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Early Childhood STEM Education Research in Türkiye: A Meta-Synthesis Study

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ABSTRACT

This research aims to establish a comprehensive framework for studying STEM education in early childhood using the meta-synthesis approach. A total of 97 studies conducted in Türkiye between 2017 and October 2024 were examined, focusing on their contributions to the field. The studies were categorized based on sample groups, research methods, data collection tools, and the impact of STEM-based educational practices on children, teachers, and teacher candidates. The findings highlight that STEM education in early childhood generally yields positive outcomes, fostering children's cognitive, social, and problem-solving skills. Teachers and teacher candidates also benefit, as these practices enhance their interdisciplinary teaching abilities and confidence in integrating STEM into their curricula. Despite the growing interest in STEM education, certain areas remain underexplored, such as long-term impacts on children, parental involvement, and the role of school administrators. Additionally, while experimental methods dominate, there is a need for more qualitative and mixed-methods research to provide a nuanced understanding of contextual and process-oriented factors. The results indicate a significant increase in research dedicated to STEM education in recent years, reflecting its critical role in preparing children for the demands of the 21st century. This meta-synthesis study provides a comprehensive overview of trends, gaps, and future directions in the field. By identifying commonalities and under-emphasized points, it offers valuable insights for researchers, educators, and policymakers aiming to advance STEM education in early childhood settings.

Keywords: Early childhood education, meta-synthesis, preschool STEM education, STEM education studies.

Introduction

In today's rapidly evolving educational landscape, driven by consant technological advancements, developing essential skills in children has become increasingly important. Fostering analytical thinking, problem-solving, creativity and collaboration from an early age is key to ensuring their future academic and professional success. STEM education (science, technology, engineering, and mathematics) has emerged as an important educational reform to meet these needs (NRC, 2011; NGSS Lead States, 2013). STEM education provides a comprehensive teaching and learning approach that combines these four disciplines (Corlu, 2013, 2014). Sanders (2009) states that integrated STEM education requires at least two or more of these disciplines to be taught together and supports the development of a qualified, well-rounded workforce.

Early childhood is particularly suitable for introducing STEM because young children are naturally curious and willing to explore their environment (Clements & Sarama, 2016; Campbell & Speldewinde, 2022). Research suggests that interdisciplinary approaches support more effective learning processes for young children (Moomaw & Davis, 2010). Engaging with STEM concepts allows children to explore, observe, experiment, compare, classify, and solve problems; processes that mirror scientific discovery (Katz, 2010). Through guided STEM activities, children's curiosity can be nurtured, helping them build a strong foundation of skills needed for their future (Eshach & Fried, 2005).

The shift in educational priorities from past to present-day needs has highlighted the necessity for all children to build a strong foundation in STEM disciplines (Clements & Sarama, 2016; McClure et al., 2017; Stone-MacDonald et al., 2011; Torres-Crespo et al., 2014). The Early STEM Matters (2017) working group report draws attention to the importance of starting STEM education in the early years of children's lives. Research shows that early STEM education supports the development of children in areas such as school readiness (Toran et al., 2020), problem-skills (Akçay-Malçok & Ceylan, 2022; Erol et al., 2023; Yalçın & Erden, 2021), basic scientific processing skills (Keçeci et al., 2019; Khamhaengpol et al., 2024), engineering skills (Başaran & Bay, 2023), creativity (Akgündüz & Akpınar, 2018; Erol et al., 2023; Temiz &Çevik, 2024; Yalçın & Erden, 2021), critical thinking (Akgündüz & Akpınar, 2018), spatial ability (He et al., 2021), and concept acquisition (Toran et al., 2020).

In early childhood STEM education, it is essential that STEM integration is compatible with children's developmental stages and meets their cognitive, social, intellectual, and academic needs. McClure et al. (2017) emphasize that a well-designed STEM curriculum should be developmentally appropriate, building on young children's natural curiosity and learning abilities. Given young children's propensity to learn through experience, a curriculum that fosters their intellectual curiosity by providing hands-on, experiential learning opportunities is important. Such a curriculum helps children make sense of their environment by encouraging exploratory behaviors and critical thinking, as suggested by Katz (2010). It is stated that participation in developmentally appropriate STEM activities in the preschool period allows children to develop more advanced skills in these areas (Aldemir & Kermani, 2016). These studies lead to the idea that STEM experiences at an early age will provide a solid foundation for children's future academic success (Tippett & Milford, 2017).

In addition to supporting the impact of STEM on early childhood education, teachers' knowledge and experience levels about STEM are critical to increasing their desire to implement and self-efficacy to effectively integrate this education in the classroom. Because, studies reveal that STEM topics are often underrepresented in early childhood classrooms (Tippett & Milford, 2017). Attention needs to be drawn to studies that raise awareness among teachers about the importance of STEM at an early age and what its effects will be in the future (Wang et al., 2011). Corlu et al. (2014), in the Call for Papers on STEM Education, drew attention to the importance of the quality of STEM expert teachers and teacher training in the field of STEM for our country. Because when it comes to preschool curriculum, teachers are responsible for designing activities that are both developmentally appropriate and engaging (Soylu, 2016). In this context, it is vital to focus on classroom practices related to STEM that aim to engage children's interest in STEM disciplines, support their exploration of these concepts, and enhance their higher-order thinking skills (Çiftçi et al., 2022). Integrating these goals into early childhood education will pave the way for children to establish a foundation for long-term interaction with STEM fields from an early age. While the importance of introducing STEM education from an early age is widely recognized (Chesloff, 2013; DeJarnette, 2018; Moomaw & Davis, 2010; Johnston, Kervin & Wyeth, 2022; Yang et al., 2022), research focusing specifically on STEM education in the preschool years remains relatively scarce compared to its implementation in higher grade levels.

Compared to its implementation in higher grade levels, STEM education in early childhood is still an emerging field. (Chesloff, 2013; Van-Keulen, 2018). The earlier children are introduced to integrated STEM experiences, the greater their potential to contribute to the future global workforce. As for today, it is crucial for children to learn through an integrated approach across multiple disciplines. To achieve this, teachers need to be willing to well-prepared to implement STEM activities, while parents and school administrators also have awareness and positive attitudes toward STEM. By working together, they can create a supportive environment that promotes the STEM learning for children.

Purpose of the Study

This study aims to provide a contribution to the field by conducting a comprehensive analysis of the existing literature that emphasizes the importance of early STEM education, examining findings and methodological approaches. In this context, the research includes three main questions:

- What are the general characteristics of the studies conducted (years of research, methods used, data collection tools, study groups)?
- What are the similarities and differences among the studies conducted?
- What are the effects of the studies on the study groups (preschool children, preschool teachers, and preschool teacher candidates)?

Method

Research Model

In the research, "meta-synthesis" research method, one of the qualitative research designs, was used. Meta-synthesis is a systematic statistical comparison used to illustrate the results of research, generalizations and interpretive transformations created by merging the results (Bondas & Hall, 2007; Polat & Ay, 2016). Due to the numerous studies conducted in the field, results of which confirmability is determined can be achieved due to its high generalizability (Büyüköztürk et al., 2008). In the meta-synthesis method, it is to reveal similar and different aspects of the studies with the conceptual analysis (Sandelowski et al., 2007). One of the primary goals of metasynthesis is to enhance understanding of specific phenomena by integrating findings from various studies. This integration can reveal new insights, identify gaps in existing research, and contribute to theory development (Hennebert et al., 2023; Malterud, 2018).

In the data collection process, research conducted between 2017 and October 2024, a period during which research on STEM education has intensified, was used as the dataset with the aim of accessing up-to-date studies. Due to the publication process of the article, research from the entire year of 2024 could not be included; instead, research up to October was examined. A total of 97 studies containing the keywords "STEM Education in Early Childhood, STEAM Education in Early Childhood, STEM Education in Preschool, STEAM Education in Preschool, FeTeMM Education in Early Childhood" were accessed from databases including Google Scholar, TÜBİTAK ULAKBİLİM, YÖK National Thesis Center, Educational Resources Information Center (ERIC), and Scopus. Our analysis of 97 studies, which excluded review articles, highlights the impact of diverse variables such as scientific process skills, problem-solving skills, creativity development, attitudes towards STEM education, awareness of STEM education, and related topics.

Coding Method Used in the Research

The themes dealt with in the studies, all qualitative and quantitative findings were examined and presented in Appendix 1 along with the their respective codes. In addition, the studies are listed according to the year of publication and "X_1, X_2, X_3.......X_{97}" the analyzes were made based on these coding values and are presented in Appendix 2.

Data Analysis

The analysis of the data in the meta-synthesis study is collected under 7 headings (Akuzum & Ozmen, 2013):

Table 1.
Data Analysis Titles

	Data analysis phase in meta-synthesis study	Research Done
Stage 1	Deciding and Starting a Factual Study: This is the first step in defining the subject to be researched.	In this study, the field of study was chosen as "STEM Approach in Early Childhood".
Stage 2	Deciding Which Studies to Use Regarding the Selected Field: This stage includes a literature review for the studies to be analyzed.	In accordance with the criteria determined in the research, 97 studies were selected.
Stage 3	Reading Qualitative Data:	At this stage, the concepts included in the themes and sub-themes of the included studies were examined and key expressions related to the themes were obtained.
Stage 4	Determining How the Data Are Related to Each Other: This is the stage where the similar and different aspects of the studies are determined.	The general characteristics of the studies included in the research are shown in Table 2.
Stage 5:	Transforming Data: Transformations are made based on assumptions generated from studies.	Transformation was made according to the general characteristics and similar characteristics of the studies included in the research.
Stage 6:	Synthesizing Transformations: This stage is used when a large amount of data is included in the research and provides a high level of abstraction.	A synthesis was formed based on the general characteristics and similar characteristics of the studies included in the research.
Stage 7	Stage 7: Expressing the Syntheses: In the last stage, the data obtained by applying the data analysis steps of the meta-synthesis research method were synthesized and expressed.	The synthesis obtained based on the general characteristics and similar characteristics of the studies included in the research was expressed.

Results

The distribution of the analyzed studies by years is shown in Table 2.

Table 2.
Distribution of Studies Included in Meta-Synthesis by Years

Year	Frequency	Percent (%)
2017	1	1.03
2018	9	9.28
2019	20	20.62
2020	15	15.46
2021	15	15.46
2022	13	13.40
2023	15	15.46
2024	9	9.28

When Table 2 is examined, 1.03% (n=1) of the STEM-based early childhood studies were conducted in 2017, 9.28% (n=9) in 2018, 20.62% (n=20) in 2019, 15.46% (n=15) in 2020 and 2021, 13.40% (n=13) in 2022, 15.46% (n=15) in 2023, and 9.28% (n=9) up to October 2024.

The research models used in the studies examined within the scope of the research are shown in Table 3.

Table 3.
*Methods Used in Examined Studies**

Research Model	Frequency	Percent
Experimental Research	52	53.61
Descriptive Research	21	21.65
Mixed Research	12	12.37
Relational Research	3	3.09
Special Case Studies	7	7.22
Action Research	2	2.06

*Note: The classification of research models was made according to Büyüköztürk et al. (2008), Creswell (2002), Erkuş (2016).

When Table 3 is examined, it is seen that 53.61% (n=52) of the studies analyzed within the scope of the research were carried out according to the experimental research model, 21.65% (n=21) were carried out in descriptive research, 12.37% (n=12) in mixed research, 3.09% (n=3) in relational research, and 2.06% (n=2) in action research. In the light of the findings, 7.22% (n=7) of the studies were special case studies. Descriptive statistics regarding the data collection tools used in the studies are given in Table 4.

Table 4.
*Data Collection Tools Used in the Studies Examined**

	Data Collection Tools	Frequency	Percent %
Quantitative	Scale	70	79.55
	Test	14	15.91
	Questionnaire	3	3.41
	Inventory	1	1.14
	Total	88	100
Qualitative	Interviews	54	70.13
	Documents	14	18.18
	Audio-visual materials	3	3.90
	Observations	6	7.79
	Total	77	100

*Note: The classification of data collection tools was made according to Creswell (2016); İlhan and Çetin (2021); Karasar (2009).

When Table 4 is examined, it is seen that 79.55% (n=70) scale, 15.91% (n=14) test, and 3.41% (n=3) questionnaire were used as quantitative data collection tools. Additionally, 70.13% (n=54) interviews, 18.18% (n=14) documents, 3.90% (n=3) audio-visual materials, and 7.79% (n=6) observations were used as qualitative data collection tools. Descriptive statistics regarding the study groups included in the studies are given in Table 5.

Table 5.
Sample Group Included in the Studies Examined

Sample Group	Frequency	Percent %
Preschool children	47	43.12
Preschool teacher candidates	28	25.73
Preschool teachers	26	23.85
Parents	6	5.50
Other (administrators)	2	1.83

When Table 5 is examined, of the studies conducted on the STEM approach in the early childhood period (n=97), 48.61% (n=35) of the study group were preschool children, 25.73% (n=19) were preschool teacher candidates, 23.85% (n=17) were preschool teachers, 5.50% (n=4) were parents, and 1.83% (n=1) were other (administrators). Considering the studies examined, it is evident that the majority of studies conducted in early childhood focus primarily on children. Following this, preschool teachers are included as participants in the studies, while studies involving parents and administrators are relatively few. Key phrases and concepts that reveal similar and different aspects of the studies examined by adhering to the steps of the meta-synthesis method are shown in Table 6.

Table 6.

Similar and Different Aspects of the Studies Examined

Code		Key Phrases and Concepts	f	%
Preschool teachers	VSA	STEM Education is important for children (X_2, X_{10}, X_{15}, X_{31}, X_{32}, X_{37}, X_6, X_{73}, X_{79}, X_{82}, X_{16})	11	18.97
		Have difficulties in the implementation (X_6, X_{16}, X_{75}, X_{76})	4	6.9
		Have no idea about STEM Approach (X_9, X_{12}, X_{48})	3	5.17
		Want to receive STEM-themed education and apply it in their lessons (X_1, X_{14}, X_{90})	3	5.17
		Key themes for successful STEM planning: materials, group work, classroom management, time management, child suitability, problem identification, activity planning, and implementation (X_{66})	1	1.72
		Most of them prepared and implemented STEM integrated lesson plans successfully. (X_{65})	1	1.72
	SSEB	Low STEM teaching self-efficacy beliefs (X_7)	1	1.72
		Lower self-efficacy levels than primary teachers (X_4)	1	1.72
		No significant difference in self-efficacy by gender/grade, but higher in those with STEM training (X_{72})	1	1.72
		STEM awareness does not vary by demographics but is higher in those with STEM training (X_{62}).	1	1.72
	STT	Struggle with STEM lesson planning but improve over time (X_3, X_{28}, X_{32}, X_{49}, $X5_2$, X_{53}).	6	10.34
		Believe preparatory activities should come first, empathy skills should be fostered, and special needs considered (X66).	1	1.72
	ASA	Does not show a significant difference according to demographic variables but differs significantly according to their STEM education status(X_{62}).	1	1.72
Preschool teacher candidates	VSA	STEM Education is important for children (X_{28}, X_{49}, X_{52}, X_{53}, X_{72}, X_{75})	6	10.34
		Have difficulties in the implementation process (X_{28}, X_{49}, X_{52}, X_{53})	4	6.9
	ASA	High awareness and orientation towards STEM (X_{55})	1	1.72
		Male candidates have higher awareness; STEM education increases awareness (X_{30}).	1	1.72
Families	VSA	STEM Education is important for children (X_{10}, X_{15}, X_{31})	3	5.17
		Have no idea about STEM Approach (X_{37})	1	1.72
Children	SSI	Associate science with living things, technology with robots, math with numbers; few mention engineering (X13).	1	1.72
	STT	STEM activities positively impact children's conceptual development and questioning skills (X_{60}, X_{79}).	2	3.45
ATS		Science, Technology and Engineering Scale of the C-PALLS+STEM (X_{46}) STEM Parent Awareness Scale (X_{36})	2	3.45

When Table 6 is examined, studies conducted with preschool teachers on the STEM approach show that 18.97% (n=11) of these studies consider STEM education to be important for children. 6.9% (n=4) of them reported difficulties in the implementation process, while 5.17% (n=3) of the teachers indicated that they had no knowledge of STEM. Additionally, 1.72% (n=1) of the studies found that teachers successfully implemented STEM activities.

In another study (1.72%, n=1), eight themes regarding solutions for the successful planning and implementation of STEM-based activities by pre-service teachers were identified, including: materials to be used, group work conducted by pre-service teachers, classroom organization and management, time management, suitability for children's level, problem identification and expression, activity planning and practice, and STEM education applications (X66). Furthermore, 1.72% (n=1) of the studies found that teachers had low self-efficacy in STEM education, and 1.72% (n=1) indicated that their self-efficacy was lower compared to primary teachers. In 3.45% (n=2) of the studies, STEM self-efficacy was found not to vary by gender or class variables but to differ according to STEM education status.

In 10.34% (n=6) of the studies, teachers initially faced challenges in preparing STEM lesson plans but improved over time. Additionally, 1.72% (n=1) emphasized the importance of considering individual differences and supporting children's empathy skills. Another 1.72% (n=1) revealed that STEM awareness did not vary according to demographic variables but did change according to whether the teachers had received STEM training.

In studies involving preschool teacher candidates, 10.34% (n=6) highlighted the importance of STEM education for children, while 6.9% (n=4) reported difficulties in implementation. In 1.72% (n=1) of the studies, candidates demonstrated high levels of awareness and orientation towards STEM education. Additionally, it was found that male students had higher awareness levels of STEM compared to female students and that STEM education had a positive impact on awareness.

Studies conducted with children on the STEM approach showed that 1.72% (n=1) associated science with the living realm, technology mostly with robots, and mathematics with numbers, with almost no child expressing an opinion on the field of engineering. In studies involving families, 5.17% (n=3) indicated that STEM education is important for children, while 1.72% (n=1) stated that families had no knowledge of the STEM approach. Lastly, 3.45% (n=2) of the studies focused on the development and adaptation of STEM-related scales.

Table 7.

Impact of STEM Education of Preschool Children

Dependent variable and code		Independent variable and research code	Affect	f	%
SSPS	Scientific Process Skills	STEM (X_{5}, X_{17}, X_{25}, X_{27}, X_{29}, X_{31}, X_{39}, X_{40}, X_{57}, X_{58}); STEM+Drama (X_{24}); STEM+A (X_{88})		12	23.08
SPSS	Problem-Solving Skills	STEM (X_{19}, X_{20}, X_{29}, X_{38}, X_{41}, X_{51}, X_{67}, X_{73}, X_{90}, X_{94}, X_{96}); STEM with simple materials and robotic (X_{23})		12	23.08
SC	Creativity	STEM (X_{18}, X_{26}, X_{38}, X_{68}); STEM+Drama (X_{24}); STEAM (X_{89}, X_{97})		7	13.46
SBD	Cognitive Thinking	STEM (X_{20}, X_{25})		2	3.85
ScriT	Critical Thinking	STEM (x_{68})		1	1.92
SSI	Scientist Image	STEM (X_{21})		1	1.92
SAVP	Visual Perception	STEM (X_{61})		1	1.92
SIBT	Inquiry-Based Thinking	STEM (X_{45})	Positively	1	1.92
SDMC	Dev. of Math. Concept	STEM (X_{42})		1	1.92
SSR	School Readiness	STEM (X_{43}); STEAM (X_{79})		2	1.92
SAASC	Academic Self-Concept	STEM assisted with Robotic (X_{23})		1	1.92
SEDP	Engineering Design Process	STEM (X_{35}, X_{94}); STEAM (X_{87})		3	1.92
SSM	Science Motivation	STEM (X_{45}, X_{82})		2	1.92
SASC	Science Conceptual	STEM with 5E model (X_{71})		1	1.92
ATS	Attitude Towards STEM	STEM (X_{35}, X_{80})		2	1.92
SES	Self-Esteem	STEM Based on Montessori (X_{70})		1	1.92
SDMS	Decision-Making	STEM (X_{29})	Limited	1	1.92
SSPS	Scientific Process Skills	STEM (X_{21})	Not	1	1.92

In Table 7, studies examining the effects of STEM applications on children from various perspectives are analyzed. It was revealed that in 23.08% (n=12) of them scientific process skills; 23.08% (n=12) of them problem solving skills; 13.46% (n=7) of them creativity; 3.85% (n=2) of them cognitive thinking; 1.92% (n=1) of them critical thinking; 1.92% (n=1) of them scientist images; 1.92% (n=1) of them visual perceptions; 1.92% (n=1) of them development of mathematic concept; 3.85% (n=2) of them school readiness; 1.92% (n=1) of them academic self-concepts; 5.77% (n=3) of them engineering design processes; 3.85% (n=2) of them science motivations; 1.92% (n=1) of them science conceptual; 3.85% (n=2) of them attitude towards STEM and 1.92% (n=1) of them self-esteem were positively affected. In addition, 1.92% (n=1) of the studies found that it had a limited effect on children's decision-making, and it was revealed that 1.92% (n=1) did not contribute to scientific process skills.

Table 8.
Impact of STEM Education of Preschool Teacher

Dependent variable and code		Independent variable and research code	Affect	f	%
SSEB	Self-Efficacy Belief	STEM (X_{47}, X_{56}, X_{78})	Positively	3	21.43
ATS	Attitude Towards STEM	STEM (X_{47}, X_{56}, X_{80})		3	21.43
SRT	Reflective Thinking	STEM (X_{50})		1	7.14
SATP	Attitude Towards Profession	STEM (X_{34})		1	7.14
ASA	Awareness of STEM	STEM (X_{22})		1	7.14
SSPS	Scientific Process Skills	STEM (X_{22}, X_{88})		2	14.29
SASC	Science Conceptual	STEM (X_{64}, X_{90})		2	14.29
SATS	Attitude Towards Science	STEM Based on Montessori (X_{11})		1	7.14

When Table 8 is examined, studies examining the effects of STEM practices on pre-school teacher candidates from various perspectives are analyzed. In the studies reviewed, 21.43% (n=3) positively affected self-efficacy beliefs; 21.43% (n=3) influenced attitude towards STEM; 7.14% (n=1) impacted reflective thinking; 7.14% (n=1) affected attitude towards profession; 7.14% (n=1) enhanced awareness of STEM; 14.29% (n=2) improved scientific process skills; 14.29% (n=2) supported science conceptual understanding; and 7.14% (n=1) influenced attitude towards science.

Table 9.
Impact of STEM Education of Preschool Teacher Candidates

Dependent variable and code		Independent variable and research code	Affect	f	%
ScriT	Critical Thinking	STEM (X_{59}, X_{75}), UCT-STEM (X_{77}) STEM Based on Montessori (X_8, X_{33})	Positively	5	27.78
SCT	Computational Thinking	STEM (X_{59})		1	5.56
S21stCS	21st Century Skills	STEM (X_{59}, X_{81})		1	5.56
SC	Creativity	STEM (X_{76}, X_{81}), STEM Based on Montessori (X_8, X_{11})		4	22.22
SPSS	Problem-Solving Skills	STEM (X_{76}), STEM Based on Montessori (X_8)		2	11.11
SDLS	Self-Directed Learning Skills	STEM (X_{95}), STEM Based on Montessori (X_{63}, X_{69})		2	11.11
SLLT	Lifelong Learning Tendency	STEM (X_{95}), STEM Based on Montessori (X_{69})		2	11.11
SCLE	Constructivist Learning Environment	STEM Based on Montessori (X_{69})		1	5.56

When Table 9 is examined, studies examining the effects of STEM applications on preschool teacher candidates from various aspects revealed that 27.78% (n=5) of them showed positive effects on critical thinking; 5.56% (n=1) on computational thinking; 5.56% (n=1) on 21st century skills; 22.22% (n=4) on creativity; 11.11% (n=2) on problem-solving skills; 11.11% (n=2) on self-directed learning skills; 11.11% (n=2) on lifelong learning tendency; and 5.56% (n=1) on constructivist learning environment.

Discussion

This meta-synthesis research aims to present the general framework of recent studies on the STEM approach in early childhood and to shed light on future research. To this end, 97 studies conducted in the field of STEM in early childhood between 2017 and October 2024 were examined. The analysis of the findings shows that STEM-based educational practices have a positive impact on children, preschool teachers, and teacher candidates in early childhood. This finding supports the literature emphasizing the developmental significance of STEM education in early childhood: Research indicates that high-quality early childhood education, which includes STEM learning, is vital for fostering curiosity and a love for learning STEM disciplines in young children (Campbell & Speldewinde, 2022). There is a consensus internationally on the importance of starting STEM education at an early age. For instance, the National Academies emphasize that students without early STEM experiences until fourth grade generally lag behind in basic math and science skills (Pantoya et al., 2015).

Our findings indicate that STEM studies based on early childhood have generally increased over the years. Similar results were obtained in the studies by Yıldırım (2016) and Herdam and Ünal (2018). It is observed that children's participation in the study groups of the examined research is higher. Subsequently, it was emphasized that preschool teacher candidates and preschool teachers are also included in the study groups. However, we can say that studies involving parents and other stakeholders (e.g., administrators) are relatively few. In the future, increasing research conducted with these study groups is important for evaluating the STEM approach from various aspects. Most of the research methods used in the studies were experimental and descriptive research types. It is important to prefer experimental studies more to reveal the effects of STEM-based educational practices on children. It is observed that mixed, relational, and special case and action research methods are more limited. Sandelowski emphasizes that mixed methods can enhance the quality and relevance of research by integrating various perspectives (Sandelowski, 2013). An exploratory case study conducted by Poyraz and Kumtepe (2019) provides valuable insights and is effective for understanding the dynamics of STEM teaching. Rowland et al. (2019) discuss the use of qualitative techniques in STEM education research and state that it can lead to significant insights, especially in underrepresented subfields.

Most of the data collection tools used in the studies are scales and interviews. Documents and tests are also used; however, audiovisual materials, observations, and inventories are utilized to a limited extent. The widespread use of interview forms, which are a suitable data collection tool for STEM, is an important finding. Additionally, the use of children's drawings, product/activity evaluation rubrics, and STEM notebooks supports the idea that the STEM approach focuses not only on outcomes but also on processes. However, the lack of process-oriented portfolios for children and teachers is striking. In developed countries, portfolio-based studies that monitor the development of children and teachers are an important aspect of early childhood STEM education practices (Harris et al., 2016; Milford & Tippet, 2015). Future research in this area should prioritize the use of portfolios for children, teachers, and even families to document developmental progress in the educational process.

STEM education has become a significant focus area in early childhood education. The studies synthesized in this work highlight the positive effects of STEM education on both preschool children and their teachers. The results indicate that STEM education positively impacts various skills and attitudes, such as scientific process skills, problem-solving skills, creativity, self-efficacy beliefs, and attitudes toward STEM and science. It appears that the most emphasized topic is the effect on children's scientific process skills. The studies conclude that the educational practices of the STEM approach positively influence children's scientific process skills. However, one study found that STEM-based educational practices did not affect children's scientific process skills. Research in the literature emphasizes that exposure to STEM concepts at an early age enhances fundamental skills of scientific literacy, such as critical thinking, problem-solving, and inquiry-based learning, and increases learning motivation (Salahova, 2023; Sydon & Phuntsho, 2022). Piasta et al. (2013) emphasize that a significant percentage of preschool classrooms provide opportunities for children to engage in critical thinking experiences, which are essential components of scientific process skills, such as predicting, observing, and questioning. STEM activities enable children to actively participate in a natural learning environment and reinforce their scientific thinking skills (Bagiati et al., 2015). Supporting children's skills with STEM in early years contributes to their academic success in later years (Uğraş & Genç, 2018).

The findings of this study summarize the perspectives of preschool teachers, teacher candidates, families, and children regarding STEM education in early childhood. Most preschool teachers believe that STEM education is important for children, but they face challenges in the implementation phase. However, they are developing themselves in the process of preparing STEM lesson plans. While it was found that teachers receiving STEM education have a higher level of awareness, preschool teacher candidates also have a positive and high level of awareness and orientation. STEM education is also important for families but research involving parents is quite limited compared to other studies. Activities prepared based on the STEM approach positively affect preschool children's conceptual development and inquiry-based thinking skills. This situation indicates a lack of pedagogical content knowledge about the STEM approach among preschool teachers. Indeed, studies examining the effects of the STEM approach on teachers' attitudes, awareness, and self-efficacy beliefs have concluded that the STEM education provided to teachers has a positive impact on their attitudes, awareness, and self-efficacy beliefs regarding the STEM approach. This situation is also compatible with the aforementioned scenario. Although preschool teachers may have negative attitudes toward the STEM approach, a lack of knowledge, and low self-efficacy beliefs, training supported by pedagogical content knowledge for STEM education positively influences their attitudes, awareness, and self-efficacy beliefs. Therefore, providing more STEM training will enhance the quality of preschool teachers' STEM practices in the classroom. Studies have shown that when teachers receive sufficient training and support, their self-efficacy and confidence in teaching STEM subjects increase, which positively affects their students' learning outcomes (Demircan, 2021; Gözüm et al., 2022). Aldemir and Kermani (2016) found that a well-designed STEM curriculum improves teachers' attitudes and professional competencies. Supporting this view, Fridberg et al. (2022) state that increased knowledge and experience in STEM can significantly enhance teachers' instructional practices and their ability to facilitate STEM learning in the classroom. Stohlmann et al. (2012) advocate for integrated STEM education approaches that encourage collaboration and problem-solving among young students. The effective implementation of STEM education requires not only adequate training but also supportive educational environments that foster collaboration and innovation among educators (Kastriti et al., 2022). Additionally, it is important for teacher training programs to include components that specifically address the integration of STEM into early childhood education (Shernoff et al., 2017). Papadakis et al. emphasize the importance of understanding the challenges teachers face in implementing STEM curricula, suggesting that education should address these specific needs (Papadakis et al., 2021).

This meta-synthesis illustrates the evolving landscape of STEM education in early childhood, underscoring its widespread recognition as a powerful approach for enhancing young learners' foundational skills in science, technology, engineering, and mathematics. Through an analysis of studies spanning recent years, this work has highlighted not only the benefits of STEM education for children's cognitive and scientific skill development but also the growing interest in equipping teachers and teacher candidates with STEM-related competencies. Furthermore, while early findings predominantly focus on children and teachers, the limited exploration of STEM's impact on families and broader educational stakeholders points to potential areas for expansion in future studies. The diverse methodologies employed and tools used across studies also suggest a dynamic field, with promising avenues for further innovation in both experimental and mixed-methods research. The cumulative evidence thus reinforces the importance of integrating STEM into early childhood education as a means to nurture inquisitive, resourceful learners ready to meet the challenges of an increasingly STEM-oriented world.

Conclusion and Recommendations

The findings of this study support the idea that STEM education is beneficial for both preschool children and teachers. The positive effects on skills and attitudes, such as scientific process skills, problem-solving skills, creativity, and self-efficacy beliefs, align with the goals of early childhood education aimed at developing children's cognitive, social, and emotional skills. By introducing STEM to children at an early age, we can help them develop essential problem-solving and critical thinking skills that will benefit their academic and professional careers. In addition to the benefits provided to children, STEM education also demonstrates a positive impact on the attitudes and skills of teacher candidates. STEM education can help teachers improve their reflective thinking, STEM awareness, and attitudes toward STEM and science. This situation may lead to the development of more equipped teachers who possess the knowledge and skills to provide effective STEM education to young children. It indicates that not all areas of STEM education have been equally researched, and the effects of some variables have only been examined in a single study. Therefore, more research is needed to fully understand the benefits and limitations of STEM education in early childhood education.

In our current research, a limited number of databases were used, and a restricted time frame was considered. Future research could focus on interdisciplinary STEM studies for preschool teachers and teacher candidates, studies involving the participation of parents and other educational stakeholders (administrators, school personnel), greater emphasis on mixed methods and qualitative research methods, studies on child portfolios, process-oriented evaluations, focusing on relatively underexplored areas of social and emotional development, international comparisons, or the development of datasets through meta-synthesis or meta-analysis studies.

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