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Trends, Opportunities, and Pipelining in Preschool STEM Education: A Scoping Review

Okul Öncesi STEM Eğitiminde Eğilimler, Fırsatlar ve Eksiklikler: Bir Kapsam Belirleme İncelemesi

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ABSTRACT: This study was planned with the aim of conducting a comprehensive literature analysis of preschool STEM education research and evaluating future opportunities. Scoping Review was conducted by analyzing 29 articles in journals published by Springer, Taylor & Francis, Elsevier, and SAGE, which were obtained using combinations of the keywords "STEM," "STEM education," "kindergarten," and "preschool." The results show that the literature on STEM research in preschool, which has largely developed in the United States, has grown in recent years, forming a relatively new and expanding field. It is concluded that preschool STEM education research promises to be a popular field in the future. Studies in which different STEM activities were carried out were identified along with the examinations. In these studies, activities focus on games, teacher roles, or program and model development. For such activities, factors such as the role of sample groups in the process and their impact on the process should be determined. In other words, there is a need for studies focusing on the evaluation dimension of STEM education in preschool education.

Keywords: Preschool, scoping review, STEM, STEM education.

ÖZ: Bu çalışma, okul öncesi STEM eğitimi araştırmalarına ilişkin kapsamlı bir literatür analizi yapmak ve gelecekteki fırsatları değerlendirmek amacıyla planlanmıştır. Kapsam Belirleme İncelemesi, Springer, Taylor & Francis, Elsevier ve SAGE tarafından yayınlanan dergilerde yer alan ve "STEM", "STEM eğitimi", "anaokulu" ve "okul öncesi" anahtar kelimelerinin kombinasyonları kullanılarak elde edilen 29 makale incelenerek yapılmıştır. Sonuçlar, Amerika Birleşik Devletleri'nde büyük ölçüde gelişen okul öncesi STEM araştırmalarına ilişkin literatürün son yıllarda büyüyerek nispeten yeni ve genişleyen bir alan oluşturduğunu göstermektedir. Okul öncesi STEM eğitimi araştırmalarının gelecekte popüler bir alan olmayı vaat ettiği sonucuna varılmıştır. İncelemelerle beraber farklı STEM aktivitelerin gerçekleştiği çalışmalar tespit edilmiştir. Bu çalışmalarda aktiviteler oyunlara, öğretmen rollerine veya program ve model geliştirmeye odaklanmaktadır. Bu tür faaliyetler için örneklem gruplarının süreçteki rolü ve sürece etkisi gibi faktörlerin belirlenmesi gerekmektedir. Diğer bir deyişle, okul öncesi eğitimde STEM eğitiminin değerlendirme boyutuna odaklanan çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Okul öncesi, kapsam belirleme, STEM, STEM eğitimi.

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To facilitate students' learning through exploration and experimentation, the integration of science, technology, engineering, and mathematics (STEM) is an international priority (Bybee, 2013). One factor that has been identified as significantly contributing to young children's later school achievement is early exposure to STEM knowledge and skills (Morgan et al., 2016). Alongside recommendations on engaging students in STEM education, the importance of introducing children to STEM opportunities early in their education is often highlighted (National Research Council [NRC], 2011). STEM education is important in terms of nurturing and maintaining young children's natural interests in the relevant subjects and career fields and developing their problem-solving, critical, and logical thinking skills while strengthening intellectual habits (Ata-Aktürk & Demircan, 2021; Lange et al., 2019). Over the years, great importance has been placed on STEM as a field of study that is key for a country to gain a competitive advantage on the global stage, leading to a shift in educational paradigms emphasizing the importance of STEM (Kayan-Fadlelmula et al., 2022). With a simple Google search, 450 million websites can be accessed using the terms "STEM," "STEM education," and "STEM education research" (Li et al., 2020). This is because STEM education contributes to students in various ways, including academic success, attitude, and motivation. Moreover, it is recognized as an important factor for meeting future job-need expectations (Psycharis, 2018). However, academic identity development in STEM in early childhood and its potential impact on future STEM participation is largely neglected, both in research and in practice (Early Childhood STEM Working Group, 2017). A better understanding of the ways in which STEM education research is defined and related to the preschool period will contribute to the identification of trends, opportunities, and deficiencies.

Literature Review

Preschool Education

Researchers, policy-makers, and educators focus on the positive impact of high-quality early childhood education on children's development, as they do for other education levels (Brenneman et al., 2019). One of the main goals of early childhood education is to create an environment that supports lifelong learning. Therefore, one important question is what kinds of experiences in early childhood education are most valuable in the learning environment (Katz, 2010). Preschool children have a natural inclination toward science due to their sense of curiosity and ability to find solutions based on creativity and imagination (DeJarnette, 2018). During early childhood, the development of abilities such as self-regulation, working memory, and inhibitory control increases exponentially, thus establishing this period as a window of opportunity for interventions aimed at promoting child development (Tsujimoto, 2008). Furthermore, the impact of preschool education on cognitive development has been explored in studies such as Yan et al. (2021) The study found that the impact of preschool education on children's cognitive development varies depending on the cognitive ability and the length of time. This suggests that preschool education can have differential effects on different aspects of cognitive development, such as language cognition and mathematical cognition.

STEM Education

In today's modern, digitalized, and unpredictable world where knowledge changes faster than educational systems, STEM skills are perceived as the key to innovatively solving the problems of contemporary life, overcoming social and economic disparity, and achieving sustainable living (Karaşah Çakıcı et al., 2021; Jang, 2016). STEM is an interdisciplinary approach that helps students understand the concepts and contents that form the related fields based on daily-life problems. Through STEM education, students can develop 21st-century skills such as adaptability, problem-solving, communication skills, and systematic thinking (NRC, 2010). STEM education contributes to students becoming better problem-solvers, innovators, logical thinkers, inventors, and technology users (Morrison, 2006). STEM is also seen as an important field in enabling children to recognize future professions, and early STEM education shapes participation in STEM fields in the future (Campbell et al., 2020). Children have natural tendencies that enable them to learn STEM topics easily, such as the ability to make sense of experiences, analyze, hypothesize, and predict (Katz, 2010). Effective STEM education should start early, preferably from the preschool years, as it positively influences students' aspirations in relation to tertiary STEM study and STEM career pursuits (Murphy et al., 2018). However, there is a need for instructional guidelines and curricular materials for integrated STEM teaching (Guzey et al., 2016). Therefore, it is crucial to consider how to design integrated STEM activities and evaluate their effectiveness. Since there is no universal guide or model for the implementation of STEM activities, it may be difficult to implement STEM activities (Wang et al., 2011). However, field studies can serve as guides for effective practices.

Preschool STEM Education

Learning science and engineering practices in early childhood increases children's curiosity and pleasure in exploring the world around them and builds the background knowledge for science learning in the K-12 years (National Academy of Engineering and National Research Council [NSTA], 2014). One of the indicators of high-quality early childhood education is the introduction of STEM opportunities to children (NRC, 2011). Appropriate STEM experiences in early childhood may be starting points for supporting children's further success in STEM fields at the primary, secondary, and post-secondary levels (Tao, 2019). However, studies show that research on STEM education in early childhood is still in its infancy (Tippett & Milford, 2017), which is unfortunate because children are inherently naturalists and engineers (Brophy et al., 2008). Although there is an increasing awareness of the importance of early childhood STEM education and efforts are being made to include it in curricula, it is seen that teachers usually do not include interdisciplinary STEM content in their lesson plans (Tao, 2019). This is because, although teachers may know the importance of STEM education, they often do not have sufficient content knowledge and are unprepared for teaching STEM topics (Hammack & Ivey, 2017). Studies show that preschool educators rarely have in-depth knowledge of mathematics and science, and due to their insufficient content knowledge, they lack confidence in their own abilities to implement quality STEM learning experiences (Greenfield et al., 2009). A critical step to improve outcomes for children is to improve the support for educators to provide high-quality STEM experiences in the preschool period (Brenneman et al., 2019). This can be done by creating rich content for the development of STEM activities. It has been previously demonstrated that the quality of children's learning environments before the age of six has an impact on their later academic achievements (Hadzigeorgiou, 2002). For this reason, they should learn the basic concepts and contents of STEM with hands-on activities in the preschool years within rich learning environments (Leung & Xinyun, 2019). On the other hand, effective methods for early childhood STEM education, teacher training, and curriculum design are important. One important factor is the professional preparedness of teachers in teaching STEM subjects. Research has shown that teachers' lack of self-confidence and inadequate training in STEM areas can hinder the provision of quality STEM learning experiences (Aldemir & Kermani, 2016). Therefore, providing teachers with the necessary training and support is essential to enhance their confidence and pedagogical beliefs in STEM education (Yang et al., 2021). This can be achieved through professional development programs that focus on integrating STEM practices into early childhood classrooms (Sydon & Phuntsho, 2022). In addition to teacher training, the curriculum design and learning environment also play a significant role in the effectiveness of early childhood STEM education. It is important to create developmentally appropriate STEM practices that align with the interests and abilities of young children (Çetin & Demircan, 2020). This can be achieved by incorporating play-based learning approaches, which have been effective in promoting early childhood STEM learning (Sydon & Phuntsho, 2022). Furthermore, integrating technology, such as touchscreen devices, can supplement early STEM education and enhance children's learning experiences (Aladé et al., 2016). Another aspect to consider is the development of children's STEM habits of mind. STEM process skills developed during the early years have lifelong positive effects on young children (Yang et al., 2023). Therefore, it is important to assess and foster children's STEM habits of mind through appropriate educational interventions. Moreover, career awareness and exploration can be integrated into early childhood STEM education to provide children with a broader understanding of the relevance and applications of STEM subjects (Manowaluilou & Nilsook, 2023). This can be achieved through the use of career linkage strategies that connect STEM education with real-world careers (Manowaluilou & Nilsook, 2023). Overall, effective early childhood STEM education requires a comprehensive approach that includes teacher training, curriculum design, learning environment, technology integration, and the development of children's STEM habits of mind.

Aim of the Study

It is common in educational research to conduct reviews to discover situations and trends in certain disciplines (Karampelas, 2021). In this study, research conducted on STEM education in early childhood is examined. This work will contribute to the identification of the needs and trends, opportunities, and deficiencies in STEM education in early childhood. In line with the identified needs, this study will also provide information about the contents, methods, and analytical techniques of research in the field of STEM education in early childhood, offering suggestions about research to be done in the future, as well.

The aim of this study is to synthesize the existing body of knowledge about STEM education in the preschool period and examine how the relevant factors are related to each other. Within that framework, this research was designed with the aim of presenting the contents of educational activities based on a thorough analysis of the articles published on STEM so far. The main questions addressed in this study are as follows: Among articles published on the topic of STEM education in the preschool period, (a) what are their distributions according to publishers and publication years? (b) In which journals were they were published? (c) What are the distributions of countries and subjects? (d) Which research methods are used, and what is the typical research duration? (e) What are the distributions of sample (observation) group types and numbers? (f) What keywords are used? (g) What data collection tools are used? (h) How do the results of the articles align with the aim in the context of STEM education?

Method

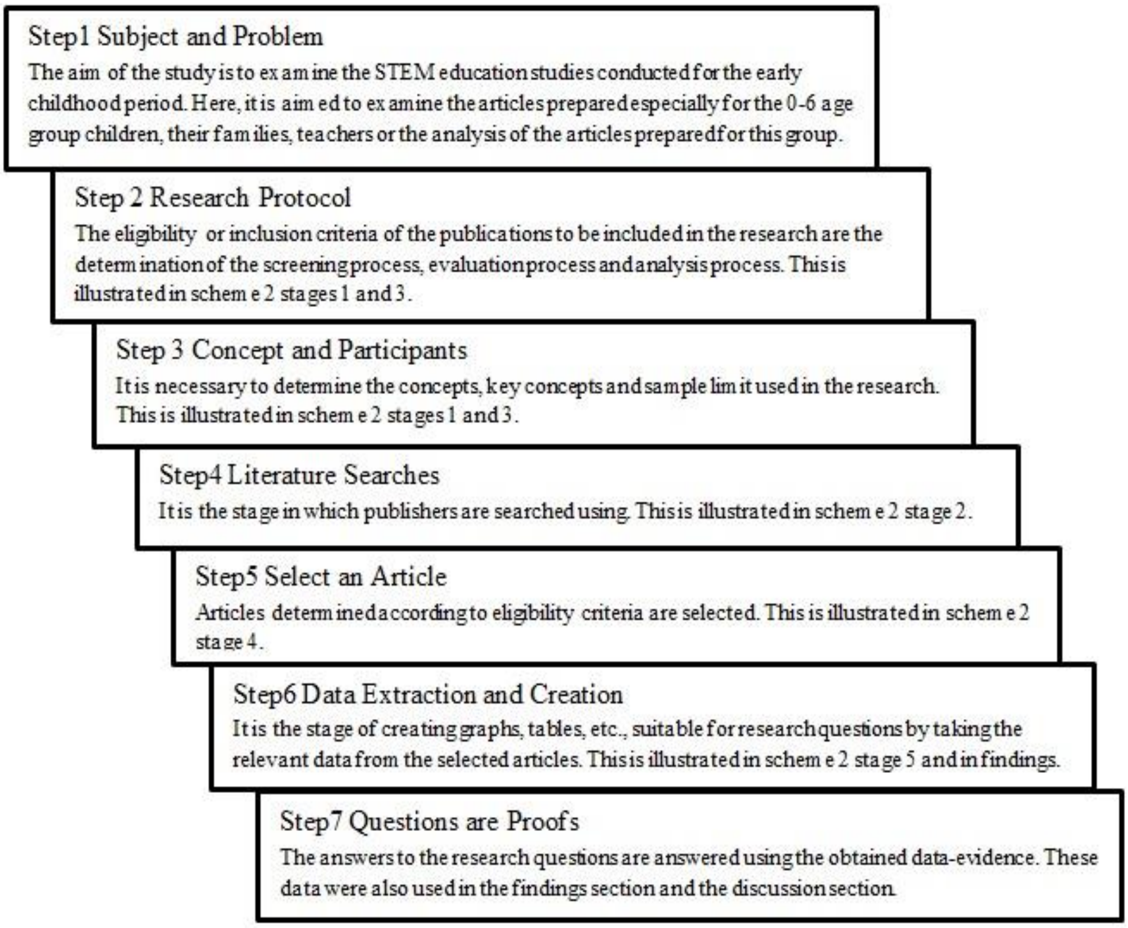
It is particularly important to apply scoping review, or numerical analysis, in studies of the development and characteristics of STEM education research at more specific levels (e.g., the age group of 0-6 years) with statistical methods (Kürklü, 2019). Scoping reviews involve locating, analyzing, and presenting relevant data to gather evidence in a specific area, all done by adhering to a prescribed protocol within the existing literature (Munn et al., 2018). Although this approach is relatively new, it is used to reach conclusions by narrowing the scope of wide-ranging topics (Pham et al., 2014). This type of research enables a large amount of literature to be examined quickly and transferred to the reader. It can be used especially in answering questions made or curious about a specific subject in large time intervals (Tricco et al., 2015). The present study was designed with the aim of conducting a comprehensive literature analysis of preschool STEM education research and evaluating future opportunities. The findings provide important insight into current STEM education trends, using the current evidence base as a reference for future STEM education research and development. Scoping reviews are a type of literature review that aims to map the existing literature and provide an overview of the available evidence on a particular topic or research area (Colquhoun et al., 2014; Phan-Le et al., 2022). They are particularly useful when the topic has not been extensively reviewed, or the literature is complex and heterogeneous (Phan-Le et al., 2022). Scoping reviews differ from other types of literature reviews in terms of their purpose, methodology, and reporting. Unlike systematic reviews, which aim to answer a specific research question and provide a comprehensive synthesis of the available evidence, scoping reviews have a broader objective of mapping the literature and identifying key concepts, gaps in the research, and types and sources of evidence to inform practice, policymaking, and further research (Colquhoun et al., 2014). Scoping reviews are often conducted as standalone projects and can be undertaken when an area is complex or has not been comprehensively reviewed before (Colquhoun et al., 2014). Scoping reviews tend to focus on the breadth of existing literature rather than the depth of coverage (Arksey & O'Malley, 2005). They are an ideal tool for determining the scope or extent of literature on a particular topic and providing an overview, whether broad or detailed, as well as assessing the volume of literature and studies available (Munn et al., 2018). These reviews are especially valuable for examining emerging evidence when it is not yet clear if specific research questions can be formulated, making them a precursor to more definitive systematic reviews (Armstrong et al., 2011). The overarching goal of conducting scoping reviews is to systematically identify and map the available evidence on a given topic, thereby providing a comprehensive landscape of the existing literature (Munn et al., 2018). While Arksey & O’Malley (2005) conducted the coverage review, we recorded the following information;

- Author(s), year of publication, place of study
- Type of intervention and comparator (if applicable); response time
- Study populations,
- Objectives of the study
- Methodology
- Outcome criteria
- Important results.

In this study, we adhered to the following procedures: “Define the aims and scope of the scoping review,” “Choose the techniques for scoping review,” “Collect the data,” and “Run the analysis and report the findings.” The steps of the plan processed in the scoping review are given below.

Schema 1

Steps Followed in Scoping Review Planning



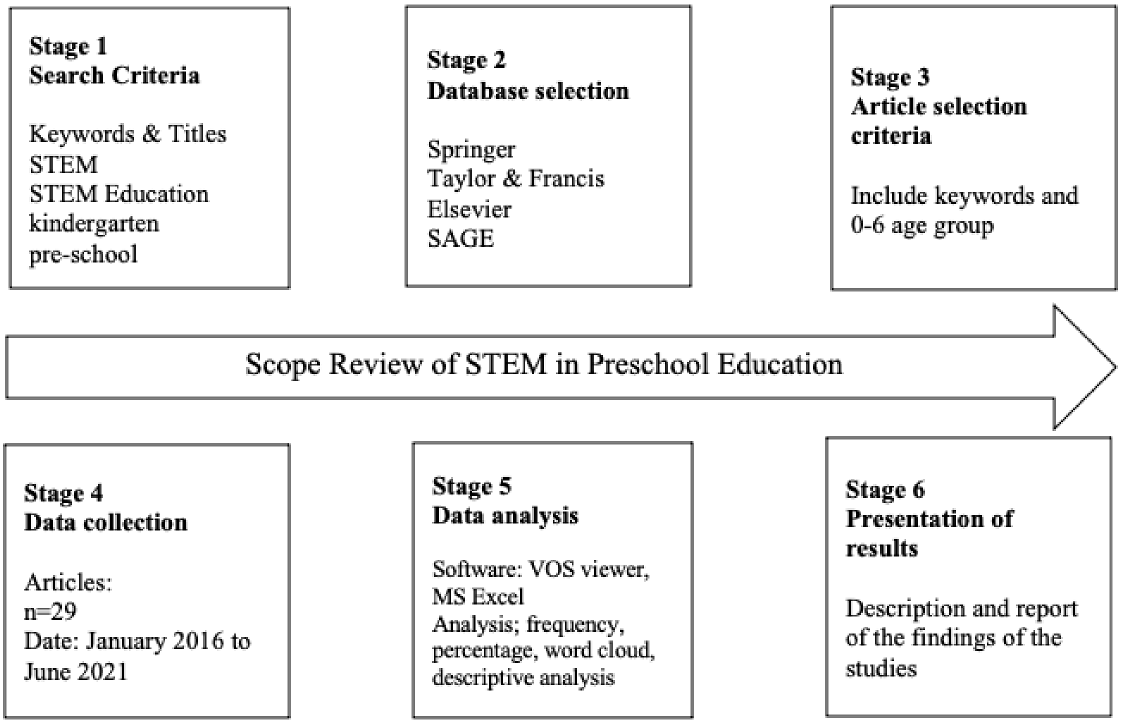
The steps followed in planning the scoping review for the research are shown in Schema 1. In this schema, seven steps of the method are followed in the research. These steps were created by researchers using Munn et al. (2018), Peters et al. (2015), and Scoping reviews (Phan-Le et al., 2022) studies.

Data Collection Process

The data collection process for this scoping review followed a systematic and rigorous approach to ensure the reliability and replicability of the study. The criteria used to select the articles to be analyzed were clearly defined to maintain the quality of both the analysis and the selected articles (Hemingway & Brereton, 2009; Moule & Goodman, 2009; Özkaya, 2018). To identify relevant articles, we focused on publications from reputable sources such as Springer, Taylor & Francis, Elsevier, and SAGE, which are known for their high-quality content in the field of STEM education. The decision to focus on these publishers aimed to target articles with significant academic rigor and relevance. Keywords such as “STEM,” “STEM education,” “kindergarten,” and “preschool” were carefully selected based on their relevance to the research context. These keywords were then used to conduct systematic searches on the selected platforms, namely Springer, Taylor & Francis, Elsevier, and SAGE. The search process was conducted with precision and consistency to ensure that relevant articles were retrieved. To align with the research focusing on STEM education in preschool, the publication years of the selected articles were restricted to those published between January 2016 and June 2021. The choice of this timeframe was deliberate as it aimed to capture the most recent studies that would be instrumental in identifying current trends and practices. Throughout the search and selection process, adherence to the criterion that the articles analyzed should address the 0-6 age group was rigorously maintained. This criterion was central to maintaining the relevance and alignment of the study with the research objectives. As a result, 25 articles were excluded from the analysis on the grounds that they failed to meet this criterion. As a result, the scoping review focused on a comprehensive analysis of 29 articles that met all the identified criteria. A multifaceted approach was used to analyze the data. First, keywords relevant to the research scope were chosen, and selected academic publishers (Springer, Taylor & Francis, Elsevier, and SAGE) served as the primary platforms for data collection. The search process was systematically conducted on these platforms using the identified keywords. The collected publications were then subjected to a rigorous analysis based on several key criteria. These criteria included year of publication, country of origin, sample characteristics, journal of publication, topic, and relevance of the results to the research objectives. The analysis was carried out using tools such as Excel for data organization and VOS (Visualizing Output of Science) to create visual representations, concept clouds, and graphical representations to facilitate understanding of data trends and relationships. The stages followed in data collection are given in Schema 2.

Schema 2

Research Implementation Steps



Schema 2 shows the stages of the present research. The researchers completed the study within the framework of these stages.

Analysis of Data

Initially, keywords were selected in order to examine the outputs of research on preschool STEM education in detail. Springer, Taylor & Francis, Elsevier, and SAGE were then chosen for the platform. The search process was carried out on the selected platform with the determined keywords. The relevant publications were then analyzed in terms of publication year, country, samples, journal, subject, and the relationship of results and aims. Excel and the VOS program were used while analyzing the data. The obtained data are provided as frequencies, percentages, and concept clouds.

This scoping review was rigorously conducted to map the existing literature and provide an overview of the current evidence on STEM education in preschool. The research aimed to identify trends, gaps, and opportunities in this area, offering insights that can inform practice, policymaking, and future research efforts.

Findings

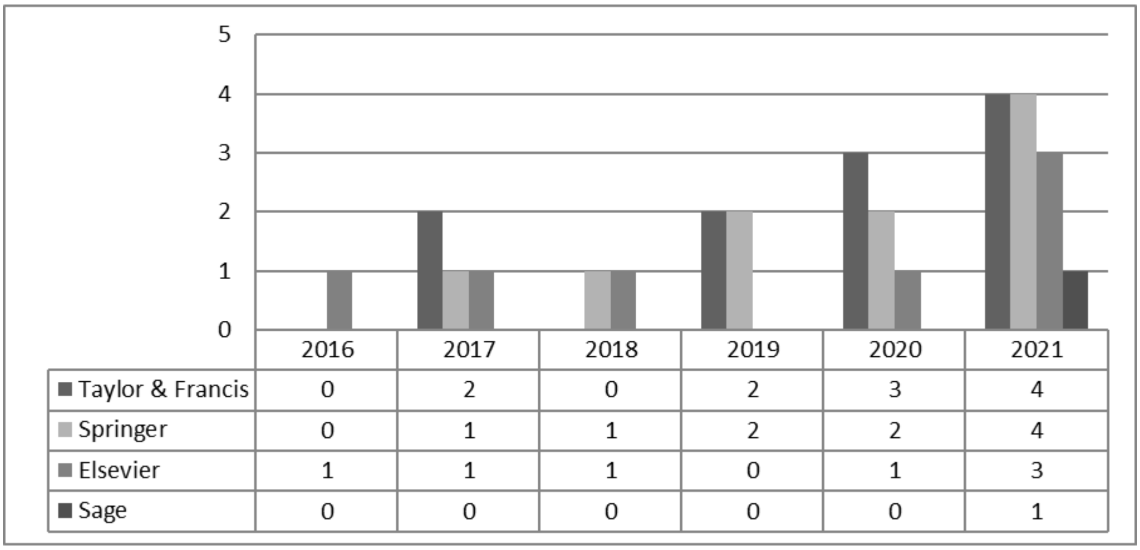
The findings obtained from this research are presented below in the order of the research questions.

Distribution of Articles by Publisher and Publication Year

The distribution of publishers for 2016-2021 is illustrated in Graph 1.

Graph 1

Number of Relevant Articles Published over the Years by Each Publisher



As seen in Graph 1, Springer published relevant articles in all the years under consideration, excluding 2016. Springer has the highest average number of publications per year; particularly noteworthy are its four relevant articles in 2021. Taylor & Francis did not publish any relevant articles in 2016 or 2018. However, they published a total of 11 relevant articles across the other considered years. Springer published a total of 10 relevant articles in the years under consideration. Elsevier published relevant articles in all the years considered except 2018 and 2019. SAGE only published one relevant article in 2021.

Distribution of Articles by Journals

The international journals publishing research on STEM education in early childhood are given in Table 1.

Table 1

Journals Publishing Relevant Research on STEM Education in Early Childhood

Order	Journals	*f*	%
1	Early Childhood Education Journal	6	22.22
2	Early Education and Development	2	7.41
3	Computers in Human Behavior	1	3.70
4	Disability and Rehabilitation: Assistive Technology	1	3.70
5	Early Child Development and Care	1	3.70
6	Early Years International Research Journal	1	3.70
7	European Early Childhood Education Research Journal	1	3.70
8	International Journal of Early Childhood	1	3.70
9	International Journal of Early Years Education	1	3.70
10	International Journal of Educational Research	1	3.70

11	International Journal of Science and Mathematics Education	1	3.70
12	Journal for STEM Education Research	1	3.70
13	Journal of Applied Developmental Psychology	1	3.70
14	Journal of Children and Media	1	3.70
15	Journal of Early Childhood Research	1	3.70
16	Journal of Early Childhood Teacher Education	1	3.70
17	Journal of Experimental Child Psychology	1	3.70
18	Learning, Culture, and Social Interaction	1	3.70
19	Media Psychology	1	3.70
20	Research in Science Education	1	3.70
21	Science Activities Projects and Curriculum Ideas in STEM Classrooms	1	3.70
22	Thinking Skills and Creativity	1	3.70
23	Early Childhood Research Quarterly	1	3.70

Table 1 shows that 29 relevant articles were published in 23 different journals. Six of these articles were published in the *Early Childhood Education Journal*. A single relevant article was published in each of the other journals.

Country and Subject Distributions of the Articles

The results of the analysis of the relevant articles about STEM in early childhood in terms of country and subject are given in Table 2.

Table 2

Subject Distribution of Relevant Articles from Different Countries

Subjects	Countries where the research was conducted								
	USA	Australia	Turkey	China	Canada	Sweden	Taiwan	UK & USA	Total
Gender studies	3	3						1	7
Models design	3								3
STEM activities			2						2
Using robotics					1	1			2
Technology integration	1	1							2
Art integration						1			1
Analysing articles				1					1
Creativity process			1						1
Engineering design process			1						1
STEM identity	1								1
Integration				1					1
Teaching Mathematics				1					1
Intellectual Habits		1							1
Professional development		1							1

Program development					1				1
Self-efficacy							1		1
Teaching STEM	1								1
Thinking styles			1						1
Total	9	6	5	3	2	2	1	1	29

Table 2 outlines the relationships between the countries where these articles were published and the STEM topics considered. The United States is the country producing the highest number of relevant articles, with nine articles. Australia is in the second place with six articles, and Turkey is in the third place with five articles. Furthermore, most of the articles were written on the topic of gender in STEM education (*f*=7). This is followed by the topics of STEM models, activities, and robots.

Method and Duration of the Research

The applied methods and durations of research of the analyzed articles on STEM education in early childhood from 2016-2021 are given in Table 3.

Table 3

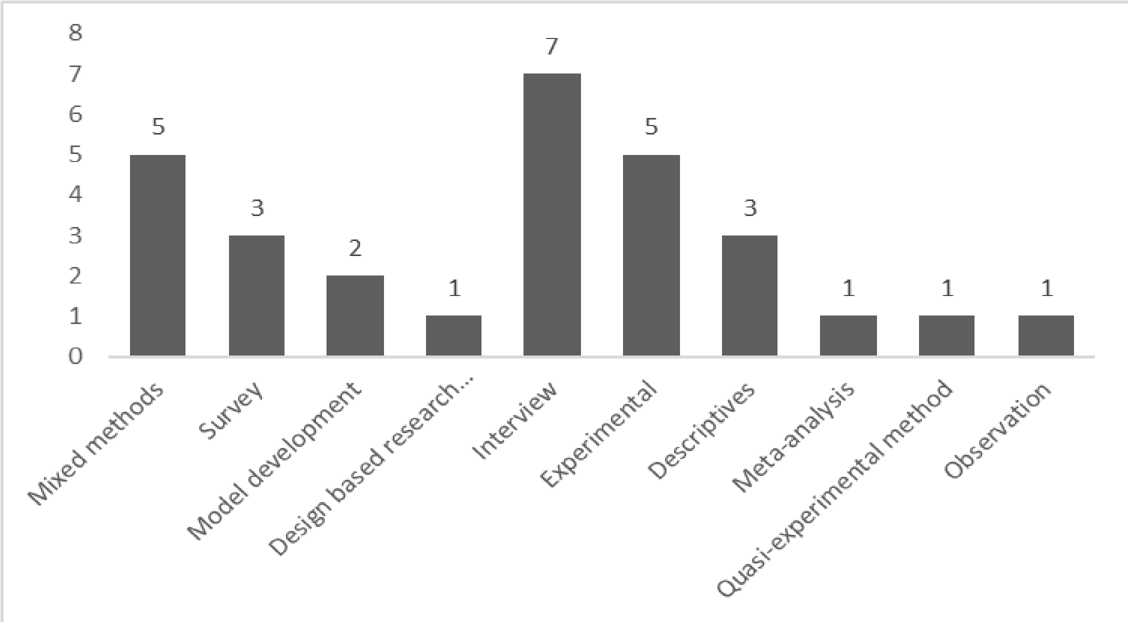
Methods and Research Durations of the Considered Articles

Methods	Qualitative	*f*	Quantitative	*f*	Mixed	*f*	Others	*f*
	1 session	6	8 weeks	3	52 weeks	1	104 weeks (design-based)	1
	104 weeks	1	12 weeks	1	10 weeks	1	72 weeks (meta-approach)	1
Time	52 weeks	1	4 weeks	1	8 weeks	1	6 weeks (Model development)	1
	2 weeks	2	1 week	1	1 session	2	1 session (workshops)	1
			1 session	4				
Total		10		11		5		4

Table 3 provides an overview of the timeframes used in early childhood STEM education research, categorized by research methods. The majority of qualitative studies (*f*=10) were conducted within shorter timeframes, such as one session or two weeks. Quantitative research (*f*=11) extended over various durations, most commonly eight weeks. Mixed methods (*f*=5) research exhibited diverse timeframes, ranging from 1 session to 104 weeks, with some involving design-based approaches. The category "Others" (*f*=4) includes various timeframes, with one study lasting for 72 weeks using a meta-approach and others involving workshops or one session.

Graph 2

Research Design of the Considered Articles



Graph 2 outlines the various research methodologies employed in early childhood STEM education studies. Mixed methods (*f*=5) emerge as a popular choice, reflecting the comprehensive approach researchers take to investigate this complex field. Interviews (*f*=7) are widely used, highlighting the significance of gathering firsthand insights from key stakeholders such as educators, parents, and children. Experimental methods (*f*=5) indicate a focus on empirical research to assess the impact of STEM education interventions. Surveys (*f*=3) and descriptives (*f*=3) demonstrate an interest in collecting quantitative data and statistical analyses. Model development (*f*=2) suggests efforts to create innovative frameworks for early childhood STEM education, and the presence of meta-analysis (*f*=1) shows an inclination toward synthesizing existing research findings.

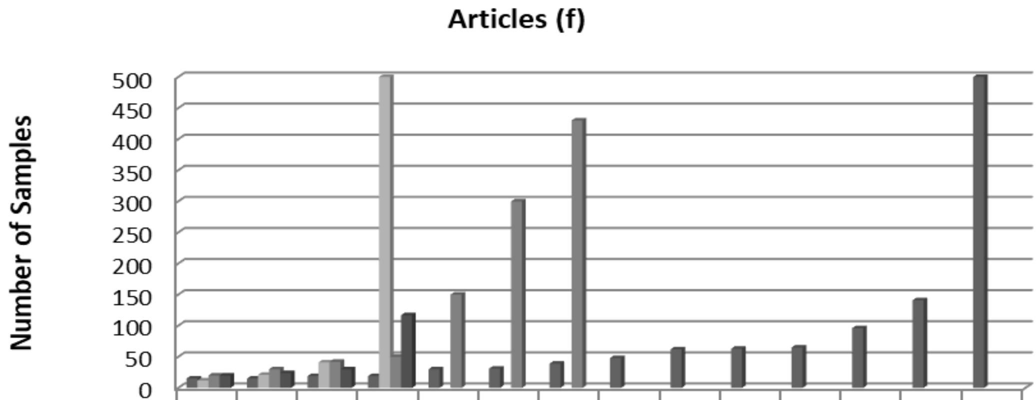
Sample Types and Sample Numbers

The sample types and numbers of the considered articles on STEM education in early childhood are illustrated in Graph 3.

Graph 3 indicates that 14 articles focused solely on children in the 0-6 age group as their sample. These studies involved a minimum of 15 and a maximum of 500 students. Additionally, four articles included both children and teachers or parents, with participant numbers ranging from 12 to 500. Seven articles centered on teachers as the sample, while four others involved different groups, such as experts, or were based on the analysis of observations of children aged 0-6 years. These articles included a minimum of 20 and a maximum of 430 participants.

Graph 3

Sample Types and Numbers of the Considered Articles



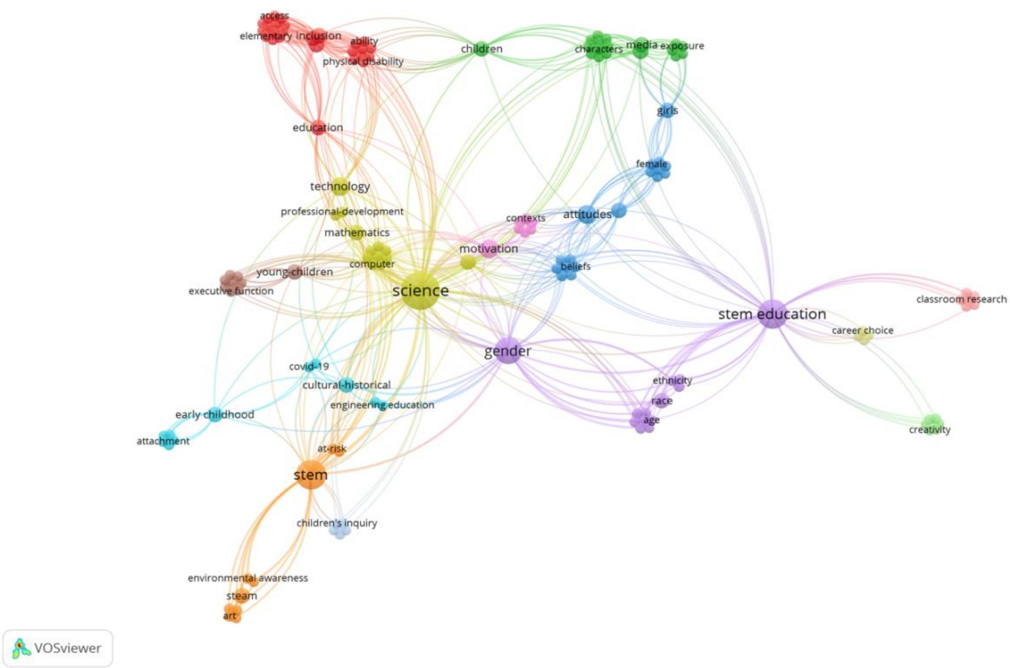
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Only Child	15	15	19	19	30	31	39	48	62	63	65	96	141	500
Child (0-6)+	12	21	41	500										
Teacher	20	30	42	50	150	300	430							
Others	20	24	30	117										

Keywords Used in the Articles

When the keywords of the considered articles published between 2016 and 2021 were examined, the concept cloud in Figure 1 was obtained.

Figure 1

The Concept Cloud is Formed by the Keywords of the Considered Articles



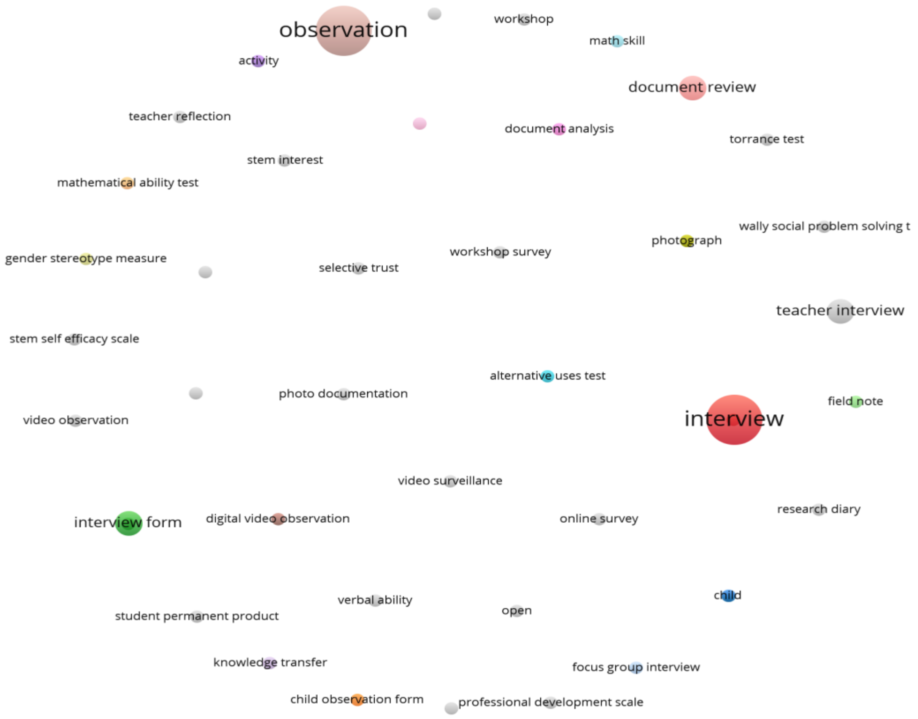
When Figure 1 is examined, it is evident that key concepts such as science, STEM education, childhood, and early childhood education are particularly prevalent. These keywords are natural for the research topics at hand. However, concepts such as gender, professional development, and science education also emerge among the keywords. In more recent research, COVID is also a topic of interest.

Data Collection Tools Used in the Articles

When the data collection tools used in the considered articles published between 2016 and 2021 were examined, the concept cloud in Figure 2 was obtained.

Figure 2

Concept Cloud of the Data Collection Tools of the Considered Articles



When Figure 2 is examined, it is evident that interviewing and observations are most prevalent among the data collection tools. In addition to these, document reviews, interview forms, and teacher interviews are also used. It can be noted that there are differences in the data collection tools used in these articles.

Relationships of the Results and Aims of the Articles

Data regarding the activities used in the considered articles published between 2016 and 2021 are presented in Table 4.

Table 4

Relationships of the Results and Aims of the Articles

Aims	Results
Model Development	1. A model was developed for bilingual students by conducting a workshop under the supervision of education leaders. 2. It was determined that the model prepared with STEM activities gave students a high level of understanding.

Effects of Gaming	1. With the support of the PlayWorld game, it was determined that girls contribute to the formation of STEM identities.
	2. It was determined that technology-integrated games contribute to the development of STEM skills.
	3. With technology-integrated games, it was determined that girls' interest and self-efficacy are strengthened as much as that of boys.
	4. It was determined that girls participate as much as boys on playgrounds where it is difficult for girls to enter.
Program Development	1. A STEM program with parent participation was developed.
	2. Expert opinions about the Little Scientists program, which was implemented for two years, were analyzed.
	3. The Makerspace program was piloted for the formation of students' STEM identities.
	4. A STEM program was developed for early childhood.
	5. As a result of the pilot application of a STEM robotics program, it was determined that children with disabilities enjoyed the activities and gained knowledge.
	6. How digital and analog programming and the use of decontextualized language may influence teachers' and children's communication about robotics and STEM in preschool was understood.
Activity Effects	1. It was determined that girls had difficulties during engineering applications and their movements were limited.
	2. Children's STEM identities are formed in environments such as science museums, zoos, and aquariums. In addition, it was found that boys stated that they were better than girls in STEM subjects.
	3. STEM activities increased children's creative thinking and problem-solving skills.
	4. As a result of STEM activities, an increase in mathematical skills was observed, especially among middle-level and low-level students.
	5. By showing children videos on STEM disciplines and gender, it was determined that the selective confidence of male characters was equal to that of boys and that of girls to male and female characters.
	6. A STEM activity for egg transport was designed and explained in detail.
	7. It was revealed that the effect on children's creativity was positive and permanent.
	8. They showed that Makerspace environments that support 3D design can be used to encourage preschool children's STEM literacy.
	9. It showed that parents' attitudes and beliefs towards science and mathematics were related to children's evaluations. Differences in reasoning and gender of the target were also identified.
Data Collection	1. Expert opinion was obtained to determine STEM concepts, ideas, and beliefs.
	2. Attitudes and opinions of teachers towards STEM practices in kindergartens were obtained.
	3. The STEM self-efficacy of teacher candidates was analyzed.
	4. The teachers' strategies and methods in the STEM activities process were determined.
	5. A strategy was determined for teachers to understand and teach STEM and to conduct art activities using digital technologies.
	6. A workshop was held to increase teachers' STEM activities with Ramps & Pathways events.
	7. An analysis of TV programs providing STEM education was conducted. In general, it was determined that the programs tended to exhibit more egalitarian structures.
	8. An analysis of 24 articles published on early childhood was conducted.

The connections between the results and aims of the articles were examined, as shown in Table 4. In terms of the results of the methods and activities applied in these articles, the aims were classified into five groups. Nine articles aimed to understand the effects of activities, eight aimed at data collection, six explored program development, four considered the effect of playing games, and two aimed at model development. In articles investigating the effects of activities, goals included developing children's thinking, mathematical skills, and creativity in the STEM field, sometimes in the context of gender. In the articles aimed at data collection, information about early childhood was collected from teachers, experts, and sources such as TV programs. In the articles on program development, STEM programs were developed with Little Scientists, Makerspace, robotic applications, and digital or analog applications. In the articles addressing the effect of playing games, it was concluded that the STEM gender roles of girls generally matured. In the articles on model development, a model was designed for bilingual children and expected to have a higher level of understanding.

Discussion

As a result of this research and analysis of articles on STEM in early childhood, it is clear that researchers have had an interest in the STEM field ever since the concept of STEM education emerged in the late 1990s and early 2000s. With the publication of more articles on STEM education, scoping reviews continued to grow in number in the following years. For example, Thibaut et al. (2018) analyzed 23 STEM articles as a result of ERIC and Web of Science research. Martín-Páez et al. (2019) analyzed 27 articles on STEM education published between 2013 and 2018 by searching in the Web of Science database. Özkaya (2019) conducted a scoping review of STEM education studies published between 1992 and 2017. Wan et al. (2020) analyzed 24 articles using the same keywords in databases such as EBSCOhost and ERIC for studies published between 2009 and 2020. Sırakaya and Sırakaya (2020) studied research on augmented reality in STEM education from 1980 to early 2019 and analyzed 42 articles from ERIC, ProQuest, EBSCO, ScienceDirect, and Web of Science. In the study conducted by Li et al. (2020), a total of 798 articles from 45 journals on STEM subjects or disciplines published between 2000 and 2018 were examined. Takeuchi et al. (2020) analyzed a total of 143 interdisciplinary STEM articles published between 2007 and 2017. As a result of these scoping reviews performed over the years, it can be said that there has been an increase in both the number and variety of publishers and articles addressing STEM topics. Novia et al. (2021) recently examined 260 articles on educational games in the STEM field published between 2010 and 2020. Arifin and Mahmud (2021) reviewed six databases (SCOPUS, Science Direct, ERIC, Taylor & Francis, Web of Science, and Springer) and analyzed seven articles on design-oriented STEM education. In addition, in the study undertaken by Jin (2021), 24 articles on science and STEM education published between 2011 and 2020 were analyzed in a systematic review. When we look at the reviews published in 2021, it is clear that this research was performed based on articles provided by specific publishers. Considering both the journals and publishers examined within the scope of this research, it is also evident that there has been an increase in the number of articles published on the subject of STEM education from 2016 to 2021. The scoping review further indicates a rise in the number of publications in STEM education journals in recent years. The publication of relevant studies in many different journals also supports this finding. An exception is the scoping review conducted by Denton and Borrego (2021), who examined 42 articles on STEM education at the K-12 level in their study.

When the considered articles are examined, it is evident that they were published based on research conducted in the USA, Turkey, and Australia in that order of prevalence. Thus, consistent with previous reviews, the majority of publications on STEM education research were made by authors from the USA, where STEM and STEAM education first arose. Martín-Páez et al. (2019), Jin (2021), Le Thi Thu et al. (2021), and Han et al. (2021) all reported the most publications being made by authors from the USA in their analysis of articles on STEM education. At the same time, authors from Australia, Canada, Taiwan, and some other parts of Asia have become more active in this field over the past few years (Li et al., 2020). Although these previous findings are consistent with the present study's findings, there has been a trend toward increasing numbers of STEM education publications in Turkey in recent years. Regarding topics, our research revealed that the largest number of articles addressed gender in STEM education. Other subjects of particular interest were STEM models, activities, and robots. Similarly, Tselegkaridis and Sapounidis (2021) stated that robotic applications were common in STEM education studies. Martín-Páez et al. (2019) determined that articles largely focused on STEM education, STEM literacy, and STEM curricula. Thus, while articles on STEM education and STEM curricula have historically been dominant in literature reviews, gender in STEM education has grown more prominent as a research topic in recent years, according to our analysis.

In the considered articles on STEM education in early childhood, qualitative methods were mostly preferred, and most studies were performed with one-time applications. In addition to qualitative methods, experimental, mixed, and screening methods were also used. While some considered articles presented the results of one-time applications, others had research durations extending to 104 weeks. Similarly, in the analysis of articles on STEM education, Jin (2021) reported a majority of qualitative methods with application periods ranging from 2 weeks to 1 year. Similarly, in the analysis of STEM articles by Jayarajah et al. (2014), it was concluded that qualitative studies were in the majority. These findings support the conclusions of the present work. In contrast, Martín-Páez et al. (2019) reported that a majority of STEM education articles employed mixed methods. Seven and Uçar (2020) identified quantitative methods as being predominant in an examination of theses on preschool education. It is clear that qualitative methods have been generally preferred in recent years for studies of STEM education in preschool, in addition to other studies conducted with methods such as quantitative and mixed methods. Both short-term and long-term studies were carried out within this framework.

In terms of sample types and numbers, the majority of articles focused on sample groups consisting solely of children aged 0-6 years. These articles were prepared with a minimum of 15 students and a maximum of 500 students. Other publications have considered teachers, parents, experts, and previously published articles addressing students aged 0-6 years. In this group of articles, sample sizes range from 12 to 430. Since the present study specifically considered STEM articles addressing the age group of 0-6 years, the samples predominantly comprised preschool students and stakeholders (teachers, parents, experts). For this reason, no similar study could be identified in the literature. However, there are related studies supporting these findings. For example, Martín-Páez et al. (2019) stated that very few publications address STEM education for preschool children. Ahi and Kıldan (2013), Çifçi and Ersoy (2019), and Şahin and Bartan (2017) determined that sample groups generally comprised children in their analyses of theses written about the preschool period. In addition, when Kiremit (2019) and Karoğlu and Esen Çoban (2019) analyzed publications on language development in children, they determined that the majority of the sample groups comprised children. This is thought to be related to the research subjects at hand. Sırakaya and Sırakaya (2020) and Le Thi Thu et al. (2021) determined that their considered articles were mostly written with secondary school students as the sample populations, while Jayarajah et al. (2014) determined that the majority of participants were in the age group of 12-24 in their analysis of STEM education articles published between 1999 and 2013. As can be seen here, STEM education studies have mostly been conducted for middle school students or the age group of 12-24 years (i.e., high school and university) rather than preschool. When studies are examined in terms of the sizes of samples, Jin (2021) determined the number of participants to range between 24 and 42 in the study. Çifçi and Ersoy (2019) and Sırakaya and Sırakaya (2020) found that the majority of considered articles were based on research conducted with 31-100 participants. These findings are similar to those of the present study.

In the articles published between 2016 and 2021, the keywords “STEM,” “STEM education,” “childhood,” and “early childhood education” particularly stand out. These keywords are logical considering the topics of the articles. Similarly, Oğurlu and Çayır (2014) analyzed the key concepts explored in publications on gifted people. They determined that the key concepts most often considered were related to the subject at hand, such as intelligence or science and art centers. In the present study, in addition to the key concepts directly related to the subject, concepts such as gender, professional development, and science education are also observed. Furthermore, in the most recent studies, the COVID-19 pandemic is mentioned. Notably, interviews and observations are primarily used as data collection tools in articles on STEM education in early childhood. In addition, tools such as document reviews, interview forms, and teacher interviews may be mentioned. Thus, there are differences in the data collection tools used in the considered articles, varying depending on sample types and study methods. Sırakaya and Sırakaya (2020) found that the majority of their considered studies involved secondary school students, and the data were accordingly collected mainly through achievement tests, screenings, and interviews. Although interviews and screening techniques were similarly observed in the present research, there were no findings for achievement tests.

The activities or practices applied in the considered articles were classified into five groups according to their purposes. Generally, the majority of the aims included determining the STEM identities of girls with games; developing child-specific or parent-participation programs such as robotics, Little Scientists, or Makerspace; applying STEM activities to determine their effects on assorted variables; and collecting data, primarily from teachers, on the application of STEM education. Similarly, Wan et al. (2020) reported articles addressing the effects of digital games and robotic applications on assorted variables and STEM education with the opinions of teachers, parents, and experts. These research findings are similar to the results of the present study in terms of classifying the aims of the reviewed articles. Takeuchi et al. (2020)

found that most of the considered articles focused on students' STEM career plans. Thibaut et al. (2018) stated that the articles they considered were predominantly about STEM integration. These findings are compatible with those of the present study as well. The effects of STEM activities on variables such as selective confidence, mathematical skills, and problem-solving have been examined in the relevant literature. In their study, Ha et al. (2020) evaluated scientific results on STEM education, including engineering and computing education. Jin (2021) reported that among the aims of the articles he analyzed, improving scientific inquiry skills, developing interest in and positive attitudes towards STEM subjects, and building STEM identities were the top ones. Although these findings do not exactly overlap with those of the present work, there are similarities. Sırakaya and Sırakaya (2020) classified the purposes and learning outcomes of the articles they considered and reported a focus on the effect of learning, the outcomes of training, and interactions. In addition, Martín-Páez et al. (2019) concluded that their considered articles were mostly about cognitive development and attitudes. In the analysis of STEM articles published between 2010 and 2015, McDonald (2016) concluded that the role of teachers in quality learning is important as they can increase students' interest in and positive attitudes towards STEM subjects with effective pedagogical formation. Thus, these studies mostly focus on analyzing changes in interests, attitudes, and cognitive development based on STEM education in different sample groups.

In general, it can be asserted that studies on STEM education in early childhood show great promise. Involving children in STEM activities with robotics applications, games, activities, models, or program development contributes to the field. Moreover, better STEM activities can be planned with studies conducted based on the opinions of teachers and experts. The engagement of parents in this process is considered particularly promising for future studies and the development of successful STEM education. These findings reflect that achievements in STEM activities will have impacts at home, at school, on the streets, and in all areas of daily life. Based on the assumptions and limitations of studies conducted to date, new studies can be undertaken, and the impact of STEM education can be increased. In addition, it can be noted that studies aimed at providing a gender balance in STEM education have become widespread. There may be classroom interactions in which girls and boys will participate at similar rates. Finally, the quality of education should be increased for individual students by taking economic and intellectual variables into account. The effects of using STEM disciplines for the acquisition of daily life skills have become particularly evident.

Conclusion and Recommendations

Although there has been an increase in the number of articles on preschool STEM education published between 2016 and 2021, this is still a relatively new and growing field compared to STEM education studies for different age groups. For this reason, it is recommended that STEM education researchers focus more on STEM education in the preschool period.

Upon reviewing the publication of articles on STEM education in early childhood, it has been determined that there is a stronger tendency to conduct STEM education research in developed countries than in developing countries. Developing countries should be supported in this regard, and the STEM subjects studied for the preschool age group should be diversified.

Qualitative methods were primarily used in the articles analyzed in this research, although other methods were also observed. It is recommended to use the operational research method for both close monitoring and individual development at the preschool level. In addition, although both short-term and long-term studies were observed in terms of the duration of research, more programmatic or achievement-oriented studies should be conducted.

In this examination of articles addressing the age group of 0-6 years, it was noted that the sample groups also included relevant stakeholders. The number of studies addressing these stakeholders should be increased. In addition, studies with differing sample sizes were observed, and it should not be forgotten that it is important that the number of samples be appropriate for the selected method.

While it was generally clear that articles on STEM education in early childhood use keywords related to their subjects, the concepts of gender, professional development, and science education were particularly prevalent. The use of different concepts enriches the field. It is suggested that a common standard be embraced due to differences in keywords, such as “STEM” in some studies and “STEM education” in others.

The prevalent use of interviews and observations as data collection tools was an expected finding due to the fact that these articles were largely based on qualitative methods and the majority of participants, i.e., children aged 0-6, were illiterate. It is recommended to use multidimensional data collection tools simultaneously to evaluate studies conducted with children.

When the STEM activities for preschoolers in the considered articles were examined, it was determined that different activities are carried out to increase the effects of STEM education. These activities designed for the age group of 0-6 generally focus on games, teachers’ roles, or program and model development. For such activities, it is necessary to determine factors such as the role of sample groups in the process and their impact on the process. In other words, there is a need for studies focusing on the evaluation dimension of STEM education in preschool.

Limitations

The study focused on articles published by specific publishers (Springer, Taylor & Francis, Elsevier, and SAGE). This approach may not capture the entire body of relevant literature in the field of preschool STEM education, potentially leading to publication bias. The study analyzed articles published from January 2016 to June 2021, which may exclude earlier research that could provide valuable historical context and insights into the development of STEM education in the preschool period. The criterion of analyzing articles addressing the age group of 0-6 years led to the exclusion of 25 articles. This selection criterion may introduce subjectivity and potentially exclude relevant studies with slightly different age group classifications. Scoping reviews, by design, provide a broad overview of the literature but may lack the depth of analysis and critical appraisal seen in systematic reviews. This limitation should be acknowledged, as it may impact the level of detail in the review.

Compliance with Ethical Standards

This research has not been done with humans, animals, or any other living things. The research does not contain elements that would threaten the health of any living thing. In the research, previous academic publications on a specific subject were analyzed. Information and data belonging to others were not used in the research, and references were made to the publications used. There was no potential conflict of interest in the study, neither between the authors nor with anyone else. This research is not a part of a study; it shows integrity in itself. The research was not sent to any journal other than this journal in accordance with the publication ethical rules.

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All parts of the article were co-written by the authors. All sections such as Introduction, Method, Results, comment, discussion, and conclusion were written together. All expenses related to the article were made by the authors.

Conflicts of Interest

There is no conflict of interest since the authors or the article do not have a financial, commercial, legal or professional relationship with any person or organization.

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