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Review

Starting at Home: What Does the Literature Indicate about Parental Involvement in Early Childhood STEM Education?

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Abstract: Developing STEM (Science, Technology, Engineering, Mathematics) competencies is a global priority. In response to this educational need, initiatives have been implemented mainly at the school level. However, in preschool education, the STEAM programs are more recent. Research advances orient preschool teachers to reach these competencies in school-based programs, although parental involvement has been systematically forgotten as a critical factor. This article describes the current issues on research about parental participation in STEM education in early childhood to identify advances and gaps. We selected documents published between 1995 and 2021 in the leading educational databases, identifying 11 documents explicitly related to parental involvement in STEM education in preschoolers. The results show that STEM activities can promote parental engagement, improve the value parent attribute to STEM, and positively affect STEM learning in preschoolers. Moreover, parents shape children's interests and self-efficacy about STEM and content application that can favor their children's approach to STEM. This article discusses the scarcity of research published on the connection between STEM and parental influence, despite the fundamental role of parents in early STEM education. We present practical criteria to guide the development of early STEM education in the family context and questions to guide the planning of research and intervention programs.

Keywords: STEM; STEAM; science education; early childhood; preschools; parental involvement; engagement

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1. Introduction

Parental involvement in children's education (the use of the terms "parental", "fathers", or "mothers" is not limited to biological fathers, but includes any adult who assumes a role of caring for a child (e.g., grandparents, legal guardian, etc.) can create a virtuous circle that helps cope with the world's technological, environmental, and social changes [1]. When parents participate in the early construction of STEM competencies in a relevant and familiar context for children [2], this constitutes an engine which drives a more equitable and sustainable society [1,3].

Exploring what the literature reveals about parental involvement in STEM education in preschoolers is worthy, considering the relevance of parental involvement and its possible effects on academic outcomes, processes, and psychological characteristics such as self-efficacy, self-regulation, and motivation [4,5]. Two reasons sustain this assertion: parental participation is an innovative research field with the potential for high-stake program implementation decisions [6] and early childhood systemic interventions has a well-known positive cost/effectiveness [7].

1.1. STEM Education

Technological changes are transforming all areas. Indeed, education has been one of the sectors in which technology has moved the boundaries of status quo practices.

The interest in STEM education (science, technology, engineering, mathematics) has increased during the last decades; highlighting the need to develop skills associated with these disciplines [8,9], such as problem-solving, critical thinking, inductive and deductive reasoning, goal setting, decision making [10–12].

Added to this is the impact that the shortage of people in these disciplines generates on nations and individuals, and the role STEM disciplines have in achieving sustainable development goals [3]. The 17 goals in the 2030 Agenda on Sustainable Development approved by the United Nations in 2015 seek to eradicate poverty, combat climate change, improve education, and promote gender equality [3,13].

Thus, STEM skills have been prioritized internationally [8,10,14,15]. Practical actions have advanced policies and programs to provide infrastructure and technological resources, teacher training, communication campaigns, and educational material [16]. Nonetheless, promoting family involvement and informal learning at home has been suggested but less implemented [14,17,18].

There is currently no agreed-upon definition of STEM literacy. However, there are common points: (a) the importance of addressing real and contextualized problems so that the concepts are relevant at a societal and cultural level, (b) the need to promote the integration of STEM disciplines within programs and activities, as they share concepts and practices allowing students to apply their knowledge and skills, make connections, gain an understanding of concepts, and solve complex problems [2].

Although there is agreement among researchers about the importance of integrating the different STEM disciplines [2,19,20], two areas of debate are detected: (1) the degree of integration versus the separation between disciplines and (2) the integration of additional disciplines.

For this literature review, we used the notion of the continuum by Moore et al. (2020) [2]. We included articles reporting parent-child involvement in activities ranging from the low integration of STEM disciplines to project- or problem-based learning with a greater integration of disciplines. Additionally, incorporating other fields into STEM is considered in the current study, such as visual and plastic arts, including the A into the acronym STEAM [2,21–23]. We include the arts because it helps contextualize problems, favor children's learning, and promote their creativity, communication, and teamwork [2]. It brings science closer to those who have not had contact with it, making it more familiar and accessible [24].

1.2. STEM Education, Preschoolers, and Parent Engagement

The early exposure of children to STEM areas is feasible and would positively impact their learning. This is due to their innate curiosity and creativity and their willingness to analyze, hypothesize, and predict. Hence, children could feel motivated by concepts related to these disciplines, facilitating their learning [25].

Preschoolers can already conceptualize and create mental representations of natural phenomena, which is the basis for acquiring new and more complex learning [26]. Because of this, STEM concepts and skills developed at an early age would allow children to explore and understand more complex concepts in the school period [25,27]. Moreover, if these concepts are socially and culturally relevant, children perceive the impact of STEM in their lives and the opportunities to pursue a career in these fields [2].

Despite this enormous potential to promote learning and open career opportunities, early childhood classrooms have shown some reluctance to include STEM content in a meaningful way [27,28], with some exceptions such as the incorporation of engineering design challenges, which allow for the integration of science and mathematics knowledge, to solve real problems [29]. A few studies link early childhood with science, technology, engineering, and mathematics [28,30,31]. Thus, there are challenges for program and research implementation, such as examining aspects of STEM education in preschool classrooms (e.g., program design and content and STEM teacher education, among others) and at home [28]. Regarding STEM education at home, parents play a crucial role. Indeed, evaluating the impact of informal scientific opportunities and designing policies that promote STEM teaching in early childhood while allowing caregivers and teachers to merge STEM learning with family experiences is recommended [28]. The inclusion of parents could facilitate adapting everyday life with STEM skills [31].

Parental involvement, inside and outside the school, is recognized as one of the most transcendent factors within children's educational process, given the impact on their academic performance and the psychological processes that contribute to it [4,5]. The definitions of parental involvement are multiple within the literature. For instance, it can be understood as participation in activities carried out in the school (e.g., meetings of parents, walks), decision-making and communication with the school, and participation in educational activities within the home [4]. From this perspective, the involvement of parents in STEM education would favor children's learning, knowledge transfer, content control, exposure, and access to concepts, skills, and tools related to STEM [25].

2. The Objective of the Literature Review

The present review seeks to determine what the literature points out about the involvement of parents in early childhood STEM education in a novel way. STEM education in preschools and integrating these topics with parental involvement are a niche of recent research concern [28,30,31]. The findings of this work may help identify advances for informing the practice of STEM preschool education and guiding future research and programs in this field. It may also promote parental involvement positioning as a relevant source of contextual support for children's integral development.

3. Methods

A scoping review of previous works was used to describe the state of the field and empirically shed light on the area of parental involvement in preschool STEM education. According to the PRISMA framework [32], the scoping review is a broader approach to evidence synthesis when formulating discrete research questions that are premature.

Anticipating that we might find a few empirical studies in the field, we considered theoretical and empirical documents such as articles, books, and book chapters. Moreover, we continued through a snowball sampling to follow seminal papers or authors of interest. The following inclusion criteria for searching in the Web of Science (WoS)) and Scopus databases were used: (a) documents that included in their title, abstract, and keywords (from the author and/or plus), the words: (STEM OR STEAM OR Science education) AND (early childhood OR childhood OR preschool*) AND (parent* involvement OR family involvement). (b) reporting empirical or theoretical studies; (c) publication dates between 1995 and 2021. This search was conducted between June and July 2021. It is important to note that "formal education" and "informal education" or similar concepts were not intentionally included or excluded as search terms in this review. Therefore, the database search results suggested studies focused on parent and child participation in both settings, mainly at home, classroom, and workshops. Other spaces such as museums, zoos, and parks did not appear in these databases using the search terms. We did not search for the terms Science, Technology, Engineering, and Mathematics separately. The exclusion criteria were: (a) conference proceedings (b) documents associated with areas other than education (e.g., medicine).

As shown in Figure 1, the Boolean search resulted in four articles extracted from the Web of Science database and six documents (five papers and one handbook) from the Scopus database. Repeated records were deleted. In addition, the handbook was reviewed thoroughly, but one article only addressed parental involvement in children at a general level. The result obtained was four documents (three papers and one handbook chapter) complemented by snowball sampling. The references section of each document obtained in the databases and texts included in the introductory section of this review were reviewed. Authors who had participated in books that fit the inclusion criteria were also identified.

At this stage, six articles and one book chapter were detected that met the inclusion criteria and were added to the documents selected in the previous step.

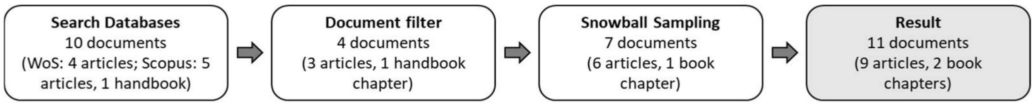

Figure 1. Flowchart of review stages.

The final selection process included 11 documents (nine articles and two book chapters), characterized by considering aspects such as authors, year of publication, origin, topics discussed, and results. The selected articles are detailed in Table 1. Although the search covered the period between 1995 and 2021, the documents that met the inclusion criteria were published between 2004 and 2021, with a concentration of 90.9% between 2017 and 2021.

Table 1. Summary of documents included in the literature review.

N°	Authors	Year	Journal or Book	Country	Discipline (S-T-E-M)	Type of Study (Emp-Theo)	Methodology (Ql, Qt, Mx)	Sample (Tch, P, Ch)	Context	Focus
1	* Ata-Aktürk, & Demircan [33]	2021	Early Childhood Education Journal (A)	Turkey	E	Emp	Qi	2 Tch 5 P 5 Ch (5–6 years old)	Classroom	Test curriculum with emphasis on engineering
2	* Thomas et al. [34]	2020	Handbook of Research on STEM Education (BC)	United States; Turkey	S T E M	Theo				Literature review
3	* Ulutaş & Kanak [35]	2018	NeuroQuantology (A)	Turkey	S	Emp	Qt	60 P 60 Ch (5–6 years old)		Investigate the impact of the parent–child science education program on basic process skills
4	* Ginsburg & Golbeck [36]	2004	Early Childhood Research Quarterly (A)	United States	SM	Theo				Reflect on directions of early teaching of mathematics and science
5	** Strickler-Eppard, Czerniak & Kaderavek [37]	2019	Early Childhood Education Journal (A)	United States	S E	Emp	Mx	5 P 5 Ch (4–8 years old)	Home	Describe how families utilize science activity packs at home
6	** Raynal et al. [38]	2021	Early Childhood Education Journal (A)	United States	S	Emp	Qt	88 P82 Ch (4–8 years old)	Workshop for parents, home	Explore a model designed to support family science
7	** Tippett & Milford [39]	2017	International Journal of Science and Mathematics Education (A)	Canada	S E M	Emp	Mx	2 Tch 11 P 14 Ch (4–5 years old)	Classroom	Evaluate STEM activities in the preschool classroom considering the parental perception
8	** Tay, Salazar & Lee [40]	2018	Journal for the Education of the Gifted (A)	United States	S T E M	Emp	Qi	55 P (parents of PK-K children)	Saturday STEM enrichment program for children	Know parents' perceptions of the influence of STEM programs on preschoolers and their attitudes toward STEM
9	** Gilligan et al. [41]	2020	European Early Childhood Education Research Journal (A)	Ireland; United States	S	Emp	Qt	85 P (parents of children from 4–8 years old)	Workshop for parents	Evaluate parents' attitude towards science
10	** Pattison & Dierking [42]	2019	Science Education (A)	United States	S	Emp	Qi	7 P 7 Ch (4 years old)	Head Start Program	Understand the development of interest in science in children from underserved communities
11	** Ünlü-Çetin, 2020 [43]	2020	Key points for early childhood STEM education and involving parents (BC)	Turkey		Theo				Promote parental involvement in STEM (First deliverable ParentSTEM project)

* Document obtained from database search; ** Document obtained through snowball sampling. A = Article; BC = Book Chapter/S = Science; T = Technology; E = Engineering; M = Mathematics. Emp = Empirical; Theo = Theoretical/Qi = Qualitative; Qt = Quantitative; Mx = Mixed. Tch = Teachers; P = Parents; Ch = Children.

The content of the revised papers was grouped into categories related to the question that we sought to answer through this review: What does the literature point out about parental involvement in early childhood STEM education?

4. Results

Research on parental involvement in early childhood STEM education is recent and still scarce. Most papers included in this review were from the United States (6) and

Turkey (4). Three papers were theoretical, and eight were empirical studies. From the latter, three used quantitative methodology, two used mixed methods, and three used qualitative methods. The samples were mostly parents and their children (aged 4–8 years), and only two studies considered the participation of teachers. Sample sizes ranged from 5 to 88 parents, 5 to 82 children, and 2 teachers. The studies were about interventions and programs focused on the home, classroom, and STEM workshops for parents and children. The number of empirical studies addressing STEM disciplines was science (8), technology (1), engineering (4), mathematics (3). The documents, in general, have been cited little, perhaps due to the recent date of publication of some of them.

The findings support that parental involvement in early childhood STEM education has focused primarily on describing how parents engage in STEM activities and the effect on their children's STEM learning. Furthermore, the research describes the influence of their education or experience on their participation and children's learning, their beliefs and emotions about STEM, and perceptions about STEM programs. Finally, it described the potential of STEM activities to promote parental involvement. These points are presented below:

4.1. Ways in Which Parental Involvement Is Expressed during the Performance of STEM Activities

Parents have differences in expressing their emotions, affection, and interest in their leadership style and how they try to capture their children's attention during STEM activities. For example, during STEM activities, parental involvement is expressed in various ways. Moreover, differences are observed in the way parents interact with their children and express affection, emotions, and interest. Some parents explicitly praise their children, give them continuous feedback, and express their enthusiasm for STEM activities, while others verbalize frustration, impatience, or lack of interest [42]. A similar pattern can be found regarding the leadership that parents assume during STEM activities, ranging from a managerial style—i.e., deciding for their children—to a passive style—giving space for children to choose more frequently and explore more autonomously.

Finally, there are also differences in the strategies parents use to redirect children's attention during STEM activities, ranging from capturing their attention by explaining the activity and allowing greater participation to encourage children to continue the activity or to abandon it and move on to the next one [42].

4.2. Effects of Parental Engagement on STEM Learning

Parental involvement can positively and negatively affect STEM learning in preschoolers. Indeed, parents' engagement with STEM activities might generate satisfaction in children, which would favor their learning [33]. In addition, the participation of parents contributes to increasing the results obtained by children in tests that measure scientific process skills such as observation, classification, comparison, measurement, and communication [35]. Overall, parents are crucial for increasing children's participation in early science [41].

Another positive aspect is the role of parents as providers of resources and stimuli that bring children closer to STEM topics (e.g., computers, books) [36]. Parents can also be role models and sources of help and knowledge [36]. Parental involvement is also a source of educational advantages for children, enhancing quantitative and problem-solving skills [34].

Nonetheless, parental involvement in STEM activities can also be affected by the overly intrusive attitude in the activities, which might impact their children's performance during the activities [33]. Moreover, parents can transmit stereotypes that constitute barriers to learning, such as the idea that STEM is not for young children or nor suitable for girls [43], or even transfer fears about STEM, especially regarding mathematics [36]. Likewise, some parents might put excessive pressure on children to learn a particular subject, which can be counterproductive [36].

Additionally, there is a mediating effect of culture and belonging to certain social groups on parental involvement, which can positively and negatively impact children's

STEM learning [34]. For example, a higher socioeconomic status and ethnicity (e.g., Americans, Japanese) are associated with greater parental involvement in STEM learning [34].

To sum up, all the above shows that parental involvement can have a mixed impact on preschoolers' learning, outcomes, participation, self-efficacy, and beliefs about STEM.

4.3. Effects of Parents' Education or Experience on Their Involvement in STEM Activities and on Their Children's Learning

According to the literature consulted, parents' education and their previous experience in STEM disciplines have a variety of effects. On the one hand, the lack of experience or prior training in science is not a limitation for parents to provide scientific experiences aimed at their children, to the extent that they are provided with activities and good support material to help them in this work [37]. Indeed, without their educational level or experience being an obstacle, parents can conduct STEM activities where their children learn scientific practices, concepts, and processes [37].

On the other hand, a higher level of parents' STEM education does not necessarily translate into an advance in parents' confidence to talk about science and participate in scientific activities with their young children. For instance, in Gilligan et al.'s (2020) study [41], although participants had a high level of education, approximately half felt less confident discussing science and participating in STEM activities with their children, with mothers expressing greater insecurity than fathers. Likewise, the parents' training in a STEM discipline such as engineering is not associated with a greater competence of their children in activities related to this subject [33].

The above findings suggest that a higher level of training and experiences linked to STEM is not necessarily related to parents' greater capacity and security to address STEM issues and activities and higher competences of their children in these disciplines.

4.4. Parents' Beliefs and Emotions about STEM

Parents' beliefs and emotions about these disciplines can be positive or negative, considering their impact on children's STEM learning. On the positive side, parents express interest and enthusiasm toward both STEM activities and learning [38,42], and the belief that science teaching should begin in the preschool stage [41]. On the negative side, parents' lack of interest or impatience experienced during STEM activities with their children has also been reported [42]. Additionally, some parents experience insecurities when talking about science or doing scientific activities with their children [41]. These findings show that parents' beliefs and emotions during STEM activities or related to STEM learning are factors that can facilitate or hinder children's STEM learning.

4.5. Parents' Perception of the STEM Programs in Which They or Their Children Participated

Parents tend to positively perceive STEM programs and activities they or their children are involved in and, in general, they favorably evaluate the STEM classes their children attended [40]. Besides, many parents value the opportunity for their children to participate in STEM programs, perceive STEM disciplines as necessary in their children's education, and think science is practical; to solve the problems of today's world and achieve better results in the work environment [39]. In addition, there is evidence reporting parents' positive perception of the STEM knowledge acquired by their children and the enthusiasm of their children to learn and participate in STEM activities [39,40]. Similarly, parents can detect positive changes in their children's attitudes and behaviors, such as a greater openness to new experiences and learning when participating in STEM activities [40].

While positive perceptions and assessments about STEM activities prevail, parents also raise needs or expectations, such as receiving more information about STEM activities in the classroom, STEM in general, and how they might use STEM in interactions with their children outside the school [39].

The above insights show a general satisfaction and valuing of parents toward STEM activities and the needs and expectations linked to a greater access to STEM information.

4.6. Potential of STEM Activities to Promote Parental Involvement

When designed externally and with the support of diverse actors, such as daycares, schools, universities, museums, zoos, etc., STEM activities can foster parental involvement in science practices by helping parents engage their children in a discourse about scientific concepts and processes [37]. Moreover, STEM activities can foster enthusiasm for solving problems collaboratively between parents and children [38], as well as the curiosity and amazement of parents [43].

STEM programs also allow science to be brought closer to parents, especially those who have not accessed it previously, due to a lack of resources or bad experiences that threaten the ability to address scientific issues with their children [38]. In this sense, STEM activities make parents more confident and increase their interest in learning scientific topics and performing scientific tasks with their children [38].

Besides, a curriculum that includes STEM can also effectively involve parents in the STEM education of their preschool children [33]. In addition to the activities designed and offered by schools or other agencies, parents also perform STEM-related activities in their everyday environment, such as exploring nature, building, observing, playing with puzzles or games related to science, visiting places related to science [41]. The findings noted above reinforce the positive potential of STEM activities to promote parental involvement in those disciplines, inside or outside the educational settings.

4.7. Key Points of Vigilance Studying Parental Involvement

Some of the issues revealed in the empirical studies covered by this review are: firstly, most of the studies have small sample sizes, which might constrain the type of analysis and the generalizability of the results. Secondly, the participants' proximity and prior knowledge of STEM needs to be taken into consideration as a variable potentially affecting the programs and the study of parental involvement Thirdly, there are a few programs focused on STEM as integrated education initiatives; and, finally, there is a scarcity of emerging results that have been followed up in studying parental involvement.

5. Discussion

This article aimed to answer the question: What does the literature indicate about parental involvement in early childhood STEM education? to identify advances and gaps in this newly explored field [28,30,31]. The relevance of this review stand from the high potential of STEM education in the early years to generate positive social, technological, economic, and environmental changes [1,3,7]. Moreover, STEM in preschoolers has become an area of high interest in countries looking to reinforce their human and economic development. Nonetheless, the reported research has so far centered mainly on institutional programs inside or outside the school (i.e., Cabello et al., 2021 [6]), and little knowledge is available about the advances and new research lines regarding STEM in children at home or the parents' involvement in its development.

The results showed the relevance of parental involvement in STEM education during early childhood. Different forms of parental participation and their positive and negative effects on the configuration of interests, skills, and self-efficacy in STEM in children were detected. These include praise, feedback, and attention-getting strategies that promote children's STEM learning. In contrast, expressions of frustration, impatience or lack of interest, or a very directive style on the part of parents would hinder children's approach to STEM. Likewise, the association between the experiences, training, perceptions, and emotions of parents and the willingness and confidence of children to participate in STEM activities were identified. These findings are consistent with what has been stated in the literature about the relationship between parental involvement and the development of psychological characteristics and processes that would be at the basis of academic performance [4,5], such as children's motivation, interests, and self-efficacy. The need for parents to have support and information to facilitate their children's STEM learning was also detected.

Finally, the potential of activities to promote STEM learning in children and parental involvement beyond school was also identified. These activities, which can reach families from diverse social, economic, educational, and racial backgrounds, bring STEM content closer to children's context and daily lives. The above would give social and cultural relevance to STEM concepts, helping children connect new information to their meaningful reality and understand its impact on the environment [2,44]. This could be a springboard for them to develop STEM skills that, in the future, would enable them to engage in these disciplines and contribute to the achievement of the Sustainable Development Goals, reaffirming the positive effects of investing in the early years [7,45].

This systematic literature review will help researchers interested in STEM in preschoolers, incorporating parental involvement as a moderating variable. This can be a new research question. It will also be helpful for organizations that design or implement STEM activities aimed at families. Limited to a few papers but ample in scope, the findings of this study will provide relevant information to plan activities, establish objectives, contents, and methodologies, provide theoretical support, and anticipate the needs of children and parents, among others.

While the results are promising and attractive, it is essential to remember that they are based on a small number of investigations, mainly of a descriptive nature, carried out with small samples and a low geographical variability. These factors are a limitation of this review, as they reduce the possibility of extending the results to a broader population, so they should be analyzed and used with prudence. We recommend that future literature reviews broaden the search criteria to access a more significant number of empirical studies and generate more robust results. Moreover, the present literature review might be complemented with other meta-analysis or research reviews oriented to parental involvement in the disciplines—for instance, centered separately on early science, technology, engineering, and mathematics. This would provide a more comprehensive view, which could be compared to the present review focused on the STEM or STEAM, knowing that the activities occur on a continuum ranging from a lower to a greater degree of integration of the disciplines [2].

Nonetheless, it is worth having a panoramic overview of parental involvement in early childhood STEAM education, especially considering the relevance of the supportive role of parents in child development in the current pandemic context, in which homeschooling has brought a different perspective on parents' involvement in children's education. On the other hand, the use of different databases, beyond Web of Science and Scopus, is recommended. This will allow the access to studies published in emerging media and diversify the bibliographic sources, which will promote the multicultural perspective necessary to understand the dynamics of parental involvement.

Apart from the limitations described above, we have recommendations derived from the issues detected in the articles cited. For instance, increasing the sample size is possible if the study aims to generalize the conclusions. However, since parental involvement in STEM in preschoolers is still an emergent field of research, we think it is also valuable to opt for descriptive studies with small samples. Moreover, if working with samples that participate in workshops or programs, it is recommended to include a control group.

Likewise, we suggest investigating formal (e.g., classrooms) and informal contexts (e.g., home, museums, zoos). Future research might include those as search terms to make them visible in the analysis, because differences might appear between those types of education. Finally, it is worth pointing out the serendipitous results or emergent topics, even if they contradict previous findings. Researchers can detect new issues and research questions and critique their findings (e.g., parenting style and STEM education) in a collective, constructive way.

Beyond the limitations indicated, the results of this literature review also invite us to continue studying STEM education in preschools and parents' role in it. New research could draw on the exposed results to deepen and validate them, using more sophisticated designs and larger samples with fewer biases. Likewise, the encouraging findings could motivate future interventions with a multidisciplinary, integrated, and gender approach, incorporating art and including the involvement of diverse families. This is relevant because programs in early childhood are proven to be cost-effective [7], and family participation has been positioned as a crucial factor contributing not only to the academic achievement of children but also to the achievement of sustainable development goals [1,3].

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