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STEM and Early Algebra: Reflections from Primary School Teachers' Practices

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ABSTRACT

This study aims to determine the opinions of primary teachers about the implementation of STEM-based practices in early algebra teaching. The phenomenology design, one of the qualitative research method designs, was used. The study group of the research was determined using the criterion sampling technique, one of the purposive sampling techniques. The study group consists of 5 primary teachers who have received STEM education and have implemented STEM-based applications in early algebra teaching. A semi-structured interview form was used to collect the data. The qualitative data obtained at the end of the research were described with the content analysis method. In light of the findings, most teachers noted that STEM-based applications in early algebra teaching could be given from the first grade of primary school. The teachers, who indicated that STEM-based activities are applicable in early algebra teaching, stated that these applications would have advantages such as gaining a positive attitude towards the mathematics lesson, providing fun learning environments, facilitating learning, and embodying abstract subjects. In addition, teachers commented that they experienced difficulties such as a lack of materials, crowded classrooms, dense curriculum, and insufficient technological infrastructure. Teachers suggest that teachers and administrators who carry out STEM-based practices in early algebra teaching should conduct research, take STEM education, and apply it in their classrooms.

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STEM ve Erken Cebir: Sınıf Öğretmenlerinin Uygulamalarından Yansımalar

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ÖZET

Bu çalışmanın amacı, erken cebir öğretiminde STEM temelli uygulamaların yürütülmesine ilişkin sınıf öğretmenlerinin görüşlerini belirlemektir. Araştırmada, nitel araştırma yöntemi desenlerinden olan fenomenoloji deseni kullanılmıştır. Araştırmanın çalışma grubu, amaçlı örnekleme tekniklerinden biri olan ölçüt örnekleme tekniği kullanılarak belirlenmiştir. Çalışma grubunu, STEM eğitimi almış ve erken cebir öğretiminde STEM temelli uygulamaları gerçekleştirmiş 5 sınıf öğretmeni oluşturmaktadır. Araştırmanın verilerinin toplanmasında yarı yapılandırılmış görüşme formu kullanılmıştır. Araştırma sonunda elde verilen nitel veriler, içerik analizi yöntemi ile betimlenmiştir. Elde edilen bulgular ışığında öğretmenlerinin çoğunluğu, erken cebir öğretiminde STEM temelli uygulamaların ilkokul 1. sınıftan itibaren verilebileceğini ifade etmiştir. STEM temelli etkinliklerin erken cebir öğretiminde uygulanabilir olduğunu ifade eden öğretmenler bu uygulamaların; matematik dersine yönelik olumlu tutum kazandırma, eğlenerek öğrenme ortamları sunma, öğrenmeyi kolaylaştırma, soyut olan konuları somutlaştırma gibi avantajlarının olacağı belirtilmiştir. Ayrıca öğretmenler; materyal eksikliği, sınıf mevcutlarının kalabalık olması, müfredatın yoğun olması, teknolojik alt yapı yetersizliği gibi zorluklar yaşadıklarını belirtmişlerdir. Öğretmenler, erken cebir öğretiminde STEM temelli uygulamaları yürütecek öğretmen ve yöneticilere; bu alanda araştırma inceleme yapmalarını, STEM eğitimi almalarını ve sınıflarında uygulamalarını önermektedir.

1. Introduction

1.1. STEM

STEM is an acronym created by combining the initials of the words Science, Technology, Engineering, and Mathematics (Bybee, 2010; Gonzalez & Kuenzi, 2012; Langdon et al., 2011). Although the concept of STEM, which is an interdisciplinary approach that includes the disciplines of Science, Technology, Engineering, and Mathematics, is holistic, these fields intersect with each other (Chen, 2009; Dugger, 2010; Gilmer, 2007; Taljaard, 2016; Thomas, 2014). Carnevale, Melton, and Smith (2011) defined STEM education as the adoption of a purposeful, meaningful, and holistic approach to the learning process of individuals by basing on interdisciplinary integration and establishing a link between disciplines.

The STEM education approach is one of the most effective educational approaches among 21st-century skills that include high-level skills such as problem-solving, logical reasoning, creative thinking, effective communication, and critical thinking (Mercan, 2019). The fields of science, mathematics, engineering, and technology play an important role in gaining high-level skills such as research, inquiry, creativity, analytical thinking, critical thinking, logical reasoning, and decision-making skills that we expect qualified individuals to have (Yamak et al., 2014).

The foundations of the STEM education approach go back more than a century. This approach was put forward by the Committee of Ten at Harvard University towards the end of the 1800s, to reach a standard for schools in which agricultural studies were conducted (Ostler, 2012). In 1990, "SMET" was used as an abbreviation of the words "science, mathematics, engineering, technology" by the National Science Foundation (Sanders, 2009). In 2001, the "National Science Foundation" was first used by NSF as an abbreviation of "STEM" to express integrated programs in the fields of science, technology, engineering, and mathematics (Harkema et al., 2009). One of the factors in the emergence of the STEM approach is shown to be less inclination of students to doctoral programs related to science and engineering in the United States of America (Çorlu et al., 2014). The STEM education movement, which was put forward by leaders and politicians, is accepted as a reform movement that emerged to ensure that the USA has an active role in the global economy (Dugger, 2010; Wang et al., 2011). As a result of the reports published by organizations such as ASEE (American Engineering Education Society), NAE (National Engineering Academy), and ITEEA (International Technology and Engineering Education Association) for STEM education in the USA, the 21st century. The need for an increase in the number of qualified individuals who can fulfill the requirements of the age has drawn attention. These reports made an impact in many countries, especially the USA, and paved the way for the rapid spread of STEM education (Çepni, 2017). In many countries, especially in countries such as the USA, Japan, Korea, and China, studies on STEM education at preschool, primary, and secondary education levels have begun to be carried out to create an innovative society (Gonzalez & Kuenzi, 2012; Yılmaz et al., 2017).

With the increase in the importance and budget given to STEM education in developed countries and the effect of STEM in reaching the level they aimed as a result, the needle of my education in Turkey was turned to STEM. Studies in the field of STEM have begun under the leadership of scientists (Azkin, 2019). To develop and disseminate STEM education in Turkey, some targets have been determined in the 2015-2019 Strategic Plan (Wendell et al., 2010). In the STEM Education Report prepared by MoNE YEGITEK in 2016, the aims of strengthening STEM were included (MoNE, 2016). Since the expected level of success could not be achieved in PISA and TIMSS exams in Turkey, research was conducted on the reasons for this. The education policies of countries such as America and South Korea, which have high success levels in PISA and TIMSS exams, have been examined and education policies for STEM education have been adopted in our country, as in many other countries in the world (Akgündüz et al., 2015). While the Scientific and Technological Research Council of Turkey (TUBITAK), which supports the Ministry of National Education in the STEM field, included supportive statements in the field of STEM in its 2017-2023 National Science, Technology and Innovation Strategy Report, science fairs should be organized to make primary and secondary school students love science. TÜBİTAK provides support to students, teachers, and academics in STEM education. Science centers carry out activities to popularize and popularize science among primary and secondary school students (TÜBİTAK, 2016).

STEM education aims to use the subjects of Science, Technology, Engineering, and Mathematics holistically with an interdisciplinary approach, by establishing a relationship with the subjects in real life to train future engineers, scientists, and technologists who have a high level of scientific creativity, can innovate and can compete in the global economy (Breiner et al., 2012; Sanders, 2009). Students who receive STEM education will contribute to sustainable development and a strong economy with technological innovations as future scientists, engineers, and mathematicians (Ensari, 2017). Thomas (2014) explains the aims of STEM as follows: To provide job opportunities to individuals who have gained STEM literacy, to offer innovative ideas to countries in the development of the economy, and to have competence in new business areas.

The information and technology era you live in shows a rapid acceleration is expected that people will have the qualifications to adapt to this acceleration. Therefore, there is a need for qualified individuals who research, question, criticize, be analytical, and have decision-making skills (Yamak et al., 2014). STEM education approach has an important place in gaining these skills. STEM provides the opportunity to have the knowledge and skills that the individual needs (Beane, 1991). The main purpose of STEM is to provide knowledge and skills in science, mathematics, engineering, and mathematics disciplines to contribute to the solution of daily life problems by producing creative solutions (Thomasian, 2011).

1.2. The Discipline of Mathematics in STEM

Mathematics is conceptually a way of thinking and reasoning, with the techniques of calculating and measuring using numbers. Mathematics enables us to analyze data and synthesize organized data by creating strategies. Mathematics is a newly learned language for students. Students need to learn numbers and symbols to learn this language. Numbers and symbols have an important place both in mathematics and in our daily life (Pesen, 2020). The acquisition of mathematical skills affects individuals to live independently, increase education and employment opportunities, and develop socioeconomic status in today's society. How mathematical skills are acquired, what kind of difficulties are experienced in gaining these concepts, and overcoming these difficulties are extremely important (Mutlu, 2020). Thanks to mathematics, individuals make sense of facts and events using mathematical concepts and relationships (Olkun & Toluk, 2003). Thanks to mathematics, he tries to make the unknown structure of the universe known. Individuals with knowledge and skills in the discipline of mathematics will be pioneers in many areas in their future lives (MoNE, 2009).

In the STEM education approach, mathematics is frequently included in every discipline area (Mayorova et al., 2021). Therefore, one of the most important components of STEM education is mathematics (MoNE, 2006). Problem-solving, critical thinking, and analytical thinking skills, which are the basis of STEM education, can be developed by using mathematics (Maass et al., 2019). In this context, the discipline of mathematics has an indispensable role in STEM education and mathematics education has many effects on STEM applications (Cooke & Walker, 2015). While STEM applications make a positive contribution to the development of students' mathematical reasoning skills and higher-order thinking skills, they also improve mathematical literacy skills (Weber et al., 2013). STEM education provides an increase in mathematics academic skills (Acar et al., 2018; McClain, 2015), and it reflects positively on their attitudes toward mathematics (Koçyiğit & Yenilmez, 2022).

Although mathematics is considered important by everyone, learning and teaching mathematics is a very difficult process. Mathematical thinking skills have an important effect on learning and teaching mathematics more effectively and healthily. Mathematical thinking skills differ in mathematics depending on the nature of the mathematical techniques that take place in various fields such as geometry, arithmetic, algebra, and probability (Dindyal, 2003). Mathematics is an important tool in the development of thinking skills. (Umay, 2003).

1.3. Early Algebra

The "Primary School Mathematics Curriculum in Turkey consists of four learning areas: Numbers and Operations, Geometry, Measurement, and Data Processing." Although the acquisitions related to the algebra learning field are not included at the primary school level, they appear for the first time at the 6th-grade level (MoNE, 2018). Although the achievements of the algebra learning field are not included in the primary school mathematics curriculum, generalization in arithmetic, being able to generalize from equations and symbolic explanations, generalizing in series, generalizing the rules establishing numerical relations to other situations, simplification and arrangement, inverse relationship, working with unknowns, understanding the connections between equality and inequality, Algebra and subjects that make up the infrastructure of algebra such as being able to see the functions in symbols and the relationship between different presentations, awareness of the mathematical structure, making explanations and verifications, estimation and backward working, problem-solving are included (Turgut, 2016).

Although all fields are necessary in mathematics, the algebra learning field has an important place in solving problems that exist in daily life (Altun, 2005). Algebra has different functions. It is possible to express algebra as a mathematical language, thinking tool, problem-solving tool, or a school lesson (Dede & Argün, 2003). Sutherland and Rojano (1993) described algebra as a language to explain ideas. Sfard (1995) expressed algebra as a science of computation. According to Usiskin (1997), algebra is a mathematical language classified as "unknowns, formulas, patterns, placeholders, and relations". On the other hand, Turgut and Temur (2017) define algebra in the most general sense as "the expression of unknown values in mathematics with letters or various symbols, and putting forward an equation for the solution of unknowns based on knowns".

Algebra has existed since the first years of education (Carraher et al., 2017) and algebraic thinking begins to develop from early grades (Cai & Knuth, 2011). Early algebra is the transitional process between arithmetic and algebra. Kieran (1991) defined early algebra as the process in which arithmetic experience forms the basis of algebra and algebraic thinking begins to develop. In Turkey, algebra teaching in the Mathematics Curriculum is included in the primary school level, patterns and ornaments sub-learning domain (MoNE, 2009). In the 2015 Mathematics Curriculum, there was a sub-learning area of transition to algebra at primary school (1, 2, 3, and 4th grades). Algebraic concepts such as patterns, generalization, and variables were emphasized in the program, which was put into practice since the 2016-2017 academic year (MoNE, 2015). While it is right to teach students algebraic thinking and reasoning skills at a young age, it is necessary to pay attention to appropriate learning tools and methods (NCTM, 2000; Yackel, 1997).

1.4. Integration of Stem-Based Applications in Early Algebra Teaching

It is possible to talk about three approaches in the integration of the curriculum: multidisciplinary, interdisciplinary, and supra-disciplinary (Drake & Burns, 2004). In the multidisciplinary approach, concepts, and skills are taught separately for each discipline on a common theme. The in-depth teaching of two or more disciplines is provided by an interdisciplinary approach. The transdisciplinary approach, on the other hand, is taught by focusing on real-life problems based on two or more disciplines (English, 2016). Although STEM is an interdisciplinary approach, it seems that it has been integrated with many fields since its emergence and moved to a transdisciplinary dimension. In STEM education, science, technology, engineering, and mathematics should be integrated (Morrison et al., 2019). The discipline of mathematics has a lot of influence on the STEM approach (Cooke & Walker, 2015). Algebra is one of the sub-discipline areas within the discipline of Mathematics. In this context, studies on early learning can be carried out by providing STEM integration in algebra teaching.

2. Method

The phenomenology design, one of the qualitative research designs, was used in this study, which aims to reveal the experiences of primary teachers regarding the implementation of STEM-based applications in early algebra teaching. Phenomenology is a research design that aims to investigate the phenomena that occur in the face of events, perceptions, experiences, concepts, orientations, and situations that exist in daily life that we are aware of but do not have a deep understanding of (Yıldırım & Şimşek, 2021). In phenomenological research, the researcher reveals the common aspects of the participants who have experienced a phenomenon and handles it as it is from the perspective of the experienced people (Bocheński, 2008; Creswell, 2021; Giorgi, 1985). In phenomenological studies, participants reveal how they perceive the situations they have experienced from their perspectives (Balcı, 2021; Saban & Ersoy, 2019).

2.1. Study Group

The study group of this research consists of 5 primary teachers who apply the STEM education approach in early algebra teaching. The purposive sampling selection method was preferred in the study (Miles & Huberman, 1994). In the purposive sampling method, it is possible to study the situations that are assumed to be rich in information in depth (Patton, 2014; Tanrıöğen, 2014). The individuals at the center of the research consist of people who experience the phenomenon and can express this phenomenon (Yıldırım & Şimşek, 2021). The criterion sampling method, which is one of the purposeful sampling methods, was preferred because of the study of cases that met a set of predetermined criteria in the study (Büyüköztürk et al., 2021; Yıldırım & Şimşek, 2021). Criteria in the selection of primary teachers included in the research was determined that STEM education was taken and that STEM-based applications were included in early algebra teaching. Within the framework of research ethics, the personal information of the participants was not included, and coding was done with numbers and letters. Participants were named with the codes T1, T2, T3, T4, and T5. Table 1 includes the demographic information of the teachers in the study group.

Table 1.

Demographic information about the study group

Participants	Age	Gender	Seniority
Teacher 1	39	Female	16
Teacher 2	51	Female	24
Teacher 3	37	Female	14
Teacher 4	32	Female	8
Teacher 5	36	Male	10

According to Table 1, the ages of the participating teachers vary between 32 and 51 and their average age is 39. Four of the participating teachers are female and one is male. Their professional seniority is between 8 and 24 years and the most senior teacher has 24 years of teaching experience.

2.2. Data Collection Tools

A semi-structured interview form developed by the researcher was used as a data collection tool in the research. Semi-structured interviews are powerful data collection tools that individuals reveal by reflecting their feelings, thoughts, opinions, and experiences on their voices (Wengraf, 2001). With the semi-structured interview form, the questions asked to the researcher during the interview are supported with different questions in the process, various dimensions are addressed, and new ideas are revealed (Merriam, 2015; Yıldırım & Şimşek, 2021). The researcher has the flexibility to immediately ask questions about the issues that were not clarified in the interview. It can catch clues to examine the superficial information given by the participants in-depth (Çepni, 2010; Karasar, 2022).

In this study, a measurement tool consisting of 14 open-ended questions under 5 sub-problems developed by the researcher and finalized by taking expert opinion was used as a data collection tool. Semi-structured interview form was carried out by using the Zoom application online with 3 teachers and by face-to-face interviews with 2 teachers. To avoid data loss during the interviews, voice recording was taken with a voice recorder after obtaining the consent of the participants. The recorded sounds were then converted to text without skipping data.

2.3. Data Analysis

Content analysis technique, one of the qualitative analysis methods, was used in the analysis of the data of the research conducted to examine the views of teachers on the implementation of STEM-based applications in early algebra teaching. The main purpose of content analysis is to enable the researcher to reach the concepts and relationships that he can explain the data he collects. While performing content analysis, it is necessary to interpret it by categorizing and arranging it in a way that the reader can make sense of, within the framework of certain concepts and themes that have similarities with each other (Yıldırım & Şimşek, 2021). In content analysis, raw data is coded and converted into standard formats (Babbie, 2007). There are four stages in the interpretation of data in content analysis. These stages are coding the data, finding the themes, organizing the codes and themes, and defining and interpreting the findings (Yıldırım & Şimşek, 2021).

While analyzing the data in the research, the data obtained by the researcher were examined and divided into meaningful sections. The conceptual meanings of these parts were found. Codes were created by dividing each section into subsections. The coded data were systematically tabulated to be categorized under certain themes and sub-themes. Tables containing the themes, sub-themes, codes, and frequency values that emerged after the analysis are presented in the findings section.

2.4. Validity, Reliability, and Ethics

Various precautions were taken by the researchers to minimize or eliminate the factors that affect and threaten the validity and reliability of the research (Yıldırım & Şimşek, 2021). In qualitative research, diversification is used to increase internal validity (credibility). According to Yıldırım and Şimşek (2021), diversification is defined as the whole efforts to increase the credibility of research results by using different methods in data sources, data collection, and data analysis (Yıldırım & Şimşek, 2012). In the process of creating the semi-structured interview form, which will be used as a data collection tool in the research, the literature was examined, and draft questions were created. The semi-structured interview form prepared as a draft was submitted to the opinion of 6 academicians who are experts in the field to ensure internal validity. After the feedback from the experts, the semi-structured interview form was edited and given its final shape. Before the semi-structured interview form was applied to the participants, the pilot application was applied to two primary teachers to determine the suitability of the interview form for the study. It was tested whether the questions in the piloted form were clear and understandable, the final arrangements were made, and the application was started. The teachers who will participate in the research were informed in detail about the research beforehand, and a consent form was obtained indicating that they participated in the study voluntarily. The names of the teachers in the study group of the research were not reflected in the study in any way and were kept confidential. In the study, the real names of the teachers were not included, and codes were given to all participants regardless of gender. The data were transferred to the participants in the research by giving the codes T1, T2, T3, T4, and T5. The interviews conducted by the researcher individually with the participants lasted an average of 50 minutes. The participants were assured that the records could only be accessed by the researcher, their consent was obtained, and the interviews were recorded with a voice recorder to avoid data loss. After the interview, the audio recordings were converted into text and the texts were presented for the approval of the participants. It has been confirmed that the interview reports are correct and complete, and in this way, internal reliability is ensured.

To increase the validity and reliability of the findings presented in the study, frequent quotations were made from the views of the participants. The study group selection of the research, data collection tools, and data collection process are described in detail. Within the framework of the results obtained by the researcher, the codes were extracted, and these codes were compared with each other. By interpreting and conceptualizing the obtained codes, they formed patterns that the participants were not aware of (Yıldırım & Şimşek, 2021). Adhering to the problem and purpose of the research, unnecessary codes were removed, or new codes were added. In this way, deep-focused data were obtained with the thought of contributing to the reliability of the research.

To ensure internal consistency (reliability) in coding, the data were analyzed separately by each researcher and the reliability formula suggested by Miles and Huberman (1994) was used for reliability calculation. To ensure the consistency of the data within the scope of reliability in the research, the expert opinion of the external auditor, who was excluded from the study, was consulted in the analysis and reporting processes, and the themes and sub-themes obtained were compared with the literature findings. In addition to the researcher, a second coding was made by the external auditor and the score of compatibility between the two codings was calculated. The fit formula developed by Milles and Hubberman (1994) was used to calculate the fit score among the coders.

Reliability Coefficient = Number of Consensus / (Total Consensus + Disagreement)

As a result of the content analysis made with the Miles and Hubberman (1994) formula, the percentage of coding compliance was found to be 0.92%. A concordance of over 70% indicates that there is a concordance between the two coders and is considered reliable for the research.

To ensure external validity in the research, detailed descriptions of the research model, study group, data collection tools, data collection, data analysis, and how the findings were organized were stated. Within the scope of external validity (transferability) in the research, the purposive sampling method was used and suitable individuals were determined to serve the purpose of the study, based on the criteria that the participants had received education in the field of STEM and included STEM-based applications in early algebra teaching.

3. Result

In this section, the findings obtained as a result of the interviews with the primary teachers who carry out STEM-based applications in early algebra teaching are presented under the titles of research sub-problems in the semi-structured interview form. Under the sub-problem titles, the analysis of the questions to be researched on that subject is given. Each sub-problem contains more than one question. In the analysis of the data, tables were created by classifying sub-themes and similar themes with the codes created within the framework of the answers given by the teachers. In the tables, it was tried to present a holistic and deep perspective by giving place to the example expressions and one-to-one quotations of the teachers.

3.1. Opinions of Primary teachers Carrying out STEM-Based Practices in Early Algebra Teaching on their Competence in the Field of STEM

STEM Education Approach and STEM-Based Practices

"What do you know about STEM-based applications? What do you think STEM is?" questions were highlighted. The findings regarding the views of teachers about the STEM education approach and STEM-based practices are presented in 2. Table.

Table 2.

STEM Education Approach and STEM-Based Practices

Themes	Sub Themes	*f*	Example Statements from Teachers' Opinions on STEM Education Approach and STEM-Based Practices
Approach	Interdisciplinary approach	5	*"I know that STEM education is an interdisciplinary educational approach that integrates science-technology-engineering and mathematics." T1*
	Science-technology-engineering-mathematics disciplines	5	
	Integrated approach	3	
	Process-based approach	3	
	Art approach	2	
	Design-based approach	1	
Developed skills	Engineering skills	4	*"They are activities for applications that develop engineering skills that enable them to use many technological tools as well as develop their 21st-century skills." T2*
	Ability to use technology	3	
	21st-century skills	2	
	Problem-solving skill	2	
	Design skill	1	*"STEM is an approach to solving real-life problems that allow it to solve this problem in connection with 4 basic discipline areas." T5*
	Robotics and coding skills	1	
	Communication skill	1	
Required competency	Creativity	3	*"It is an interdisciplinary learning approach that supports creative thinking by creating generations that produce STEM-based applications." T3*
	Innovation	3	
	Productivity	2	
	Originality	1	
Application method	Project-based learning method	3	*"For example, the 5E learning model should be in STEM. We know it as a process-based, design-oriented approach in which group work is important, including various method techniques." T5*
	Group work method	2	
	Research-based learning approach	1	
	Collaborative learning method	1	
	5E model	1	
The purpose	Real-life problems	3	*"There are real-life problems in STEM, and after these problems were determined, we set out from 4 disciplines, even in art, some methods are applied to solve them." T4*
	The process of perceiving the world	1	

When Table 2 is examined, the findings of the primary teachers who carry out STEM-based practices in early algebra teaching regarding STEM education approach and STEM-based practices are gathered under five main themes: approach, skills developed, necessary competencies, application method, and output purpose. In the approached theme, there are sub-themes of an interdisciplinary approach, Science-Math-Engineering-Mathematics disciplines, integrated approach, process-based approach, art approaches, and design-based approach. The developed skills theme includes engineering skills, technology use skills, 21st-century skills, problem-solving skills, design skills, robotic coding skills, and communication skills. There are sub-themes of creativity, innovation, productivity, and originality under the theme of required competencies. Project-based learning approach, group work method, inquiry-based learning approach, cooperative learning method, and 5E learning model approach are sub-themes under the application method theme. The sub-themes of the exit purpose theme are daily life skills and the process of perceiving the world.

STEM Field Competency

To the primary teachers who participated in the research, "Where and from which institution did you receive your STEM education? Could you give information about its content, level, duration of the training, etc.? questions were asked. Findings regarding STEM field competence are presented in Table 3.

Table 3.

STEM Competency

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on STEM Field Competence
Content of the training	Preparing lesson plan acorrding to 5E model	5	*"We learned the application and steps of the STEM approach. It was a training that taught how to develop applications for the 5E plan in practical training." T2*
	Application-based studies	5	
	STEM application steps	4	
	Engineering processes	3	*"We received training on preparing a lesson plan according to the 5E method and then using practical activities" T4*
	Write a problem situation	1	
	Modeling	1	
Level of education	Basic level	5	*"In STEM education, I first took the STEM basic level course. First, I took it through a course that was opened centrally by the ministry. Later on, we took the advanced level course." T3*
	Advanced level	4	
	Instructor training	3	
Training institution	In-service training under the Ministry of National Education	4	*"Although the training was online, it was a hands-on training and lasted for two months. It was quite full of content. We prepared a lesson plan according to the 5E model." T1*
	Online education	3	
	Distance education within the university	2	

When Table 3 is examined, the findings regarding the STEM field competencies of the primary teachers who carry out STEM-based practices in early algebra teaching are gathered under three themes: the content of the education, the level of education, and the institution of education. The content theme of the training includes preparing a lesson plan according to the 5E model, application-based studies, STEM application steps, engineering processes, problem writing, and modeling sub-themes. Basic level, advanced level, and trainer sub-themes are the sub-themes within the scope of the level of education theme. In the theme of the institution where the education is received, the sub-themes of in-service training within the Ministry of National Education, online training, and distance education within the university.

Conducting STEM-based activities

To the primary teachers who participated in the research, “Do you conduct STEM-based activities in your lessons? Could you tell us about the activities you are carrying out now or in the past?” questions were asked. Findings for conducting STEM-based activities are presented in Table 4.

Table 4.

Conducting STEM-Based Activities

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Receiving STEM Education
Science based	Decaying	1	*“The students were asked to design a house with sound insulation as a result of the noise problem they experienced in the classroom and a sound problem coming from outside.” T2* *“In addition, we bring the fruits to the classroom for days so that they can make one-on-one observations of the children, and we watch the decay by showing the change of the class from day to day.” T3*
	Earthquake-resistant house model	1	
	Recycle	1	
	Frictional force	1	
	Sound insulation	1	
	Electrical circuit	1	
	Sustainability	1	
Technology based	Robotic coding	3	*“We showed how to classify living things using Minecraft by designing a New World in Minecraft game” T3* *“I provide STEM education with the First lego kits of the science heroes association.” T5*
	Minecraft	1	
	Lego sets	1	
	Scratch	1	
Mathematics based	Four operation skills	3	*“I can do it in advanced subjects, but I did activities on patterns in fractions in my previous classes.” T4*
	Fractions	1	
	Length measurements	1	
	Patterns	1	
Art based	Drama	1	*“We bring real-life problems to life with drama.” T1*

According to the findings obtained for the execution of STEM-based activities according to Table 4, there are four themes: science-based applications, technology-based applications, mathematics-based applications, and art-based applications. Science-based applications themes are decaying, earthquake resistant house model, recycling, friction force, friction force, sound insulation, weather, and sustainability. Robotic coding, Minecraft, lego sets, and Scratch are sub-themes under the theme of technology-based applications. Under the theme of mathematics-based applications, there are sub-themes of four operation skills, fractions, length measures, and patterns. Drama is the sub-theme under the theme of art-based practices.

Class Levels and Implementation Times of STEM-Based Activities

"How long have you been conducting STEM-based applications? At which grade levels did you include these applications?" questions were asked. The findings regarding the conduct of STEM-based activities are presented in Table 5.

Table 5.

Class Levels and Implementation Times of STEM-Based Activities

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Class Levels and Implementation Periods in which STEM-Based Activities are Conducted
Grades	4th grade	5	*"I continued the studies from where I left off from the 3rd grade." T1*
	3rd grade	5	*"I couldn't apply many activities at the 1st-grade level. I did it in 4th graders. There were studies that I applied in 3 classes." T4*
	2nd grade	3	
	1st grade	2	*I give STEM-based applications in the 2nd, 3rd, and 4th grades. Some more difficult applications are carried out in the 1st grades." T5*
Application time	For 2 years	3	*"I have been running STEM-based applications for 4 years." T3*
	For 4 years	2	*"I have been conducting STEM-based studies for about 2 years." T5*

When Table 5 is examined, there are two themes, grade level, and grade level, according to the findings obtained regarding the grade levels and application times in which STEM-based activities are carried out in early algebra teaching. 4th-grade, 3rd-grade, 2nd-grade, and 1st-grade sub-themes were determined under the class levels theme, and 2 years and 4 years sub-themes under the application durations theme.

3.2. Opinions of Primary School Teachers Carrying Out STEM-Based Practices in Early Algebra Teaching on Algebra Content Knowledge

Early Algebra Teachability Level and Early Algebra Content Knowledge

To the primary teachers who participated in the research, "Do you think algebra can be taught to primary school children? What do you think early algebra teaching means?" questions were asked. Findings on early algebra teachability and what early algebra means are presented in Table 6.

Table 62.

Early Algebra Teaching

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Early Algebra Teaching
Subject areas	Shapes used in place of unknowns/Placeholders	5	*"Early algebra is when a student learns these relationships with patterns and spatial relationships with shapes away from numbers and forming links for shapes." T2* *"We started with spatial relations in 1st grade. It's a bit closer to algebraic expressions in spatial relations. The equality expression can be used later." T3*
	Patterns	4	
	Symbols	3	
	Geometry	2	
	Formulas	2	
	Equal sign	2	
	Numbers	2	
	Spatial relationships	2	
	Shapes	2	
	Length measurements	1	
Developmental impact	Early life	1	*"At the same time, giving these studies to students from an earlier age is to give early algebra application at an early age. T1* *"Early algebra practice enables students to use a more disciplined method of learning and connect." T4*
	Establishing a bond	1	

All of the primary teachers who carry out STEM-based practices in early algebra teaching stated that algebra can be taught in the early period. The findings regarding the opinions of the teachers participating in the research are examined in two themes: the subject area that can be taught algebra and the developmental effect. Under the theme of subject areas, there are sub-themes of shapes (placeholders), patterns, symbols, geometry, formulas, equal signs, numbers, spatial relations, shapes, and length measures used instead of unknowns. Early period and bonding are sub-themes under the developmental impact theme.

Level of Teaching Algebra and Starting Teaching Algebra Topics

"At what age should children start learning algebra? So what algebra subjects can be taught at this age? From where?" questions were asked. The findings regarding the level of early algebra teaching and the subjects that are considered to start early algebra teaching are presented in Table 7.

Table 7.

Learning Age of Algebra / Topics to Begin Teaching

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Age of Learning Algebra and Which Topics to Start in Algebra Teaching
Subject area to be started	Patterns	4	*"The first thing that comes to my mind in early algebra teaching is the use of spatial relations. First of all, it can be started from these topics, that is, concepts such as behind, in front, on the right, on the left, and the bottom can be given." T2* *"As a symbol, if we consider numbers as a symbol, it can be given. Of course, spatial relations can also be given within this subject." T5*
	Spatial relationships	3	
	Geometrical shapes	2	
	Numbers	2	
Age group/grade	4 years old	4	*" I think it can be started at the simplest level, starting from the 1st grade. Maybe it can even be reduced to kindergarten because the first concepts taught in the name of mathematics start from preschool." T1* *"Early algebra education should start from the preschool period, or it can be started within the age group of 4, I say pre-school, my teacher, it has to be pre-school." T4*
	1st grade	4	
	4th grade	1	

Table 7 shows the findings regarding the opinions of teachers who carry out STEM-based practices in early algebra teaching. Algebra is examined in two themes, which are the subject area that is thought to start teaching and age group/class level. Subject areas thought to have not started to be taught in algebra are patterns, spatial relations, geometric shapes, and numbers. Preschool age 4, 1st-grade, and 4th-grade sub-themes are given as sub-themes under the age group/grade level theme.

Applications in Early Algebra Teaching

To the primary teachers who participated in the research, "Have you carried out any practice in your classroom for teaching algebra? Can you give information?" questions were asked. In light of the answers given by the teachers participating in the research, the findings regarding the practices they carried out in teaching algebra are presented in Table 8.

Table 8.

Application Areas in Early Algebra Teaching

Theme	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Practices in Early Algebra Teaching
Application areas in early algebra teaching	Geometric shapes and objects	3	*"When I was talking about weighing, I explained it not numerically, but with objects. For example, 2 oranges are equal to the weight of an apple. We conducted studies in the dimension of comparing weights and establishing relationships." T2*
	Greater-less than sign	2	
	Four operations skills	2	
	Spatial relationships	2	
	Length measurements	2	
	Placeholders	2	
	Teaching numbers	2	*"I generally use it in four-operation skills to concretize mathematics for children. You know, we use symbols very often while this addition operation gives unknowns in subtraction." T4*
	Unknowns	1	
	Graphics	1	
	Measurement	1	*"We can put a shape in any box, and we can use placeholders when dealing with unit cubes." T5*
	Patterns	1	
	Symbols	1	
	Weighing	1	

When Table 8 is examined, the findings regarding the opinions of the teachers who carry out STEM-based applications in early algebra teaching are geometric shapes and objects, the concept of greater-than-less than, four operation skills, spatial relations, length relations, placeholders, number teaching, unknowns, graphics, under the theme of application areas in algebra teaching, measuring, patterns, symbols and weighing were examined in thirteen sub-themes.

3.3. Opinions of Primary School Teachers Who Carry out STEM-Based Practices in Early Algebra Teaching on the Integration of STEM Education Approach to Early Algebra

Early algebra integration of STEM education approach

To the primary teachers who participated in the research, "Can STEM applications be used while teaching algebra to primary school children? How did you include STEM-based applications in early algebra teaching? Can you explain?" questions were asked. In light of the answers given by the teachers participating in the research, the findings regarding the early algebra integration of the STEM education approach are presented in Table 9.

Table 93.

Implementing STEM-Based Practices in Early Algebra Teaching

Theme	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Implementation of STEM-Based Practices in Early Algebra Teaching
STEM-based activities applied in early algebra teaching	Geometric shapes and objects	4	*"The hangers we were going to make for our class came in different models. We were just going to deal with the pattern issue. We designed this subject and I stated that we would apply the best result on our hanger." T2*
	Length measurements	3	
	Robotics and coding	2	
	Statistics	1	
	measuring	1	
	patterns	1	*"We made a STEM application using distance, that is, length measurements. We made simulations by building houses with Legos. We did the earthquake simulation with robotic coding and created a real shape." T3*
	Weighing	1	
	Spatial relationships	1	
	Measuring time	1	*"While giving the length relations, I conducted studies by establishing relations with other subjects both with lessons and with mathematics." T4*

When Table 9 is examined, the theme of STEM-based activities applied in early algebra teaching according to the findings obtained in the implementation of STEM-based applications in the early algebra teaching of the teachers participating in the research is included. Within the scope of this theme, there are sub-themes of geometric shapes and objects, length measures, robotic coding, statistics, measurement, patterns, weighing, spatial relations, and measuring time.

Methods and Techniques Used in the Realization of STEM-Based Applications in Early Algebra Teaching

To the primary teachers who participated in the research, the "Instructional technology and materials should be used to successfully apply the STEM approach in early algebra teaching?" question was asked. In light of the answers given by the teachers participating in the research, the findings on which method and technique should be used to successfully apply the STEM approach in early algebra teaching are presented in Table 10.

Table 4.

Methods and Techniques Used in the Implementation of Applications

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Methods and Techniques Used in the Implementation of STEM-Based Practices in Early Algebra Teaching
Methods and techniques	Project-based learning method	5	*"I used experiments method, brainstorming, project-based learning, computer-assisted teaching, learning by doing research, learning by doing, modeling, drama methods, and techniques in STEM applications in early algebra teaching." T1* *"Especially in the STEM approach, the project method, the 5E learning model, is widely used in our country. In other words, the 5E learning model is a method that we use more. Drama is used at a much younger age." T3* *"We used the 5E model in our projects. In general, there are certain stages of this, there are design stages. You know, we already used the project-based project-based teaching method in our studies." T4*
	Role-playing/Dramatization	5	
	Problem-based learning method	5	
	Teaching through inquiry	4	
	5E model	3	
	Brainstorming technique	2	
	Computer-assisted instruction	2	
	Context-based learning	2	
	Inventive learning method	2	
	Method of learning by doing	1	
	Test method	1	
	Design-based learning approach	1	

When Table 10 is examined, under the theme of the methods and techniques used by the teachers participating in the research while conducting STEM-based activities in early algebra teaching, project-based learning method, role-playing/dramatization, problem-based learning method, inquiry-based teaching method, 5E learning model approach, brainstorming technique, computer-assisted teaching, context-based learning, discovery learning method, learning by doing, experimental method and design-based learning approach

3.4. The Opinions of Primary School Teachers Who Carry out STEM-Based Practices in Early Algebra Teaching on the Applicability of STEM Education Approach in Early Algebra Teaching

Applicability Level of STEM Education Approach in Early Algebra Teaching

To the primary teachers who participated in the research, "What level do you think the applicability level of the STEM education approach is in early algebra teaching in the current system? From where?" questions were asked. In light of the answers given by the teachers participating in the research, the findings regarding the applicability of the STEM education approach in early algebra teaching are presented in Table 11.

Table 5.

Applicability Level of STEM Education Approach in Early Algebra Teaching

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Applicability Level of the STEM Education Approach in Early Algebra Teaching
Applicability	Insufficient	5	*"The applicable level is a bit difficult in the current system. I think it's not enough." T2*
	Difficult	5	
The dimension associated with the education system	Intensive curriculum	4	*"If you try to integrate into STEM, you can do it on your own. It is a little difficult to do activities for gains here. I think the source of our trouble is the gains." T3* *"If it were up to me, I would study all my lessons with the STEM approach, but the difficulties in raising the curriculum limit us a little." T5*
	Inappropriateness of the current system	2	
	Difficulty integrating STEM applications into learning outcomes	1	
	favorable physical conditions	1	
Knowledge and skill dimension	Teachers' lack of STEM practice skills	3	*"Besides, students have not been trained in this subject or the knowledge and skills on this subject do not have the readiness." T2* *"Of course, there has to be readiness. It's easier to put it on if it's ready. They learn more easily. Maybe they don't have any worries." T5*
	Students have no prior knowledge	3	
	Lack of prior knowledge of parents	2	
Attitudes dimension	Negative attitudes of teachers	3	*"There is also the fact that teachers do not volunteer and see this as a workload. They don't want to improve themselves. They do not have the knowledge and skills in the STEM field." T4*
	Negative attitudes of the school administration	2	
	Negative attitudes of parents	1	

When the findings regarding the applicability level of the STEM education approach in early algebra teaching are examined in Table 11, there are four themes of applicability, the dimension related to the education system, the dimension of knowledge and skills, and the dimension of attitudes. There are insufficient and difficult sub-themes under the theme of applicability. In the dimension related to the education system, there are sub-themes that the curriculum is dense, the current system is suitable, the integration of STEM applications into the learning outcomes is difficult, and the physical conditions are favorable. Teachers' lack of STEM application skills, students' lack of prior knowledge, and parents' lack of prior knowledge are the sub-themes within the scope of knowledge and skills. In the Attitudes dimension, there are sub-themes of negative attitudes of teachers, negative attitudes of school administration, and negative attitudes of parents.

Required Conditions for the Application of STEM Education Approach in Early Algebra Teaching

To the primary teachers who participated in the research, "What are the necessary conditions for the successful implementation of the STEM education approach in early algebra teaching? (Physical, social…)" was asked. In light of the answers given by the teachers participating in the research, the findings regarding the conditions required for the implementation of the STEM education approach in early algebra teaching are presented in Table 12.

Table 126.

Required Conditions in Application

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Necessary Conditions in the Application of STEM Education Approach in Early Algebra Teaching
Physical conditions	Class size	5	*"I think that STEM education corners can be prepared. So this class layout can be made into merging rows that break down accordingly. In other words, we are trying to implement it over the old order. We are working by pushing the conditions." T2 Class size must be appropriate. It is difficult in large classrooms. It is necessary to ensure the classroom order, to group the students, and to provide the appropriate environment for this." T4*
	Having STEM workshops	4	
	No shortage of material	4	
	Provision of technological equipment	3	
	Improvement of physical infrastructure	1	
	Ensuring adequate budget	1	
Attitudes	Positive attitudes of parents	4	*"Other than that, my work needs to be supported. Motivation needs to be internal motivation." T1*
	The supportive attitude of the school administration	3	
	Teachers' positive perspectives	3	*"At the same time, the parent needs to have the potential on this issue. They should contribute to the work we do." T3*
	Teacher motivation	2	
	Teachers are open to the development	2	
	Preliminary information on students and parents	2	*"The school administration should also offer support in this regard. You should not see your work as unnecessary." T5*
Content	Grade level compliance	4	*"Besides, the large number of classes and the intense curriculum is a major problem." T1*
	The curriculum is not intensive	3	

The conditions required for the execution of STEM-based applications in early algebra teaching were examined in three themes: physical conditions, attitudes, and content themes. Under the theme of physical conditions, there are sub-themes of low-class size, having STEM workshops, not experiencing material shortages, providing technological equipment, improving physical infrastructure, and providing an adequate budget. The theme of attitudes includes the sub-themes of positive attitudes of parents, supportive attitudes of school administration, the positive perspective of teachers, motivation of teachers, the openness of teachers to development, the openness of students and parents to development, and prior knowledge of students and parents. Compliance with the grade level and the lack of an intensive curriculum are sub-themes in the content theme.

3.5. The Opinions of Primary School Teachers Who Carry Out STEM-Based Practices in Early Algebra Teaching on the Problems and Suggestions Encountered in the Execution of STEM-Based Practices in Early Algebra Teaching

Advantages of Using STEM Educational Approach in Early Algebra Teaching

The primary school teachers who participated in the research were asked the question "Are there any advantages to including STEM-based applications while teaching early algebra?", "If you think there are advantages, can you explain them?". In light of the answers given by the teachers participating in the research, the findings regarding the advantages of applying the STEM education approach in early algebra teaching are presented in Table 13.

Table 137.

Advantages of the Application

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Necessity of STEM-Based Approaches in Early Algebra Teaching
Advantages	Gaining a positive attitude toward the mathematics lesson	5	*"For example, some children are afraid of math class. They are worried that I will not succeed. These apps make teaching so easy that they make it easier for children to learn even difficult subjects." T1*
	Providing fun learning environments	4	
	Making learning easier	4	
	Concretization	3	
	Contribution to the school-parent union	3	*"There may be parts that come easy, I can explain the difficult subjects more easily. Especially in mathematics classes, the averages are very low. Children perform lower in mathematics lessons than in other subjects. These studies cause students to love mathematics and science." T3*
	Increasing academic success	3	
	Reducing anxiety about math class	3	
	Enabling effective learning	2	
	Increasing student motivation	2	
	Increasing teacher motivation	2	*"Students already love STEM applications. They are very enthusiastic about events. Everyone wants to bring something. Of course, this affects their attitudes towards school positively." T5*
	Developing creativity	2	
	Making a positive contribution to career choice	1	

All of the teachers who participated in the research stated that there are advantages to applying the STEM education approach in early algebra teaching. The advantages of applying the STEM education approach in early algebra teaching were examined under a single theme, and under this theme, positive attitude towards the mathematics lesson, providing fun learning environments, facilitating learning, concretizing, contributing to parent-teacher unity, increasing academic success, reducing anxiety towards mathematics lesson, providing effective learning. There are sub-themes of increasing the motivation of the teacher and making a positive contribution to the choice of profession.

Problems Encountered in Executing STEM-Based Applications in Early Algebra Teaching

The primary teachers who participated in the research were asked the question "Did you experience any difficulties in the process of applying STEM-based applications while teaching algebra to your students?", "If you did, can you talk about these difficulties?". In light of the answers given by the teachers participating in the research, the findings regarding the problems encountered in the implementation of the STEM education approach in early algebra teaching are presented in Table 14.

Table 14.

The difficulties in the application

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on the Problems Encountered in the Implementation of STEM-Based Practices in Early Algebra Teaching
The difficulties	Lack of material	5	*"We do our work there. But of course, not every school has these opportunities. Of course, it is difficult to carry out these studies when these physical conditions are not met. In other words, there should be a tablet computer in the supply of materials and the use of technology." T1* *"There were problems in that group when a student from the group did not participate in the study or did not bring his material. Of course, we have a shortage of materials." T2"The problem for us is the density of the curriculum. For example, if the curriculum was not so intense, we could do more activities." T4"As the expectation of the parents is for more academic success, they may not give support. "T5*
	Large class size	5	
	Intensive curriculum	4	
	Lack of technological infrastructure	4	
	Lack of readiness of students	3	
	The negative attitude of school administration	2	
	Lack of physical infrastructure	2	
	Parent attitudes/expectations	1	

In Table 14, the problems encountered in the implementation of STEM-based applications in early algebra teaching are examined under a single theme, under this theme, the lack of materials, crowded classrooms, dense curriculum, insufficient technological infrastructure, lack of readiness of students, negative attitude of the school administration, lack of physical infrastructure and parent attitudes/expectations sub-themes.

Suggestions for Teachers and Administrators to Include STEM-Based Practices in Early Algebra Teaching

The *primary teacher*s were asked "Do you have any suggestions for teachers and administrators who will include STEM-based applications in early algebra teaching?" question was posed. In light of the answers given by the teachers participating in the research, the findings of the suggestions to the teachers and administrators regarding the implementation of the STEM education approach in early algebra teaching are presented in Table 15.

Table 158.

Suggestions to Teachers and Administrators

Themes	Sub-Themes	*f*	Example Statements from Teachers' Opinions on Suggestions to Teachers and Administrators in the Implementation of STEM-Based Practices in Early Algebra Teaching
Personal development dimension	Reviewing resources	4	*"The 21st century is a fast-moving time. We do not know what most of the future professions are and we are preparing this generation for those we do not know. Let them first open their horizons, develop themselves, change them." T3* *"I suggest they scan the available resources." T2*
	Conducting research	4	
	Reading articles, magazines	3	
	Watching educational videos	2	
	Improving yourself	2	
	Being innovative	1	
	Being creative	1	
Professional development dimension	Participating in in-service training	4	"They can do research, learn by reading articles from magazines." T1 "I recommend that they apply for in-service training provided by the national education and participate in online training." T2
	Get training from a STEM expert	3	
	Taking online training	2	
Application dimension	Making apps	3	*"By taking this training, they can both do activities and exercise, I recommend that teachers participate in such training and make practices." T4*
	Opening exercise	2	

In Table 15, there are three themes: personal development dimension, professional development dimension, and application dimension for suggestions to teachers and administrators who carry out STEM-based activities in early algebra teaching. Under the theme of personal development, there are sub-themes of examining resources, doing research, reading articles and magazines, watching educational videos, realizing oneself, and being innovative and creative. In the professional development dimension, there are sub-themes of participating in in-service training, receiving training from STEM specialists, and participating in online training. The sub-themes of making applications and opening exercises are the sub-themes within the scope of the application theme.

4. Discussion and Conclusion

This research was carried out to determine the opinions of primary teachers on the implementation of STEM-based applications in early algebra teaching. In this study, which was carried out using the phenomenology design in qualitative research designs, the opinions of the teachers participating in the research on the implementation of STEM-based applications in early algebra teaching were obtained using a semi-structured interview form prepared by the researcher, and expert opinion was taken. In the semi-structured interview form used as a data collection tool, five sub-problems and 14 open-ended questions were included under these sub-problems. The results obtained as a result of the answers given to the questions in the interview form by 5 primary school teachers working in public schools affiliated with the Ministry of National Education, who received STEM education, taught early algebra in their classes, and carried out applications for STEM education approach in early algebra teaching, were presented under sub-problem headings.

4.1. Discussion and Conclusion on the First Sub-Research Question

In this part of the study, the results obtained by discussing the findings obtained from the views of the teachers by asking "opinions of the primary teachers who carry out STEM-based practices in early algebra teaching on their competencies in the field of STEM" are included. According to the findings obtained for the first sub-problem: all of the teachers expressed STEM as an interdisciplinary approach covering the disciplines of Science, Technology, Engineering, and Mathematics. In addition, teachers expressed the STEM education approach as an integrated and process-based approach. Bybee (2010) defines STEM as a Science Technology-Engineering-Mathematics-STEM (Science, Technology, Engineering, Mathematics) approach, and states that the STEM education approach is an interdisciplinary holistic approach created by integrating Science and Mathematics disciplines with Technology and Engineering disciplines. has done. In the studies conducted by Ramli and Talib (2017) and Süldür (2019), teachers defined STEM as science, technology, engineering and mathematics. According to the findings, teachers expressed that the STEM education approach can be integrated with the art discipline. Belardo (2015) remarked that the STEAM education approach is a bridge that bridges the gap between science and art and stated that science and art are similar in many ways and that STEM can turn into STEAM by including art. Teachers highlighted that STEM is a design-based approach.

The teachers participating in the research indicated that engineering skills, technology use skills, 21st-century skills, problem-solving skills, design skills, communication skills, robotics, and coding skills are among the skills developed by the STEM education approach. MoNE (2016) emphasized that STEM education has an important place in gaining high-level skills such as 21st-century skills. In this context, the STEM education approach contributes to the development of skills such as problem-solving skills, critical thinking skills, cooperation and communication skills, and creativity skills (Liao, 2016; Şahin et al., 2014).

In terms of the competencies gained by the STEM education approach, our teachers used the expressions of creativity, innovation, productivity, and originality. Siew (Siew, 2018; Siew et al., 2015) noted that the STEM education approach should be adopted in raising innovative individuals who are open to innovations, have scientific curiosity, research, question, produce, and are innovative.

When the methods and techniques applied in the approach of STEM education are examined, and the most frequently used method is the project-based learning method. Cepni (2017) highlighted that one of the most common methods used in STEM education is the project-based learning method. This method, created within the framework of John Dewey's views, sees education as life itself and emphasizes that the individual should construct his knowledge. The STEM approach also includes similar approaches. In addition to the project-based learning method, the group work method, research-based learning approach, collaborative learning approach, and 5E learning model are among the methods and techniques applied in the STEM education approach. Bybee (Bybee, 1997) says that when the 5E learning model is used in STEM education, the student can focus on the subject, and explore the information by exploring, organizing, and learning deeply, that is, transfer to situations.

When we look at the origin of STEM, we see that there are real-life problems at the beginning of STEM, and STEM is expressed as the process of perceiving the world. Süldür (2019) also included similar statements on the "Determination of primary school teachers' views on STEM education". One of the main purposes of STEM education is to bring creative solutions to the problems faced by the individual in daily life (Thomasian, 2011).

Teachers who include STEM-based applications in early algebra teaching stated that they benefited from in-service training, STEM field experts, online training, and STEM training given within the university. MoNE (MoNE, 2016) STEM Action Plan includes in-service training activities for teachers to have a positive attitude toward STEM education and to have knowledge and skills on this subject. In this field, studies have been carried out by universities, private institutions, and R&D units of the Directorate of National Education (Aydeniz, 2017).

Teachers who carry out STEM-based activities mostly include studies on the disciplines of Science and Mathematics in their activities. In technology-based applications, studies in the field of robotic coding are used in STEM-based activities. Üçgül (2013) states that robot education applications will be implemented effectively in STEM education. Students working with robots work in integration with the STEM discipline, focusing on solving real-life problems. Barak & Assal (2018) explored that robots can be used with high motivation in interesting environments to provide a quality education in the field of STEM.

4.2. Discussion and Conclusion on the Second Sub-Research Question

In this part of the study, the results obtained by discussing the findings obtained from the opinions of the teachers by asking "the opinions of the primary teachers who carry out STEM-based practices in early algebra teaching on the content knowledge on early algebra" are included. According to the findings for the second sub-problem: all of the teachers see algebra as placeholders used instead of unknowns. According to Turgut (2016), algebra is the letter or various symbols used in place of unknowns in mathematics in the most general and simplest sense. In other words, it is putting forward an equation regarding the solution of the unknowns based on the knowns. The teachers involved in the research expressed algebra as patterns, symbols, geometry, formulas, equal signs, numbers, spatial relations, shapes, and length measures in the discipline of mathematics. According to Usiskin (1997), algebra is expressed as a mathematical language consisting of five components. These components are "unknowns, formulas, patterns, placeholders, and relations". Algebra focuses on the symbolic side of arithmetic, functions represented by symbols, and solving algebraic equations (Tabach & Friedlander, 2008). Sometimes it is perceived as a symbolic language and sometimes as a learning area within the curriculum.

Krieran (1991) describes early algebra as the transitional process between arithmetic and algebra. This period is also called the pre-algebraic period (Kieran & Chalouh, 1993). The teachers who participated in the research included the expressions of the early period and bonding while defining early algebra. In this context, early algebra acts as a bridge between algebra and arithmetic.

While the majority of the teachers participating in the research indicated the age and grade level at which children will be taught algebra, they expressed the age of 4 as the pre-school period and primary school 1st-grade level. One of the teachers highlighted that the preschool and 1st-grade levels are not suitable for learning algebra early and that algebra will be taught from the 4th grade because algebraic expressions will be more abstract, and the 4-7 age period is not yet ready for abstract thinking skills. In the Mathematics Curriculum published by the Ministry of National Education in 2015, as of the 2016-2017 academic year, there are sub-learning areas for the transition to algebra gradually starting from the 1st, 2nd, 3rd, and 4th grades of primary school. The aim is not to start algebra subjects, but only to contribute to the development of algebraic thinking in preparation for algebra subjects taught in upper grades (MoNE, 2015). Cia and Kunth (2005) argue that expressions of early algebra begin earlier than in middle school and high school. According to NCTM (2000), algebra teaching should be started earlier. Turgut (2016), at the 3rd and 5th-grade levels, students can be given general expressions by using boxes, letters, and symbols.

Early algebra NCTM (2000) defines it as recognizing patterns and relationships, understanding functions, using algebraic symbols, being able to show numerical relationships, using models, and analyzing the change in different situations. Participants in the research stated that early algebra should be taught with the subjects of patterns, spatial relations, geometric shapes, and numbers. In the 2015 Mathematics Curriculum of the MoNE, algebra teaching included concepts such as pattern, variable, and generalization.

Early algebra teaching can be started with the subject areas of patterns, spatial relations, geometric shapes, and numbers. According to Smith (2003), the concept of pattern forms the basis of relativistic thinking. Usiskin (1997) expressed algebra as a mathematical language and divided it into five elements. These five elements are "unknowns, formulas, patterns, placeholders, and relationships." NCTM (2000) highlighted that all of the concepts in algebra will be related to the generalization of patterns and relations between patterns and that this will form the essence of mathematics. Geometric shapes, on the other hand, are not specified as a subject area, but as expressions to be used instead of letters or symbols in displaying variables (Dede & Argün, 2003).

Teachers about the necessary conditions for performing STEM-based activities in early algebra teaching indicated that the classrooms must not be physically crowded, that the classroom layout is appropriate, that the infrastructure and technological equipment are sufficient, that a sufficient budget is provided, and that there is no shortage of materials. Sinan and Terzi (2021) found similar results in their study titled "The Opinions of STEM-Educated Teachers on STEM Teaching".

4.3. Discussion and Conclusion on the Third Sub-Research Question

In this part of the study, the results obtained by discussing the findings obtained from the views of the teachers by asking "the opinions of the primary teachers who carry out STEM-based practices in early algebra teaching on the integration of STEM education approach to early algebra" are included. According to the findings for the third sub-problem: all of the teachers stated that STEM-based applications can be included in early algebra teaching. While Morrison (2019) argues that in the approach of STEM education, the fields of Science, Technology, Engineering, and Mathematics should be integrated with one-to-one, Corlu et al. (2014) argues that at least two of these four disciplines can be carried out in an integrated manner. Early algebra is a learning area within the discipline of mathematics. Therefore, STEM is based on the discipline of mathematics and includes algebra in mathematics. Therefore, STEM can be integrated into early algebra.

In early algebra teaching, teachers carried out STEM-integrated activities in the subject areas of geometric shapes and objects, patterns, weighing, spatial relations, and measuring time. They noted that they used many methods and techniques, especially project-based learning methods, problem-based learning methods, inquiry-based teaching methods, and drama methods, to carry out these activities successfully. Sandal et al. (2018) explored that it would be necessary to use project-based and problem-based methods in classrooms where STEM education is applied. Kaleci and Çınar (2020), on the other hand, discussed that while carrying out STEM-based applications, most of them use cooperative learning and problem-based learning methods.

For STEM integration, STEM practitioners must offer different perspectives. In the integration process of the STEM education approach, approaches, and models such as project-based learning, problem-based learning, design-based learning, mastery learning, context-based learning, and the 5E learning model are used (National Research Council, 2014). Bybee (1997) noted that the use of the 5E learning model in STEM-based activities is beneficial for the student to understand the subject, discover the information, learn by researching and learning in-depth, and adapt the learned information to new situations.

4.4. Discussion and Conclusion on the Fourth Sub-Research Question

In this part of the study, the results obtained by discussing the findings obtained from the views of the teachers by asking "the opinions of the primary teachers who carry out STEM-based applications in early algebra teaching on the applicability of the STEM education approach in early algebra teaching" are included. According to the findings obtained for the fourth sub-problem: participant teachers find the applicability of the STEM education approach in early algebra teaching insufficient and difficult. Among the reasons for this are the reasons arising from the education system, the reasons arising from the knowledge and skills dimension, and the reasons arising from the attitude dimension. Some reasons such as the fact that the curriculum is too dense, especially in the 4th grade, and that the literacy process takes a long time in the 1st grade have been put forward due to the reasons included in the education dimension. In addition, the large size of the class causes the number of groups to increase in the studies to be carried out, and thus, the lack of suitable physical conditions. In addition, the place gains in the program do not exactly match the STEM-based activities to be implemented. It is possible to come across similar findings in different studies (Çiftçi & Çınar, 2017; Eroğlu & Bektaş, 2016).

The teachers who will carry out STEM-based activities do not receive adequate training in this field from the right people. Therefore, since the competencies of the teachers in this area are not at the desired level, problems arise in the application dimension. The teachers involved in the research stated that the students and parents did not have knowledge about the practices or they had the wrong information.

Participating teachers who carried out STEM-based activities indicated that their work was not supported by other teachers, and they even had negative attitudes about it. The feasibility of conducting such studies is low because school administrators do not provide the necessary convenience to teachers and exhibit negative attitudes. In addition, participant teachers stated that parents focus on academic success and do not support such activities, and exhibit negative attitudes. Within the framework of all these, it is concluded that the implementation of the STEM education approach in early algebra teaching is not at the desired level and is insufficient.

Teachers about the necessary conditions for performing STEM-based activities in early algebra teaching noted that the classrooms must not be physically crowded, that the classroom layout is appropriate, that the infrastructure and technological equipment are sufficient, that a sufficient budget is provided, and that there is no shortage of materials. Sinan and Terzi (2021) found similar results in their study titled "The Opinions of STEM-Educated Teachers on STEM Teaching".

Parents, school administration, and other teachers should approach the studies positively and constructively. At the same time, teachers should be highly motivated and open to innovation. Parents and students should have prior knowledge about these applications and students should come to the classes by doing research. In addition, they expressed their opinions about the simplicity of the curriculum and the reduction of the subjects, especially at the 4th-grade level.

4.5. Discussion and Conclusion on the Fifth Sub-Research Question

In this part of the study, the results were obtained by discussing the findings obtained from the opinions of the teachers by asking "the positive aspects and suggestions of the primary teachers who carry out STEM-based practices in early algebra teaching, of including STEM-based activities in early algebra teaching" are included. According to the findings obtained for the fifth sub-problem: including STEM-based activities in early algebra teaching causes the student to have a positive attitude towards mathematics lessons. These applications facilitate learning and offer fun learning environments. Teachers see mathematics as an abstract field and state that such practices embody the concepts of mathematics. Therefore, it reduced the anxiety of the students towards the mathematics lesson and provided effective and permanent learning, and as a result, the academic success of the student increased. It contributes positively to the career choice of students in the future. Çepni (2017) noted that STEM education contributes to the development of high-level skills such as 21st-century skills individuals. These skills appear in international assessment exams, in choosing a profession, and in many other branches. Integration of STEM into the curriculum is also extremely important in gaining 21st-century skills.

The teachers who participated in the study noted that they had the most material shortage while carrying out STEM-based activities in early algebra teaching. The overcrowded class size, the dense curriculum, and the insufficient technological infrastructure are among the difficulties faced by teachers while performing these practices. In addition, negative attitudes of schools, parents, and other teachers are among the problems that teachers face in practice. STEM requires cooperation between stakeholders in school culture (Basham et al., 2010). In STEM school culture, there should be a continuous exchange of knowledge and experience between administrators and teachers. In the study conducted by Park et al. (2017), the lack of materials, lack of time, lack of professional development, lack of parent participation, and negative attitudes of teachers in the implementation of STEM-based activities were indicated.

The teachers involved in this study made the following suggestions to teachers and administrators for the realization of such practices to support their personal development, the teachers suggested that they scan the sources, read articles and magazines by doing research, review the video content on this subject, and be innovative and creative individuals.

Participating teachers stated that to contribute to the professional development of teachers and administrators, they should attend in-service training and receive training from experts in their fields. Teachers need to receive STEM education. Teachers should be trained to gain knowledge, skills, and experience in line with the importance of STEM education (Wang et al., 2011). After this training, teachers can practice in their classrooms and even plan extracurricular exercises.

Ethical Declaration

In this study, all scientific ethical rules were followed.

Conflict Interest and Author Contributions

All stages of study were organized and conducted by Author. There is no conflict to interest.

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