

Article

Examination of STEM Parent Awareness in the Transition from Preschool to Primary School

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Abstract: This study, which aims to examine STEM parent awareness in the transition from preschool to primary school, used a survey model, one of the quantitative research designs. The study group consisted of 400 parents with children aged 5–7 years (preschool and primary school age) who participated in the study voluntarily from different provinces of Turkey. The STEM Parent Awareness Scale, was used to collect data. The STEM Parent Awareness Scale evaluated parents' STEM awareness in knowledge and attitude. Data collection took place online using volunteer participants. Data analysis consisted of descriptive analyses using quantitative data and MANOVA to analyze the STEM awareness of parents with preschool children and the STEM awareness of parents with children in primary school. Data analysis revealed that STEM parent awareness did not differ according to the children's education levels but the parents' and the children's STEM education status. To raise awareness, the authors recommend organizing training activities, courses, and workshops for families and increasing STEM studies in out-of-school activities.

Keywords: awareness; parents; preschool; STEM; transition to primary school



Citation: Mercan, Z.; Papadakis, S.; Can Gözümlü, A.İ.; Kalogiannakis, M. Examination of STEM Parent Awareness in the Transition from Preschool to Primary School. *Sustainability* **2022**, *14*, 14030. <https://doi.org/10.3390/su142114030>

Academic Editor: Antonio P. Gutierrez de Blume

Received: 9 October 2022

Accepted: 25 October 2022

Published: 28 October 2022

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1. Introduction

Children in preschool education must be allowed to learn by exploring and finding out about their environment through play. High value is placed on preschool children being able to experiment using hands-on materials. Children's exploration, inquiry, and problem-solving through play and research form the basis for developing concepts in the fields of Science, Technology, Engineering and Mathematics (STEM) [1–3]. Research [4–8] tells us that children's early experiences build brain architecture and form the basis of lifelong thinking skills and learning approaches, which are critical to STEM success. According to [9], early STEM education provides contexts to design active learning environments linked to children's natural curiosity about the world. It systematically involves children involved in original research using critical and creative thinking to build knowledge, acquire skills, and develop self-confident dispositions for STEM learning. STEM requires a strong learning mindset and trust when faced with new knowledge or challenges and sound thinking tendencies such as curiosity and inquiry, assessment, and analysis. These should be developed from infancy to third grade to lay the foundations for STEM success in a child's early education [1]. Ref. [10] states that children spend only 15 per cent of their waking time in school from kindergarten to third grade. In [10], additionally, many children do not have access to formal education until they are five. Furthermore, almost all children spend the first three years of their lives in informal settings (such as childcare or family), emphasizing that STEM education should also be supported in out-of-school settings.

The literature review found that beneficial parental participation aligns with parents' STEM awareness, supporting STEM content programs in children's out-of-school settings [11]. While research emphasizes the need to start STEM education early, it points

out that parents positively affect children's learning in informal learning processes, out-of-school learning areas, any time, and anywhere [12–14]. STEM activities based on children's development level [15,16] may be effective in children's future careers and academic achievement [17,18]. Early experiences play a critical role in developing long-term STEM interests and learning [19]. Children's early exposure to STEM domains positively affects their learning because children are willing to analyze, make assumptions, and guess with their innate curiosity and creativity. STEM concepts and skills developed at an early age allow children to discover and understand more complex concepts during school [20].

Recent scientific studies have focused on STEM awareness, family, and early childhood children [1,10,21–23]. The research in [23] underlines that family participation is a dynamic process. It emphasizes that family, society, researchers, and educators must work together. In its study on children's early learning and well-being, the study [22] states that early learning occurs due to combining the learning environment at home and early childhood experiences (blended with culture) with individual personality traits. In [24], STEM + Families project has three steps: direct families, declare mobilization, and raise awareness. Thus, parent awareness is a considerable step toward parent involvement regarding STEM education for children.

The Noyce Foundation uses the “stem ecosystem” metaphor to describe the creation, enrichment, and integration of various learning opportunities to improve children's and young people's knowledge of and participation in STEM and better prepare them to become STEM literate members of society [25]. STEM learning ecosystems benefit from educators, families, policymakers, informal science institutions, businesses, after-school and summer practices, higher education, and many others toward a comprehensive vision of STEM learning for all children. They encompass schools, community settings such as summer and after-school programs, science centers, museums and experiences that form a rich range of learning at home and in various settings. A learning ecosystem draws on the unique contributions of all these different environments to provide all children with STEM learning [25]. Children's access to STEM learning ecosystems and parents' STEM awareness are critical in supporting their informal learning.

The literature review explains what is meant by parents' STEM awareness and describes the theoretical foundations and STEM education in early childhood.

1.1. Literature Review

Theoretical Approach to the Parent-Child Relationship

Bronfenbrenner's bioecological system model explains human development in four systems (microsystem, mesosystem, ecosystem, and macrosystem) based on human interaction with the environment. The bioecological system model states that the people or institutions closest to the child (e.g., families, siblings, etc.) are directly influential on the child and their effect on child development is critical. The bioecological system model places the child at the center of these systems. Microsystems include environments that closely affect the child's daily life. Families, siblings, early childhood educators, and caregivers are the people/institutions that make up this system and greatly influence children [1,26,27].

Many scientific studies on the relationships between children and families reveal the longitudinal effects of the family on children. The authors in [28] focus on the ecology of family experiences in their research. While emphasizing the positive effects of positive relationships and experiences with the family on human development, they emphasize the importance of the activities that families undertake with their children and the time they spend with them. The authors in [29] emphasize that “family discourses” can be considered as the transfer, exchange, and transformation of families' experiences within generations. From an ecological perspective, the transfer of “families' experiences” and “family discourses” are also affected by interconnected systems (microsystem, exosystem, and macrosystem).

There is a close and intense interaction between the child and the environment in early childhood practices. The child develops language and expression skills in this environment and learns values and attitudes. Bronfenbrenner defines mesosystems as the interaction of two or more microsystems. The interaction between the two environments, namely schools and families, is significant because both closely effect the child [26]. The authors in [25] focus on four dimensions when defining STEM Learning Ecosystems: home, school, STEM-oriented institutions, and after-school or summer programs. They state that the family's STEM awareness is essential in the STEM learning ecosystem and that the development of this awareness affects not only children but also families and society. They also emphasize that social projects should become widespread to increase this awareness.

Bronfenbrenner includes society, cultural values, attitudes, and the child's beliefs in the macro system. According to [30], culture consists of people/situations in which the individual interacts in his/her immediate or distant surroundings and different environments. This means that families use values, attitudes, and beliefs to transfer the reflection of culture to future generations. The importance of the sociocultural environment should be mentioned here. Vygotsky focuses on this issue in the Sociocultural Development Theory: the way for children to learn is through collaborating with their environment. Children can receive STEM education with their parents when in learning environments conducive to their development (in a cultural context). Their parents can assist them in solving STEM problems that they cannot work out by themselves, and in such cases, depending on their STEM awareness, parents can use STEM scaffolding tools for their children. The place and importance of the family in STEM education, which supports the development of the child's convergent development area, cannot be denied [31–33]. Parents are expected to develop STEM awareness to support their children in early childhood, which is critical for child development, so the children's convergent development areas can be supported through STEM education.

A chronosystem is a system that reflects change or continuity over time and affects all the other systems. Childhood is shaped by the conditions in which children grow up. Historically, beliefs and attitudes have influenced the roles children are allowed to assume [26]. We can thus talk about 21st century skills and STEM education. The most obvious signs are that today's children are known as the "Z" generation, plus the increase in digitalization and its incorporation into education systems [18,34,35]. Improved parent STEM awareness strengthens communication between Gen-Z children and their parents. Parents play the digital games children play together and guide their children in STEM education [36].

Four key interaction development elements—process, context, time and human—are highlighted in the final depiction of Bronfenbrenner's bioecological model. The process in this model is highlighted bio-psychologically as the primary mechanism responsible for the development when an active person becomes increasingly complex, seen through processes of mutual interaction with people, symbols and objects in their immediate vicinity. Bronfenbrenner (1999) pointed out the importance of finding five aspects at the same time in the definition of the convergent process:

- For development to take place, the person must engage in an activity;
- For interaction to be effective, it must take place on a relatively regular basis over long periods and cannot be effective if practiced only occasionally;
- Activities may be increasingly complex, hence the need for a stable period;
- For convergent processes to be effective, there might be reciprocity in interpersonal relationships;
- For mutual interaction to occur, symbols and objects in the immediate vicinity must trigger the developing person's attention, discovery, manipulation, and imagination Hayes et al. [26].

Sociocultural theoretical approaches in parent–child interactions suggest that parents' STEM awareness is essential for the child's development and for regulating the relationships between the family and the child during the STEM education process.

1.2. Parental Awareness in Early Childhood STEM Education

When children engage in STEM learning inside and outside school, they find opportunities to explore and discover joy and learning. They are actively attended in science, engineering, and mathematical experiences. Thus, creating a “STEM identity” should be enhanced with children’s positive STEM experiences that can be linked to children’s self-confidence, problem-solving abilities and STEM interest. Additionally, it should be effective regarding parental support for children’s investigations and interest in STEM [25]. Parents can support children as they form their foundations. For example, when parents define their role in STEM education, they can help their children to develop relevant knowledge and skills. A conversation about a bridge that a parent and child are interacting with may be an opportunity for the child to explore new concepts in engineering, math and science. Parents may make their children sense the importance of engineering in daily life by offering the tower as an engineering product that makes our lives easier and discussing how towers support great weights without collapsing [37,38].

Similarly, children who have difficulty seeing the other side due to the fence of the schoolyard may find a solution to the problem by building a tree house with their families. In the meantime, skills related to generating and testing ideas, researching, designing, making improvements, and problem-solving may also develop [39]. All these reasons display the importance of consociating between schools and parents by focusing on the education process for preschool children and STEM education initiatives [37,40,41].

The study by [36] examined the educational aspects of STEM content digital games played by preschool children and the active co-playing mediation strategy used by parents when the children played digital games. That study reported that parents play digital games with STEM content with their children and support their children when they encounter levels in the game that are hard to overcome. They use the active co-playing strategy by answering the questions asked by their children. It determined that parents who use the active co-play strategy consciously and in consultation with experts make their children play games with STEM content. It also determined that the digital games that children play are aimed at supporting STEM content education. Depending on their STEM awareness, the children’s parents may use the conscious mediation strategy for their children and play digital games with STEM content.

Other studies that mention the importance of out-of-school learning environments in forming STEM ecosystems focus on the relationships between children, families, and society. In particular, studies that emphasize the need for families to be included in STEM activities address the effect of parents’ attitudes and behaviors toward STEM on children. They further emphasize the importance of parents in fostering children’s curiosity toward STEM, developing a positive attitude and STEM identity, and becoming interested in a STEM career [25,42–44]. The study in [23] states that in STEM activities, parents effectively develop or increase children’s interest. They also have a significant role in children’s academic permanence and success, standardized test results, and career choice because parents “are important players in raising young people’s/children’s awareness of the value of STEM and enabling them to join in activities that improve STEM competencies”.

The study in [45] emphasizes that families/parents should participate in children’s STEM processes. To this end, the Fund has developed a STEM participation project that addresses the critical importance of families’ participation in STEM processes, demands that STEM-oriented organizations improve their capacity to involve families and focuses on providing STEM materials for practitioners. While expressing the need to promote awareness about family participation, it also emphasizes the importance of sharing effective practices and listening to and learning from families.

The three strategies identified in the project [24] STEM + Families are Strategy #1 Lead; Strategy #2: Mobilize; Strategy #3: Build/Raise Awareness. Figure 1 shows the strategies of the STEM + Families project and their descriptions.

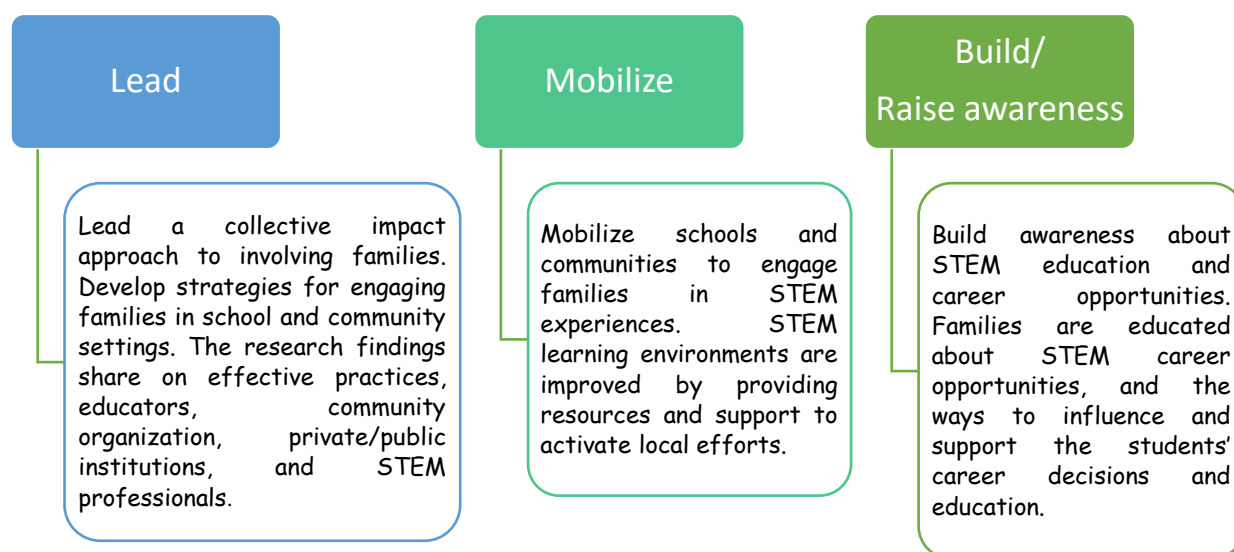


Figure 1. Strategies of the families' project for STEM.

The study in [46] states that early childhood programs allow parents to participate. Research identifies parental participation as an essential principle of best practice in STEM education. It states that parents significantly impact students' learning outcomes but also points out low awareness in the STEM field.

Starting primary school is a critical stage in a child's academic life. One of the most important criteria for a child to pass this stage successfully is a sufficient level of readiness for primary school education [47]. One of preschool education programs' main aims and basic principles is to prepare children for primary school. "The program has been developed to ensure that their development reaches the highest level in all developmental areas as language, motor, cognitive, emotional and social development, gaining self-care skills and being ready for primary school" [48]. Systematic thinking and questioning children in preschool education institutions help them prepare for primary school [47]. The STEM approach is essential in acquiring systematic thinking and questioning skills from preschool, and parental awareness is critical in supporting and maintaining these skills. Therefore, this study aimed to explore parents' STEM awareness in the transition from preschool to primary school, which is especially critical for children's early STEM experiences.

A literature review revealed that various early childhood studies for STEM parental awareness focused only on the preschool period [48–50]. Their results emphasize family, child, and community education for STEM awareness in the early years [1,10,21–24,51]. While limited, our review found no research correlating parent and child education levels in parent STEM awareness studies. This study is expected to contribute to the literature examining the interaction between parental STEM awareness and the child's and the parents' education levels.

2. Methods

This study used a survey method suitable for quantitative research [52]. Survey studies usually collect data from a broad audience by using the answer options determined by the researcher. Researchers in survey studies are usually interested in how opinions and characteristics are distributed across the individuals in the sample rather than why they originate [53]. This study aimed to express the existing situation by examining the STEM awareness of the parents based on the education levels of parents of children aged 5–7 years, whether or not their children had received STEM education and their level of education.

The answers to the following research questions were thus sought:

- Is a significant difference in parents' awareness of STEM and its subdimensions based on their children's education level?
- Is a significant difference in parents' awareness of STEM and its subdimensions based on their children's STEM education?
- Is a significant difference in parents' awareness of STEM and its subdimensions based on their education levels?

The demographic information of the participants of the study is explained below.

2.1. Participants

The study's participants consisted of the parents of children aged 5–7 who volunteered to participate in the study and were selected using the random sampling method appropriate to the quantitative survey method [52]. Study Group Table 1 gives the demographic information of the 400 parents and their children who participated in the study online.

Table 1. Demographic data of the children and parents participating in the study.

	Child's			Parent's		
	Variable	f	%	Variable	f	%
Gender	Boy	230	50.0	Male	85	21.25
	Girl	170	50.0	Female	315	78.75
	Total	400	100.0	Total	400	100
Education Level	Preschool	200	57.5	Middle School	153	38.3
	Primary School 1	200	42.5	High School	135	33.8
	Total	400	100.0	Undergraduate	112	28.0
				Total	400	100.0
Received STEM Education or Not	Yes	251	62.7			
	No	149	37.3			
	Total	400	100.0			

According to the 2021–2022 National Education Statistics Formal Education data announced by the Ministry of National Education of the Republic of Turkey, the number of children between 5 and 7 is over 1,800,000 [54]. The sample ratio was calculated according to the sample size for an infinite population ($S = Z^2 \times P \times [(1 - P)/M^2]$). The symbols in the formula are: S = sample size for infinite population, Z = Z score (1.960), P = population proportion (Assumed as 50% or 0.5), M = Margin of error (0.05).

The minimum sample representing the population at a 95% confidence interval was calculated as 385. In this context, 400 parents, the number of participants in the research, represent the universe with a 95% confidence interval and 4.89% margin of error.

The demographic information in Table 1 of the children and parents participating in the study shows that 400 parents participated. When the gender of the parents is examined, 85 men are 315 women. When the parents' education levels are examined, 153 are middle school graduates, 135 are high school graduates, and 122 are undergraduate graduates. When the education levels of the children are examined, 200 are in preschool, and 200 are in primary school. When the gender of the children is examined, 230 of them are male, and 170 are female. When the children's status of receiving STEM education was examined, 251 of them had received STEM education and 149 of them had not.

2.2. Data Collection

2.2.1. Data Collection Tools

The Personal Information Form and STEM Parental Awareness Scale were used to collect the data for this study.

2.2.2. Personal Information Form

The researchers prepared a personal information form to collect the personal information of the participating parents and their children. The introduction section of the personal information form included consent to participate in the research. The personal information form included information about the gender and education levels of the parents, the education levels of the children (kindergarten and primary school), their gender, and whether they had received STEM education or not.

2.2.3. STEM Parental Awareness Scale

The study used the STEM Parental Awareness Scale, which was developed by [55], adapted by [56], and tested for reliability and validity by [57] as the data collection tool. It was used to evaluate parents' STEM awareness in knowledge and attitude. The scale covers 35 items, 16 for STEM knowledge and 19 for attitude toward STEM. The STEM Parental Awareness Scale, which is a 5-point Likert-type scale, includes the options "5, Strongly Agree"; "4, Agree"; "3, Undecided"; "2, Disagree" and "1, Strongly Disagree". The minimum possible score on this scale is 35, and the maximum is 175.

The item-total correlations of the STEM Parental Awareness Scale, which was developed by [55], adapted by [56], and tested for validity and reliability by [57], were calculated within the scope of the validity studies conducted for the two subdimensions, namely, knowledge and attitude, and correlation values. They were seen to range between 0.55 and 0.86. An Independent *t*-test was used to compare the group averages below 27% and above 26% for item discrimination. It was significant for all test items at $p < 0.001$. The correlation value between the knowledge and attitude subdimensions was 0.51 and significant at $p < 0.001$. Confirmatory Factor Analysis was performed for the construct validity of the STEM Parental Awareness Scale. The fit indices were examined and found to be at an acceptable level ($\chi^2/df = 2.48$, NNFI = 0.96, CFI = 0.96; RMSEA = 0.11, PGFI = 0.57) [57]. Cronbach's Alpha value was examined as the internal consistency coefficient as part of the reliability analysis of the STEM Parental Awareness Scale. Cronbach's Alpha coefficients were 0.96 for the knowledge subdimension. Similarly, 0.97 was found for the attitude subdimension, meaning that the tool and its subdimensions are highly reliable.

2.3. Reliability Analysis of the Data Collection Tool

Since the sample of validity analyses conducted by [57] includes the psychometric characteristics of the participants of this study, it is thought to be appropriate in terms of temporal validity. The reliability values of the data collection tool were examined.

This study calculated Cronbach's Alpha coefficients to determine the internal consistency of the STEM Parental Awareness Scale. The Internal consistency coefficients were 0.96 for the knowledge subdimension. Similarly, it was calculated at 0.88 for the attitude subdimension and 0.84 for the total scale, explaining the reliability of the data collection tool.

2.4. Data Collection Process

The data for the study were collected using Google Forms. The researchers sent the data collection tools to the participants via online communication tools. The researchers were asked to share the data collection tool with parents of children in early childhood. The participants were asked to answer the research questions by first approving the statement "I agree to participate in the research voluntarily" on the electronic form. The data were collected from parents in different provinces of Turkey in January and February 2022 with the snowball effect.

2.5. Data Analysis and Analysis of Assumptions

The SPSS 23 statistical package program was used to analyze the research data. The Kolmogorov–Smirnov test was performed to check the data for normal distribution and is suitable for parametric tests. According to the Kolmogorov–Smirnov test results, the STEM Parental Awareness Scale shows normal distribution ($p > 0.05$). Descriptive statistics and multivariate analysis of variance (MANOVA) were performed to test the problem situation created in line with the purpose of the research. Data analysis was performed by meeting the assumptions of MANOVA analysis. The first assumption is the multivariate normality state [58]. The study determined that multivariate normality was achieved by examining the Mahalanobis distance values [59]. The Levene test was performed to test the homogeneity of the research data [60]. As a result of the Levene test, it was determined that the homogeneity of the data showed distribution. Among the MANOVA analysis assumptions, the dependent variables were examined for multicollinearity [61]. The Pearson Moments Correlation coefficient was examined to check for multicollinearity between the dependent variables in the MANOVA analysis. The correlation coefficient between the total scale, knowledge, and attitude subdimensions were 0.71 and 0.78. According to [62], multicollinearity problems are caused when the relationship between dependent variables is more significant than 0.80 or 0.90. No multicollinearity problem was found between the independent variables in this study. Another assumption of MANOVA analysis is the homogeneous distribution of variance-covariance matrices. Whether this assumption was met was examined by conducting the “Box’s M” test. As the Box’s M test results were not statistically significant ($p > 0.05$), the assumption that variance-covariance matrices are homogeneous was met. The significance measure in the homogeneity assumption of variance-covariance matrices was taken as 0.05.

Two-way MANOVA analysis examines the effect of two or more independent variables on more than one dependent variable. The simultaneous analysis of two or more dependent variables is to prevent experiment (μ) error. The main advantage of the MANOVA test is that instead of performing separate tests, it analyzes all dependent variables at once and examines the interaction between them. Therefore, the probability of type-1 error is reduced [63]. In this study, two-way MANOVA analyses were performed to reduce the probability of type-1 error and to examine the effect of independent variables on dependent variables.

3. Findings

This section includes the descriptive statistics of this study, which aims to examine STEM parent awareness during the transition from preschool to primary school. Table 2 presents the descriptive statistics of the study.

Table 2 gives the mean and standard deviation scores for parent awareness in the STEM awareness scale and its subdimensions in terms of whether or not the children receive STEM education based on the level of education they are receiving.

Table 2 gives the statistical values according to the children’s education level and whether or not their children receive STEM education. In Table 3, when Bonferroni correction was used to check Type I errors for multiple ANOVAs, the significance level between groups was tested and found to be 0.017.

Table 3 shows the values of the STEM awareness scale and its subdimensions according to the level of children’s education, whether they have received STEM education or not, and whether the parents show STEM parent awareness according to their education level.

Is a significant difference in parents’ awareness of STEM and its subdimensions based on their children’s education level? When the findings of this research question are examined, Table 3 shows no significant difference between parental awareness of STEM levels based on their children’s education level ($\lambda = 0.996$, $F_{(3,386)} = 0.515$, $p = 0.67$).

Table 2. Descriptive Statistics.

Factor/Scale	Child's Educational Level	Does Your Child Receive STEM Education?	N	$\bar{x}$	SD
Knowledge	Preschool	Yes	128	58.55	11.92
		No	72	42.62	16.39
		Total	200	52.82	15.66
	Primary School 1	Yes	123	56.47	14.81
		No	77	42.83	16.67
		Total	200	51.22	16.88
	Total	Yes	251	57.53	13.43
		No	149	42.73	16.48
		Total	400	52.02	16.28
Attitude	Preschool	Yes	128	79.67	14.76
		No	72	72.72	20.69
		Total	200	77.17	17.41
	Primary School 1	Yes	123	78.95	14.46
		No	77	75.49	18.24
		Total	200	77.62	16.07
	Total	Yes	251	79.32	14.59
		No	149	74.15	19.45
		Total	400	77.39	16.73
STEM Awareness	Preschool	Yes	128	138.24	24.08
		No	72	115.29	31.06
		Total	200	129.98	28.92
	Primary School 1	Yes	123	135.43	25.74
		No	77	118.32	27.67
		Total	200	128.84	27.72
	Total	Yes	251	136.86	24.90
		No	149	116.85	29.30
		Total	400	129.41	28.29

“Is there a significant difference in parents’ awareness of STEM and its subdimensions based on their education levels?” When the findings of this research question are examined, Table 3 shows no significant difference between the levels of parental awareness of STEM based on their education levels ($\lambda = 0.933$, $F_{(6.772)} = 4.515$, $p = 0.00$, $p < 0.01$).

It can be seen that parents’ STEM awareness does not differ significantly based on the interaction between the child’s education level variable and the child’s STEM education variable ($\lambda = 0.995$, $F_{(3.386)} = 0.601$, $p = 0.61$, $p > 0.01$). The parents’ STEM awareness does not differ significantly based on the interaction between the child’s education level variable and the parent’s education level variable ($\lambda = 0.977$, $F_{(6.772)} = 1.509$, $p = 0.17$, $p > 0.01$). The parents’ STEM awareness does not differ significantly based on the interaction between the child’s STEM education variable and the parent’s education level variable ($\lambda = 0.979$, $F_{(6.772)} = 1.405$, $p = 0.21$, $p > 0.01$). The parents’ STEM awareness does not differ significantly based on the interaction between the child’s education level variable, the child’s STEM education variable, and the parents’ education level variable ($\lambda = 0.980$, $F_{(6.772)} = 1.333$, $p = 0.24$, $p > 0.01$).

Table 3. Multivariate Tests.

Effect	λ	F	Hypothesis df	Error df	<i>p</i>	η_p^2
Intercept	0.042	2914.826	3.000	386.000	0.000	0.958
Child's Educational Level Variable	0.996	0.515	3.000	386.000	0.672	0.004
Child's STEM education variable	0.796	33.026	3.000	386.000	0.000	0.404
Parent's education level variable	0.933	4.515	6.000	772.000	0.000	0.334
Child's education level variable * Child's STEM education variable	0.995	0.601	3.000	386.000	0.615	0.005
Child's education level variable * Parent's education level variable	0.977	1.509	6.000	772.000	0.172	0.012
Child's stem education variable * Parent's education level variable	0.979	1.405	6.000	772.000	0.210	0.011
Child's education level * Child's stem education * Parent's education level	0.980	1.333	6.000	772.000	0.240	0.010

When the significant difference between the parents' STEM awareness levels based on the child's STEM education variable is examined, a significant difference can be seen in the knowledge sub-dimension ($F_{(1,386)} = 97.338, p = 0.000, p < 0.01$), the attitude sub-dimension ($F_{(1,386)} = 10.454, p = 0.001, p < 0.01$), and stem awareness ($F_{(1,386)} = 55.609, p = 0.000, p < 0.01$) (see Table 4). The significant difference in parents' awareness of STEM and its sub-dimensions is in favor of the parents of children who receive STEM education (see Table 2).

Table 4. Tests of Between-Subjects Effects.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	<i>p</i>	η_p^2
Corrected Model	Knowledge	25,885.947	11	2353.26	11.42	0.00	0.24
	Attitude	7704.977	11	700.45	2.61	0.00	0.06
	STEM Awareness	54,720.563	11	4974.59	7.28	0.00	0.17
Intercept	Knowledge	909,307.450	1	909,307.45	4413.78	0.00	0.91
	Attitude	2,100,754.168	1	2,100,754.16	7834.65	0.00	0.95
	STEM Awareness	5,773,645.630	1	5,773,645.63	8459.67	0.00	0.95
Child's Educational Level Variable	Knowledge	94.563	1	94.56	0.45	0.49	0.00
	Attitude	102.077	1	102.07	0.38	0.53	0.00
	STEM Awareness	0.211	1	0.21	0.00	0.98	0.00
Child's STEM education variable	Knowledge	20,053.066	1	20,053.06	97.33	0.00	0.20
	Attitude	2803.156	1	2803.15	10.45	0.00	0.22
	STEM Awareness	37,952.638	1	37,952.63	55.60	0.00	0.12
Parent's education level variable	Knowledge	4168.387	2	2084.19	10.11	0.00	0.35
	Attitude	909.526	2	454.76	1.69	0.18	0.00
	STEM Awareness	7806.820	2	3903.41	5.71	0.00	0.32
Child's education level variable * Child's STEM education variable	Knowledge	41.302	1	41.30	0.20	0.65	0.00
	Attitude	286.015	1	286.01	1.06	0.30	0.00
	STEM Awareness	557.312	1	557.31	0.81	0.36	0.00
Child's education level variable * Parent's education level variable	Knowledge	791.583	2	395.79	1.92	0.14	0.01
	Attitude	2168.306	2	1084.15	4.04	0.01	0.32
	STEM Awareness	5441.267	2	2720.63	3.98	0.01	0.32

Table 4. Cont.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	p	η_p^2
Child's stem education variable * Parent's education level variable	Knowledge	609.598	2	304.79	1.47	0.22	0.00
	Attitude	1252.919	2	626.46	2.33	0.09	0.01
	STEM Awareness	3656.060	2	1828.03	2.67	0.07	0.01
Child's education level * Child's stem education * Parent's education level	Knowledge	483.595	2	241.79	1.17	0.31	0.00
	Attitude	1654.054	2	827.02	3.08	0.04	0.31
	STEM Awareness	3831.353	2	1915.67	2.80	0.06	0.01
Error	Knowledge	79,933.893	388	206.01			
	Attitude	104,036.821	388	268.13			
	STEM Awareness	264,806.374	388	682.49			
Total	Knowledge	1,188,252.000	400				
	Attitude	2,507,891.000	400				
	STEM Awareness	7,018,565.000	400				
Corrected Total	Knowledge	105,819.840	399				
	Attitude	111,741.798	399				
	STEM Awareness	319,526.937	399				

Child's Educational Level Variable = Preschool or Primary School 1, Child's STEM education variable = Yes or No, Parent's education level variable = Middle School, High School or Undergraduate.

A significant difference can be seen in the knowledge sub-dimension ($F_{(2,772)} = 10.117$, $p = 0.000$, $p < 0.01$) but not in the attitude sub-dimension ($F_{(2,772)} = 1.696$, $p = 0.185$, $p > 0.01$). A significant difference was found in STEM awareness ($F_{(2,772)} = 5.719$, $p = 0.004$; $p < 0.01$) (see Table 4). When the direction of significant difference is examined, a significant difference is seen between the middle school and undergraduate education levels in the knowledge sub-dimension ($p < 0.01$) in favor of the undergraduate education level. Similarly, in the knowledge subdimension, a significant difference is seen between the undergraduate and high school education levels in favor of the undergraduate education level. When the significant difference in education level based on the STEM awareness total score is examined, a significant difference can be seen between the middle school and undergraduate education levels ($p < 0.01$) in favor of the parents with an undergraduate education (see. Table 5).

The significant difference levels of the children's STEM education variable based on the parents' different education levels (middle school, high school, and undergraduate) are examined separately in Figure 2 (Knowledge), Figure 3 (Attitude), and Figure 4 (STEM awareness score).

Figure 2 shows a significant difference in the STEM awareness of parents with a middle school education between those parents whose children received STEM education and those who did not, based on whether their children received STEM education [$t_{151} = 6.387$; $p = 0.000$, $p < 0.001$]. A significant difference was found in the STEM awareness of parents with a high school education between those whose children received STEM education and those who did not [$t_{133} = 6.918$; $p = 0.000$, $p < 0.001$]. A significant difference was found in the STEM awareness of parents with an undergraduate education between those whose children received STEM education and those who did not [$t_{110} = 3.917$; $p = 0.000$, $p < 0.001$]. When checked to see whether the significant difference based on the parents' education levels was in favor of the children who received STEM education or not, children who received STEM education favored parents' STEM awareness at all education levels, middle, high school, and undergraduate.

Table 5. Multiple Comparisons, Bonferroni.

Dependent Variable	(I) Parent Education Level	(J) Parent Education Level	Mean Difference (I–J)	Std. Error	Sig.
Knowledge	Middle School	High School	0.6187	1.69486	1.000
		Undergraduate	6.9587 *	1.78492	0.000
	High School	Middle School	0.6187	1.69486	1.000
		Undergraduate	6.3399 *	1.83452	0.002
	Undergraduate	Middle School	6.9587 *	1.78492	0.000
		High School	6.3399 *	1.83452	0.002
STEM Awareness	Middle School	High School	3.5455	3.08484	0.753
		Undergraduate	9.5712 *	3.24875	0.010
	High School	Middle School	3.5455	3.08484	0.753
		Undergraduate	6.0257	3.33903	0.216
	Undergraduate	Middle School	9.5712 *	3.24875	0.010
		High School	6.0257	3.33903	0.216

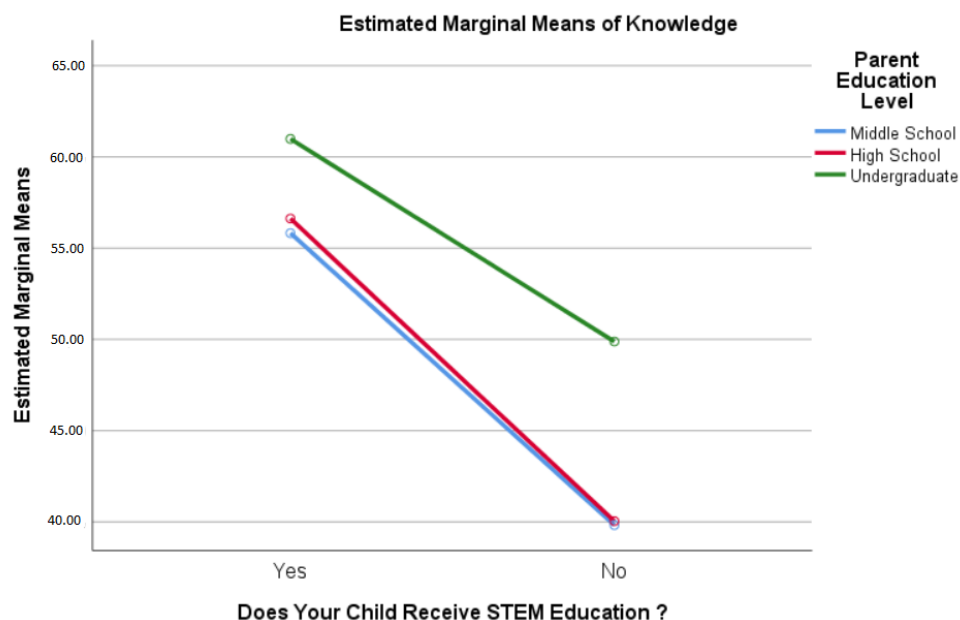
* $p < 0.01$.**Figure 2.** Profile plot of information subdimension.

Figure 3 shows a significant difference in the STEM awareness of parents with a middle school education between those parents whose children received STEM education and those who did not, based on whether their children received STEM education [$t_{151} = 3.266$; $p = 0.006$; $p < 0.001$]. A significant difference was found in the STEM awareness of parents with a high school education between those whose children received STEM education and those who did not [$t_{133} = 3.410$; $p = 0.002$, $p < 0.001$]. There is no significant difference in the STEM awareness of parents at the undergraduate level between those whose children received stem education and those who did not [$t_{110} = 0.272$ $p = 0.786$; $p > 0.001$]. When checked to see whether the significant difference based on the parents' education levels was in favor of children who received STEM education or not, children who received STEM education favored parents' STEM awareness at all education levels, middle, high school, and undergraduate.

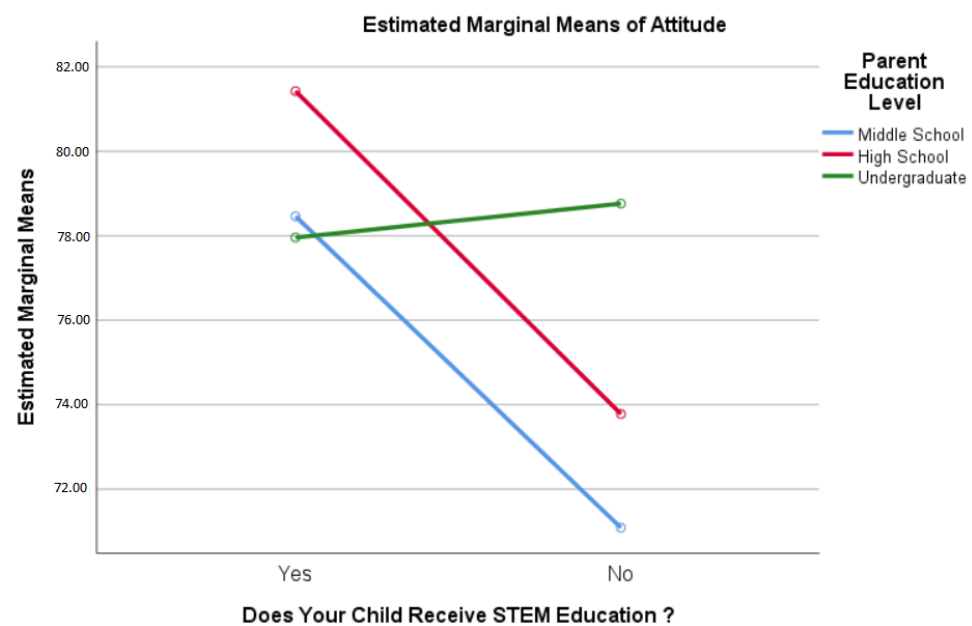


Figure 3. Profile plot of the attitude subdimension.

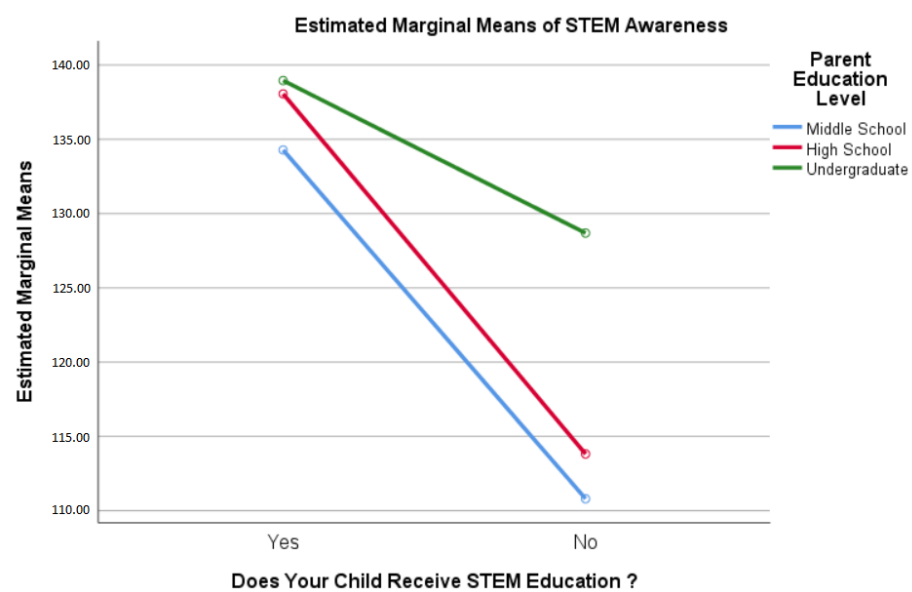


Figure 4. Profile plot of STEM Awareness total dimension.

Figure 4 shows a significant difference in the STEM awareness of parents with a middle school education between those parents whose children received STEM education and those who did not, based on whether their children received STEM education [$t_{151} = 4.641$; $p = 0.000$, $p < 0.001$]. A significant difference was found in the STEM awareness of parents with a high school education between those whose children received STEM education and those who did not [$t_{133} = 6.531$; $p = 0.000$, $p < 0.001$]. There is no significant difference in the STEM awareness of parents with an undergraduate education between those whose children received STEM education and those who did not [$t_{110} = 1.987$; $p = 0.049$; $p < 0.001$]. When checked to see whether the significant difference based on the parents' education levels was in favor of children who received STEM education or not, children who received STEM education favored parents' STEM awareness at all education levels, middle, high school, and undergraduate.

4. Discussion and Conclusions

This study, which aims to examine STEM parent awareness in the transition from preschool to primary school according to various variables, found no significant difference in the STEM awareness of parents with children attending kindergarten (60–72 months). Similar results were revealed for parents attending the 1st grade of primary school (73–84 months) based on the children's education level variable.

The study in [46] states that parents' participation in the STEM process and education yields significant outcomes for children at all levels of education. It does, however, emphasize that family/parent participation is higher in preschool education programs than in primary school and later school programs. Although [46] emphasizes that parental awareness of STEM is critical and encourages family engagement, it also reveals that parents' awareness is low. This study found no significant difference between the parents' STEM awareness with children attending primary school and parents with children attending preschool. Thus, parents with children in preschool and primary school education have similar knowledge of and attitudes toward STEM. The STEM activities to be held in the preschool and primary school periods have similar content. Parents participate less in STEM activities when they do not believe they have the necessary knowledge to help their children learn math and science. Parents of children in preschool and primary school 1st Grade may participate more in activities and support STEM education outside the school if they think that they know the science and math content well enough. However, parents may avoid supporting their children outside of school if they think they will not be able to give them sufficient support in learning STEM when they transition to middle and high school [64,65].

According to the current research, there is no significant difference in STEM awareness among parents whose children are in preschool or primary school 1st grade. This situation shows that parents do not gain STEM awareness in preschool. However, parents' gaining STEM awareness from the early stages will cause them to develop this awareness in the following periods. Parents with high STEM awareness will be more willing to participate in STEM activities and direct their children to STEM education and studies. Additionally, parental beliefs in their abilities to help support children in STEM-related activities are crucial to parental awareness. Parents tend to cooperate with the school less when they believe that they cannot support their children's STEM activities in school [66]. Supporting parents' STEM awareness in the early childhood period, when cooperation with the school is highest, is expected to positively impact the next education level. Supporting parents' STEM awareness affects children's STEM learning and STEM attitudes. Parents whose STEM awareness is supported in their child's early years can take on a role in wanting their children to take STEM lessons in high school. It is predicted that parents who develop STEM awareness will impact their children's STEM career planning [67].

The current research is one of the limited studies on parental awareness. When the literature is examined, the links between family participation and STEM are often discussed, but studies on family/parent awareness are limited. However, it is seen that studies are mainly conducted at the primary school level and beyond. Alternatively, they follow a structure that continues from early periods to adulthood. The current research is vital in terms of focusing on early childhood and emphasizes the importance of STEM parent awareness in this period. The literature review found that beneficial parental participation aligns with parents' STEM awareness, supporting STEM content programs in children's out-of-school settings [11]. While research emphasizes the need to start STEM education early, it points out that parents positively affect children's learning in informal learning processes, out-of-school learning areas, any time, and anywhere [12–14]. STEM activities based on children's development level [15,16] may be effective in children's future careers and academic achievement [17,18]. Early experiences play a critical role in developing long-term STEM interests and learning [19]. Children's early exposure to STEM domains positively affects their learning because children are willing to analyze, make assumptions, and guess

with their innate curiosity and creativity. STEM skills and concepts developed earlier enable children to understand and discover more complex concepts during school [20].

Recent scientific studies have focused on STEM awareness, family, and early childhood children [1,10,21–24,51]. The study in [23] underlines that family participation is a dynamic process. It emphasizes that family, society, researchers, and educators must work together. In its study on children's early learning and well-being, the research in [22] states that early learning occurs due to combining the learning environment at home and early childhood experiences (blended with culture) with individual personality traits. [24] STEM + Families project has three steps, direct families, declare mobilization, and raise awareness. Thus, parent awareness is essential in their involvement regarding children's STEM education.

The study found that the STEM awareness of the parents of children who receive STEM education differs significantly from those of children who do not receive STEM education. These results favor the parents of children who receive STEM education. The studies in [1,51] stated that parents should be supported and equipped with sufficient resources because they matter for children's EARLY stem experiences and because their children are "the first and most important STEM guides". According to [20], parents favor STEM programs and activities involving them or their children and regard the children's STEM attendance positively. Many parents also value the opportunity for their children to participate in STEM programs. Parents consider STEM disciplines necessary in their children's education and think that science may be applied to solving the problems of today's world and achieving better results in the working environment. Parents can determine positive changes in the children's behaviors and attitudes, such as greater openness to learning and new experiences when attending STEM activities. Parental engagement is affected when parents believe that their children's cognitive development is backed by STEM-supported education [66]. This can also increase the belief of a parent with a child in early childhood that STEM activities support its math skills, thus positively affecting the parent's engagement in STEM education and supporting the parent's STEM awareness [68]. Research also shows that society's and parents' STEM awareness is mirrored in children. This is because STEM learning takes place inside the STEM ecosystem. As Bronfenbrenner states in his theory of ecological systems, learning takes place in the interactions of various systems with each other, and children are at the center of this learning. Therefore, the importance of parents, schools and society in the child's immediate environment when learning STEM cannot be denied [25,43]. The author in [69] emphasizes the importance of "Communities of Practice" in STEM learning. Communities of practice are "groups of people who share a passion or an anxiety for something they do and learn how to do it better as they regularly interact" [70]. According to [20], culture and belonging to a specific community influence family engagement and children's behavior. In this case, including children in STEM Practice Communities starting in the early years is essential for STEM awareness, learning, and professions. This can only be achieved if the parents are aware and engaged, supporting this study's findings that parents with greater awareness will be more likely to direct their children to STEM learning and education.

Although the subdimension regarding STEM awareness and knowledge showed a significant difference based on the parents' education levels, no significant difference was found in the item regarding attitude. A significant difference was found in STEM awareness between parents from middle schools and those with an undergraduate education. In the knowledge subdimension, parents with an undergraduate education differ significantly from parents with middle and high school education levels. The difference favored parents with an undergraduate education in the STEM awareness and knowledge subdimension. The study by [71] examined the status of STEM awareness at different education levels. Although that study covers schools, not parents, it is similar to the current study in that it includes STEM awareness at different levels of education. According to [71], schools, in general, are pretty aware of the importance of STEM education. This is particularly common at the post-primary level, where STEM education awareness is defined as satisfactory or better in 94% of the schools visited.

Similarly, 88% of the schools visited at the primary school level were considered well aware of the national STEM education agenda. In a significant minority of early learning and care settings visited, inspectors reported: “A lack of awareness among the practitioners of the national STEM education agenda and the related policy statement and implementation plan. It was acknowledged that almost one in three environments visited did not have a satisfactory awareness of the STEM education agenda”. Although [71] states that STEM awareness in primary and post-primary schools is higher than in early childhood education institutions, this study’s findings do not support this.

Scientific research in the literature often predicts the relationship between science, technology, engineering and mathematics studies and family involvement. Studies addressing STEM disciplines and parents’ awareness, engagement, and opinions show that parents can affect children’s science learning outcomes. According to [72], parental engagement and awareness are critical elements in the development of scientific literacy. Scientific studies in which parents’ education levels are associated with awareness, engagement, and opinions on science activities report that parents with a high level of education also show high levels of awareness and engagement [73–75]. Their study discussed parents’ education levels and children’s science/science learning skills. The study in [76] determined that the difference in the opinions of the parents of children aged 60–72 months regarding science activities was in favor of parents with a college education between “undergraduate” and “primary education” and the same between “undergraduate” and “middle school education”.

Studies addressing STEM disciplines and parents’ awareness, engagement, and opinions show that parents can also affect children’s technology learning outcomes. Parents’ digital literacy levels are associated with their attitudes and approaches toward their children using these tools. However, no significant difference was found in studies examining parents’ education levels and parents’ use of technology [72,77–79]. This can be explained by the fact that technology was used less than it was today when the parents were learning and the limited integration of technology in the curricula back then.

Studies addressing STEM disciplines and parents’ awareness, engagement, and opinions show that parents can also affect children’s engineering learning outcomes. A study by [80] revealed that children’s interest in STEM professions differed significantly based on their mothers’ education levels. No difference was observed between postgraduate and undergraduate education levels regarding interest in the engineering profession, but there was a difference between other education levels. Accordingly, interest in engineering is supported when the mother has a high level of education. The authors in [81] conducted a multivariate study that examined primary school students’ attitudes toward STEM. When the STEM attitudes of the children were examined based on their mothers’ education level, the results proved in favor of high school education between the middle school and high school education levels and in favor of college education between the middle school and college education levels.

Studies addressing STEM disciplines and parents’ awareness, engagement, and opinions show that parents can also affect children’s math learning outcomes. Math skills, considered one of the early academic skills in the preschool period, are affected by children’s experiences with their parents [82]. According to [83], parents perceive mathematics as a more difficult lesson as the grade level progresses. This problem can be solved by increasing mathematics-related experiences starting in the early years and associating these experiences with daily life. Many scientific studies predict the relationship between parental awareness, mathematics education, and mathematics skills [84–86]. They report that parents’ awareness of mathematics positively affects children’s learning and reduces negative feelings, anxiety, and fears about mathematics.

When the relationships between parents’ awareness of mathematics and their education levels are examined, ref. [87] found that undergraduate parents have higher perceptions of parental participation in math education than parents with only a primary, middle school, or high school education. Similarly, parents who consider themselves successful in mathematics have higher perceptions of parental participation in mathematics

education than parents who consider themselves average or unsuccessful in mathematics. According to [88], mothers with a high level of education greatly influence their children's learning outcomes in mathematics, which may also be related to mothers' interests and attitudes toward mathematics. Similarly, the findings of this study confirm that parents with a high level of education have a high level of awareness.

Based on all these studies, it can be said that there is a relationship between the skills and learning outcomes related to the STEM disciplines of science, engineering, and mathematics and the educational status of parents. Considering that the studies on technology are more recent than in other fields and that there was zero or limited integration of technology in the curricula when the parents were at school, this can explain why there is no relationship between technology and the education levels of the parents. Increased parental awareness and engagement increase children's awareness of STEM disciplines, engagement, and skills acquisition. The literature confirms that parents with an undergraduate degree and a high level of education also have a high level of awareness and engagement.

While the current research supports these studies, it differs from the studies in that it deals with STEM disciplines in an integrated way. With this research, STEM awareness was addressed, and science, technology, engineering and mathematics studies were not considered separately but in an integrated way. This is also consistent with the integrated structure of the STEM education approach.

Another objective of the study was to examine the STEM awareness of the parents of children who receive and do not receive STEM education based on their different education levels. This study found that the knowledge (see Figure 2), attitude (see Figure 3), and STEM awareness of the parents of children who receive STEM education differed significantly compared with the parents of children who do not receive STEM education (see Figure 4). Only in the attitude subdimension of STEM awareness was no significant difference caused by the children of undergraduate parents receiving STEM education (see Figure 3). Although the parents' education levels differ, their STEM awareness was positively supported by their children's STEM education. The study in [44] participated in by children up to the primary school 5th Grade, and their parents discussed parent's awareness of and attitude toward STEM. The study reported a positive change in the perceptions and attitudes of parents and children toward STEM after education. This study had similar results. In their study emphasizing the importance of home settings and family awareness in STEM learning, ref. [10] said families/parents were crucial to developing children's literacy skills and providing STEM learning at home. When the essential behaviors, skills, and attitudes children are expected to acquire in the transition from preschool to primary school are considered, the importance of positive links between early literacy and STEM and family/parent participation in STEM and early literacy processes is once again revealed. When parents whose children receive STEM education participate in STEM activities, this increases their self-confidence toward STEM and bolsters their interest in carrying out scientific activities with their children [89].

Finally, parents' STEM awareness does not differ significantly in the transition from preschool to primary school but does when children receive STEM education. Although the study found that the parents' education levels provided a significant difference in STEM awareness, it also found that children receiving STEM education supported their STEM awareness at different parent education levels.

5. Recommendations

In light of all these results, it can be seen that parents' STEM awareness does not differ based on the child's education level but the parent's education level and whether or not the child receives STEM education. In this case, the following recommendations can be made:

- STEM education should be provided within STEM learning ecosystems. School, family, and society influence children's learning and should work cooperatively. National and international projects can support collaborative efforts to establish STEM learning ecosystems.
- Considering the importance of families' engagement in STEM learning ecosystems, initiatives based on effective practices and scientific research must be designed to increase this engagement and awareness.
- Children's STEM education also impacts families'/parents' STEM awareness. The STEM process should be supported by in-school and out-of-school activities at all levels of education, starting from early childhood.
- There is a need for long-term/longitudinal research on parental awareness starting in the early years. This requires increasing the number and quality of longitudinal studies on STEM parent awareness.

Author Contributions: Conceptualization, Z.M.; Data curation, Z.M.; Formal analysis, A.İ.C.G.; Funding acquisition, S.P. and M.K.; Investigation, Z.M.; Methodology, A.İ.C.G.; Resources, Z.M. and A.İ.C.G.; Supervision, S.P. and M.K.; Validation, A.İ.C.G.; Visualization, A.İ.C.G.; Writing—original draft, Z.M. and A.İ.C.G.; Writing—review & editing, S.P. and M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. Article Processing Charges CHF 2000.00. Author Voucher discount code (97a27635acf5f30e) CHF (2000.00). Subtotal without VAT CHF 0.00. VAT (0%) CHF 0.00. Total with VAT CHF 0.00.

Institutional Review Board Statement: The study was conducted in accordance with the Bartin University, and approved by the Social and Human Sciences Ethics Committee (Protocol code: 2022 SBB-0399)". for studies involving humans.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article.

Conflicts of Interest: The authors declare no conflict of interest.

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