza)
	Conditions	Lack of material (n = 1)	I have difficulty planning my lessons because I don't have materials in my classroom that fit the level of the students (Hamza)
		Lack of resources (n = 1)	I have a hard time finding sample lesson plans to prepare one (Ali)
	Time	Challenges of specifying the duration of an activity (n = 1)	I have difficulty figuring out how long an activity should take. (Hatice)
		Lack of time (n = 1)	I end up spending too much time preparing a lesson plan, and there is never enough time. (Fatma)

Table 4 What to consider for lesson planning

Theme	Code	Quotations
Things to consider	Compatibility with STEM fields (n = 12)	I would like to deliver my lectures in accordance with preschool STEM fields and so I make sure that those fields are addressed in my lesson plan. (Büşra)
	Matching students' levels (n = 9)	I try to make sure that my teaching is in line with the age level of my students. (Fatma)
	Interesting (n = 7)	Preschool students are easily distracted, so, activities should attract their attention. Otherwise, they are easily distracted. (Hatice)
	Applicable (n = 2)	I try to prepare applicable STEM lesson plans because not every STEM field is easy to apply, so I take applicability especially into account. (Merve)

Table 5 Preschool STEM activities

Theme	Codes	Quotations
STEM activities	Robot design (n = 4)	We design mini robots. For example, we design robots that draw pictures. (Burak)
	Biomimicry (n = 3)	We observe the animals in nature and try to do it. (Mert)
	Computerless coding (n = 3)	We did computerless coding activities this year and used Bee-Bot for that. (Beyza)
	Design from waste materials (n = 3)	I encourage them to use waste materials to design things. (Hamza)
	Design drawings (n = 2)	I get them to make design drawings within the scope of artistic activities. (Ayla)
	Carpet-weaving (n = 1)	We got them to weave carpets as part of a STEM activity. (Demet)
	Designing ships (n = 1)	We design ships that do not sink. (Merve)
	Astronomy activities (n = 1)	We do STEM activities about space. (Büşra)
	Lego design (n = 1)	We use Legos to design models and things. (Emine)
	STEM activities involving games (n = 1)	All children's games involve math and engineering, so we play games during STEM activities. (Fatma)
	STEM activities involving stories (n = 1)	I use stories to perform STEM activities. (Ayça)

Table 6 Challenges of STEM activities

Theme	Category	Codes	Quotations
	Teacher-related	Poor time management (n = 3)	Time management should be a priority but I have time management problems. (Ali)
Challenges	Student-related	Distraction (n = 2)	Some children have a short attention span, so completing the lesson plan takes longer than it should
		Problems arising from individual differences (n = 2)	The biggest problem is that every child is interested in the process, but I can't devote enough time to each of them. (Ayla)
		Team work problems (n = 1)	Preschoolers are self-centered, so I have a hard time getting them to do team work. (Beyza)
	Environment and condition-related	Lack of material (n = 3)	I've had difficulty doing STEM activities due to problems in material supply and lack of suitable material. (Büşra)
		Lack of secondary elements (n = 2)	I think that there should be someone who assists the teachers of 5–6 years old preschoolers during STEM activities. (Ayça)
		Physical barriers (n = 2)	There is no suitable classroom or space for STEM activities. (Beyza)
		Overcrowd (n = 2)	We are limited by overcrowded classrooms and unfavorable conditions. (Fatma)

Table 7 Strategies, methods and techniques for STEM activities

Theme	Category	Codes
Teaching strategies, methods, and techniques	Strategy	Learning through research and inquiry (n = 5)
		Learning through presentation (n = 4)
	Method	Design-based learning (n = 5)
		Project-based learning (n = 5)
		Play-way method of learning (n = 4)
		Instruction (n = 2)
		5E learning model (n = 2)
		Case (n = 1)
		Showing and getting it done (n = 1)
	Technique	Brain storming (n = 2)
		Experiment (n = 2)
		Drama (n = 1)
		Question–Answer (n = 1)

Table 8 Methods of measurement and evaluation during STEM activities

Theme	Category	Codes	Quotations
Measurement and evaluation methods	Alternative	Rubric (n = 6)	I carry out product-oriented activities for preschoolers, and so I use rubrics to evaluate the product. (Fatma)
		Performance evaluation (n = 2)	I observe and evaluate what they do during activities. (Hatice)
		Peer assessment (n = 2)	I ask them to evaluate each other's performance. (Beyza)
		Portfolio (n = 1)	I use portfolios. I photograph the STEM activities that students are involved in throughout the year. (Hamza)
		Self-assessment (n = 1)	We have a chat with students for assessment after class. We ask them to assess themselves and their classmates. (Burak)
	Conventional	Question–answer (n = 3)	I evaluate them in different ways. For that, I use the question and answer method. (Büşra)
		Matching cards (n = 1)	I show the students picture cards about a topic and ask them to match them. (Ali)

Table 9 The Effect of STEM training on teacher professional competence

Theme	Subtheme	Codes	Quotations
General professional competence	Professional knowledge	Content knowledge (n = 6)	I've learned about STEM education and realized that some of the STEM concepts that I thought I knew were wrong. (Ayşe)
	Professional skills	Providing learning environments (n = 2)	I think it's helped me to provide students with more enjoyable and lasting learning environments. (Emine)
		Planning education and training (n = 6)	After the STEM-TPDP training, I can plan the whole process and integrate the four main disciplines and plan the preschool program (Beyza)
		Measurement and evaluation (n = 1)	I've learned how to evaluate activities. (Ali)
		Managing the teaching–learning process (n = 2)	It's helped me develop activities in a more professional way and make modifications to the process. (Hamza)
	Attitudes and values	Personal and professional development (n = 4)	I think that the training helps me keep my knowledge active and up-to-date. (Büşra)
		Approach to students (n = 2)	I try to engage my students more actively in the learning process and stimulate their curiosity. This encourages them to carry out projects with their parents at home every day and bring them to class (Merve)
		National and universal values (n = 1)	The training has encouraged me to take steps to become an idealistic teacher and made me think together with my students about what we can develop and produce for our country. (Melike)

Participants' Classroom Observations

The tenth research question addressed participants' classroom observations (Table 10).

Participants stated that students mostly paid attention to designs and expressed their predictions about them, used language for interaction and expressed their creativity during STEM activities. They stated that STEM activities also improved their own content knowledge and self-efficacy.

Discussion and Conclusion

This study investigated preschool teachers' views of STEM activities and reached the following results:

The first research question addressed participants' views of the importance of preschool STEM education. They stated that STEM education can help students develop critical thinking, problem-solving, communication, cooperation, creativity and scientific process skills. They also stated that STEM education can be used to teach basic STEM concepts. They think that STEM education increases children's interest in STEM professions and helps explore their STEM skills. This result has been reported by previous studies (Aronin and Floyd 2013; Chesloff 2013; DeJarnette 2012; Katz 2010). For example, Chesloff (2013) argues that STEM education should start at the preschool period in order to teach children important concepts and to help them develop twenty-first century skills. Some other studies show that preschool STEM education activities help children to develop positive attitudes towards STEM professions in the future (Gonzalez and Freyer 2014; Şahin 2013; Maltese and Tai 2010; Tindall and Hamil 2004). Campbell et al. (2018) argue that preschool STEM education increases children's interests in and knowledge of basic STEM fields, and allows them to have experience with these fields. Our results are consistent with the literature.

The second research question addressed participants' views of the target skills of STEM education. They indicated that STEM education should help children to develop problem-solving, critical thinking, cooperation, communication, creativity, and innovation skills as well as different life and career skills such as entrepreneurship, leadership, and responsibility. They also stated that STEM education

Table 10 Participants' classroom observations

Theme	Subtheme	Category	Codes	Quotations
Teacher observations	Child	Cognitive development	Paying attention to designs (n = 5)	Children had longer attention spans. They did not leave the classroom even if the bell rang during design and product development. (Ali)
			Expressing predictions about designs (n = 4)	Children also express their predictions about their designs, like thinking like their friends will come with flying balloons to save the birds. (Hamza)
			Solving problems (n = 4)	Children perceive design problems and solve them. (Melike)
			Asking questions constantly (n = 3)	The more active and stimulating the activity is, the more learning and interest. They constantly ask questions to learn throughout the process. (Hatice)
			Being curious (n = 3)	Children love STEM activities and are curious about them. (Büşra)
		Language development	Using language for interaction (n = 2)	We evaluate them in terms of communication and social skills at the end of activities. Each group presents its design. (Fatma)
			Expressing what they listen to (n = 1)	Students listen with enthusiasm. I get them to talk about what they listen to. (Ayla)
		Social and Emotional Development	Expressing creativity (n = 3)	I realized during the presentation stage that the students were able to think differently and creatively. They suggested different ways in their presentations. (Emine)
			Cooperate with classmates to solve problems (n = 2)	They listen to each other and make decisions together for design solutions. This improves the teamwork process. (Merve)
			Respect your teammates (n = 1)	I get them to do activities to help them develop teamwork skills. I get them to engage in team plays to teach them to respect one another. (Ayşe)
			Fulfilling responsibilities (n = 1)	I tell the kids that they will evaluate themselves at the end of the activity, which get them to fulfill their responsibilities. (Beyza)
	Teacher	General professional competence	Content knowledge (n = 5)	I've realized that I can use STEM concepts in the right place at the right time. (Ayşe)
			Self-efficacy (n = 3)	I've realized that I enter the classroom more confidently to perform STEM activities. (Burak)
			Effective use of time (n = 2)	Lesson plans allow me to use time more effectively. (Hamza)
			Planning education and training (n = 2)	Lesson plans allow me to plan classroom activities better. (Beyza)

should help children develop scientific process skills such as technology literacy and observation skills. Research also shows that STEM education helps children develop twenty-first century skills (Brophy et al. 2008; Moomaw and Davis 2010; NSTA 2014; Stoll et al. 2012) and scientific process skills (Gonzalez and Freyer 2014; Gökbayrak and Karışan 2017; Yamak et al. 2014). Our results are consistent with the literature.

The third research question addressed participants' views of the challenges of lesson planning. They stated that they did not know enough about STEM fields, and therefore, had difficulty planning lessons due to a lack of material, resources, and time, and failure to specify the duration of activities. Karamustafaoğlu and Özmen (2004) argue that the most important factor that prevents teachers from planning lessons is lack of content knowledge. It is, therefore, of paramount importance for teachers to have sufficient content knowledge to be able to plan lessons (Kırıkkaya 2009). Research also shows that preschool teachers do not know enough about STEM fields (Durland et al. 2009). Our results are consistent with the literature.

The fourth research question investigated the types of factors participants considered for lesson planning. Participants stated that they made sure that their lessons plans were interesting, applicable, and compatible with STEM fields, and suitable for students' levels. Atik Kara and Sağlam (2014) also reported that teachers made sure that their lessons plans were applicable and long enough and suitable for students' levels. Our results are consistent with the literature.

The fifth research question addressed participants' views of preschool STEM education. Participants stated that they used STEM activities related to different subject matter during class. They employed robot design, biomimicry, computerless coding, and design from waste materials, and engaged their students in ship design, astronomy, and carpet-weaving. They also used STEM activities through play and stories during class. Our results are consistent with the literature (Akgündüz and Akpınar 2018; Campbell et al. 2018; Stoll et al. 2012; Torres-Crospe et al. 2014; Uyanık Balat and Günşen 2017).

The sixth research question addressed participants' views of the challenges of STEM activities. They stated that they had difficulty managing time, keeping students focused on the lesson, and getting them to do teamwork. They also suffered from lack of materials, unfavorable classroom environments, and overcrowding. These results have been reported by previous studies (Jho et al. 2016; Uğraş 2017; Yıldırım 2018). For example, Uğraş (2017) state that preschool teachers have a hard time getting the materials necessary for STEM education and have problems with time management because the preschool curriculum does not involve STEM education. Wang et al. (2011) argue that the major reason why STEM education is applied incorrectly is because there is no STEM education program tailored to teachers and students. These results indicate that teachers experience similar problems during STEM activities.

The seventh research question investigated what strategies, methods and techniques participants used during STEM activities. They stated that they employed presentation and learning through research and inquiry strategies, design-based, project-based, and play-way method of learning methods, and experiment and brain storming techniques. They also used the 5E learning model, case study, showing and getting it done and instruction methods and brain storming, drama, experiment and question–answer techniques during STEM activities. These results show that preschool teachers use different strategies, methods, and techniques during STEM education. Research shows that methods and techniques used by teachers increase children's interest in STEM fields and help them develop positive attitudes towards them (Okur Akçay 2015; Ünal and Akman 2006). Teachers should, therefore, use different strategies, methods, and techniques during STEM activities. Research also shows that teachers employ different teaching–learning processes during STEM education (Alumbaugh 2015; Evans 2015; Çalışandemir and Bayhan 2011; Katz and Chard 2000; Uyanık Balat and Günşen 2017). For example, Çalışandemir and Bayhan (2011) state that different models (the project-based learning model, etc.) should be used to create stimulating conditions to discover cognitive potential in children. Moreover, Snow (2011) argues that the play-way method of learning is one of the most effective methods that helps preschoolers develop STEM skills. Given the age groups of children, the play-way method of learning should be used for STEM activities because play-based STEM activities facilitate a smooth transition to school and stimulate preschoolers' interest in STEM fields. Our results are consistent with the literature.

The eighth research question investigated what measurement and evaluation tools that participants used during STEM activities. They stated that they used rubrics, performance evaluation, peer assessment, self-evaluation, portfolios, and matching and Q&A cards to evaluate their students' performance in STEM activities. Studies also show that teachers use similar assessment methods during STEM activities (Yıldırım 2018).

The ninth research question addressed the effect of the STEM-TPDP training on participants' professional competence. Participants stated that the STEM-TPDP training provided them with information on content and measurement and evaluation methods, improved their approach to students, raised their awareness of national and universal values, and helped them provide stimulating learning environments, plan education and training, and guide teaching–learning processes. These results indicate that the STEM-TPDP training has a positive effect on teachers' professional competence, which has been reported by previous studies (Bers et al. 2013; Uğraş and Genç 2018; Yıldırım 2018). Both our results and those of others show that preschool teachers should develop professional competence and that future teachers of STEM education should first develop sufficient professional competence (Felix and Harris 2010; Kennedy et al. 2008; Stohlmann et al. 2012; Wang et al. 2011). We can therefore state that STEM training helps preschool teachers develop professional competence.

The tenth research question addressed participants' classroom observations. Participants stated that students mostly paid attention to designs and expressed their predictions about them, solved problems, and constantly asked questions. They also stated that students put their language skills into practice and expressed their creativity, respected their teammates' ideas and worked with them to solve problems, and fulfilled their responsibilities during activities. Participants also reported high self-efficacy in content knowledge, effective use of time, and planning education and training. These results show that STEM education not only helps children develop cognitive, affective, and psychomotor skills, but also helps teachers develop professional competence. The observation and interview results were congruent.

Recommendations

STEM education within the scope of a program helps preschool teachers develop professional competence. Preschool teachers should therefore be offered long-term professional development programs based on the STEM-TPDP.

Preschool teachers face some problems during STEM activities, suggesting that training programs should be revised in the light of those problems in order to make the teacher training process more effective.

Preschool teachers have a gap in their content knowledge. Therefore, they should be provided with in-service training to increase their knowledge of STEM fields.

Preschool teachers think that preschool STEM education helps children develop cognitive, affective, and psychomotor skills. STEM education should, therefore, start in early childhood to provide children with the opportunity to develop different skills.

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Appendix 1: Preschool Teachers Interview Form (PTIF)

1. Why is preschool STEM education important?
2. What skills do you think STEM education should help students develop?
3. What problems do you face when preparing preschool STEM lesson plans?
4. What factors do you consider when preparing preschool STEM lesson plans?
5. What kind of preschool STEM activities do you use in class?
6. What are the challenges of STEM activities?
7. What strategies, methods, and techniques do you use for preschool STEM education?
8. How do you evaluate your students' performance on preschool STEM activities?
9. What do you think is the effect of the STEM-TPDP training on your professional development?
10. What are your classroom observations during preschool STEM activities?

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