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ORIGINAL ARTICLE

Primary School Teachers' Attitudes and Views toward STEM Education

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ABSTRACT

To produce ideas, products, and industries for the 21st-century scientists, technologists, engineers, and mathematicians are needed. It is necessary to increase the number of people who provide technical support to the problems of individuals, set a standard for the lives of the people of the world, and manage global or national life with a sustainable decision-making mechanism. Raising these individuals can only be possible through education. Countries trying to make themselves technologically aware are looking for modern methods of teaching, one of which is science, technology, engineering, and mathematics (STEM) education. This research aimed to determine the attitude of primary school teachers toward the STEM approach and to find out their views on the STEM approach in the primary school curriculum. Students encounter the STEM approach while they are in primary school. However, all primary school teachers do not teach only science and math; they also teach other courses such as social sciences, language, ethics, music, and art. Therefore, teacher orientation toward the STEM approach in science and math courses is crucial. This research was concurrent mixed-method research that collected quantitative and qualitative data simultaneously. The STEM attitude scale was used as a quantitative data collection tool and qualitative data were collected using semi-structured interviews and focus group interviews. The qualitative data were analyzed using descriptive and content analyses. The study's most important results showed no significant difference between STEM attitude scores regarding technology familiarity. Another significant result was that teachers who participated in quantitative and qualitative studies scored above average on the STEM attitude scale. The research results imply that pre-service primary school teachers should be given the STEM approach.

KEY WORDS: Mixed method research; primary school curriculum; primary school teacher; science, technology, engineering, and mathematics attitude

INTRODUCTION

Education is vital in terms of being an essential arena, in which states enact strategies for national improvement and being the main arena, in which information transfer occurs at various development levels. New interdisciplinary approaches to education today affect the education system, and one modern approach is science, technology, engineering, and mathematics (STEM). Since 2010, STEM has become a central approach in education in Turkey, mainly due to the rapid developments in science and technology. STEM is integrated into education systems and presents an interdisciplinary approach (English, 2016), developing the ability and knowledge required to solve problems in different disciplines (NAE and NRC, 2009; Vázquez-Villegas et al., 2022).

Moreover, STEM education is seen as a qualified human resource, in which students employ creative thinking in their problem-solving processes, leading to innovations in the process (ISR, 2015). STEM is a teaching approach that not only shapes these processes and integrates them into education but also examines them separately (Brown et al., 2011). Regular scientific and technological innovations involving the integration of different disciplines point to the importance of the STEM teaching approach.

STEM education is a set of disciplines used interactively or separately (Bybee, 2013). Although interdisciplinary interaction means content, it can also be seen as bringing together different disciplines around a predominant discipline (Moore et al., 2013). Brand new disciplines such as biomedical engineer, forensic science technician, computer network architect, and cost estimators are also emerging with the coming together of different disciplines. As a result, teaching approaches have incorporated these changes to address teachers' and students' needs.

Morrison (2006) stated that STEM education provides individuals with innovation, problem-solving, openness, self-confidence, and technological development. Similarly, Thomasian (2011) stated that STEM education is crucial for gaining professional skills and increasing problem-solving skills that fit the features of current-day situations.

Research conducted by English et al. (2009) stated that integrating engineering-related concepts into the STEM-based secondary school curriculum positively affects students'

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problem-solving skills. Examination of the data obtained in the research showed that students used physical materials to design a system, understood abstract concepts in a process and made positive progress in motivation. The findings from teachers indicate that students' engineering skills improved positively, with the suggestion of transferring this process through STEM-based teaching to individuals to gain awareness of engineering.

Research examined teachers' behaviors in STEM teaching stages in engineering design processes. In the study conducted by Wendel et al. (2016), it was stated that it is essential to examine every step of teachers' behaviors and the decisions students make in the face of these behaviors. It was observed that teaching is crucial to be sensitive to students' needs; teaching should be student-centered. The research briefly stated that because teachers play a vital role in STEM education, they should have the necessary competencies to give guidance.

Background of Research Problem

There are prominent studies regarding the use of the STEM approach in the teaching process. One research study looked at engineering processes with primary and secondary school students and found that working in small groups, students used interpretation, differentiation, sequencing, and teamwork to devise a solution model from a mixed data pool and came up with their own definitions (English and Mousoulides, 2011). This research concluded that STEM-based engineering education is vital for developing students' intense curiosity and learning how engineering shapes their world and supports the many needs of our society. In light of these findings, the research states that it is essential to revise secondary school curricula, integrating the STEM approach. The research emphasizes that such students may become trainee engineers. Therefore, they must experience an up-to-date approach to education processes with STEM to maintain the motivation and development necessary to address their curiosity and maintain a positive attitude to research.

Attitudes toward the STEM approach are closely related to people's ability to carry out STEM activities as teachers and students. Mills's (2013) research aimed to examine STEM career choices within the framework of forward-looking decisions and to determine the changes in students' attitudes toward STEM careers. The research data measuring STEM content found that students' motivation, creativity, and attitudes are vital for determining their career direction. The research states that gender is also a significant variable in process orientation. The connection between technology and science and gender was examined, and the research results found that technology is crucial for boys while science is for girls.

Further studies suggest that teachers' attitudes and views about STEM can be altered and that teachers with more positive attitudes and beliefs will likely apply the STEM approach more successfully. In "Engineering Innovation and Design for STEM Teachers," a 6-week professional development program, Pinnell et al. (2013) showed that teachers' attitudes and beliefs regarding science education and STEM changed positively.

As indicated in the above studies, STEM has been widely integrated into education, and studies have been carried out to measure the impact of the process in the international arena. As a result of the integration of STEM education, for a country to have leadership qualities; it is foreseen that it can solve serious problems in areas such as energy, health, environmental protection, and national security. Furthermore, "It will help produce the capable and flexible workforce needed to compete in a global marketplace. It will ensure our society continues to make fundamental discoveries and to advance our understanding of ourselves, our planet, and the universe." (PCAST, 2010, p. 1).

Children first come across the STEM fields of mathematics and science in their primary school years, where primary school teachers have the most impact on student development, particularly in students' literacy goals in the first grade. However, primary school teachers are also responsible for teaching courses such as mathematics and science, which are quite different from language lessons. As technology develops, the importance of mathematics and science increases daily. Through their teacher education, primary school teachers receive teaching for the instruction of various courses. However, the teaching received by teachers depends on their particular field, which can give more weight to a specific branch. Teachers should be trained to apply STEM approaches that include the discipline of engineering in their curriculum (Kimmel et al., 2007). Students' involvement in STEM activities, whether formal or informal, enables them to build their careers in the STEM field (Wang et al., 2021). For this reason, it is essential for teachers to have knowledge about STEM education and to guide their students in STEM.

The STEM approach should be applied for the 1st time at the primary education, but preschool should not be neglected (MoNE, 2016). The success of STEM approach applications at the primary school level may be related to teachers' attitudes towards it and their proper teaching of STEM subjects in the curriculum. In this context, the aim of this study was to determine the attitudes of primary teachers toward the STEM approach and their views on the STEM approach in the curriculum. Determining the STEM attitudes of the teachers and their views on the STEM approach in the curriculum is crucial in correctly designing the in-service training to be given to teachers working in primary schools.

Research Aim and Research Questions

Teachers carry out teaching processes in schools within the curriculum framework. The curriculum is the mechanism that includes all activities planned during teaching a course (Demirel, 2015) and is developed according to emerging needs. Primary school curricula are renewed as changes occur. In Turkey, STEM-related issues have been integrated into the training program since 2018 (MoNE, 2017). Arrangements have been made to create STEM awareness in the curricula of information technologies and technology design courses for

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mathematics, science, physics, chemistry, and biology from primary school to high school. The arrangements made in primary school stand out in mathematics and science lessons. Primary teachers give these two courses rather than middle and high school subject teachers. However, primary school teachers state that they need STEM education as much as mathematics and science teachers (Yıldırım and Türk, 2018). Without it, they tend to transfer their STEM practices using inappropriate presentation strategies (Breiner et al., 2012). Herdem and Ünal (2018) note that, in their STEM research-related meta-analysis in Turkey, only a tiny amount of research relates to primary school teachers' STEM attitudes. Furthermore, there is no research on the relationship between the STEM approach and the curriculum of primary teachers who undertake primary school mathematics and science lessons where STEM applications are included. In line with this main purpose of the research, it is thought that determining the attitudes of primary teachers toward the STEM approach and views on the STEM approach and primary school curriculum may contribute to the literature that associates STEM applications with primary school mathematics and science lessons.

This study aimed to investigate primary school teachers' views about the STEM approach in the primary school curriculum and their attitudes toward the STEM approach. The research considered two fundamental questions, one related to the qualitative part of the research, "What are the primary school teachers" views about the STEM approach in the primary school curriculum?' and the second for the quantitative part of the research, "What are the primary school teachers' attitude towards the STEM approach?."

METHODOLOGY

General Background

This research was carried out using a mixed-method approach carried out with a concurrent design. Qualitative and quantitative research sequences were conducted simultaneously. In the concurrent design, also called a simultaneous parallel design, the quantitative and qualitative sequences were executed simultaneously and applied independently (Mertkan, 2015).

Parallel design studies aim to increase the validity of findings by providing variations by simultaneously conducting quantitative and qualitative studies which complement each other with quantitative and qualitative data collection tools (Creswell, 2013; Mertkan, 2015). Quantitative and qualitative data were collected simultaneously and interpreted independently during the spring and fall semesters of the 2021 academic year.

Participants

Qualitative study

In the qualitative phase of the study, ten teachers were selected with a purposeful sampling method, and those who voluntarily accepted being interviewed took part in providing data. Semi-structured interviews (SSI) were conducted with six primary school teachers and one focus group (FG) interview with four. As shown in Table 1, two male and six female primary school teachers participated in SSI. The participants were equally distributed in private and public schools, and their professional experience varied between 3 and 23 years. Their familiarity with technology was generally high. One FG interview was done with four participants. Three participants were female and one was male. A FG interview was done to enlighten and check the findings obtained in the SSI. In total, three teachers participating in the qualitative part of the research were male and seven were female; their average age was 31.2, and their ages ranged between 28 and 45.

Quantitative study

In the quantitative phase of the study, electronic forms were sent to primary school teachers selected with a convenient sampling method.

One hundred and three primary school teachers who answered the questionnaires constituted the research group. 71.8% (74) were female, and 28.1% (29) were male. Forty-two (40.8%) had 6–15 years of experience, and 61 (59.2%) had 16 years or more experience. According to their assessment, 26 teachers (25.2%) were "partially familiar," and 77 teachers (74.8%) were "familiar" with technology.

Instrumentation and Procedures

Qualitative study

As noted, qualitative data were collected through a SSI and FG interview. The questions created by the researchers were directed to teachers in SSI, and their answers were noted in writing. Then, according to the participants' answers, new questions were asked to acquire more detailed information, and the participants' views were clarified. Furthermore, a FG interview was conducted with four volunteer primary school teachers. The FG interview was completed in about an hour. Interview questions were prepared in advance, but questions such as "why," "how," and "could you explain a little more" were posed to confirm the answers given during the interview and to encourage participants to give more explanation. The previously prepared questions were finalized with the guidance of an academic expert in assessment and evaluation. Individual interviews took 15–20 min, and FG meetings lasted 60 min. Particular attention was paid to including teachers who held a certificate for STEM education and integrating it into their lessons in the FG interview. The FG interview was conducted with four teachers using the purposeful sampling technique.

Quantitative study

The first part of the quantitative data collection tool sent to teachers was a personal information form created by the researchers, which collected information about the participant teachers' gender, professional experience, and self-assessment of their level of familiarity with technology. This part of the study consisted of 74 (71.8%) females and 29 (28.2%) males. These participants' professional experience was 6-15 years for 42(40.8%) participants and 16 years and over for 61(59.2%). In addition, 26(25.2%) participants are partially familiar with

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Table 1: The demographic characteristics of teachers participating in the qualitative study

Participant	Age	Gender	Type of school	Professional experience	Familiarity with technology
SSI 1	28	Female	Private	3	Familiar
SSI 2	31	Male	Public	8	Familiar
SSI 3	33	Female	Private	9	Partially familiar
SSI 4	27	Female	Public	3	Familiar
SSI 5	45	Female	Public	23	Partially familiar
SSI 6	33	Male	Private	10	Familiar
FG 1	28	Female	Public	5	Familiar
FG 2	35	Male	Private	12	Partially familiar
FG 3	26	Female	Private	4	Familiar
FG 4	26	Female	Private	4	Familiar

SSI: Semi-structured interview, FG: Focus group

Table 2: The demographic structure of teachers participating in the quantitative study

Variables	Groups	Frequency (%)
Gender	Female	74 (71.8)
	Male	29 (28.2)
Professional experience (years)	6–15	42 (40.8)
	16 and over	61 (59.2)
Familiarity with technology	Partially familiar	26 (25.2)
	Familiar	77 (74.8)
Total		103 (100.0)

technology, see Table 2, whereas 77(74.8) are familiar with it. In addition, the STEM Education Attitude Scale developed by Derin et al. (2017) was used. The scale consists of two dimensions, Meaningfulness, and Feasibility, and 32 items. According to the Confirmatory Factor Analysis results obtained due to scale development, the χ^2/df ratio was recorded as 2.08. Other fit indices (RMSEA = 0.056, RMR = 0.093, SRMR = 0.064, CFI = 0.96, NNFI = 0.96) revealed that the adapted scale exhibited an acceptable level of fit. Cronbach Alpha values of the scale were found to be 0.92 for meaningfulness, 0.84 for feasibility, and 0.77 for the total scale. These reliability coefficients are similar to the values obtained in the original scale development study (0.84 for meaningfulness, 0.76 for feasibility, and 0.74 for the total scale).

Data Analysis

For the qualitative part of the study, the analysis of qualitative data was carried out by descriptive analysis and content analysis. The data set was read and coded by identifying the repeated words. By combining the codes, categories were created through pattern coding (Baltacı, 2021). The extent to which these categories represent the data was also checked. In the FG interview, the stages of breaking down and categorizing the data were used with content analysis. Codes similar to each other were brought together. A few of the teachers' expressions are presented without any change. According to these themes, FG interview questions were formed, and an expert's view was taken. Two independent experts reviewed the responses to the FG interview questions. The teachers' views were given without being digitized, and their expressions were grouped according to their similarities. The Miles-Huberman coder reliability formula was used for encoder validity (Miles and Huberman, 1994). According to the coding control that provides internal consistency, the agreement between the coders is expected to be at least 80% (Patton, 2002). As a result of applying the coder reliability formula in this study, the consistency between the two coders was found to be 0.89 (89%). This value shows that the coding is done reliably. It was prepared by classifying the expressions according to their similarities, considering the views from the FG interview.

Statistical analysis was also carried out for the quantitative phase. A t-test was implemented for the group differences among analyzed variables due to the normal distribution of data. The skewness values of the STEM Attitude Scale, the meaningfulness, and the feasibility dimensions are −0.375, 0.645, and −0.372, respectively. Furthermore, the kurtosis values of the STEM Attitude Scale, the meaningfulness, and the feasibility dimensions are −0.342, −0.182, and −0.516, respectively. According to Tabachnik and Fidell (2018), skewness and kurtosis values between −1 and +1 can be evidence of meeting the normality assumption.

FINDINGS

Results of the Qualitative Data

The descriptive and content analysis produced three themes, which are presented with the subthemes in Figures 1 and 2. Two primary school teachers stated that STEM education should be given as a separate course, three stated that it should be given in lessons, and one said that it should be given in science and mathematics lessons in primary school.

For the question, three primary school teachers said they had not previously used STEM education in their lessons, while the other teachers said they had used it as an interdisciplinary study. Four primary school teachers stated that STEM education could be taught as a course. Two primary school teachers said it would be advantageous for teachers' resumes to have STEM education.

Themes, subthemes, and codes were created to organize the descriptive information obtained in the SSI. Two subthemes and five codes emerged for the "Need of Stem Education" theme in

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Table 3. The views on "Need of Stem Education" were stated in detail by the semi-structured interview coded 1 (SSI1) class teacher and semi-structured interview coded 4 (SSI4) class teacher.

SSI1: *I think STEM education gives children the opportunity to acquire many skills that should be acquired in primary school: communication skills, collaboration skills, problem-solving, critical thinking, taking responsibility, and creativity*. (Theme 1 - Subtheme 1).

SSI 4: *Cognitive comprehension power increases. The student has more opportunities to get to know him/herself emotionally, and his/her attitudes become clear. Learns to control the body in a dynamic sense.* (Theme 1 - Subtheme 2).

Two subthemes and five codes emerged for the "Primary School Curriculum and STEM" theme in Table 4. The views on second theme were stated in detail by the SSI1 class teacher and SSI3 class teacher.

SSI 1: *STEM can be integrated into all lessons. Many themes/acquisitions are suitable for this, especially if the areas that can be integrated with added back features are developed.* (Theme 2 – Subtheme 1).

SSI 3: *We are trying to use STEM's "Technology" title with a smartboard application in our classrooms. However, this is made functional in a limited way. If a computer workshop is established, all children being active on the computer will make the technological field more useful. To cover other STEM areas, conditions such as the necessary materials and compatible environment must be suitable. We can only partially support learning by "doing living" using the structuralism of education right now.* (Theme 2 - Subtheme 2).

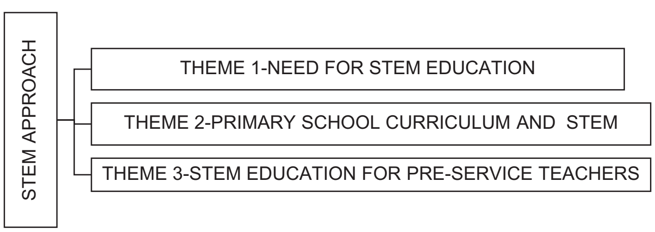

Figure 1: Themes Created about the STEM Approach

Three subthemes and seven codes emerged for the "STEM Approach for Teacher Education" theme in Table 5. The views on third theme were stated in detail by the SSI3 class teacher, SSI2 class teacher, and SSI4 class teacher.

SSI 3: *As we deem implementation appropriate in the 12-year education process, teachers who will contribute to 1-12-year education in education faculties should be familiar with STEM education. Spending 12 years with quality teachers well-equipped in this field is necessary.* (Theme 3 – Subtheme 1).

SSI 2: *Since STEM aims at an interdisciplinary approach, this training at university increases the student's thinking and problem-solving skills. It enables teachers to explain their knowledge more efficiently.* (Theme 3 - Subtheme 2).

SSI 4: *For years, a stereotype has been said: "Our education system is rote learning." Everyone uses this word, from the grocer, greengrocer, and doctor to the teacher. STEM education can be an excellent opportunity to break from the rote learning system. If children know what and why they are learning, and if they learn the rationale behind the subjects, we will have taken a very positive step in our education system.* (Theme 3 - Subtheme 3).

Contributions to STEM Education were addressed in a FG meeting with four primary school teachers who work in private schools and have similar experiences with STEM education. The primary teachers were coded FG1, FG2, FG3, and FG4. The researchers provided an hour-long interview at a round table to address the main questions. While one of the researchers took notes, the other asked additional questions to deepen the discussion. Internal validity (credibility) was attempted by obtaining participant confirmation by reporting the data obtained through FG interviews.

Table 6 shows the main ideas in the FG discussion: there is an opportunity to move on from the current rote system into the curriculum, and that primary school teacher should be familiar with STEM education. Some sentences, including the views of teachers, are given below:

It can be used for the student to gain a skill focused on finding

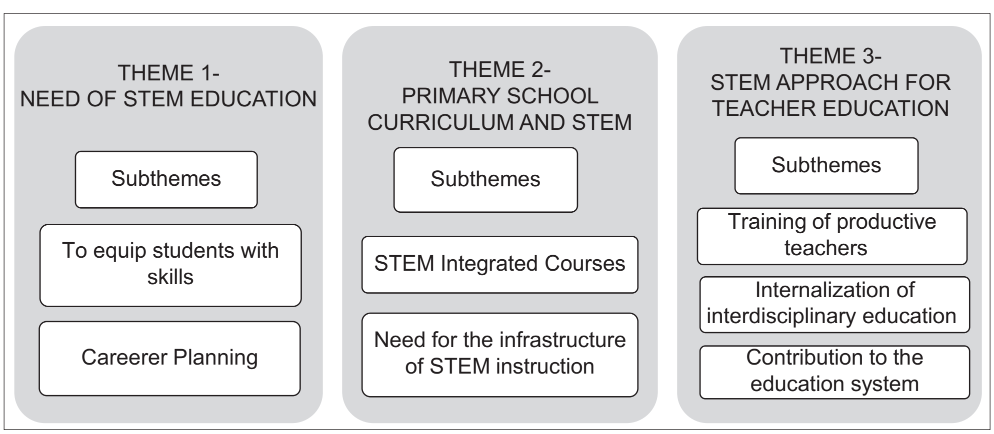

Figure 2: Themes and Subthemes Created about STEM Education

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solutions based on solution-oriented thinking and curiosity in children for problems encountered.

Table 3: Theme 1 - Need of Science, Technology, Engineering, and Mathematics education

Themes	Subthemes	Codes
Theme 1 - Need of stem education	1-To equip students with skills 2-For student's career planning	Opportunity to acquire skills Solution-oriented thinking Students know themselves Cognitive improvement Being high-quality employees

Table 4: Theme 2 – Curriculum and Science, Technology, Engineering, and Mathematics interaction

Themes	Subthemes	Codes
Theme 2 - Primary school curriculum and stem	1-STEM integrated courses 2-Need for the infrastructure of STEM instruction	Integration to all courses STEM applications in different courses Need for computers Need for technology Appropriate learning environment

STEM: Science, Technology, Engineering, and Mathematics

Table 5: Theme 3 - Science, Technology, Engineering, and Mathematics education for preservice teachers

Themes	Subthemes	Codes
Theme 3 - Stem approach for teacher education	1-Training of productive teachers	Well-equipped teachers Quality of teachers Teacher's production
	2-Internalization of interdisciplinary education	Interdisciplinary approach Efficient knowledge transfer
	3-Contribution to the education system	A positive step for education Alternative to rote learning

Table 6: Focus group meeting

Main ideas	FG 1	FG 2	FG 3	FG 4
It may be an excellent opportunity to move on from the "rote system"	✓	✓	✓	✓
By making associations between courses (science, life studies, and mathematics), the student's thinking skills, and problem-solving skills increase	✓	✓		
Well-equipped teachers are needed to spend quality time		✓	✓	✓
It should be appropriately integrated into the curriculum	✓	✓	✓	✓
We can only partially support learning by "doing and living" using the structuralism of education	✓			
Primary school teachers should be familiar with STEM education	✓	✓	✓	✓
It is transforming education for the student profile		✓	✓	

STEM: Science, Technology, Engineering, and Mathematics, FG: Focus group

I thought I had to learn for my students born in the technological age and catch up with them. When I lectured classically, it took a short time for them to focus on the lesson.

STEM can be integrated into all courses. Already many themes/acquisitions are suitable for this. Especially with the added art feature, the areas that can be integrated are developed.

The use of interdisciplinary relations ensures permanent learning and strengthens problem-solving skills.

Results from the Quantitative Data

For the problem of the quantitative part of the research, "What are the primary school teachers" attitudes toward the STEM approach?," means and standard deviations were calculated. They are presented in Table 7. Furthermore, *t*-test analysis was done to check whether there was a significant difference between means in terms of the gender variable. The results are presented in Table 8.

The STEM Attitude Scale mean of the teachers participating in the research is 110.09, and the standard deviation is 13.30. The mean and standard deviation values for the meaningfulness level of the scale dimensions are 60.69 and 11.20, respectively. For the feasibility dimension, they are 49.40 and 9.01, respectively. Considering that the maximum score that can be obtained from the whole scale is 160, and the meaningfulness and feasibility dimensions are 90 and 70, respectively, it can be said that the teachers' averages are not very high.

Table 8 shows no significant difference between the STEM attitudes of primary school teachers regarding gender ($P > 0.05$). In addition, *t*-test analysis was done to check whether there was a significant difference between means in the professional

Table 7: Descriptive analysis of Teacher's Science, Technology, Engineering, and Mathematics Attitude Scale

Dimensions	*n*	Mean	SD
Meaningfulness	103	60.69	11.20
Feasibility	103	49.40	9.01
STEM attitude	103	110.09	13.30

STEM: Science, Technology, Engineering, and Mathematics, SD: Standard deviation

Table 8: Independent group *t*-test values of the Science, Technology, Engineering, and Mathematics Attitude Scale, and subdimensions scores of teachers according to the gender variable

Dimensions	Groups	*n*	Mean	SD	*t*	*P*-value
Meaningfulness	Female	74	61.05	11.71	0.508	0.612
	Male	29	59.79	10.22		
Feasibility	Female	74	49.12	9.24	−0.496	0.621
	Male	29	50.10	8.48		
STEM attitude	Female	74	110.18	13.34	0.0095	0.924
	Male	29	109.90	13.44		

*p-value is significant at 0.05 level. FG: Focus group, STEM: Science, Technology, Engineering, and Mathematics, SD: Standard deviation

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Table 9: Independent group *t*-test values of the Science, Technology, Engineering, and Mathematics Attitude Scale and subdimensions scores of teachers according to the professional experience variable

Dimensions	Groups	*n*	Mean	SD	*t*	*P*-value
Meaningfulness (years)	6–15	42	61.88	11.01	0.882	0.380
	16 and over	61	59.88	11.47		
Feasibility (years)	6–15	42	49.50	8.17	0.095	0.925
	16 and over	61	49.32	9.60		
STEM Attitude (years)	6–15	42	111.38	12.87	0.811	0.419
	16 and over	61	109.21	13.62		

*ρ-value is significant at 0.05 level. STEM: Science, Technology, Engineering, and Mathematics, SD: Standard deviation

Table 10: Independent group *t*-test values of the Science, Technology, Engineering, and Mathematics Attitude Scale, and subdimensions scores of teachers according to the familiarity with technology variable

Dimensions	Groups	*n*	Mean	SD	*t*	*P*-value
Meaningfulness	Partially familiar	26	60.65	12.28	−0.024	0.981
	Familiar	77	60.71	11.00		
Feasibility	Partially familiar	26	48.92	8.84	−0.230	0.819
	Familiar	77	49.55	9.11		
STEM attitude	Partially familiar	26	109.57	11.63	−0.310	0.758
	Familiar	77	110.27	13.88		

*ρ-value is significant at 0.05 level. STEM: Science, Technology, Engineering, and Mathematics, SD: Standard deviation

experience variable. The results are presented in Table 9.

Table 9 shows no significant difference between primary school teachers' STEM attitudes regarding the professional experience variable ($\rho > 0.05$). In terms of the professional experience variable, a *t*-test analysis was done to check whether there was a significant difference between the means. The results are presented in Table 10.

According to Table 10, there was no significant difference between the STEM attitudes of primary school teachers in terms of familiarity with the technology variable ($P > 0.05$).

DISCUSSION

The results of the qualitative analysis of primary school teachers' views indicated three themes. The first one was that the STEM approach should be used to equip students with skills and for students' career planning. The second theme was about the primary school curriculum and STEM approach. The participants felt there should be STEM-integrated courses, and the infrastructure of STEM education should be prepared in schools to apply for STEM-integrated courses. The last theme from the qualitative data was the STEM approach to teacher education. For the education of pre-service primary school teachers, the STEM approach may help train productive teachers and support them in the internalization of interdisciplinary education. Furthermore, using the STEM approach in teacher education will contribute to the education system as an alternative to rote learning.

Examining teachers' views makes it clear that STEM education is necessary to provide opportunities for developing skills, gaining an interdisciplinary perspective, enabling gifted students to fulfill their potential, and ensuring permanent learning. Furthermore, when the STEM teaching approach is used, teachers stated that it was a necessary approach in terms of contributing to the development of students' thinking skills, triggering a sense of curiosity, facilitating collaborative work, increasing familiarity with real-life problems, increasing the level of competence in mathematics and science lessons, and appearing as the application of the constructivist approach. The results of some studies in Turkey (Barış, 2019; Gömleksiz and Yavuz, 2018) overlap with some studies outside Turkey (Kumar and Sharma, 2017; Winkler et al., 2015).

Regarding how STEM education is included in the curriculum, teachers suggested that it should be integrated with other courses, provided in each course, or given as a separate course. Another teacher suggested that STEM education should only be incorporated into science classes. This view also appears in the Middle School Science Curriculum revised in 2018 by Elmas and Gül (2020). In other words, it is concluded that STEM education applications are highly appropriate for the science course.

One of the primary school teachers who had used STEM education stated that he used it not only in primary school but also outside the classroom, and another teacher stated that he could demonstrate the daily life applications of geometry to his students very quickly. However, the interviews revealed that some teachers have yet to use STEM education in their lessons, which can create an obstacle in applying the STEM-teaching approach.

When asked whether STEM education should be taught as a course at university, teachers said that STEM education should be taught in various disciplines. Moreover, the STEM approach should be implemented to produce graduates who can take a decisive step into business life, are equipped according to the needs of the age, are open-minded, and become teachers equipped to educate students in this way. Furthermore, teachers suggested that STEM education should be taught at university as a subject covered in all courses or as a single course.

Aslan-Tutak et al. (2017) state that STEM education should be added to the curriculum in universities to inform students of the field and educate them as teachers equipped for the current age. STEM education studies conducted by the faculty of education with pre-service teachers studying mathematics and chemistry determined that pre-service teachers would like to see projects in this field and that this education should be included in teaching programs.

In the quantitative analysis, no significant difference was found according to the gender variable. The process of expanding STEM education in Turkey is continuing. Wei and Maat

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(2020) compared primary school teachers' attitudes toward STEM education according to the gender variable and found no statistically significant difference between them. Similarly, Hsu et al. (2011) compared the design, engineering, and technology attitudes of 192 primary school teachers according to the gender variable and found a significant difference in the duration of professional experience. However, no significant difference could be found in this study.

No significant difference was found in the STEM education attitudes of the primary school teachers participating in this research according to their professional experience. According to the literature, Thomas (2014) found no significant relationship between teaching time and STEM education attitude. This result may be because the research did not consider the time spent with STEM education. In other words, the duration of teaching experience may not affect STEM attitudes, although, on the other hand, the fact that there is no difference between attitudes may mean that there is no resistance to innovation among teachers with different experiences. Whether the level of primary school teachers' professional experience affects attitudes to STEM education has not been demonstrated by research in Turkey. However, Özdemir and Cappellaro (2020) examined STEM awareness according to the length of professional experience variable and found significant differences. The researchers argue that STEM awareness does affect teachers' attitudes.

The familiarity with technology variable was examined in two groups, and no significant difference was found between the groups' STEM attitude scores and the scores of the sub-dimensions. Teachers' familiarity with technology was self-assessed. Therefore, there is no significant difference in the STEM attitude scale and sub-dimension scores of teachers who are either partially familiar or familiar with the technology. From another perspective, technology competence may not be a determining factor in STEM attitudes alone. Following technological developments may not directly affect knowledge and the ability to integrate technology into STEM applications. People with STEM education develop a positive attitude toward technology (Ardies et al., 2014), but the opposite may not be accurate because knowing about technology is not enough for STEM education. The way that teachers perceive and position technology in STEM education is also essential (Kılınç et al., 2018). Perceptions and attitudes of teachers who will use a STEM-based teaching approach can be influential in determining the approaches they use in learning environments. How the teacher perceives and positions technology in STEM education is also essential (Kılınç et al., 2018) because the perceptions and attitudes to STEM of teachers who will use a STEM-based teaching approach can be influential in determining the approaches they use in learning environments.

Eighteen primary school teachers scored above average in both dimensions of the STEM attitude scale. Nineteen primary school teachers scored above average in the first sub-dimension, but their score in the second dimension was below average. While 33 primary school teachers scored below average in the first sub-dimension, their score in the second sub-dimension was above average. Based on this, it can be said that teachers believed in the feasibility of STEM education but were uncertain about making sense of it. Primary school teachers have to master all disciplines at the primary school level, so they see STEM education as an interdisciplinary education that is possible to apply. It can be said that their knowledge of STEM education and adoption of STEM education philosophy is not yet deep enough, but they are willing to deepen their knowledge. In other words, the popularity of STEM education can motivate teachers to learn. However, for STEM education to be carried out successfully, harmony must be achieved between the philosophical approach of the teacher and how he/she perceives STEM (El Nagdi et al., 2018). Adopting the philosophy of STEM education gives students a vision of why and how to teach STEM education, which is a requirement for STEM teachers (Chesky and Wolfmeyer, 2015).

There are other studies, on the other hand, in which STEM education is not always seen as applicable due to the intensity of the curriculum, that is, STEM philosophy was not seen as applicable in practice, and some practitioners' views were predetermined (Coşkun et al., 2020). The primary school teachers whose views were taken in the research consist of teachers who scored above average on the STEM attitude scale. However, only one teacher scored above average in both sub-dimensions was identified. When other teachers were examined, they got above-average points from the meaningfulness sub-dimension, namely, the first sub-dimension. Examination of the qualitative data shows that all the teachers believed in the necessity of STEM education and that the infrastructure necessary to facilitate implementation should be reviewed. Therefore, the teachers interviewed were people who had more information about STEM philosophy compared to the initial sample. Teachers participating in the FG interview expressed views in support of the data in the qualitative interview. Therefore, the qualitative data were found reliable and included in the findings section. As a result of the data analysis obtained from teachers who participated in both quantitative and qualitative studies, it is clear that the teachers' qualitative and quantitative responses overlap. Primary school teachers are the first to enter students' formal science and mathematics lessons (Özdemir and Cappellaro, 2020). While research on STEM education focused on the high school level, it can be thought that the primary school level is not so important, probably because a single teacher teaches all the courses (English and King, 2015). However, it should not be forgotten that primary school teachers are in a position to discover the inventors of the future and their talents early (Chiu et al., 2015). Primary school is a critical time to increase students' interest in STEM (McClure et al., 2017), but primary school teachers do not consider themselves competent in STEM education (Shernof et al., 2017). This study, however, indicated that primary school teachers are interested in STEM education, support the introduction of STEM-related courses

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in universities, and try to educate their students better and understand their language. Teachers interested in STEM education are expected to absorb the philosophy of education first (Yıldırım, 2018).

Improving students' attitudes toward STEM may affect students' future careers in STEM. As the grade level increases, the positive attitude towards STEM decreases. The fact that primary school students are successful in science or have high self-efficacy in engineering/technology may indicate that they have high expectations or value beliefs in the STEM field (Zhou et al., 2021). Therefore, students' acquaintance with the STEM field in primary school may strengthen their ability to cope with knowledge-based economic challenges in global competition (Kayan-Fadlelmula et al., 2022).

CONCLUSIONS AND IMPLCIATIONS

Primary school teachers expressed that the STEM approach should be implemented in the primary school curriculum. By implementing the STEM approach, primary school teachers will give their students critical skills, knowledge, and capability for their career planning. Schools should have sufficient infrastructure to use the STEM approach in primary schools. Especially for the education of pre-service primary school teachers, the STEM approach should be added to the curriculum of the teacher training of pre-service primary school teachers. Primary school teachers also have a medium-level positive attitude toward the STEM approach in terms of the STEM Attitude Scale.

The need for primary school teachers to organize the curriculum according to a more STEM approach should be evaluated by policymakers. A curriculum that supports the effective use of the STEM approach should be designed to renew the existing primary school curriculum. For the education of pre-service primary school teachers, the curriculum of the faculty education and primary school departments should be developed to allow the implementation of the STEM approach.

More scientific work needs to be done in STEM education with primary school teachers in Turkey. There are almost no self-contained studies with primary school teachers. However, one of the most easily applicable levels of STEM education seems to be the primary school level, and while studies have been conducted with primary school students, the number of such studies is low. Therefore, the attitudes toward STEM of primary school teachers should be studied first because their attitude directly affects their students' attitudes.

Teachers interested in STEM education are expected to absorb the philosophy of education first. However, this is valid not only for STEM education but also for all kinds of education. Therefore, teachers in the system should have access to in-service training. Trainee teachers should be given appropriate training to design their philosophy rather than deal with direct applications while learning a new approach or educational model at university. Otherwise, training cannot go beyond popularity and is applied too quickly.

This research accessed 103 primary school teachers who knew STEM education, a small number, and researchers could access more teachers in different provinces to carry out this study. This research was limited to the primary school mathematics and science curricula framework. Mixed method research involving design courses should be carried out by considering more disciplines. Moreover, a project can be produced for STEM education to be successful in primary school years, allowing primary school teachers and branch teachers to cooperate. Experimental studies give more insight into the absorption and applications of STEM education, so quantitative research should be conducted with experimental research.

Ethical Statement

The ethical committee of Istanbul Sabahattin Zaim University gave ethical committee consent on January 17, 2019 with a number 2019/01.

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