www.ijres.net

Science Teachers' Views on the STEM Approach and their Levels of Integration of Technology, Engineering and Mathematics Disciplines into Science Education

Hanife Gamze Hastürk
Tokat Gaziosmanpaşa University, Turkiye

Yasemin Ünaldı
Tokat Gaziosmanpaşa University, Turkiye

To cite this article:

Hasturk, H.G. & Unaldi, Y. (2025). Science teachers' views on the STEM approach and their levels of integration of technology, engineering and mathematics disciplines into science education. *International Journal of Research in Education and Science (IJRES), 11*(3), 570-587. https://doi.org/10.46328/ijres.1310

IJRES International Journal of Research in Education and Science
2025, Vol. 11, No. 3, 570-587 https://doi.org/10.46328/ijres.1310

Science Teachers' Views on the STEM Approach and their Levels of Integration of Technology, Engineering and Mathematics Disciplines into Science Education

Hanife Gamze Hastürk, Yasemin Ünaldı

Article Info

Article History

Received:
27 January 2025
Accepted:
23 June 2025

Keywords

STEM education
Technology integration
Engineering integration
Mathematics integration
Science teachers

Abstract

When the revised and updated 2018 and 2024 science curricula are examined, it is seen that the integration of engineering, technology and mathematics disciplines into the teaching of science subjects is supported. The integration of these four disciplines is defined by the science-technology-engineering-mathematics (STEM or STEM) approach. As this approach has gained a foothold in schools, STEM education has become a topic of increasing focus. In order to provide STEM education in schools successfully, teachers' level of integration of STEM disciplines and their self-efficacy in this regard are important factors. In this sense, the aim of this study is to determine science teachers' views on their level of integrating STEM disciplines into science courses and their self-efficacy in this regard. The study group of research consists of 10 science teachers working in public schools in a provincial center located in the Eastern Anatolia region in the spring semester of 2022-2023. The study was designed in accordance with qualitative research methodology. Semi-structured interview technique was used as a data collection tool. In the interview, the participants were asked 10 open-ended questions developed by the researcher with expert opinion and audio recordings were taken during the interview. The voice recordings were analyzed and the data were analyzed, tables were created, categories were determined in the tables and teachers' opinions were expressed with codes. According to the findings, it was determined that science teachers correctly defined STEM, were able to associate STEM education with other disciplines, expressed their thoughts on integrating STEM disciplines into the science course, and expressed the problems they encountered or could encounter in STEM applications. Teachers mostly expressed the problems they encountered as insufficient materials, infrastructure problems, and insufficient teacher knowledge.

Introduction

Today, we see that science is changing rapidly, the need for technology is increasing and technology is changing rapidly in line with this need. Alternative teaching methods should be used to prepare today's students for this changing and developing world (Tantu, 2017). In addition, it has become imperative to implement a new education

program in order to raise individuals who have critical thinking skills in the fields of science, engineering, technology and mathematics and who can produce creative solutions to the problems they face (Yıldırım & Altun, 2015). Science, Technology, Mathematics and Engineering (STEM-STEM) education, which is a type of approach consisting of the integration of science, engineering, technology and mathematics disciplines in determining and meeting the needs of humanity, has been developed (Çorlu, 2014; Gülhan & Şahin, 2016). The origin of the concept of STEM dates back to the 1950s (Yıldırım, 2018). The STEM approach emerged in the United States of America, and it is aimed to connect STEM disciplines at all levels (Bybee, 2011; MEB, 2015). "STEM education takes its name from the first letters of the terms Science (science), Technology (technology), Engineering (engineering), Mathematics (mathematics)" (Dugger, 2010, p.4). "In Turkey, STEM education stands for STEM education, which stands for Science, Technology, Engineering and Mathematics disciplines" (Çorlu, 2014, p.4). There are many definitions of STEM (Dugger, 2010; Thomas, 2014). In our country, STEM education appears in daily life in three dimensions. These dimensions can be stated as popularity, being supported by policy makers, and being included in the curriculum with the educational aspect. Among these, the most common one is the popular aspect (Aşık, Doğança Küçük, Helvacı, & Corlu, 2017).

The important approach of STEM integration is the integration of science with mathematics, engineering and technology disciplines (Dugger, 2010). It is seen that considering science, technology, mathematics and engineering disciplines as a whole has a positive effect on students' choice of the right profession (Baran, Canbazoğlu Bilici, Mesutoğlu, 2015; Biçer et al, 2015; Gencer, 2015; Guzey, Harwell, & Moore, 2014; Yıldırım & Selvi, 2017). Technology and engineering disciplines are used in many fields around the world and respond to the needs and expectations of all humanity and produce solutions to the problems they face in daily life (NRC, 2012). "Engineering and technology applications are also said to support science teaching" (Czerniak, 2007; Czerniak, 2007; NGSS, 2014; Ceylan, 2014; Özlüleci& Kayacan, 2023; Yıldırım, 2016a; Çiftçi, 2018, p.2). These two disciplinary fields also have an important place in the economic development of countries (Roberts, 2012). The important approach of STEM integration is the integration of science with mathematics, engineering and technology disciplines (Dugger, 2010). It is seen that considering science, technology, mathematics and engineering disciplines as a whole has a positive effect on students' choice of the right profession (Baran, Canbazoğlu Bilici, Mesutoğlu, 2015; Biçer et al, 2015; Gencer, 2015; Guzey, Harwell, & Moore, 2014; Yıldırım & Selvi, 2017). Technology and engineering disciplines are used in many fields around the world and respond to the needs and expectations of all humanity and produce solutions to the problems they face in daily life (NRC, 2012). "Engineering and technology applications are also said to support science teaching" (Altan, 2018, 2019; Czerniak, 2007; Czerniak, 2007; NGSS, 2014; Ceylan, 2014; Yıldırım, 2016a; Çiftçi, 2018, p.2). These two disciplinary fields also have an important place in the economic development of countries (Roberts, 2012).

In Turkey, has started to give importance to STEM education in order to create a competitive environment in economy and technology with different countries. STEM education is strategically important in international competitiveness (Corlu, Capraro, & Capraro, 2014). The reason why STEM approach is important is that it provides benefits in many educational fields. According to Thomas (2014), "the main purpose of this educational approach is to provide students with 21st century skills" (p.368). "In STEM approach, students can easily learn 21st century skills such as communication skills, problem solving skills, self-control and systematic work, and

they can produce better solutions to current problems (Bybee, 2010). It is also stated that it will be effective in raising entrepreneurial and productive individuals and supporting their innovative thinking (MoNE, 2015). Many reasons such as achieving success in exams such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) (OECD, 2010; Yıldırım, 2016b); making progress in science and technology (Öner & Capraro, 2016; Aydeniz, 2017); contributing to economic developments (Bybee, 2010; Veenstra, Padro, & Furst-Bowe, 2012) etc. have led countries to STEM. However, according to the results of international exams, it was revealed that students had difficulty in using what they learned in daily life and outside of daily life (Buyruk and Korkmaz 2016, Gürler and Önder 2014, MoNE 2016b).

It is important that teachers, who are one of the prominent people in the STEM education approach, should be experienced and improve themselves (Wang, 2012). In order to realize the goals, there is a need for teachers who have sufficient knowledge in STEM integration and teach their lessons in line with this information (Akgündüz, Ertepınar, Ger, Kaplan Sayı, & Türk, 2015). According to the study conducted by Şahin (2019), it was seen that the STEM application competencies of teachers who did not receive STEM education were not at a sufficient level. In some studies, teachers stated that they did not find themselves sufficient in the integration of technology and mathematics (Yıldırım, 2017). The reason for this is that prospective teachers are not given the necessary level of education in the fields of engineering and technology in faculties of education (Yıldırım, 2018). Cuijck, Keulen, and Jochems (2009), in their study with 19 teachers, stated that the majority of teachers stated that MTTFE should be used in science education, but that they lacked self-efficacy. Hsu, Purzer, and Cardella (2011) found that teachers think that engineering and technology are important, but teachers do not have enough knowledge and are not competent in teaching. Bakırcı and Kutlu (2018) emphasized that the STEM views of teachers and prospective teachers are important in order to provide students with many skills such as leadership, entrepreneurship, and technology literacy.

The problem statement of the study was determined as 'What are the views of science teachers on STEM approach and their level of integrating technology, engineering and mathematics disciplines into science education? The sub-problems determined according to the problem statement are given below:

- What are science teachers' views on the definition of STEM (STEM) education?
- What are science teachers' views on integrating i) technology ii) engineering iii) mathematics into science education?
- What are the problems they face in terms of the use of i) technology ii) engineering iii) mathematics disciplines during STEM applications?

Method

Research Methodology

Qualitative research method was used to reveal the knowledge status of STEM-trained science teachers about STEM and their level of integrating technology, engineering and mathematics disciplines into science teaching. Qualitative research method is a study in which qualitative data collection methods such as interviews and observations are used to reveal the events realistically and holistically (Yıldırım & Şimşek, 2011).

Study Group

This study consists of 10 science teachers working in public schools in a city center in Eastern Anatolia in the second semester of the 2022-2023 academic year. Participants were tried to be selected with a balanced distribution in terms of gender. In addition, the participants were as diverse as possible in terms of professional experience. Purposive (non-probability) sampling method technique was used for the teachers.

Demographic characteristics of the teachers such as gender, education level, years of professional experience and STEM education status are given in Table 1. 10 science teachers were coded as T1,T2,T3,.....,T10 in the tables.

Table 1. Demographic Characteristics of Teachers

Teacher Code	Gender	Educational Status	Stem Education	Professional experience
T1	Male	Undergraduate	educated	11-15 Years
T2	Female	Master's degree	educated	11-15 Years
T3	Female	Master's degree	educated	16-25 Years
T4	Female	Undergraduate	not trained	6-10 Years
T5	Female	Master's degree	educated	6-10 Years
T6	Female	Undergraduate	educated	11-15 Years
T7	Male	PhD	not trained	11-15 Years
T8	Male	Undergraduate	not trained	6-10 Years
T9	Male	Undergraduate	not trained	11-15 Years
T10	Female	Undergraduate	not trained	6-10 Years

According to Table 1, teachers' years of experience varied between 6-25 years. Teachers consisted of 6 women and 4 men. While 7 teachers have bachelor's degree, 2 teachers have master's degree and 1 teacher has a doctorate degree. Five of the teachers received STEM education and five of them did not receive STEM education.

Data Collection Tool

In the study, a semi-structured interview form developed by the researcher was used as a data collection tool. The first 12 questions were determined by the researcher and these questions were reduced to 10 questions by taking the opinions of expert educators (2 field experts, 1 measurement and evaluation expert). In line with the aims of the study, the literature was reviewed and items were determined to determine the views of teachers on STEM education. In the form consisting of open-ended questions, information was obtained about teachers' STEM knowledge levels and their level of integrating technology, engineering and mathematics disciplines into science education. The interview questions are given below:

1. What do you think STEM (STEM) education means?
2. What are the trainings you have received on STEM approach?
3. What are your thoughts on the use of STEM approach in science lessons?

4. What do you think about integrating technology into science teaching?
5. What do you think about integrating engineering into science teaching?
6. What do you think about integrating mathematics into science teaching?
7. How is your competence in integrating STEM disciplines into your lessons? Why?
8. What are the problems you face in terms of the use of technology discipline during STEM practices?
9. What are the problems you face in terms of the use of engineering discipline during STEM practices?
10. What are the problems you encounter in terms of the use of mathematics discipline during STEM applications?

Data Collection

The interview form developed by the researcher and the expert was applied to 10 science teachers working in schools affiliated to the Ministry of National Education. Interviews with the participant teachers were conducted by determining appropriate dates and times. Each teacher was interviewed for approximately 15 minutes and no guidance or influence was given to the teachers throughout the process and an environment where they could feel comfortable was created. The interview questions were directed to each participant with the same words. This phase continued for approximately 40 days. The interviews were recorded with a voice recorder with the consent of the participant teachers.

Data Analysis

In this study, semi-structured interview technique was used as data collection method. Initially, 12 questions were determined by the researcher. These questions were reduced to 10 questions by consulting the opinions of expert science educators (2 field experts, 1 measurement and evaluation expert). The final version of the semi-structured interview questions was examined by the expert educator. Before starting the data analysis, the interview records were transcribed and the written texts were read several times. In the data analysis, teachers' knowledge about STEM, their level of integration of technology, engineering and mathematics disciplines into science teaching, and the difficulties they experienced in implementation were examined.

According to Yıldırım and Şimşek's (2006) content analysis, codes such as T1, T2, ... were used to identify the participants' answers and teachers instead of their real names. T10 were used instead of their real names. Coder reliability in terms of coding was calculated with the formula [(Agreement/Agreement + Disagreement)*100] (Miles & Huberman, 1994). As a result of the analyses conducted by the researcher and the expert, the reliability coefficient was calculated as 0.82. Therefore, it was concluded that the content analysis data were reliable (Yıldırım & Şimşek, 2006).

Findings

Defining STEM Education

Participants' definitions of STEM education are presented in Table 2.

Table 2. Science teachers' Definitions of STEM Education

Category	Teacher Code	n
STEM definitions		
Bringing STEM disciplines Together	T1, T2, T3, T5, T6,7,8,9,10	9
Product creation	T4,T5, T9	3
Project-based learning	T8	1
Adaptation to daily life	T10	1

When Table 2. is examined, science teachers' definitions of STEM education are seen. Accordingly, teachers defined STEM education as 'STEM education is an educational approach in which science, technology, engineering and mathematics are presented to students together'. The teachers who mentioned the product creation aspect of STEM defined it as 'STEM education is the use of science, mathematics, engineering and technology together to create a work of art'. When the table is analyzed, similarities were found in the STEM definitions of teachers who received STEM education and teachers who did not receive STEM education.

Using the STEM Approach

The opinions of science teachers on the use of STEM approach in science courses are presented in Table 3.

Table 3. Science Teachers' Opinions on the Use of STEM Approach in Science Courses

Category	Teacher Code	n
Using the STEM Approach		
Developing creative thinking skills	T3	1
Developing problem solving skills	T3	1
Adaptation to daily life	T1, T5, T9	3
Providing learning by doing and experiencing	T6, T8	2
Positive attitude and academic success	T7, T10	2
Developing scientific process skills	T10	1
Converting abstract information into concrete	T4, T10	2

When Table 3. is examined, the opinions of science teachers on the use of STEM approach are given. According to this, teachers expressed the biggest advantage of STEM approach as 'Adaptation to daily life'. Among the teachers, T6 and T8 stated that 'It provides learning by doing-living', T7 and T10 stated that 'Students develop positive attitudes and contribute to student academic achievement', and T4 and T10 stated that 'It transforms abstract information into concrete'. When the teacher responses were analyzed, similarities were found in the opinions of teachers who received STEM education and teachers who did not receive STEM education.

Technology Integration

The opinions of science teachers about technology integration into the science curriculum are presented in Table 4. When Table 4. is examined, the opinions of science teachers about the integration of technology into the science curriculum are given. According to this, the majority of the teachers expressed the integration of technology into science as 'gaining 21st century skills'. Some of the teachers expressed it as 'Making learning concrete', 'Facilitating understanding' and 'Using different web tools'. When the table is analyzed, it is determined that although a few teachers who have not received STEM education and a few teachers who have received STEM education give different answers, they have similar opinions in general analysis.

Table 4. Science Teachers' Opinions on Technology Integration into the Science Curriculum

Category	Teacher Code	n
Technology Integration		
Attracting interest	T1	1
Providing learning by doing and experiencing	T3	1
To be able to perform potentially harmful experiments	T3	1
Providing ease of assessment and evaluation	T3	1
Making learning concrete	T1, T6	2
Gaining 21st century skills	T6, T7, T8	3
Providing the opportunity to conduct scientific studies	T10	1
Facilitating understanding	T4, T6	2
Ability to use different web tools	T3, T7	2

Engineering Integration

The opinions of science teachers about the integration of engineering into the science curriculum are presented in Table 5.

Table 5. Science Teachers' Opinions on the Integration of Engineering into the Science Curriculum

Category	Teacher Code	n
Engineering Integration		
Adaptation to daily life	T2	1
Facilitating understanding	T2	1
Product creation	T4	1
Engineering skill development	T4, T7	2
Providing creative thinking skills	T6, T7, T10	3
Developing problem solving skills	T7, T10	2
Supporting sustainable development	T7	1
Combining the discipline of mathematics and nature	T7	1
Developing aesthetic thinking skills	T6	1

When Table 5. is examined, the opinions of science teachers about the integration of engineering into the science curriculum are given. According to this, the majority of the teachers expressed the integration of engineering into science as 'Developing creative thinking skills'. Some of the teachers expressed it as 'Developing engineering skills' and 'Developing problem solving skills'. When the table was analyzed, it was determined that teachers who received STEM education and teachers who did not receive STEM education made similar statements.

Math Integration

The opinions of science teachers about the integration of mathematics into the science curriculum are presented in Table 6.

Table 6. Science Teachers' Opinions on the Integration of Mathematics into the Science Curriculum

Category	Teacher Code	n
Math Integration		
Not understanding science without mathematics	T1, T2, T4, T6, T7, T9	6
Having math calculations in science class	T3, T4, T8, T10	4
Cooperative work	T5	1
Working in coordination	T5	1
Mathematics should not be excluded from science	T2, T3, T6, T8	4

When Table 6. is examined, the opinions of science teachers about the integration of mathematics into the science curriculum are given. According to this, the majority of the teachers expressed the integration of mathematics into science as 'Not understanding the science course without mathematics'. Some of the teachers expressed it as 'Having mathematical calculations in science' and 'Not removing mathematics from science'. When the table is analyzed, it is determined that teachers who received STEM education and teachers who did not receive STEM education made similar statements.

Technology Integration Problems

The opinions of science teachers about the problems they face or may face in terms of the use of technology discipline during STEM applications are presented in Table 7.

Table 7. Science Teachers' Opinions about the Problems They Face or May Face in Terms of the Use of Technology Discipline during STEM Applications

Category	Teacher Code	n
Technology Integration Problems		
Lack of materials	T1, T5, T7, T9, T10	5
Limited class hours	T1, T9	2
Economic inefficiency	T2, T3	2

Category	Teacher Code	n
Difficulty understanding technology	T6	1
High number of students	T7	1
Lack of student readiness	T8	1
Lack of information	T8	1
Inadequate infrastructure	T9	1
Internet problem	T4, T10	2

When Table 7. is examined, the opinions of science teachers about the problems they encounter or may encounter in terms of the use of technology discipline during STEM applications are given. Accordingly, the majority of the teachers stated the problem they faced in terms of using technology discipline as 'Lack of materials'. Some of the teachers stated 'limited class hours', 'economic insufficiency' and 'internet problem'. When the table is examined, it is determined that although a few teachers who did not receive STEM education made different statements, they made similar statements with the teachers who received STEM education.

Engineering Integration Problems

The opinions of science teachers about the problems they face or may face in terms of the use of engineering discipline during STEM applications are presented in Table 8. When Table 8. is examined, the opinions of science teachers about the problems they encounter or may encounter in terms of the use of engineering discipline during STEM applications are given. Accordingly, the majority of the teachers expressed the problem they faced in terms of using engineering discipline as 'Not being able to create a product'. Some of the teachers stated that 'Time limitation', 'Weakness of imagination', 'Lack of knowledge', 'Technological inadequacy' and 'Lack of equipment'. When the table is examined, it is determined that although teachers who did not receive STEM education generally made different statements, they also had similar statements with teachers who received STEM education.

Table 8. Science Teachers' Opinions about the Problems They Have Encountered or May Encounter in terms of the Use of Engineering Discipline during STEM Applications

Category	Teacher Code	n
Engineering Integration Problems		
Time constraints	T1, T2	2
Limited class hours	T1	1
Poor imagination	T2, T6	2
Lack of information	T3, T8	2
Technological inadequacy	T5, T7	2
Lack of hardware	T5, T6	2
Prejudices	T7	1
Failure to create a product	T4, T9, T10	3

Mathematics Integration Problems

The opinions of science teachers about the problems they encounter or may encounter in terms of the use of mathematics discipline during STEM applications are presented in Table 9.

Table 9. Science Teachers' Opinions About the Problems They Have Encountered or May Encounter in Terms of the Use of Mathematics Discipline during STEM Applications

Category	Teacher Code	n
Math Integration Problems		
Math deficiency	T1, T4, T5, T7, T8, T10	6
Prejudgment	T2, T3, T9	3
Courses are not taught in parallel	T7	1

When Table 9. is examined, the opinions of science teachers about the problems they face or may face in terms of the use of mathematics discipline during STEM applications are given. According to this, the majority of the teachers expressed the problem they faced in terms of using mathematics discipline as 'lack of mathematics'. Some of the teachers expressed it as 'prejudice'. When the table was analyzed, it was determined that teachers who received STEM education and teachers who did not receive STEM education made similar statements.

Discussion

The aim of this study is to determine science teachers' views on STEM approach and their level of integrating technology, engineering and mathematics disciplines into science education.

In the first problem of the study, teachers' definitions of STEM were examined. The teachers generally defined STEM as the combination of science, mathematics, engineering and technology disciplines. In a similar study by Eroğlu and Bektaş (2016), when teachers were asked to define the STEM approach, it was seen that teachers defined the STEM approach using at least one of the concepts of science, engineering, mathematics and technology. Aslan-Tutak et al. (2017) stated that teachers defined STEM as an approach in which different fields are taught together or taught in an integrated way. Sarı and Yazıcı (2019) found in their study that teachers defined the science course as an approach that integrates engineering and other different disciplines.

The majority of the teachers defined STEM as the emergence of a product by blending disciplines. Students can create different products by developing creative thinking skills, problem solving skills and different perspectives through disciplines. Science teachers who have received STEM education state that STEM-based courses are effective in the development of students' creative thinking skills (Eroğlu & Bektaş, 2016). When students encounter any problem, the learning process starts for them, they reach the solution of the problem with their own knowledge and show their abilities (Şenocak & Taşkesengil, 2005).

When the results were examined, it was determined that they were compatible with the literature (Çorlu, 2014;

Gülhan & Şahin, 2016; Dugger, 2010). For example, T1, T5, T7 answered that STEM education is an educational approach in which science, technology, engineering and mathematics are presented to students together. Although the answers of teachers who received STEM education and teachers who did not receive STEM education were similar to each other, it was seen that teachers who received STEM education made more detailed and regular definitions.

In the second problem of the study, when their opinions on the use of STEM approach in science lessons were examined, teachers stated that STEM approach develops creative thinking skills, develops problem solving skills, learns by doing and experiencing, adapts to daily life, contributes to achievement development, transforms abstract knowledge into concrete and develops scientific process skills. In a similar study by MoNE (2016), it is emphasized that STEM education transforms the abstract information processed in theory into concrete and produces products with creative thinking. Deveci (2018) stated that creative thinking skills are high in students in classes where STEM approach is applied. Bybee (2013) emphasized that the programmatic progress and encouragement of STEM education contributes to the development of creative skills in students.

Some of the teachers stated that the use of STEM approach in science courses increased students' interest in the course and had a positive effect on their achievement. In his study with pre-service science teachers, Belek (2018) concluded that STEM activities positively affect students' interest in science courses. In a similar study, it was stated that creating an environment that attracts the student's interest and motivates the student is of great importance in the use of STEM integration (Moore et al. 2014). Juškevičienė et al. (2021) stated that adding STEM disciplines to the education program to develop creative thinking skills will have a positive effect.

These findings are in parallel with some studies in the literature. For example, Eroğlu and Bektaş (2016) found that science teachers integrated other disciplines into their lessons. Similarly, Şenocak and Taşkesengil (2005) stated that students start learning when they see the problem and reach the solution on their own. In addition, Deveci (2018) concluded that the creative thinking skills of students in classes where STEM activities are included are high. As a result of the research, T1, T3, T4, and T5 stated that the use of STEM approach in science lessons had a positive effect on students' wide-ranging and forward-looking thinking, making abstract knowledge concrete, and revealing new products.

In the third problem of the research, when the opinions of science teachers about the integration of technology into the science curriculum were examined, they stated that it provides opportunities to attract interest, to learn by doing and experiencing, to perform experiments that are not possible to do, to provide ease of measurement and evaluation, to gain 21st century skills, and to facilitate understanding by making learning concrete. These findings are in parallel with some studies in literature. For example, Birişçi, Coşkun, and Metin (2013) stated that technology integration positively affected the education system. As a result of the research, T1, T3, T4, T5 emphasized that technology integration in science course has positive effects in many areas such as raising students as science literate individuals and concretizing abstract experiments.

In the fourth problem of the research, when the opinions of science teachers about the integration of engineering

into the science curriculum were examined, they stated that developing engineering skills in students, adapting to daily life with creative thinking skills, facilitating understanding, creating products and contributing to sustainable development. Hacıoğlu, Yamak, Kavak (2016) investigated the views of 58 physics, chemistry, biology and science teachers on the use of engineering disciplines in science courses. As a result of the study, it was revealed that although teachers expressed some negative opinions about engineering integration, the majority of them had positive opinions. Sarı and Yazıcı (2019) revealed in their study that teachers were able to associate engineering discipline with science course. Brunsel (2012) mentioned that engineering discipline should be added to other disciplines. Capobianco and Rupp (2014) found that teachers were successful in integrating engineering discipline into their lessons.

Some teachers said that engineering is a different field but when combined with science, a different approach emerges. Dym et al. (2005) found that students' transfer of engineering skills in the process encourages STEM learning. Teachers said that this discipline should be integrated into the science course for students to gain engineering skills. In a similar study, Yıldırım (2017) emphasized that in order to gain engineering skills, students should actively participate in the science course and learn by doing and experiencing.

These findings are in line with some studies in literature. For example, Dare et al. (2014) stated that teachers integrate engineering discipline into their lessons more than other disciplines because they can easily associate the subject with daily life, engineering discipline improves students' problem solving skills and provides many positive contributions. As a result of the research, a few teachers who received STEM education stated that engineering discipline is a separate field, but it has a positive effect on the integration of science into the science course. A few teachers who did not receive STEM education stated that engineering is the basis of science and has an important place in gaining creative thinking skills and designing products.

In the fifth problem of the research, when the thoughts of science teachers about the integration of mathematics into the science curriculum were examined, they stated that it contributed to collaborative and coordinated work. As a result of the study, some of our teachers with and without STEM education also stated that they lacked knowledge about mathematics. Kim et al. (2015), in his study with pre-service teachers, found that pre-service teachers used mathematics discipline less when preparing lesson plans, and said that this was due to their lack of knowledge in mathematics. They also said that they could not explain the science lesson without mathematics and that their students would not understand it. These findings are in line with some studies in the literature. For example, Judson and Sawada (2000) reported that the integration of mathematics discipline into the science curriculum had a positive effect on student achievement. As a result of the study, all teachers stated that science would not be possible and understood without mathematics, but it was emphasized that after learning mathematics, science should move on to numerical subjects.

In the sixth problem of the research, when their thoughts about the problems they encountered or could encounter in terms of the use of technology discipline during STEM applications were examined, they stated that there were basic reasons such as lack of materials, limited class hours, economic inadequacy, large class size, lack of knowledge and infrastructure, and lack of student readiness. In Yıldız's (2021) study, teachers stated that

overcrowded class sizes and inadequate classroom management would cause problems. In their study, Eroğlu and Bektaş (2016) revealed that teachers' limited time for STEM application, lack of materials, and lack of subject mastery caused problems. In Dadacan's (2021) study, teachers stated that if there is a school with the technology and materials required for STEM teaching, they can do a good activity. These findings are in line with some studies in literature. For example, Siew, Amir, and Chong (2015) conducted a study with teachers and pre-service teachers and found that similar to this study, teachers faced many problems such as limited time, economic inadequacy, and lack of STEM knowledge of teachers. Similar results were found in some studies in the literature (Baran et al., 2015; Yılmaz & Pekbay, 2017). As a result of the research, T1, T2, T9, T10 emphasized that they faced problems such as insufficient technology and infrastructure and lack of materials.

In the seventh problem of the research, when their thoughts about the problems they encountered or could encounter in terms of the use of engineering discipline during STEM applications were examined, they mentioned that time, physical conditions, imagination, knowledge and technology were insufficient. They also stated that students have prejudices. Alagöz and Sözen (2021), in their study, expressed the disadvantages as insufficient materials, time constraints and crowded class sizes, and added that it became difficult to practice due to these problems. Karslı Baydere et al. (2021), on the other hand, revealed in their study that lack of material, limited time and inability to go down to the student level caused problems in gaining engineering skills. In a similar study, Kurtuluş et al. (2017) also mentioned problems such as time constraints, high number of students, and differences in perspective. As a result of the research, S3, S5, S7 emphasized that the society is prejudiced, the material is lacking, the student imagination is weak and these problems arise.

In the eighth problem of the research, when their thoughts about the problems they encountered or could encounter in terms of the use of mathematics discipline during STEM applications were examined, they mentioned the lack of mathematics in students, the lack of parallel teaching of the lessons and the prejudice problems in students. In the research, T2, T4, T5, T7 emphasized that students' lack of mathematical knowledge and lack of interest in mathematics caused problems. Teachers said that it would take time to create a suitable education system and a suitable environment for STEM education. It was determined that the study of Nadelson et al. (2013) was similar to this study

Conclusions

As a result of the research, the results obtained for the main problem and sub-problems of the study are as follows: As a result of the research;

1. Teachers defined the STEM approach as an approach in which science, technology, mathematics and engineering are blended and presented to students, they can create products by using various materials and they can use the information they learn in daily life. It was determined that the STEM definitions of teachers who did not receive STEM education and teachers who received STEM education were similar.
2. It was determined that the implementation and use of STEM education in science lessons had a positive effect. It was determined that teachers who received STEM education and teachers who did not receive STEM education were similar in the sense that STEM approach should be used in science lessons.

3. It was determined that the integration of technology into the science course had a positive effect. It was determined that teachers who received STEM education and teachers who did not receive STEM education gave similar answers in the direction of integrating the technology discipline into the science course in order to benefit from the beneficial aspects of technology.
4. It was determined that integrating engineering into the science course had a positive effect on practice and learning. It was determined that teachers who received STEM education and teachers who did not receive STEM education gave similar answers.
5. It was determined that the integration of mathematics discipline into the science course had a positive effect, but there was a lack of mathematical knowledge. It was seen that teachers with and without STEM education gave similar answers.
6. In the integration of technology discipline into the science course, it was determined that reasons such as lack of materials, limited courses, insufficient student financial status, high class size, lack of infrastructure caused problems and these problems negatively affected the course. It was determined that teachers who received STEM education and teachers who did not receive STEM education gave similar answers.
7. In the integration of engineering discipline into the science course, it was determined that reasons such as limited physical conditions and time, weak student imagination, lack of knowledge, lack of materials caused problems and these problems negatively affected the course. It was determined that teachers with and without STEM education gave similar answers.
8. It was determined that reasons such as lack of mathematical knowledge and prejudiced approach caused problems in the integration of mathematics discipline into the science course and that these problems negatively affected the course. It was determined that teachers with and without STEM education gave similar answers.

Recommendations

In the light of the results obtained in the study, the following suggestions were made.
The study was limited to 10 science teachers. It may be recommended to keep the sample group larger for similar studies.
The study was limited to science teachers. It may be recommended to conduct a study with different branch teachers.
Teachers who are STEM education practitioners should be given more trainings such as seminars and application studies to inform them about STEM.
The study was conducted with qualitative research method. It may be recommended to conduct similar studies with quantitative research method.
It may be recommended to provide different web tools in technology and to correct the lack of infrastructure.
It can be suggested to eliminate the lack of materials in schools.
Reducing class size and increasing class hours can be recommended.

Notes

Ethics Committee Approval: Permission for the research was obtained from Tokat Gaziosmanpaşa University

Social and Human Sciences Research Ethics Committee on 12.01.2023 with decision number 242687.

Contribution of the Researchers: In this study, both authors contributed equally to all stages of the research.

Conflict Statement: There is no conflict of interest between the authors in this study.

This paper was prepared from the second author's master's thesis under the consultancy of the first author.

References

Altan, E. B., Ozturk, N., & Turkoglu, A. Y. (2018). Socio-scientific issues as a context for STEM education: A case study research with pre-service science teachers. *European Journal of Educational Research*, *7*(4), 805-812.

Altan, E. B., Üçüncüoglu, I., & Öztürk, N. (2019). Preparation of Out-of-School Learning Environment Based on Science, Technology, Engineering, and Mathematics Education and Investigating Its Effects. *Science Education International*, *30*(2), 138-148.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, Bület, Çorlu, M. S., & Öner, T. (2015). *STEM education Turkey report: "Today's fashion or necessity?"* İstanbul Aydın University, İstanbul.

Alagöz, S., & Sözen, E. (2021). Classroom teachers' views on STEM education. *Third Sector Social Economic Review*, *56*(2), 1245-1266.

Aslan-Tutak, F., Akaygün, S., & Tezsezen, S. (2017). Collaborative STEM (Science, Technology, Engineering, Mathematics) education practice: Investigation of chemistry and mathematics pre-service teachers' STEM awareness. *Hacettepe University Journal of Faculty of Education, 32*(4), 794-816.

Aydeniz, M. (2017). Our Education System and Our 21st Century Dream: A STEM-Focused Economic Roadmap for Turkey as We Move Towards 2045 Goals. *Tennessee University, USA.*

Bakırcı, H., & Kutlu, E. (2018). Determination of science teachers' views on STEM approach. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *9*(2), 367-389.

Baran, E., Canbazoğlu-Bilici, S., & Mesutoğlu, C. (2015). Science, technology, engineering and mathematics (STEM) spot development activity. *Journal of Inquiry Based Activities, 5*(2), 60-69.

Barnett, M., Connolly, K. G., Jarvin, L., Marulcu, I., Rogers, C., Wendell, K. B., & Wright, C. G. (2008). Science through LEGO engineering design a people mover: *simple machines.*

Baydere, F. K., Çakır Ç. Ş., Hacıoğlu, Y., & Kocaman, K. (2021). Graduate students' views on STEM education: Two university examples. *Trakya Education Journal*, *11*(2), 568-587.

Belek, F. (2018) *Investigation of the Effect of STEM Activities on Pre-Service Science Teachers' Self-Efficacy Beliefs, STEM Education Approach and Their Thoughts on Science Teaching. Master's Thesis, Çanakkale Onsekiz Mart University, Çanakkale*

Biçer, A., Boedeker, P., Capraro, R., & Capraro, M. (2015). The effects of STEM PBL on students' mathematical and scientific vocabulary knowledge. *International Journal of Contemporary Educational Research*, *2*(2), 69-75.

Brunsell, E. (Ed.). (2012). Integrating engineering and science in your classroom. *NSTA press.*

Buyruk, B. & Korkmaz, Ö. (2016). STEM awareness levels of pre-service teachers. Participatory Education Research, *4* (1), 272-279.

Bybee, RW (2010). What is STEM education? Science, *329* (5995), 996-996.

Bybee, RW (2011). Scientific and engineering practices in K-12 classrooms. *Science Teacher*, *78* (9), 34-40.

Bybee, R. W. (2013). The case for STEM education: *Challenges and opportunities.*

Capobianco, B. M, Rupp M, (2014). STEM Teachers' Planned and Enacted Attempts at Implementing Engineering Design-Based Instruction, *School Science and Mathematics, 114*(6), 258–270

Ceylan, S. (2014). *A study to prepare an instructional design with science, technology, engineering and mathematics (STEM) approach on acids and bases in middle school science subjects. Unpublished Master's thesis. Bursa Uludag University Institute of Educational Sciences*, Bursa.

Çiftçi, M. (2018). *The effect of the developed STEM activities on the scientific level in middle schools, their understanding of STEM disciplines and differentiating STEM professions.* Unpublished Master's Thesis, Recep Tayyip Erdoğan University Institute of Science and Technology*,* Rize.

Çorlu, MS (2014). STEM education article call letter. *Turkish Journal of Education*, *3* (1), 4-10.

Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). STEM education and its reflections on field teacher education. *Education and Science*, *39*(171).

Dadacan, G. (2021). *Investigation of Prospective Teachers' Self-Efficacy Awareness and Orientations Related to STEM Teaching in Terms of Various Variables*. Master Thesis. Hacettepe University Institute of Educational Sciences, Ankara.

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2014). Driven by beliefs: understanding challenges physical science teachers face when integrating engineering and physics. *Journal of Pre-College Engineering Education Research*, *4*(2), 47–61.

Deveci, İ. (2018). Predictive status of pre-service science teachers' STEM awareness of entrepreneurial characteristics. *Kastamonu Journal of Education*, *26*(4), 1247-1256.

Dugger, W., E. (2010). The Evolution of STEM in the United States. Knowledge in Technology Education: Proceedings of the 6th Biennial International Technology Education Conference: Volume One (TERC 2010) Volume One (TERC 2010) (pp. 117-123). Surfers Paradise, QLD: Griffith Institute for Educational Research.

Dym, C., L, Agogino A., M, Eris O, Frey D., D, Leifer L. J. (2005). Engineering Design Thinking, Teaching, and Learning, *Journal of Engineering Education*, *94*(1), 103– 120.

English, L., D & King, D., T. (2015). STEM learning through engineering design: Fourth grade students' research in the field of aviation. *International journal of STEM education*, *2*, 1-18.

Eroğlu, S., & Bektaş, O. (2016). STEM-trained science teachers' views on STEM-based course activities. *Journal of Qualitative Research in Education*, *4*(3), 43-67.

Guzey, S. S., Harwell, M., & Moore, T. (2014). Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM). *School Science and Mathematics*, *114*(6), 271-279.

Gülhan, F., & Şahin, F. (2016). The effect of science-technology-engineering-mathematics integration (STEM) on 5th grade students' perceptions and attitudes about these fields. *Journal of Human Sciences*, *13*(1), 602-620.

Gürler, N. H., & Önder, İ. (2014). 7. grade students' associating the concepts of “bacteria and virus” they learned

in science and technology course with daily life. III. Congress of Educational Research in Sakarya, *80*.

Hacıoğlu, Y., Yamak, H., & Kavak, N. (2016). Teachers' views on engineering design-based science education. *Bartın University Journal of Faculty of Education*, *5*(3), 807-830.

Herdem, K., & Ünal, İ. (2018). Analyzing studies on STEM education: A meta-synthesis study. *Marmara University Atatürk Faculty of Education Journal of Educational Sciences*, *48*(48).

Judson, E., & Sawada, D. (2000). Examining the effects of a reformed junior high school science class on students' math achievement. *School Science and Mathematics*, *100*(8), 419-425.

Juškevičienė A, Stupurienė G, Jevsikova T, (2021). Computational Thinking Development Through Physical Computing Activities in STEAM Education, *Computer Applications in Engineering Education*, *29*(1), 175–190.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*, *3*, 1-11.

Kim C, Kim D, Yuan J, Hill R B, Doshi P, Thai C N, (2015). Robotics to Promote Elementary Education Pre-service Teachers' STEM Engagement, Learning, and Teaching Computers & Education*, 91*, 14–31.

Kurtuluş, A., Akçay, A. O. & Karahan, E. (2017). Teachers' views on STEM applications in middle school mathematics courses*. Journal of Education and Training Research, 6*(4), 354–360.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2nd edition). *Thousand Oaks, CA: Sage.*

Ministry of National Education (2015). Ministry of National Education Regulation on textbooks and educational tools.

Ministry of National Education (2016). *STEM Education Report.* Ankara: Ministry of National Education General Directorate of Innovation and Educational Technologies.

Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K-12 STEM education. In *Engineering in pre-college settings: Synthesizing research, policy, and practices* (pp. 35-60). Purdue University Press.

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106*(2), 157-168.

National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: *The National Academies Press.*

Öner, A. T., & Capraro, R. M. (2016). Is STEM academy designation synonymous with higher student achievement? *Education & Science*, *41*(185).

Özlüleci, M., & Kayacan, K. (2023). Science, engineering and entrepreneurship skills assessment scale: Validity and reliability study. *Journal of national education*, *52*(1), 493-512.

Siew, N. M., Amir, N. & Chong, C. L. (2015). The perceptions of pre-service and inservice teachers regarding a project-based STEM approach to teaching science. *SpringerPlus, 4*(8), 1-20

Şahin, B. (2019). *Determining the effect of STEM activities on STEM awareness, attitudes and opinions of prospective science teachers. Master's Thesis.* Bartın University Institute of Educational Sciences, Bartın.

Şenocak, E., Taşkesenligil, Y. (2005). Problem Based Learning and Its Applicability in Science Education. *Kastamonu Education Journal, 13*(2), 359-366

Tantu, Ö. (2017). *Evaluation of mobile applications for STEM education with in-service teachers.* Unpublished Master's Thesis. Middle East Technical University, Ankara.

Thomas, T. A. (2014). *Elementary teachers' receptivity to integrated science, technology, engineering, and mathematics (STEM) education in the elementary grades.* Doctoral dissertation.

Veenstra, C. P., Padró, F. F., & Furst-Bowe, J. A. (Eds.). (2012). Advancing the STEM agenda*: Quality improvement supports STEM*. Quality Press.

Wang, H. H. (2012). A new era of science education: Science teachers' perceptions and classroom practices of science, technology, engineering, and mathematics (STEM) integration. *University of Minnesota.*

Yıldırım, B. & Altun, Y. (2015). Examining the effects of STEM education and engineering applications on science knowledge in the laboratory. *El-Cezeri*, *2*(2), 0-2.

Yıldırım, B. (2018). Examining teachers' views on STEM applications. *Journal of Educational Theory and Practice Research, 4*(1), 42-53.

Yıldırım, B. & Selvi, M. (2017). An Experimental Study on the Effects of STEM Applications and Complete Learning. *Theory and Practice in Education*, *13* (2), 183-210.

Yıldırım, P. (2017). A qualitative study on science, technology, engineering and mathematics (STEM) integration. *Journal of Atatürk University Kazım Karabekir Faculty of Education, 35, 31-55.*

Yıldız, M. (2021). Classroom teachers' views on the use of STEM applications in science course. *International Journal of Leadership Education, 2*(2), 11-27.

Yılmaz, N. & Pekbay, C. (2017). A study on the introduction of a STEM activity with pre-service science and elementary mathematics teachers. *International Congress on Politic, Economic and Social Studies, Sarajevo Bosnia Herzegovina*.

Author Information

Hanife Gamze Hastürk
https://orcid.org/0000-0002-8495-560X
Tokat Gaziosmanpaşa University
Turkiye
Contact e-mail: *gamzeyalvac@gmail.com*

Yasemin Ünaldı
https://orcid.org/0009-0009-2392-3688
Tokat Gaziosmanpaşa University
Turkiye