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A Different Perspective on Preschool STEM Education: STEM Education and Views on Engineering

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ABSTRACT
This study aimed to determine the views of thirty preservice preschool teachers recruited using convenience sampling on STEM education and engineering. Phenomenology was the design of choice. Data were collected using a semi-structured interview form and analyzed using inductive content analysis. Participants offered different definitions of STEM education and thought that it could have contributions in numerous aspects. They also remarked that preschool STEM education on civil and computer engineering skills made teachers better equipped. They mentioned designs and projects for preschool STEM education as well. However, they had the stereotypical image of engineering as a dirty job for men working in construction sites and carrying sand. Results suggest that preschool undergraduate education should integrate STEM activities and offer workshops and trainings to change preservice preschool teachers' misconceptions about engineering.

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Introduction

Advances in scientific knowledge have brought about new technological applications and a shift in expectations. Some countries have revised their education systems and integrated new approaches to meet the demand for people with the necessary knowledge and skills to stand up to the changing conditions driven by intense global competition. One of those approaches is STEM education, which integrates the disciplines of science, technology, engineering, and mathematics and associates them with everyday life (Kizilay, 2016; Morrison, 2006; Yildirim, 2018).

Countries use STEM education because it helps students develop 21st-century skills, promotes economic and technological development, and facilitates school-industry partnerships (Banks & Barlex, 2014; Karakaya et al., 2018; Ormanci, 2020). Much effort has been put into integrating STEM education into all education levels, from preschool to university because education starts in childhood, and children use the knowledge acquired at early ages in later education levels. Therefore, preschoolers should receive STEM education to acquire fundamental knowledge and develop skills at a young age.

Teachers play a critical role in STEM education (Turk et al., 2018). To achieve high academic standards, students need teachers trained in STEM (Yildirim, 2021). Students' academic performance is correlated with teacher competence (e.g., content knowledge) (Pang & Good, 2000). However, preschool teachers are less informed and less experienced in STEM than middle school and high school teachers (DeJarnette, 2018; Yildirim, 2021). Therefore, STEM education content depends on teachers' field of specialization and students' skills (Yildirim, 2021). However, higher education students can receive STEM education only if they have already acquired the basic STEM knowledge and skills during preschool and primary school years because, otherwise, they would face numerous challenges. For example, children tend to think of engineering as a profession only for men, and therefore, many girls do not even consider it as a possible career choice (Suprapto, 2016; Yildirim & Turk, 2018). This shows that the proper information at an early age plays a crucial role in career choice in the future because, from an early age, children discover the fields they may excel at and find out the kind of career they would like to pursue (Gonzalez & Freyer, 2014). According to Allen (2016), half the students lose their interest in STEM fields before making it to the final year of middle school. Moreover, half the students do not choose a career in STEM fields, perhaps because they believe that those fields are beyond their skill sets (Brophy et al., 2008). Therefore, children engaged in STEM activities at an early age can become more likely to develop positive attitudes towards STEM fields (Gonzalez & Freyer, 2014; Simoncini & Lasen, 2018). Children are called "young scientists" because they are curious from the moment they are born (Torres-Crespo et al., 2014; Yildirim, 2021). They can find solutions to problems and establish a causal relationship between events, suggesting that they already have many of the skills which STEM education targets. Therefore, they should receive STEM education to improve those (Allen, 2016; Moomaw & Davis, 2010; Yildirim & Turk, 2018).

Although it is advocated that STEM education should start at an early age, there are some concerns about preschool STEM education (Cil, 2018) on the grounds that it may be too early for preschoolers and too challenging for teachers who are not equipped to deliver it (Yildirim, 2021). Despite these concerns, STEM should be integrated into preschool education programs because it yields positive learning outcomes (Clements & Sarama, 2016; Early Childhood STEM Working Group, 2017; McClure et al., 2017; Moomaw & Davis, 2010; Soylu, 2016; Torres-Crespo et al., 2014). For example, it teaches children basic STEM concepts (Sullivan & Bers, 2016), helps them develop numerous skills, and promotes future academic performance (Milford & Tippet, 2015; Van Keulen, 2018). Teachers play a key role in preschool science and STEM education (Karademir et al., 2020; Simoncini & Lasen, 2018) because only those with a sound grasp of STEM education can successfully integrate and implement it into their lessons (Pang & Good, 2000). Teachers' in-class attitudes and self-efficacy depend on how equipped they are. For example, those with high self-efficacy are better at teaching basic math and science skills and concepts (Timur, 2012). Teachers should receive proper preschool STEM education before tailoring it to their students' interests and needs (DeJarnette, 2018; Ring et al., 2017; Yildirim, 2021).

Teachers' views and attitudes play a key role in their pedagogical decisions (Timur, 2012). Studies address teachers' and preservice teachers' views of preschool STEM education (Aslan-Tutak et al., 2017; Smith et al., 2015; Stubbs & Myers, 2016; Wang et al., 2011) and engineering education (Bozkurt Altan & Karahan, 2019). There is, however, little research on preschool teachers' and preservice preschool teachers' views of STEM education (Ugras & Genc, 2018; Park et al., 2017; Ugras, 2017; Yildirim, 2021). This study is set to help fill this gap by examining preservice teachers' views on preschool STEM education and engineering. Engineering is the design dimension of STEM, which helps children actively learn and develop cognitive, psychomotor, and affective skills (Yildirim, 2021). This study focused on engineering because teachers with a sound grasp of it can implement STEM education well. The main research question was, "What do preservice preschool teachers think about STEM education and engineering?". The sub-questions were as follows:

1. What do preservice preschool teachers think about STEM education?
2. What do preservice preschool teachers think about engineering?

Methodology

Research Design

This study adopted a qualitative phenomenological design, which allows researchers to obtain detailed information from people with a shared experience of a phenomenon or event (Yildirim & Simsek, 2011). It was the method of choice because this study aimed to gain insight into what people with STEM education experiences in theory (university) and practice (internship) thought about it.

Study Group

The study group consisted of thirty fourth-year students (22 women and eight men aged 19 to 23) from the department of preschool teacher education of the faculty of education of a public university in the fall term of the 2017-2018 academic year. Participants were recruited using convenience sampling, which allows researchers to reach people who best serve research purposes (Balci, 2015, Patton, 2002). Participants were assigned codes for confidentiality.

Data Collection Tools

Semi-structured Interview Form

Semi-structured interviews were conducted with participants to determine what they thought about STEM education and engineering. Data were collected using the Preservice Preschool Teacher Form (PPTF), a 7-item semi-structured interview form developed by the researchers. A semi-structured interview form was the data collection tool of choice because such a form allows the researcher to control the course of the interview (Merriam, 2009). The researchers first specified the PPTF items and then consulted with two experts in preschool and STEM education. Afterward, they revised the items based on expert feedback and finalized the PPTF. Interviews were held for two weeks after weekly training. Figure 1 shows the content of the STEM education. Each interview lasted about 20 minutes (600 minutes in total). All interviews were audio-recorded and then transcribed (100 pages in total). Figure 2 shows some of the PPTF items.

Figure 1

Preschool STEM Education

1. The significance and emergence of STEM education
2. The integration of STEM education into lessons, and sample activities
3. The role of teachers in STEM teaching: STEM pedagogical content knowledge
4. Preschool STEM education lesson planning
5. Preschool STEM activities-1
6. Preschool STEM activities-2
7. Preschool STEM activities-3

Figure 2

Examples of PPTF items

1. How would you define STEM education?
2. What do you think is the importance of preschool STEM education?
3. Do you think STEM education contributes to the professional development of teachers?
4. What do you think about engineers' roles/duties?
5. How would you draw an engineer if you were asked to do so?

6.	What do you think about engineers' characteristics?
7.	What are the misconceptions about engineering?

Data Analysis

The data were analyzed using content analysis. The researchers first transcribed the interviews and then coded them. They specified the codes on which they agreed and disagreed during coding and then discussed the latter to reach a consensus. Interrater reliability was calculated using the formula [Reliability = (64 number of agreements) / (64 number of agreements + 16 number of disagreements)*100] (Miles & Huberman, 1994) and was found to be .80, indicating acceptable reliability.

Ethical Considerations

The ethics committee permission required for the study was approved by the Scientific Research and Publication Ethics Committee of Mus Alparslan University in the letter dated 30.05.2018 and numbered 10879717-050.01.04. Preservice teachers were informed about the research purpose and procedure, and consent was obtained from those who agreed to participate (n =30). Participants were assigned codes for confidentiality.

Findings

This section addressed the data analysis. Codes and themes were developed and presented in tables.

Findings for the First Sub-question

Participants' Views of STEM Education

The first sub-question addressed participants' views of STEM education. We asked them questions to examine the sub-question in detail. We presented the findings regarding the interview questions one by one.

Definitions of STEM Education

The first sub-question focused on how participants defined STEM education.
They defined STEM education as (1) the acronym for the fields of science, technology, engineering, and mathematics, (2) a form of education that relates to everyday life, (3) a process of creating products, and (4) a new educational approach. The following are direct quotations from participants:

S14: STEM education is about teaching science, technology, engineering, and mathematics at the same time.

S10: STEM is an educational approach standing for science, technology, engineering, and mathematics.

S15: STEM is an educational approach that relates science and mathematics to everyday life.

S20: STEM can be defined as a process of creating products.

Contributions of Preschool STEM Education

The second question addressed participants' views on the importance of preschool STEM education. Table 1 presents the categories and codes.

Table 1

Participants' Views of Contributions of Preschool STEM Education

Theme	Category	Code
Contributions of Preschool STEM Education	Cognitive Skills	Improving Creativity (n=21)
		Problem-solving (n=15)
		Improving Social Skills (n=9)
		Improving Productivity (n=8)
		Improving Critical Thinking Skills (n=6)
		Improving Communication Skills (n=6)
		Establishing a Cause-Effect Relationship (n=3)
		Improving Imagination (n=3)
		Improving Academic Performance (n=2)
	Emotional Skills	Improving Self-confidence (n=6)
		Awareness (n=3)
		Increasing Motivation (n=3)
	Ways of Learning	Learning by Doing and Living (n=9)
		Active Learning (n=7)
		Learning Retention (n=7)
		Deep Learning (n=4)

Participants' views were grouped under three categories and 16 codes. They stated that preschool STEM education provided learning retention, improved children's creativity and self-confidence, and helped them develop problem-solving and social skills. The following are direct quotations from participants:

S2: STEM education helps children establish a cause-and-effect relationship about a situation.

S7: STEM education encourages children to cooperate.

S24: STEM education improves children's future academic performance because it addresses numerous disciplines.

S29: STEM educational materials make learning retention possible.

Participants' Views of Teachers' Qualifications

The third question looked into how important participants thought were teachers' qualifications for preschool STEM education. Most participants considered them an important part of preschool STEM education, whereas others were undecided about it. Participants believed that preschool STEM education improved teachers' qualifications. Table 2 presents the Themes and codes.

Table 2

Contributions of Preschool STEM Education to Teachers' Qualifications

Theme	Code
Teachers' Qualifications	Field Knowledge (n=10)
	Methodological and Technical Knowledge (n=4)
	Knowledge of Integration (n=4)
	Knowledge of 21st Century Skills (n=2)
	Knowledge of Guidance (n=1)

Participants stated that preschool STEM education helped teachers develop different professional qualifications such as field, methodological, integrative, and technical knowledge (Table 2). The following are direct quotations from participants:

S17: STEM education helps teachers develop different learning methods.

S18: STEM education improves our knowledge of mathematics.

S25: STEM education makes it easy for us to integrate the disciplines of science, mathematics, and engineering.

S9: STEM education is important for us to identify and support children's abilities.

Findings for the Second Sub-question

Participants' Views of Engineering

The second sub-question focused on participants' views of engineering. We asked them questions to examine the sub-question in detail. We presented the findings regarding the interview questions one by one. The fourth question addressed what participants thought were the tasks of engineers. Table 3 presents the categories and codes.

Table 3

Participants' Views of Tasks of Engineers

Theme	Category	Code
Tasks	Engineering Disciplines	Civil Engineering (n=19)
		Computer Engineering (n=10)
		Landscape Engineering (n=2)
		Electrical and Electronics Engineering (n=2)
		Environmental Engineering (n=1)
		Forest Engineering (n=1)
		Mechanical Engineering (n=1)
		Geological Engineering (n=1)
	Engineering Process	Designing Buildings (n=10)
		Drawing Projects (n=9)
		Working for the Wellbeing of People (n=4)
		Designing (n=4)
		Landscaping (n=1)
		Code-writing (n=1)

Participants' views were grouped under two categories and 14 codes (Table 3). They referred to different engineering disciplines (civil, computer, etc.) and stated that engineers designed and drew projects and buildings, wrote software codes, etc. The following are direct quotations from participants:

S28: Geological engineers seek ways of using energetic resources more efficiently.

S8: Engineers are interested in nature. For example, forest engineers are in constant contact with nature.

S3: Landscape engineers know about soil fertility and do landscaping.

S14: Engineers discover new things for the wellbeing of humanity.

S7: Computer engineers write codes.

S25: Engineers like designing things.

Gender Stereotypes in Engineering

The fifth question discussed participants' gender stereotypes in engineering. Most participants considered engineering only for men. Some participants associated women with engineering, while others stated that both men and women could be interested in engineering. The following are direct quotations from participants:

S23: Our engineer is a man, and his name is Efekan.
S22: I think that only men can be engineers.
S27: I think that both men and women can be engineers. For example, my sister is an engineer.
S9: Women can be engineers, too.

Participants' Views of Engineers' Characteristics

The sixth question investigated participants' views of engineers' characteristics.

Table 4

Participants' Views of Engineers' Characteristics

Theme	Category	Code
Characteristics	Physical Characteristics	Eyeglasses (n=13)
		Short Hair (n=8)
		Crazy Hair (n=3)
		Bald (n=3)
		Beard (n=3)
	Personal Characteristics	Hard-working (n=11)
		Neat (n=9)
		inquisitive (n=8)
		Short-tempered (n=7)
		Smart (n=7)
		Creative (n=6)
		Organized (n=5)
		Optimistic (n=4)
		High Self-confidence (n=4)
		Perceptive (n=3)
		Bookworm (n=3)
		Asocial (n=3)
		Social (n=3)
		Critical Thinker (n=2)
		Patient (n=1)

Participants' views were grouped under two categories and 20 codes (Table 4). They depicted engineers as short-haired or bald people wearing eyeglasses (physical characteristics) who were hard-working, neat, inquisitive, smart, and short-tempered (personal characteristics). The following are direct quotations from participants:

S17: Engineers have vision problems because they work very hard.
S6: Engineers do research all the time.
S21: Engineers are critical thinkers.
S20: Engineers are smart but asocial.
S27: Engineers are perceptive.

Participants' Misconceptions about Engineering

The seventh question investigated what misconceptions participants had about engineering (Table 5).

Table 5

Participants' Misconceptions about Engineering

Theme	Code
Misconceptions	Working in Construction Sites (n=6)
	Using Tools (n=2)
	Doing Paperwork (n=2)
	Carrying Sand in a Wheelbarrow (n=2)
	Supervising Workers (n=2)
	Repairing Computers (n=2)
	Operating Excavators (n=1)

Participants had some misconceptions about engineering. For example, they confused engineers with construction workers operating heavy equipment. The following are direct quotations from participants:

S11: Engineers operate excavators on construction sites.

S10: Engineers visit construction sites and supervise workers until work is done.

S19: Engineers use tools, like a screwdriver, gear, etc.

Discussion

This study addressed preservice preschool teachers' views of preschool STEM education and engineering under two sub-questions and reached the following conclusions.The first sub-question focused on how preservice teachers defined STEM education. Some participants defined it as the acronym for science, technology, engineering, and mathematics, while others defined it as a new educational approach integrating those disciplines. STEM education does not have a standard definition (Langdon et al., 2011). For example, Yildirim and Altun (2014) and Corlu et al. (2014) define it as a form of education involving science, technology, engineering, and mathematics, while the National Science Foundation (NSF) (2014) defines it as an educational approach that encompasses not only science, technology, engineering, and mathematics but also social sciences. This is consistent with our result.

The second sub-question addressed preservice teachers' views on the importance of preschool STEM education. They believed that it helped children develop critical thinking, problem-solving, social, and affective skills, improved their creativity, self-confidence, awareness, and motivation, promoted active learning by doing, and stimulated their curiosity. These results are consistent with the literature (Brophy et al., 2008; Moomaw & Davis, 2010; NSTA, 2014; Stoll et al., 2012; Soylu, 2016; Clements & Sarama, 2016).

The third sub-question addressed how important teachers' qualifications were in preschool STEM education. Most preservice teachers believed that preschool STEM education improved and was improved by teachers' qualifications. Teachers' qualifications play a critical role in education because it is teachers who implement preschool STEM education and help children acquire relevant knowledge and develop skills (Simoncini & Lasen, 2018; Turk et al., 2018; Pang & Good, 2000). Research shows that STEM education also improves teachers' professional skills (Bers et al., 2013; Ugras & Genc, 2018). However, preschool teachers do not have as much STEM knowledge and skills as branch teachers (DeJarnette, 2018; Ring et al., 2017). Preschool teachers with inadequate professional competence in STEM education are likely to apply it less effectively (Jamil et al., 2018). For example, Nugent et al. (2010) state that preschool teachers with more engineering knowledge have more self-efficacy and better integrate engineering into their lectures.

The fourth sub-question addressed what kind of duties preservice teachers thought engineers had. Their views were grouped under the categories of engineering disciplines and engineering processes. They focused mostly on civil, computer, landscape, and electrical-electronic engineering, followed by environmental, forest, mechanical, and geological engineering. Most of them thought of engineers as people who designed buildings, drew projects, did landscaping, wrote codes, and worked for people's wellbeing. Research shows that civil engineering is the type of engineering that comes to mind first (National Academy of Engineering [NAE], 2008; Lambert et al., 2007). Yildirim (2018) also found that preservice teachers thought that engineers mostly designed buildings and bridges.

The fifth sub-question looked into gender stereotypes about engineering. Most preservice teachers thought that men were better suited for engineering than women, while others believed that women could also be engineers. This result indicates the risk of preschoolers inheriting those gender stereotypes from their teachers. Preschool education plays a key role in raising the awareness of STEM fields of female students (Dasgupta & Stout, 2014; Konrad et al., 2000). Therefore, teachers should challenge gender stereotypes about jobs and encourage their students to choose a career in any field of their choice. Otherwise, women refrain from choosing a career that could provide them with power, leadership skills, and prestige (NSF, 2003). Research also shows that the misconception that men are better suited for engineering than women is prevalent (Cunningham et al., 2005; Fralick et al., 2009; Knight & Cunningham, 2004; Meihholdt & Murray, 1999; Sherriff & Binkley, 1997). The Society of Women Engineers states that approximately 20% of engineering students are women (Reinking & Martin, 2018).

The sixth sub-question discussed how preservice teachers portrayed engineers. The characteristics they addressed were grouped under two categories: physical and personal. They depicted engineers as bald or short- or crazy-haired or bearded people wearing eyeglasses (physical characteristics) who were hard-working, neat, inquisitive, smart, short-tempered, creative, organized, confident, optimistic, or perceptive (personal characteristics). For example, Kizilay (2016) and Yildirim (2018) also found that preservice teachers depicted engineers as bald and crazy-looking people who were hard-working, smart, and creative. Therefore, our findings are consistent with the literature.

The seventh and last sub-question investigated what misconceptions preservice teachers had about engineering (Table 6). They thought of engineers as people who worked in construction sites, carried sand in a wheelbarrow, did paperwork, supervised workers, repaired computers, and operated heavy equipment, which is consistent with the results of earlier studies (Cunningham et al., 2005; Knight & Cunningham, 2004).

Conclusion

Participants offered different definitions of STEM education. They held different opinions about the importance of preschool STEM education and believed that it boosted children's self-confidence, awareness, and creativity, and encouraged them to develop problem-solving skills, and learning by doing and living. They thought that STEM education helped teachers acquire professional skills. They had different opinions about engineers' roles and duties. They talked about different engineering disciplines (e.g., computer, mechanical) and stated that engineers drew projects and constructed buildings. Most participants had gender stereotypes about engineering and saw it as a job only fit for men. Participants also had misconceptions about engineering and stereotypical portrayal of engineers as short-haired or bald people wearing eyeglasses.

Preschoolers who learn about STEM fields and develop related skills (problem-solving, curiosity, leadership, etc.) are more likely to be interested in those fields in the future. Besides, they can learn new information much faster and exhibit higher academic performance in the future. STEM education can also help them acquire engineering knowledge and develop related skills. Preschool STEM education ensures academic performance and draws students to engineering. Therefore, we should provide preschoolers with STEM education.

Recommendations

Preschool STEM education should be integrated into the curricula of education faculties as it helps preschoolers develop cognitive, affective, and psychomotor skills, and teachers acquire professional qualifications. Preservice teachers have misconceptions about engineering. Undergraduates should be provided with educational activities to dispel those misconceptions because children learn basic skills and concepts from preschool teachers. What is more, preschool teachers should be provided with the right education on engineering because misconceptions learned at an early age define students' negative attitudes and misguided interests in the future.

Limitations

This study had four limitations. First, the participants consisted only of preservice preschool teachers, and therefore, the findings were sample-specific. Second, phenomenology was the design of choice, which sometimes runs the risk of focusing on the larger picture rather than nuances. Third, the findings were based on self-reports from a relatively small participant group. Fourth, the study focused only on the discipline of engineering in STEM education.

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