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Review Article

Parental Involvement in STEM Education: A Systematic Literature Review

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ABSTRACT

STEM education has been a significant subject in the world and it has been studied by researchers. But parental involvement to STEM education hasn't been on the agenda enough. In this study, findings were reached by examining 24 studies determined by literature review and PRISMA criteria. When analysis on the studies; it was concluded that there was an increase in 2021, the most in article type were written, they were mostly made in the USA, mostly primary school students were the subject, and the studies were mainly conducted in the survey model. It has seen that the subject of family participation in the STEM program (parent-child activities) is and their positively results frequently pointed. The positive effects of family career and their emotional characteristics on STEM success are frequently studied topics. In the theme of STEM activities at home, it was concluded that studies were conducted in which parents support STEM education mostly in terms of technology. Suggestions were made for performing STEM activities with the participation of families and investigating their effects.

Keywords: STEM, parent, family, involvement, participation, engagement, systematic review

INTRODUCTION

Informal practices are also very important besides formal practices in education. The literature on "informal education" or "Out-of-School-Time (OST)" learning is developing rapidly (Kruchten and O'Malley, 2016). Parental involvement is critical for academic success, motivation and self-efficacy (Varma, 2019). Parental involvement is effective in increasing the success of the child, especially at the pre-school and primary school level, where children are more easily affected (Desai, 2021). When Hill and Duke (2009) analyzed studies on parental involvement in secondary school; they determined that parent involvement positively affects success. Thomas et al. (2020) reported that parent involvement improves social, emotional and character development, reduces high school dropouts, improves attitude towards school, academic motivation, academic performance, and self-efficacy. An et al. (2018) had exemplified parents' participation in education in three areas: Behavioral, cognitive and emotional (**Table 1**).

Asoka De Silva et al. (2018) stated that home-based parent involvement has a stronger effect on students' motivation compared to school-based participation. Dani and Harrison (2021) state that with family participation science nights are important for teachers to get to know different families and ensure interaction. It is known that parents' introducing children to mathematical concepts early, guiding them to explore and talk can have a positive effect on children's mathematics learning (Zippert et al., 2017). Parental beliefs about children's math skills; it is a stronger predictor than the child's self-perception in mathematics and the child's previous mathematics

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Table 1. Species for parental participation in education (An et al., 2018: 44)

Parental participation	Behavioral participation	Cognitive participation	Emotional participation
Home-based participation	Parent supervision and help parent-children communication	Providing cognition stimulating materials	Education beliefs and expectations
School-based participation	Parent-school communication participation in school activities	Participating in parent-school cooperation	
Community-based participation	Providing after-school privative tutoring opportunities or providing rides, waiting visiting community facilities	Participating in studies during private tutoring	

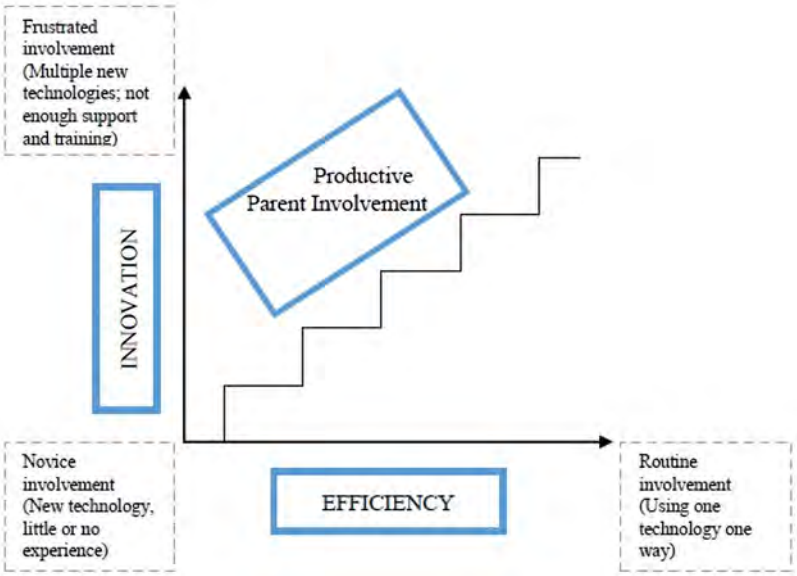

Figure 1. Technology user and productive parent involvement model (Varma, 2019: 6).

performance (Ansberry and Morgan, 2019). However, there are barriers related to the role of the teacher, demographic barriers, psychological barriers and school climate barriers in front of parents' participation in their children's education (Desai, 2021). More study is needed to examine the parent factor, which is so effective and predictive for the future.

Parental Involvement in STEM (Science-Technology-Engineering-Math) Education

Young children's everyday scientific thinking often occurs in the context of parent-child interactions (Crowley et al., 2001). The parents are less involved in their children's education in science than in reading and mathematics (Kaya and Lundeen, 2010). The family factor in STEM education offers an untapped resource that has the potential to increase students' motivation and success (Šimunović and Babarović, 2020). Parents' involvement in their children's STEM learning is a key determinant of a child's academic success in this area, but this can be difficult for parents without a STEM background (Sheahan, 2016).

Many parents believe that they are not qualified to do STEM activities with their children and that STEM can only be taught in formal school settings (Ansberry and Morgan, 2019). Barriers to home implementation of STEM education by families are that parents do not know how to lead their children to scientific inquiry, the thought that science education is only the school's duty, and the scarcity of resources supporting inquiry-based STEM education (Mei, 2017). There is a lack of resources for adult amateurs who will learn at home with their children (Sheahan, 2016). In some cases, the use of technology can help parents. Varma (2019) has developed a scheme for the balance of innovation and effectiveness in the model for the participation of parents with technology (**Figure 1**).

Fleer et al. (2020) state that STEM education starts from infancy and make suggestions about the work parents can do with their babies. Salvatierra and Cabello (2022), who examined the studies on parental involvement in STEM education in early childhood, stated that STEM activities can encourage parent involvement and positively affect children's STEM learning. The development of children's scientific literacy takes a long time, and the parent's accompanying them increases the effect (Mei, 2017). The suggestions are that for parent involvement in STEM (Ansberry and Morgan, 2019: 66):

- STEM learning in everyday situations (identifying geometric shapes of household items, swimming-sinking experiments, reading new inventions, designing creative solutions to everyday problems).
- To do activities by using the guides about STEM activities at home.

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- To organize school activities with the concept of STEM Nights that parents can attend with their children.

In STEM education, children's interest, curiosity and imagination can be stimulated by the use of building toys, lego, board games, experiment kits, and robotics toys (Mei, 2017). Homemade materials can be prepared using nature in STEM education (Mei, 2017). Activities such as home cooking, grocery shopping, outdoor games can support children's science and math knowledge (Zucker and Yeomans-Maldonado, 2022). Christenson (2017) states that ways to solve naturally occurring real-world problems of children like scientists or engineers should be sought, and gives the following example:

> "Let's say the toast in the toaster is stuck. With the child, this problem can be solved like an engineer. 'Let's unplug the machine first for safety. Now how do we make the toast? The weather is very hot and we can burn ourselves. What tool do we need?' When the child answers 'fork', 'Yes, we use a fork to remove the toast and the problem is solved. It can be said that the fork is a technological tool."

Craig et al. (2018) quoted a university student named Katrina who chose a science career in their study, describing what she did with her scientist father, as follows:

> "It was not following a workbook. It was not 'do this,' 'do that.' It was 'let's try to figure out how to do this … It was exciting. I became pumped by science taught as inquiry … I had so many ah-hah moments … I would get so excited …"

Although STEM is mostly handled within the framework of the teacher-student relationship in school environments, there are also things for parents to do.

Problem Statement of this Study

While there are many important studies on parent involvement in science and mathematics education independently, it is limited in STEM learning (Thomas et al., 2020). Asoka De Silva et al. (2018) stated that parent involvement increased students' internal and external motivation and established a strong relationship with their science learning and self-efficacy. Despite the large literature on the impact of formal factors in schools on STEM education, the issue of how informal factors such as parents and social groups influence STEM education has been little studied (Plasman et al., 2021). Despite the importance of family-child interaction in STEM education, study in this area is quite scarce (Salvatierra and Cabello, 2022; Šimunović and Babarović, 2020; Thomas et al., 2020). There is also a gap in parent-child interactive learning activities (Sheahan, 2016).

Milner-Bolotin and Marotto (2018) had examined the literature on family involvement in STEM education and gathered under five headings: STEM education as a bridge between school and family, STEM education as a gateway for children's future economic success, STEM education as a tool to develop student communication skills, STEM education and applied inquiry, increase of students STEM participation. Thomas et al. (2020) had identified three themes in their study, which aimed to create an international perspective on parent involvement in STEM education: academic advantages related to parent involvement, culture as a context for parent involvement, and teacher/school perspectives and parent involvement. There is a need for research describing and summarizing the trends in research on family involvement in STEM education.

In this study, it has been tried to review as systematic, STEM education from a parent-child perspective and studies conducted in the international arena. The study sub-problems determined for this purpose are as follows:

1. What are the descriptive features of studies on parental involvement in STEM education?
2. What are the common results of studies on parental involvement in STEM education?

METHOD

A systematic literature review was made in the study. In the study, compliance with the PRISMA 2009 checklist was carried out and the criteria in the list were applied in the screening, study, synthesis and reporting sections (Moher et al., 2009).

The literature review of this study was conducted in April 2022. ERIC, Taylor & Francis, Elsevier, Springer, Google Scholar databases were searched. The study was limited to studies that define parental involvement within the framework of STEM education, and studies that deal with four sub-fields in an interdisciplinary manner rather than just science-technology, mathematics-engineering interaction were examined. Searches were made by writing "parental involvement", "parental engagement", "parental participation", "family participation", "family engagement", "family involvement" expressions next to the word "STEM" in the searches made in the databases. It was taken as the main criterion that the studies included direct parent involvement (behavioral, cognitive or emotional participation). The stages followed according to the PRISMA criteria are summarized in **Figure 2**.

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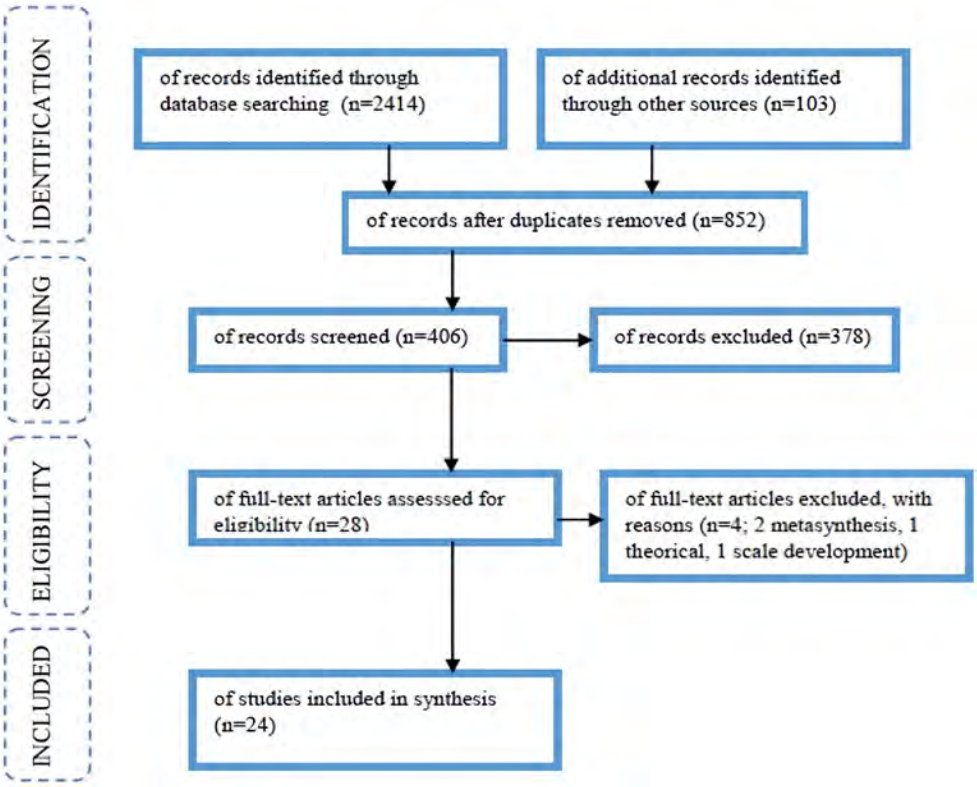

Figure 2. PRISMA flow chart in the study

In this study repeated recordings, meta-synthesis studies, theoretical studies, scale development studies, and studies that did not contain the direct parent involvement were eliminated. As a result of the eliminations, 24 studies were determined. The studies had classified according to year, study type, country, student level, number of participants, study model, data collection tools and main results (**Appendix A**). The analysis of the data in the research was made through descriptive analysis. The codes were transformed into themes in terms of the descriptive features and results of the studies. Comparisons between the themes were made and the findings were tabulated. In the findings related to the basic results of the studies, the type of activity and the effect of the activity were coded in the studies involving application. In relational studies, dependent and independent variables were coded. After the coding, the studies were organized under common themes.

FINDINGS

In this section, the findings that will answer the study problems are presented in tables and interpreted.

1) Findings for problem "What are the descriptive features of study on parental involvement in STEM education?"

The findings of the descriptive features such as the year, type, country of the study, the student group concerned, the number of people in the study group, and the model of the study are presented.

Table 2. Findings regarding the years of study

Years of study	Number of study (f)	Percentage of study (%)
2014	3	12.5
2016	2	8.3
2017	2	8.3
2018	3	12.5
2019	2	8.3
2020	3	12.5
2021	7	29.16
2022	2	8.3
Total	**24**	**100**

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As can be seen in **Table 2**, studies on parent involvement in STEM education started in 2014. While significant increases have not been observed in the following years, it is seen that study has made a significant leap in 2021 (29.16%). The increase in studies in 2021 may be due to the increased interest in the subject, as well as the fact that the COVID-19 epidemic process brought the participation of families in education more on the agenda. The number of studies in 2022 is low since the survey was carried out in April, that is, in the first months of 2022.

Table 3. Findings regarding the type of study

Type of study	Number of study (f)	Percentage of study (%)
Article	17	70.83
Conference paper	5	20.83
Study report	2	8.3
Total	**24**	**100**

As can be seen in **Table 3**, most of the studies (70.83%) examined are in the type of articles.

Table 4. Findings regarding the country of study

Country of study	Number of study (f)	Percentage of study (%)
USA	17	70.83
China	2	8.3
Croatia	2	8.3
Canada	1	4.16
Sweden	1	4.16
Turkey	1	4.16
Total	**24**	**100**

As can be seen in **Table 4**, it can be stated that most of the studies (70.83%) on the subject are originated from the USA.

Table 5. Findings regarding the student group of study

Student group of study	Number of study (f)	Percentage of study (%)
Pre-school	7	26.92
Primary school	9	34.61
Secondary school	5	19.23
High school	5	19.23
Total	**26***	**100**

***** As more than one student group was handled in 4 studies, the total number was higher than the number of studies.

As can be seen in **Table 5**, most of the studies (34.61%) focus on primary school children. However, the number of studies in other student groups is close to this.

Table 6. Findings regarding the number of people in study

Number of people in study*	Number of study (f)	Percentage of study (%)
1-10	4	16.66
11-50	6	25.00
51-100	3	12.50
101-1000	5	20.83
More than 1000	6	25.00
Total	**24**	**100**

***** While categorizing the number of people, the number of a group was written if the students and parents participated together.

As can be seen in **Table 6** that the number of people in the study group handled in the studies is between 10-50 (25.00%) and over 1000 (25.00%). It can be stated that there are large-scale studies and in-depth studies that work with small groups.

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Table 7. Findings regarding the model of study

Model of study	Number of study (f)	Percentage of study (%)
Survey	10	41.66
Case study	6	25.00
Experimental	5	20.83
Longitudinal	2	8.30
Design-based	1	4.16
Total	**24**	**100**

As can be seen in **Table 7**, it is seen that the most preferred study model on the subject is the survey (41.66%).

2) Findings for problem "What are the common results of study on parental involvement in STEM education?"

When the results of the studies were examined, the prominent points were coded. In the coding, "dependent-independent variable" or "activity type-effect of the activity" were examined according to the type of research. According to the codes, 3 themes were revealed: "The effect of family participation (parent-child activities) in the STEM program" (11), "The effect of family history and perceptions in STEM learning" (8), "The effect of implementing STEM activities at home" (3).

Table 8. Findings regarding the common results of studies

Themes of general results of study (f)	Codes of affecting/affected situations in study (f)	
The effect of family history and perceptions in STEM learning (8)	**Independent variable**	**Dependent variable**
	Family career and history (2)	STEM success (5)
	Parental support (2)	STEM self-efficacy (2)
	Parent enthusiasm (1)	STEM career (1)
	Parental perception (1)	STEM importance (1)
	Emotional involvement (1)	*One study addressed both achievement and self-efficacy
	STEM importance (1)	
The effect of family participation (parent-child activities) in the STEM program (11)	**Activity type**	**Effect of activity**
	Family Math-Science Days/Nights (4)	Positive effects (6)
	STEM program (3)	Developing parent-child speech (2)
	Tinkering lab (1)	Attitude and behavior development (1)
	Engineering (1)	STEM career (1)
	Coding (1)	Participation in parent meetings (1)
	Parent meeting (1)	
The effect of implementing STEM activities at home (5)	**Activity type**	**Effect of activity**
	Technology (2)	Positive effects (2)
	STEM activity (1)	Parent roles (1)
	Engineering (1)	No positive effect (1)
	Homeschooling (1)	Developing parent-child speech (1)
Total (24)		

The themes were formed by coding the general results of the studies and presented in **Table 8**.

An important theme in study is the effects of family history and perceptions on STEM education. The effects of family career and emotional characteristics on STEM success are frequently studied topics. Parental support, enthusiasm, perception, STEM importance are among the variables studied. It has been reported that children have positive effects on STEM self-efficacy, STEM importance, STEM career, especially on STEM success.

When the themes created for the results of the studies are examined, it is seen that the subject of family participation in the STEM program (parent-child activities) is frequently studied. The positive effects of Family Mathematics and Science Days/Nights were determined in studies involving this theme. Applications were made through specially applied STEM programs, technology-intensive applications (tinkering lab, coding), engineering practice and parent meetings. In these studies, effects such as activation of parent-child conversation, development of behavior and attitude, and STEM career desire were observed.

In the activities for the implementation of STEM activities at home, the issue of parents' use of technology and support for STEM education was studied. It was seen that STEM activity; engineering activity and homeschooling studies were evaluated in terms of STEM.

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RESULTS AND DISCUSSION

In this study, it was aimed to determine general trends by examining STEM studies containing parental involvement. The conclusion reached regarding the first study problem for summarizing the descriptive features of the studies is as follows: In the studies on parent involvement in STEM education, it was concluded that there was an increase in 2021, the most articles were written, they were mostly made in the USA, mostly primary school students were the subject, the studies were mainly conducted in survey model. The summary of the main results of the studies in response to the second study problem is as follows: It is seen that the subject of family participation in the STEM program (parent-child activities) is frequently studied. The positive effect of Family Math and Science Days/Nights is among the important issues. The effects of family career and their emotional characteristics on STEM success are frequently studied topics. In the theme of STEM activities at home, it was concluded that studies were conducted in which parents support STEM education mostly in terms of technology.

It is important that the literature on parental involvement in STEM education is an emerging topic. An international meta-analysis study on parent involvement in STEM education was conducted by Milner-Bolotin and Marotto (2018). This study differs in that it constitutes an international systematic analysis of parental involvement in STEM education. Systematic analysis studies on parent involvement in STEM education have been addressed from different perspectives: The effect of parental beliefs on STEM education (Šimunović and Babarović, 2020), the effect of parents' STEM career on children's STEM success (Thomas et al., 2020), and the effect of parents on STEM education in early childhood (Salvatierra and Cabello, 2022). Therefore, this study is important in terms of presenting a general perspective of parental involvement in STEM education.

Discussions about the descriptive features of the studies that were systematically reviewed in this study are as follows: Similarly examining STEM study on parent involvement in early childhood, Salvatierra and Cabello (2022) reported that most of its study was conducted in the USA. The result on increase in studies in 2021 may be due to the increased interest in the subject, as well as the fact that the COVID-19 epidemic process brought the participation of families in education more on the agenda. Indeed, the pandemic period has been a catalyst for eradicating the school-home separation, creating a compelling reason for parents to participate in pedagogy (Haisraeli and Fogiel-Bijaoui, 2021). The fact that studies on parental involvement in STEM education are mostly at primary school level is because it is thought that parental influence on children's education is greater at younger ages (Desai, 2021; Zippert et al., 2017). Although the fact that the studies are mostly in the survey model means reaching more participants, it also reveals the need for in-depth and experimental interventional studies. It is thought that activity-based studies involving parent-child communication will set important examples in this field (Ansberry and Morgan, 2019; Mei, 2017; Salvatierra and Cabello, 2022; Sheahan, 2016). In their bibliometric study of study involving parent involvement, Addi-Raccah et al. (2021) suggested that it be extended to extracurricular activities beyond school-related topics. Salvatierra and Cabello (2022) stated that activities involving parent participation in early childhood are mostly done in the field of science. It can be stated that importance should be given to activity studies in which the interdisciplinary nature of STEM is emphasized.

Discussions about the results of the studies that were systematically reviewed in this study are as follows: It has been shown that family background and support can have an impact on children's STEM achievement. Among the STEM activities involving family participation, the positive effect of family STEM days/nights has been noted. The positive effects of technology-supported STEM activities of this kind have been reported. It has been observed that STEM activities at home are carried out with technology support.

It has been reported that positive effects were detected in the theme of "The effect of family participation in the STEM program (parent-child activities)", which was the most studied among the determined themes (Ata-Aktürk and Demircan, 2021; De Leon and Westerlund, 2021; Klein-Gardner, 2014; Kruchten and O'Malley, 2016; Marotto and Milner-Bolotin, 2018; Pagano et al., 2020; Respres et al., 2022; Sheahan, 2016; Sheehan et al., 2019). Family Science and Math Days/Nights had been the subject of many studies (De Leon and Westerlund, 2021; Kaya and Lundeen, 2010; Landerholm et al., 1994; Marotto and Milner-Bolotin, 2018; Milner-Bolotin and Milner, 2017; Respres et al., 2022). The organizations where Family STEM activities (Laux, 2021; Reinking et al., 2017) are held, especially for STEM education, can improve parent-child interaction. Technology-based activities have produced important results especially in terms of providing parent-child conversation (Pagano et al., 2020; Sheehan et al., 2019). With family involvement engineering activities are also programs that have positive effects for STEM education (Ata-Aktürk and Demircan, 2021; Klein-Gardner, 2014; Pagano et al., 2020). Klein-Gardner (2014) showed that parents who participated in homework and engineering project presentations through the STEM summer institute program increased their daughters' desire to enter an engineering career. In addition to the effects on children, positive effects on parents have also been reported by studies. Sheahan (2016) stated that STEM design activities involving parent-student interaction improved parents' attitudes and behaviors regarding STEM issues. Especially mothers with STEM careers have higher self-efficacy for STEM participation (Zucker et al., 2021). De Leon and Westerlund (2021) found that the parents' tendencies were mostly to talk about science and

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visit the library. Zucker et al. (2021) stated that 56% of parents read with their children every day, only 35% reported any daily STEM activity. Kaya and Lundeen (2010) reported that parents were less involved in their children's science education than in reading and mathematics education. It is stated that family participation improves children's attitudes and achievements in science education (Fleer and Rillero, 1999). Kaya and Lundeen (2010) found that parents participating in family science night activities increased their interest in science learning and family interactions were positively affected. Willard et al. (2019) showed that children can be encouraged to explore or explain through parent-child interaction in the science museum. In a study of family conversations Crowley et al. (2021) noted an important finding of gender disparity, finding that parents were three times more likely to explain science to boys than girls when using interactive science exhibits at a museum. There are experimental studies indicating that science education with family participation is effective in improving the scientific process skills of preschool students (Ulutaş and Kanak, 2018; Yılmaz et al., 2018). It has been found that students' success is positively affected by interactive assignments shared by families in secondary school (Van Voorhis, 2003). It is clear that STEM education, which expresses an interdisciplinary approach, which is a few steps beyond this, has not received enough attention and has not been studied enough. In particular, parent involvement in STEM education improves quantitative skills and problem-solving skills (Thomas et al., 2020). For these reasons, standard science education activities should now be transformed into STEM activities.

The children's STEM success was the most researched variable in the theme of "The effectiveness of family background and perceptions in STEM learning" (An et al., 2018; Dotterer, 2021; Haden et al., 2014; Ing, 2014; Jungert et al., 2020). The participation of parents with a STEM background in STEM teaching is an important predictive factor (Dotterer et al., 2021; Haden et al., 2014; Zucker et al., 2021). Emotional involvement of parents in STEM education is also an important issue (An et al., 2018; Jungert et al., 2018; Šimunović et al., 2018). Dotterer (2021) stated that parents' STEM participation was a predictor of adolescents' success in STEM courses and was related to adolescents' STEM self-efficacy. While this result refers to the role of parents in STEM education, it also points to an important inference that this effect exists even in older adolescents. Ing (2014) made a comparison with STEM fields and found that parental support was related in mathematics, but no relation was found in science education. The result of this research suggested that specialized studies could be conducted for the sub-dimensions of STEM education. An et al. (2018) stated that the education level of the parents is highly effective on STEM success, the effect of family income is weak, and that emotional involvement can compensate for the negative effects of some negative family factors. The studies that indicate that family members' being in the STEM profession and their beliefs about STEM are effective in their children's STEM learning are also frequently encountered (Thomas et al., 2021). There are many studies examining the relationship between the profession of parents and children's STEM careers. There is the essential role of perceived parental expectations in shaping STEM career aspirations for teenagers (Chen et al., 2022). Nurtured by their parents, students enter STEM disciplines and STEM-related careers through multiple pathways in addition to the anticipated pipeline (Craig et al., 2018, 2021). Šimunović and Babarović (2020) found that parents' STEM beliefs have the potential to explain the differences in students' STEM-related achievement motivation, performance, and career choices. Plasman et al. (2021) finds that high school students whose parents are STEM professions related to the participation rate of STEM courses, proving the growing transfer of scientific capital from parent to child. Adams et al. (2018) found that among CFA Institute members, women are more likely than men to have parents (especially STEM mothers) who work in STEM fields, and that significant early role models, particularly female role models. Chise et al. (2020) found that the influence of fathers outweighed that of mothers in their career in science and was greater for boys than for girls. Ikkatai et al. (2019) said that improving field-specific negative perceptions may contribute to increase parental support for girls' choice of STEM fields. Plasman et al. (2021) stated in their literature synthesis that there is a positive relationship between the profession of parents and the STEM achievement of high school students, and that this effect is more on girls and minority students. The results of this study indicate that many variables related to the effect of parents on their children's STEM learning and these should be investigated.

Positive effects are also seen in the studies under the theme of "The effect of implementing STEM activities at home" (Gann and Carpenter, 2017; Hightower et al., 2019; Marcus et al., 2021; Mei, 2017; Zucker and Yeomans-Maldonado, 2022). With family involvement technology activities at home Hightower et al. (2019) noted positive results, while Burušić et al. (2021) stated that they did not contribute significantly. The prominence of technology use in study on STEM education at home is also a remarkable result. Similarly, there are many studies that enable parent participation in education through technology (Walsh et al., 2014; Olmstead, 2013; Patrikakou, 2016). Marcus et al. (2021) stated the positive effects of home engineering activities. Examining the relationship between the opportunity to learn at home and students' acquisition of science proficiency Liu and Whitford (2011) characterized the students who achieved science proficiency: Of having more than 100 books at home, not taking extracurricular courses and of their parents having a graduate education. This research is important in terms of describing the relationship between reading skills, the effect of parents' educational status, and the science teaching

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environment in science education. It is obvious that this type of description should also be done on STEM education.

The studies show that the interaction between school-parents and children's inter-active experiences are important (Thomas et al., 2020). STEM education studies involving family participation is important in terms of bringing a different perspective to STEM education. In the light of the results of this study, the following suggestions are made for future study:

1. While there are studies on teaching only science, mathematics and technology disciplines to parents in the literature, it is obvious that STEM in which these are discussed together, is a new research topic. Research can be conducted on parents' perceptions of holistic and interdisciplinary STEM education and their application with their children.
2. It is recommended to conduct studies in which STEM education is handled within the framework of parent-child interaction.
3. It is recommended to increase study on the impact of family involvement in the education of adolescents (especially career choices) as well as the education of young children.
4. Since there is a need for experimental studies on parent-child studies in which STEM activities are carried out, it is recommended to conduct study on this subject.
5. It is suggested that Math and Science Days/Nights, which have an important place in the literature, should be organized as STEM Days/Nights in interdisciplinary formatting.
6. The studies should be carried out on the importance of parental support in normal times by turning the idea of "supporting of education by parents", which has been passed necessarily due to the COVID-19 pandemic, into an opportunity.
7. This research is limited to studies that include the topic of STEM education. Specialized studies can also be conducted on other related dimensions and areas of STEM education.
8. In this study, a systematic analysis of general trends was made. Meta-synthesis studies can also be carried out by in-depth content analysis.

Ethical Statement

As the study does not involve the use of human subjects, it does not require ethical approval. There is no conflict of interest in the article.

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APPENDIX A

Table A1. Characteristics of the studies examined in the research

Study	Species of research	Country	Level of student	Number of participants	Model of research	Data collection tools	Main results
Haden et al. (2014)	Article	USA	4-8 age	130 parents	Experimental with control group	Photo narrative Buildings	The results have implications for understanding family conversations and children's STEM learning in families from diverse backgrounds.
Ing (2014)	Article	USA	Secondary school	3116 students	Longitudinal studies	Parental support and STEM career tests	Perceived early parental support was associated with growth in math achievement for men, but not for women. There was no association between perceived early parental support and growth in science achievement for both men and women.
Klein-Gardner (2014)	Conference paper	USA	High school	28 girl students and their parents	Case study	Unfinished work	The STEM summer institute program increased the willingness of their daughters to enter an engineering career by participating in homework assignments and engineering project presentations.
Kruchten and O'Malley (2016)	Conference paper	USA	5-7. grade	60 gifted students and their parents	Survey	Interview	It demonstrates value at the intersection of gifted education, OST learning, STEM content, and the arts.
Sheahan (2016)	Research report	USA	Primary school	5 children and their parents	Experimental	Survey Interview Observation	With the STEM design activities involving parent-student interaction, parents' attitudes and behaviors about STEM subjects have improved.
Gann and Carpenter (2017)	Article	USA	High school	29 parents	Case study	Survey Interview Observation	Parents of homeschooled students provided the roles of facilitator, consultant, presenter and teacher in STEM education.
Mei (2017)	Conference paper	China	Pre-school	3 children and their parents	Case study	Observation	STEM activities at home support learning.
An et al. (2018)	Article	China	Secondary school	12724 parents	Survey	Survey	The model in which parents emotionally participate in their children's school education has the greatest impact on children's STEM academic success.
Marotto and Milner-Bolotin (2018)	Article	Canada	Primary secondary school	29 parents	Mixed methods case study	Questionnaire	Family Math & Science Day activities, it was determined that the parents were satisfied with their children's STEM education and thought that family support was important.
Šimunović et al. (2018)	Article	Croatia	Primary school	1,071 students and their parents	Survey		Children's importance value of the STEM school fields was best explained by their perceptions of parental values and behaviors in STEM.
Hightower et al. (2019)	Conference paper	USA	Primary school	12	Experimental	Survey Interview	Parents finding and incorporating different forms of media into their child's informal learning.
Sheehan et al. (2019)	Article	USA	4-5 age	31 children and their parents	Case study	Interview	Coding practices with parent-child interaction improve children's ability to respond and demonstrate task-related speech.

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Table A1 (Continued).

Study	Species of research	Country	Level of student	Number of participants	Model of research	Data collection tools	Main results
Jungert et al. (2020)	Article	Sweden	High school	288 student and their parents	Survey	Survey	Intrinsic motivation mediated the relation between teacher and parent enthusiasm and change in academic success.
Muenks et al. (2020)	Article	USA	High school	117 students and their parents	Relation survey	Survey	Parents who perceived that their child had higher mental manipulation ability were more likely to encourage their child to pursue a STEM career.
Pagano et al. (2020)	Article	USA	6-8 age	61 parents	Experimental	Survey	Tinkering lab activities parent–child engineering talk during tinkering mediated the association between the program design and engineering talk when reminiscing.
Ata-Aktürk and Demircan (2021)	Article	Turkey	Pre school	2 teachers, 5 children and their parents	Design based research	Survey Interview	It was concluded that it could be used in early childhood by focusing on engineering and encouraging parent involvement.
Burušić et al. (2021)	Article	Croatia	Primary school	1205 students and their parents	Survey		The general conclusion is that engagement in technology-based activities at home does not substantially contribute to STEM achievement.
De Leon and Westerlund (2021)	Article	USA	9-12 age	18 parents	Survey	Survey	As a result of the family science nights event, it was determined that the parents' tendencies were mostly to talk about science and visit the library.
Desai (2021)	Research report	USA	K-8	7 parents	Survey	Observation Interview	In STEM Academy using various forms of communication, separating parent meetings by grade level, and implementing child involvement into parent meetings was recommended.
Dotterer (2021)	Article	USA	High school	24000 students and their parents	Longitudinal research	Survey	It has been found that parents' 9th grade STEM participation predicts the cumulative grade point average in adolescents' STEM classes.
Marcus et al. (2021)	Article	USA	4-9 age	63 children and their parents	Case study	Photo narrative reflection	The majority of families completed a building activity with different materials at home, and the majority evidenced learning transfer of the building principle demonstrated at the museum.
Zucker et al. (2021)	Article	USA	3-5 age	208 parents	Survey		Mothers with STEM careers have higher self-efficacy for STEM participation. While 56% of parents reported that they read with their children every day, only 35% reported any daily STEM activity.

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Table A1 (Continued).

Study	Species of research	Country	Level of student	Number of participants	Model of research	Data collection tools	Main results
Respres et al. (2022)	Conference paper	USA			Survey	Survey	As a result of the parent cafe, family workshops, family nights, and family STEM days applications, 93 percent of the parents stated that their children were positively affected.
Zucker and Yeomans-Maldonado (2022)	Article	USA	Pre school	181	Experimental with control group	Survey	Co-learning STEM activities for poor families during the COVID period have positive effects.

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