ITALL

Instructional Technology and Lifelong Learning Vol. 6, Issue 1, 1-30 (2025)

https://dergipark.org.tr/en/pub/itall

ITALL

Research Article

ISSN: 2717-8307

Investigation of Preservice Science Teachers' STEM Awareness and STEM Views

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Abstract

This study aims to examine the STEM awareness and perspectives of science teacher candidates, employing a convergent parallel design, which is a mixed research method combining quantitative and qualitative approaches. The participants of the research consist of 65 science teacher candidates studying in the third year of a state university. The data regarding the participants' STEM awareness were obtained through a scale, while the data regarding their STEM perspectives were gathered through semi-structured interviews. Descriptive statistics were used to analyze the quantitative data, whereas content analysis was employed for the qualitative data analysis. The findings of the study indicate that the participants generally scored high on the scale measuring their STEM awareness, with the lowest score obtained in the sub-factor of the scale related to the impact of STEM on teaching. The participants' STEM perspectives were interpreted under five themes, namely STEM definition, the importance of STEM, the advantages and disadvantages of STEM for students, the advantages and disadvantages of STEM for teachers, and their inclination towards using STEM. Based on the study findings, it was concluded that science teacher candidates are capable of accurately defining STEM, they are aware of the importance of STEM and its contributions to both teachers and students, and they have a tendency to incorporate STEM in their lessons. The relevant findings were discussed within the scope of the literature, and recommendations were provided.

Keywords: STEM, Preservice science teachers, STEM awareness, STEM views.

Citation: Ekici, F. & İzci K. (2025). Investigation of Preservice Science Teachers' STEM Awareness and STEM Views. *Instructional Technology and Lifelong Learning, 6(1)*, 1 - 3. https://doi.org/10.52911/itall.1596925

Fen Bilgisi Öğretmen Adaylarının STEM Farkındalıklarının ve STEM Görüşlerinin İncelenmesi

Özet

Bu çalışma fen bilimleri öğretmen adaylarının STEM farkındalıklarını ve STEM görüşlerini incelemeyi amaçlamaktadır. Bu amaç doğrultusunda nicel ve nitel araştırma yöntemlerinin birlikte kullanıldığı karma araştırma yöntemlerinden olan yakınsayan paralel desen kullanılmıştır. Araştırmanın katılımcılarını bir devlet üniversitesinin 3. sınıfında öğrenim gören 65 fen bilgisi öğretmen adayı oluşturmaktadır. Katılımcıların STEM farkındalıklarıyla ilgili veriler bir ölçek yardımıyla, STEM görüşleriyle ilgili veriler ise yarı-yapılandırılmış görüşmeler aracılığı ile elde edilmiştir. Elde edilen nicel verilerin analizinde betimsel istatistik, nitel verilerin analizinde ise içerik analizi kullanılmıştır. Çalışmanın bulguları fen bilgisi öğretmen adaylarının STEM farkındalıkları ile ilgili ölçekten aldıkları puanların genel olarak yüksek olduğu, ilgili ölçeğin STEM'in derse yönelik etkisi alt faktöründen katılımcıların en düşük puanı aldıklarını göstermektedir. Katılımcıların STEM görüşleri ise STEM tanımı, STEM'in önemi, STEM'in öğrenci açısından avantajları ve dezavantajları, STEM'in öğretmen açısından avantaj ve dezavantajları ve STEM kullanma yönelimleri olmak üzere 5 tema altında yorumlanmıştır. Çalışma bulguları sonucunda fen bilgisi öğretmen adaylarının STEM tanımını doğru bir şekilde yapabildiklerine, STEM'in önemini, öğretmene ve öğrenciye yönelik katkılarını farkında olduklarına ve derslerinde bu yaklaşımı kullanma yöneliminde olduklarına ulaşılmıştır. İlgili bulgular alanyazın kapsamında tartışılmış ve önerilerde bulunulmuştur.

Anahtar Kelimeler: STEM, fen bilgisi öğretmen adayları, STEM görüşleri

Date of Submission	08.12.2024
Date of Acceptance	24.06.2025
Date of Publication	30.06.2025
Peer-Review	Double anonymized - Two External
Ethical Statement	It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited.
Author(s) Contribution	**Ekici:** Conceptualization, Methodology, Writing- Original draft preparation. **İzci:** Data curation, Writing- Original draft preparation, Writing- Reviewing and Editing.
Plagiarism Checks	Yes - Turnitin
Conflicts of Interest	The author(s) has no conflict of interest to declare.
Complaints	Itall.journal@gmail.com
Grant Support	The author(s) acknowledge that they received no external funding in support of this research.
Copyright & License	Authors publishing with the journal retain the copyright to their work licensed under the CC BY 4.0.

1. Introduction

In the century we live in, developments in science and technology have caused the dynamics of society to evolve in a new direction. The changes and transformations experienced in the past under the influence of the industrial revolution are today shaped by technological products emerging as a result of scientific developments (National Reseach Council [NRC], 2012). In a century where information is constantly changing, the economic development of a country is only possible by using information creatively and producing creative solutions to the problems that arise in daily life (Aydeniz, 2017). Beyond being a follower of the rapid progress in science and technology, the way to exist in science and technology is to give importance to science, technology engineering and mathematics disciplines both today and in the future (NRC, 2012). Developments in science and technology greatly affect the employment of engineers, technicians and workers, and the economic development of countries in terms of the place they occupy in the market (Bozkurt Altan, Kırıkkaya & Yamak, 2015).

The progressions in different aspects of modern society are rapidly moving towards high standards, with advancements in the fields of science, technology, engineering, and mathematics (STEM) playing crucial roles in tackling the current and future obstacles encountered by humanity to enable the achievement of high standards (NRC, 2012). Therefore, it is imperative to raise a generation that is interested in STEM fields, innovative, entrepreneurial and creative thinkers. Educational institutions are primarily responsible for the realisation of this goal (Aktan & Tunç, 1998). In order to meet this need and to maintain the progress in science and technology, countries are making changes in the educational policies and programs to be implemented in educational institutions. The United States of America (USA) has played a pioneering role in finding solutions in this regard. The increasing need for engineering in the USA and the inability to find the desired quality in the workers have increased the interest of the business world in education and caused them to publish many reports on education (Akgündüz et al., 2015). Reports published in Europe have recognised that science and technology education is alarming and that young people's interest in science and mathematics has declined significantly. Reports published in Europe and the USA (NRC, 2012) advocate a new approach to basic sciences education. The message of these reports about education is to move from a philosophical framework to an approach that provides technical knowledge and skills, prepares students for real life, and prioritises the needs/skills of modern business life. These messages have led to the emergence of approaches that require a new understanding of the education and training process.

Both the solution of global problems and progress in science and technology are not problems that can be solved by only one discipline. The fact that many of the problems we face in an increasingly globalised world require the integration of many fields including STEM fields (Glancy et al., 2014). Therefore, the STEM approach, which proposes the integration of science, technology, engineering and mathematics as one of the new understandings in the education process, has emerged in order to respond to the need. STEM, named as a result of the abbreviation of the first letters of the words 'Science, Technology, Engineering and Mathematics', was first introduced in the USA as an educational approach that involves the realisation of teaching by using more than one discipline together. STEM is also expressed as 'an endeavour to connect the fields of science, technology, engineering and mathematics in a course through connections between these fields and real life problems' (Moore et al., 2014, p.30). Thanks to the STEM approach, it is possible for students to gain knowledge and skills related to more than one discipline, as well as 21st century skills, which are the requirements of the age, by producing solutions to real life problems. The STEM approach provides students with a problem situation. It is an approach that requires students to design to solve this problem, and in order to make this design, they analyse the current situation, collect information, access information from more than one discipline, obtain the most useful information for their purposes, brainstorm for the solution, put forward creative ideas, and in the light of this information, develop a product, a prototype, a design by blending this information and test whether this prototype developed meets the desired criteria (Çorlu, 2018; NRC, 2012).

In Turkey, STEM has started to be given importance with the changes made in the current curricula. In the 2018 science curriculum, a new skill area called engineering and design skills was added to scientific process skills and life skills in the skills learning area, and this group of skills was named domain-specific skills (Ministry of National Education [MoNE], 2013; 2018). Under the sub-heading of engineering and design skills, innovative thinking skills were included. With engineering and design skills, it is aimed to have students design a product with the knowledge and skills they have acquired (MoNE, 2018). Within the scope of 'Science, Engineering and Entrepreneurship Practices' in the science curriculum (MoNE, 2018), students are expected to define a problem from daily life related to the topics covered in the units, compare alternative solutions to solve the problem, select the appropriate one within the scope of the criteria, make plans for the selected solution, and present the product in the next stage. From this situation, it is understood that the 2018 curriculum aims to provide higher level skills than other curricula (Özcan & Koştur, 2019). However, in order for this approach to be successful, theory must be put into practice.

Teachers are an important factor in the implementation of any approach in classroom environments as targeted. At this point, teachers need to adapt and develop themselves to the STEM approach. In order for any approach to be implemented in classroom environments, teachers should have both cognitive infrastructure and affective competences related to this approach. STEM teacher competences constitute the cognitive dimension for the successful implementation of STEM approach and these competences consist of STEM content knowledge, context knowledge, integration knowledge and 21st century knowledge. Brown et al. (2011) emphasised that if the vision of STEM education is intended to yield results, it is necessary to start with increasing teachers' competencies and awareness levels regarding the STEM approach.

1.1. STEM Awareness

Teachers have a key role in preparing learning environments for the implementation of STEM approach and guiding students. It is important to determine the STEM awareness of teachers and prospective teachers in order to reflect the holistic and interdisciplinary perspective of the STEM approach to teaching (Buyruk & Korkmaz, 2016). Raising awareness about the nature of STEM professions is seen as one of the important strategies in many countries in order to further the economic development of countries (Freeman et al., 2013). At this point, it is important to determine the STEM awareness of teachers working in STEM fields. According to Öztürk (2017), teachers' awareness of STEM approach will shape the students' interest in STEM fields. In order to increase the capacity of the labour force trained in STEM fields, teachers need to shape their students' current beliefs about future careers and occupational fields (Angle et al., 2016). It is important for teachers to apply this approach in their lessons in order to guide students about how science is useful for their future careers. Teachers should have high STEM awareness in order to implement the STEM approach. Awareness is seen as a factor that closely affects the relationship between attitudes and behaviours and leads people to the disered attitudes and behaviours over time (Çevik, 2017). In addition to being one of the basic and latent processes of positive change (Fletcher et al., 2010), the concept of awareness also means that individuals and society are sensitive to the environment (Keleş, 2007). STEM awareness can be defined as knowing the importance of STEM approach for teachers, lessons and students and being aware of its positive and negative aspects. According to Koyunlu Ünlü and Dere (2019), STEM awareness means being conscious and sensitive about STEM. Teachers' STEM awareness is seen as a prerequisite for individuals to interact, to have self-efficacy and to improve themselves (Cohen et al., 2013).

Self-awareness refers to the understanding that individuals attain regarding the process of learning and their inclination to oversee said process (Heo, 2000). From this standpoint, STEM awareness can be delineated as the cognizance of equipping individuals with advanced skills, amalgamating science, technology, engineering, and mathematics disciplines, fostering creativity within engineering, exhibiting courage, demonstrating self-assurance, fostering collaboration, and effectively communicating through the application of the STEM methodology (Deveci, 2018). It is crucial for educators to comprehend the significance and benefits of the STEM approach in order to effectively implement it. Concurrently, educators' favorable perspectives and familiarity with STEM have a positive impact on their self-efficacy, which pertains to educators' convictions regarding their ability to generate a desired outcome (Stohlmann et al., 2012). Determining teachers' comprehension and perspectives on the STEM approach could enhance their capacity to implement this approach by bolstering their self-efficacy for its execution.

1.2. Purpose of the Study

For the applicability of the STEM approach, it is important that teachers, who are the realisers of this approach, are both cognitively and affective ready for the STEM approach. One of the important indicators of affective readiness is to be aware of the positive and negative aspects of STEM approach. In addition, in order for this awareness to turn into classroom practices, teachers should have positive views about the STEM approach. Because teachers who do not have awareness and positive views about STEM education do not want to apply this approach. According to Öztürk (2017), teachers' awareness of the STEM approach will also shape the interest of the students they will raise in STEM fields. While the adoption of the STEM approach by teachers and teacher candidates, who are the educators of the future, may positively affect their students' self-development and their future career lives, their failure to adopt it may have a negative impact. For this reason, it is very important for teacher educators to train prospective teachers as STEM literate and STEM aware teachers with high STEM awareness and positive views about the STEM approach in order to raise future generations (Murat, 2018). Therefore, perceptions, beliefs and views towards STEM should be evaluated and analysed at the university level (Capraro, Capraro & Çorlu, 2014). While previous studies have investigated pre-service science teachers' awareness of STEM and found mixed results (e.g. Şahin, 2019; Yaman & Aşılıoğlu , 2022), the study is unique in that it aims to investigate participants' awareness during the development of environmental STEM projects that they are required to complete for their environmental education course. In this context, this study aims to examine the STEM awareness and STEM views of pre-service science teachers who are candidates to teach science course, which is one of the important courses where STEM approach can be applied. In order to achieve this aim, the following research questions were sought to be answered:

1. What is the level of STEM awareness of pre-service science teachers?

2. What are the opinions of pre-service science teachers about STEM approach?

2. Method

In this study, mixed research method, in which qualitative and quantitative research methods are used together, was preferred in order to examine the STEM awareness and STEM views of pre-service science teachers. Mixed method is an approach in which quantitative and qualitative methods with two different paradigms are handled within their theoretical frameworks within a long-term program or research process (Creswell, 2017; Çepni, 2021). In the first step of this research, quantitative data were used to determine STEM awareness, while qualitative data were used to determine STEM opinions in the second step.

In this study, convergent parallel design, one of the mixed research method designs, was preferred. Depending on how the data will be used, each database is handled independently of each other in the convergent parallel design. In this study, the scale used for STEM awareness (quantitative) and the semi-structured interview form used for STEM views (qualitative) were collected and analysed independently. In the convergent parallel design, while the data are analysed separately, the process of interpreting or explaining the convergent or divergent findings by making comparisons or associations to determine whether the findings confirm each other or not is important (Creswell, 2013). In this study, the findings obtained from quantitative and qualitative data were combined in the conclusion and discussion section of the study.

2.1. Participants

The participants of the study consist of pre-service science teachers who were studying in the third year of the Science Teacher Education program of a state university in Turkey. Purposeful sampling method was used to select participants in line with the purpose of the study. Purposive sampling is the purposeful selection of target audience groups in some special research situations in order to examine and explain the phenomena and events in depth (Çepni, 2021; Şimşek & Yıldırım, 2013). One of the reasons why pre-service science teachers were selected as the study group in this study is that science teachers are among the educators who will train students in STEM career fields. Another reason is that pre-service science teachers have a subject area curriculum that can use the STEM approach in the future and the course includes more than one discipline together.

The participants of this study consisted of a total of 65 pre-service science teachers, 13 (20%) male and 52 (80%) female. The 65 pre-service science teachers responded to the scale applied to determine their STEM awareness, while 11 pre-service science teachers, who were determined voluntarily, participated in semi-structured interviews to determine their STEM views. Codes like P-1 (participant-1) and P-2 were employed for the purpose of elucidating the viewpoints of participants based on their responses to interview questions. Based on the information gained from the interview participants, it seen that almost all of the pre-service teachers who participated in the interview received STEM-related training and attended different courses such as Arduino, robotics coding and web design courses. We can say that such STEM experiences supported the participants to participate in the interviews voluntarily.

2.2. Data Collection Tools

In this study, a scale was used to determine the STEM awareness of pre-service science teachers and a semi-structured interview form was used as a data collection tool to examine their STEM views. Detailed information about the related data collection tools is presented below.

2.2.1. STEM awareness scale

In order to determine the STEM awareness of pre-service science teachers the STEM Awareness Scale developed by Çevik (2017) was used. The scale) was applied face-to-face at the beginning of the spring semester of the 2022-2023 academic year.

The scale was 5-point Likert type and offers options such as Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) Strongly Agree (5). The scale, which contains 15 items in total, consists of 12 positive and 3 negative items. Items 8, 9 and 10 are reverse scored items because they are negative. The scale consists of three sub-dimensions: the effects of STEM on students (6 items), lessons (5 items)and teachers (4 items). While the Cronbach's Alpha reliability coefficient of the sub-dimensions were. 81, .71 and. 70 respectively, the Cronbabch's Alpha of the whole scale was found to be .82 (Çevik, 2017). When the literature is reviewed, it is stated that the reliability coefficient of a data collection tool being. 70 or above is a sufficient value for reliability (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2010; Bayram, 2004). For the validity of the scale, Çevik (2017) reapplied the scale within the scope of the test-retest method and determined the standard deviation and mean as 0.52 and 3.95 in the first application and 0.53 and 3.91 in the second application. The fact that the first and second application values are very close to each other shows that the validity of the scale is high.

When examining the sub-components of the scale within a specific context, the impact of STEM on students is associated with how pre-service teachers assess aspects such as analytical thinking, critical perspective, hands on skills, motivation, and self-assurance. Conversely, the influence of STEM on the educational program pertains to appraisals of the instructional procedure concerning the utilization of advanced resources, classroom authority, time allocation, application of acquired knowledge in real-world scenarios, and integration of extracurricular tasks into the syllabus. The effect dimension of the scale for the teacher is related to the views of pre-service teachers on the use of technology for the teacher, planning activities, being active in the lesson and self-development. One of the reasons why this scale was preferred in this study is that the questions related to the same subject are collected in the same category and provide convenience in presenting the data regularly. In addition, the related scale was used as a data collection tool in this study because it was in contextual agreement with the semi-structured interview questions, another data collection tool used to determine the STEM views of the participants.

2.2.2. *Semi-structured interview*

In order to reveal the STEM views of pre-service science teachers, 12 semi-structured interview questions were developed to enable the participants to present their STEM views in a broad scope. The questions were examined by an academician who is an expert in qualitative research, and based on the examination; some of the questions were removed because they focused on the same concepts. The final version of the form was created to include 10 questions (Appendix-1). In general terms, the interview questions aimed to reveal the participants' views about the STEM approach, their experiences with STEM education, the advantages and disadvantages of the STEM approach, and their orientation towards using the STEM approach in the future.

In this study, semi-structured interviews were conducted with 11 pre-service science teachers who were determined voluntarily in order to elaborate the scale applied to determine the STEM awareness of pre-service science teachers. After a general picture of the situation being studied is revealed through scales, special case studies are initiated by taking a very special section from this picture (Çepni, 2021). In determining the participants' thoughts about the STEM approach, data diversification was provided by collecting data from different data sources (scale and semi-structured interview) on the same subject. Multiple tools used in data generation contribute to the credibility, realism and originality of the research (Patton, 2002).

2.3. Data analysis

The data obtained through the scale were transferred to the SPSS (Statistical Package for Social Sciences) programme and descriptive statistical analyses were performed. The positive items in the scale were scored as Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5), while items 8, 9 and 10, which contain negative items, were coded in a way that this scoring was reversed. Then, the score range of the scale was calculated. To determine the score range of the scale, the range coefficient was found with the formula Score Range = (Highest

Value - Lowest Value)/5= (5 - 1) / 5 = 4/5 = 0.80). The score ranges determined in the interpretation of the data obtained from the STEM Awareness Scale are given in Table 1.

Table 1.

Rating Used to Interpret the Arithmetic Mean of the Scale

Score Range	Grading
1.00/1.79	Strongly Disagree
1.80/2.59	Disagree
2.60/3.39	Neutral
3.40/4.19	Agree
4.20/5.00	Strongly Agree

Using the score ranges determined in Table 1, the data were interpreted by considering the averages of the items forming the scale and the averages of the three sub-dimensions of the scale. The results indicated that participants who scored within the agree or strongly agree range demonstrated a heightened level of awareness regarding the specific item. Conversely, those who scored within the disagree or strongly disagree range exhibited a diminished level of awareness. For items corresponding to the neutral range, it was interpreted that they were undecided.

In the second part of this study, the qualitative data were analysed by using content analysis method. The content analysis method involves the process of analysing data in four stages. These are: (1) coding the data, (2) identifying codes, sub-themes and themes, (3) organising the codes, sub-themes and themes, and (4) defining and interpreting the findings (Eysenbach & Köhler, 2002; Miles & Huberman, 1994). These four stages were employed to analyze the qualitative data in the study. To ensure the reliability of the analyses of STEM views peer review process was used (Creswell, 2017). The first author carefully read all the interview data to develop the codes, sub-themes and themes. The analyses of the interviews were also carried out a second time by the second author. In cases of disagreement, both authors met to reach a consensus on the discrepancies.

3. Results

In this section, findings related to the participants' STEM awareness are presented first, followed by findings concerning their views on STEM, in order to address the two relevant research questions aligned with the purpose of the study.

3.1. Findings on the STEM Awareness of Science Teacher Candidates

3.1.1. Impact of the STEM approach on students

Six different items were used in the scale to assess the impact of the STEM approach on students. The overall average of these six items, as well as the mean and standard deviation values of the responses to each item, were calculated. Findings related to the responses of science teacher candidates are presented in Table 2. A general examination of Table 2 indicates that participants are highly aware (M= 4.41) of the positive effects of the STEM approach on students. As shown by the averages of the six items related to the impact on students, participants' preferences fell within the "agree" and "strongly agree" range, indicating high awareness in this section of the scale.

Table 2.

Results on the Impact of the STEM Approach on Students

Items		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
STEM education contributes to the enhancement of students' manual skills.	f	1	1	0	26	37	4.49	.732
	%	1.5	1.5	0	40.0	56.9		
STEM education develops students' analytical thinking skills.	f	2	0	1	25	35	4.46	.812
	%	3.1	0	1.5	38.5	56.9		
STEM education motivates students in the classroom.	f	1	2	3	33	26	4.25	.811
	%	1.5	3.1	4.6	50.8	40.0		
STEM education increases students' problem-solving abilities.	f	1	2	2	20	40	4.48	.831
	%	1.5	3.1	3.1	30.8	61.5		
STEM education practices boost students' self-confidence.	f	2	1	5	22	35	4.34	.923
	%	3.1	1.5	7.7	33.8	53.8		
STEM education supports students in gaining a critical perspective.	f	2	1	5	14	43	4.46	.937
	%	3.1	1.5	7.7	21.5	66.2		
				The impact on students: 4.41				

3.1.2. Impact of the STEM approach on the course

In the context of the impact of the STEM approach on the course, five items were used in the scale. The overall average of these five items, as well as the mean and standard deviation values for each response, were calculated. Findings related to the responses of science teacher candidates are presented in Table 3. A general review of Table 3 indicates that participants are highly aware (M= 3.78) of the positive effects of the STEM approach on the course. As shown by the averages of the five items concerning the course impact, participants' preferences fall within the "neutral" and "agree" range, indicating high awareness in this section of the scale.

Table 3.

Results of Impact of the STEM Approach on the Course.

Items		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
The reflection of STEM education in daily life is inevitable.	f	1	2	6	31	25	4.18	.846
	%	1.5	3.1	9.2	47.7	38.5		
*High-quality materials are needed for STEM education.	f	9	10	20	19	7	3.08	1.203
	%	13.8	15.4	30.8	29.2	10.8		
*The implementation of STEM education negatively affects classroom management.	f	4	5	16	28	12	3.60	1.072
	%	6.2	7.7	24.6	43.1	18.5		
*STEM education activities waste a lot of time in the classroom.	f	2	6	20	20	17	3.68	1.062
	%	3.1	9.2	30.8	30.8	26.2		
STEM education activities should be included in the curricula.	f	1	1	6	24	33	4.34	.834
	%	1.5	1.5	9.2	36.9	50.8		
The impact on course: 3.78								

**The marked items are negative statements, so they have been reversed in the analyses.*

3.1.3. Impact of the stem approach on teachers

In the scale assessing the impact of the STEM approach on teachers, four different items were used. The overall average of these four items was calculated, along with the mean and standard deviation for each response. The results relating to the responses of the science teacher candidates are presented in Table 4. A general review of Table 4 shows that participants are highly aware (M= 4.09) of the positive effects of the STEM approach on teachers. As can be seen from the mean scores of the four items relating to the impact on teachers, participants' preferences fall within the range of 'agree' and 'strongly agree', indicating a high level of awareness in this section of the scale.

Table 4.

Results on the Impact of the STEM Approach on Teachers

Maddeler		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	M	sd
STEM education requires the teacher to use technology in the classroom.	f	2	3	5	24	31	4.22	.992
	%	3.1	4.6	7.7	36.9	47.7		
STEM education practices provide an opportunity for teachers to improve themselves.	f	2	0	2	25	36	4.43	.829
	%	3.1	0	3.1	38.5	55.4		
Teachers should take an active role in STEM education activities.	f	5	10	6	19	25	3.75	1.323
	%	7.7	15.4	9.2	29.2	38.5		
Teachers can easily plan STEM education in both classroom and extracurricular activities.	f	2	4	12	22	25	3.98	1.053
	%	3.1	6.2	18.5	33.8	38.5		
The impact on teacher: 4.09								

Overall, participants rated the STEM Awareness Scale, which consists of three sections: the impact of the STEM approach on students, the course and teachers. Analysis of the mean responses for these three sections showed that participants had the highest level of awareness of the impact of the STEM approach on students (M= 4.41). Following this, the section with the second highest level of awareness was the impact of the STEM approach on teachers (M= 4.09). In contrast, the impact of the STEM approach on the course lagged behind the other two sections ($\bar{x}$: 3.78).

3.2. Findings on the Views of Preservice Science Teacher Regarding STEM

Five distinct themes were identified from the interviews: definition of STEM, Importance of STEM, Advantages and disadvantages of STEM from a teacher's perspective, Advantages and disadvantages of STEM from the students' perspective, Tendencies to use the STEM approach in teaching. In the following, we present the themes and the findings related to each of them.

3.2.1. Definition of STEM

In the semi-structured interviews conducted with science teacher candidates, they were asked "What disciplines do you think are related to science? What is the relationship between science and the fields of technology, engineering and mathematics?" and "How would you define STEM, or its adapted version in Turkish, FeTeMM?" The focus was on how participants defined and interpreted STEM. Based on the answers to these questions, the teacher candidates' definitions of STEM were identified. The participants' views on the definition of STEM are summarized in Table 5.

Table 5.

Views of Preservice Science Teachers on the Definition of STEM

Theme	Sub-Theme	Code	Sample Quotations
The Definition of STEM	An interdisciplinary approach	P1, P2, P5, P8	"In everyday life, when we solve a problem or issue, we use several of the disciplines of science, technology, engineering and mathematics depending on the problem. The application of using the knowledge and skills from these disciplines is STEM". (P5)
	Science, technology, engineering and mathematics	P3, P7	“"STEM is a term related to the fields of science, technology, engineering, and mathematics.".” (P7)
	A teaching method that teachers should know	P6, P10	"It is an approach that every science teacher should know, learn, and use in their teaching." (P10)
	A system aimed at promoting scientific literacy.	P4	"It is a system aimed at cultivating scientifically literate individuals." (P4)
	Solving problems and creating products	P9	"It is an educational approach that seeks solutions to problems through science and mathematics knowledge with the assistance of engineering, resulting in product creation." (P9)
	An approach that facilitates the transformation of knowledge from theory to practice.	P11	"Students observe the real-life applicability of subjects such as science, technology, mathematics and engineering through this [STEM] system." (P11)

As can be seen in Table 5, teacher candidates coded as P1, P2, P5 and P8 emphasised the interdisciplinary nature of the STEM concept in their explanations. In addition, candidates coded P3 and P7 defined STEM as an acronym for the disciplines of science, technology, engineering and mathematics. Candidates P6 and P10 referred to STEM as a teaching method that teachers should be familiar with. Furthermore, teacher candidates also expressed the definition of STEM as a system aimed at cultivating scientific literacy (P4), as a method for problem solving and product creation (P9), and as an approach that facilitates the transformation of knowledge from theory to practice (P11).

3.2.2. The importance of STEM

Science teacher candidates were asked, "Why do you think STEM education is important?" Their responses were used to identify the importance of STEM and its contributions. The views expressed by the participants on the importance of STEM are summarised in Table 6.

Table 6.

Views of Science Teacher Candidates on the Importance of STEM

Theme	Sub-Theme	Code	Sample Quotations
The importance of STEM	Develop higher order thinking skills	P6, P7, P8,P10, P11	"STEM has improved my problem-solving skills, analytical thinking skills, and manual dexterity." (P7)
	Gain technological skills	P2, P3, P9	"I learned to build basic Arduino circuits. We had the opportunity to work with robots like Macblock. I also learned basic programming on the computer." (P2)
	Ability to apply theoretical knowledge to real life	P4, P11	"STEM has improved my creativity and problem-solving skills. I have learnt about real-life applications that can be achieved with science". (P11)
	Ability to produce more than one solution to a problem	P5	It became evident that a given problem can be approached from a variety of perspectives, thereby facilitating the generation of multiple solutions. (P5)
	Change of perspective on science	P1	"Receiving STEM education allowed me to change my perspective on science." (P1)

As evidenced in Table 6, teacher candidates coded as P6, P7, P8, P10, and P11 underscored the pivotal role of STEM in fostering advanced cognitive abilities. Furthermore, candidates P2, P3, and P9 asserted that STEM is crucial for imparting technological competencies that are pertinent to the contemporary era. Candidates P4 and P11 observed that STEM enables the practical application of theoretical knowledge in real-world scenarios. Additionally, other participants emphasised the significance of STEM for facilitating the development of diverse solutions to a problem (P5) and for fostering a shift in perspectives on science (P1).

3.2.3. Advantages and disadvantages of STEM from a teacher's perspective

Science teacher candidates were posed the following questions: "What are the advantages of utilising STEM-based activities in science classes from the perspective of the teacher?" and "What are the disadvantages of employing STEM-based activities in science classes from the perspective of the teacher?" The objective was to ascertain the participants' perceptions of the advantages and disadvantages that STEM offers teachers. Based on the responses provided to these questions, the participants' views on the advantages and disadvantages of STEM from the teacher's perspective are presented in Table 7.

Table 7.

Advantages and Disadvantages of STEM from a Teacher's Perspectiv0065

Theme	Sub-Theme	Code	Sample Quotations
Advantages of STEM for Teachers	It contributes to the teacher's self-development.	P4, P6, P10	It is my contention that teachers and students alike benefit from the development of their STEM skills, which in turn contribute to their growth as individuals who possess a nuanced understanding of the world around them, are able to generate ideas about the events they encounter, and are solution-oriented. (P4)
	Let teachers to provide meaningful learning.	P9, P11	It is my conviction that an effective teacher will facilitate enduring learning, enabling students to synthesise and apply knowledge in a way that goes beyond mere rote memorisation. Concurrently, it will provide children with a broader range of career options. (P9)
	Provides opportunities for higher-level learning and evaluation of the learning.	P2, P7	The STEM approach enables educators to observe students' creativity and their ability to utilise technology effectively. It also allows them to assess students' performance in practical tasks beyond theoretical knowledge and to determine their understanding of the steps involved in scientific research. (P2)
	It guarantees the nurturing of productive students.	P3, P8	The implementation of STEM in education has the potential to enhance the quality of learning experiences, facilitating more memorable and productive outcomes for students. (P8)
	Let teachers to conduct lessons with the integration of technology and science.	P1	"The teacher's use of STEM-based activities enables a more efficient lesson delivery by integrating evolving technology with science." (P1)
	Decrease work load of techers	P5	In light of the increased level of student engagement, the role of the teacher will evolve to that of a guide, facilitating learning in a more passive manner. Consequently, the teacher's workload will be reduced, and as students will be responsible for discovering and constructing knowledge, the learning will be more enduring. (P5)
Disadvantages of STEM for Teachers	Lack of time	P3, P4, P5, P7, P9, P10	In the event that the lesson is not meticulously planned, there may be insufficient time for the implementation of STEM activities, which could result in the activities being incomplete. (P7)

	Material supply problem	P1, P4, P5, P9	"Of course, if there is insufficient technology and environment at school for these activities, it will also cause problems for the teacher in implementing the activities." (P4)
	Classroom management	P4, P7	"...The teacher needs to maintain classroom management." (P7)
	Guidence	P2, P6	"It can be challenging to provide guidance to students." (P2)
	The challenge of supporting all learners	P8	"It can be somewhat exhausting to convey information in a manner that is accessible to all children." (P8)

As evidenced in Table 7, prospective science teachers with the codes P4, P6, and P10 most frequently identified the advantages of STEM in facilitating personal development as a key benefit for teachers. Additionally, prospective teachers with the codes P9 and P11 indicated that STEM can facilitate meaningful learning experiences for students. Conversely, prospective teachers with the codes P2 and P7 emphasised the pedagogical aspects of STEM, asserting that it provides avenues for advanced learning and the assessment of these attainments. Moreover, participants indicated that STEM can facilitate the development of productive students (P3, P8) and that lessons are taught through the integration of technology and science (P1). One other participant (P5), who appeared to hold a misconception of the STEM approach, asserted that it reduces the lesson load.

As evidenced in Table 7, regarding the disadvantages of STEM for teachers, prospective teachers with the codes P3, P4, P5, P7, P9, and P10 most frequently expressed the view that time constraints could be a disadvantage for teachers. Participants with the codes P1, P4, P5, and P9, on the other hand, considered the unavailability of materials to be a potential disadvantage. Additionally, some participants reported disadvantages related to classroom management (P4, P7), providing guidance (P2, P6), and explaining in a way that every child can understand (P8).

3.2.4. Advantages and disadvantages of STEM from the student's perspective

The prospective science teachers were invited to respond to the following questions: The participants were asked to identify the advantages and disadvantages of using STEM-based activities in science classes from their perspective. The investigation was centred on the participants' perspectives on the advantages and disadvantages of STEM for students. The responses provided by the participants to these questions were used to construct a summary of their views on the advantages and disadvantages of STEM from the perspective of the student (see Table 8).

Table 8.

Advantages and Disadvantages of STEM from the Student's Perspective

Theme	Sub-Theme	Code	Sample Quotations
Advantages of STEM from the Student's Perspective	Developing higher-order thinking skills	P2,P4, P5, P7, P9, P11	"The implementation of STEM-based activities will facilitate the growth of students into self-assured, science-oriented individuals who are capable of critical thinking, analytical reasoning, and maintaining their creative faculties." (P4)
	Boosting students' self-confidence	P4, P5	"The student's confidence will be restored as they achieve things on their own, while group activities will enhance their ability to communicate, make decisions, think critically, and think creatively." (P5)
	Increasing student interest and motivation	P10, P3	"Such STEM experiences will enhance their confidence in technology and the future, thereby providing motivation." (P3)
	Fostering active participation	P6, P11	This approach encourages students to be actively engaged in the learning process. (P6)
	Permanent learning	P1	"It (STEM) increases retention in learning." (P1)
	Raising productive individuals	P8	"The STEM curriculum encourages students to become productive members." (P8)
Disadvantages of STEM from the Student's Perspective	Lack of time	P3, P5	"The overcrowding of classrooms will impede the ability of each individual to engage in hands-on activities, and some students may lack the opportunity to participate or may be unable to do so. (P5)
	Material supply problem	Ö8, P10	"There may not always be access to the required materials." (P8)
	Lack of experienced teachers	P1, P4	"A STEM-based activity conducted by a teacher who has not received STEM education may be difficult for students to understand." (P1)
	Can be boring for students	P2, P7	"It could be an activity that bothers students who are not interested in science subjects." (P2)
	Concerns about product development	P9	"It could create a fear of not being able to find a solution to the problem and not being able to develop a product." (P9)
	No disadvantages	P6, P11	"I don't think STEM has a disadvantage." (P11)

As can be seen in Table 8, when teacher candidates coded P2, P4, P5, P7, P9 and P11 discuss the benefits of STEM from the students' perspective, they emphasise that STEM-based activities contribute to the development of students' higher-order thinking skills. In addition, teacher candidates coded P4 and P5 state that STEM-based activities will help students to achieve things on their own and gain confidence, while teacher candidates coded P10 and P3 mention that STEM-based activities will increase students' interest/motivation towards the lesson. In addition, participants indicated that STEM-based activities offer benefits such as ensuring students' active participation in the lesson (P6, P11), promoting sustained learning (P1), and providing opportunities for students to grow as productive individuals (P8).

As seen in Table 9, in their views on the disadvantages of STEM from the students' perspective, teacher candidates coded P3 and P5 mention that students may not be able to participate in activities due to time constraints. Teacher candidates coded P8 and P10 suggest that factors such as difficulties in obtaining materials or insufficient technological resources could also be a disadvantage for students. In addition, teacher candidates coded P1 and P4 state that they believe that STEM-based activities can be disadvantageous for students if teachers (or trainers) are not adequately trained, as the activities may not be understood by students, resulting in a disadvantage. Some participants also reported disadvantages such as students who are not interested in science being bored or struggling (P2, P7), while another participant focused on the implementation phase of STEM and mentioned that students may feel anxious about product development (P9). Finally, in the section on the disadvantages of STEM for students, there are two participants (P6, P11) who believe that STEM does not have any disadvantages for students.

3.2.5. Views on using the STEM approach in teaching

The pre-service science teachers were asked the question: "Do you think that STEM-based science teaching can be used to strengthen science teaching in middle schools? The participants' responses focused on their inclinations to use the STEM approach in future science teaching, whether these inclinations are conditional, and the reasons for using the approach. Based on the participants' answers to this question, their inclinations to use the STEM approach are summarized and presented in Table 9.

Table 9.

Views on Using the STEM Approach in Teaching

Theme	Sub-Theme	Code	Sample Quotations
Views on Using the STEM Approach in Teaching	Preference to use	P1, P2, P3, P7, P9, P10, P11	"I will use STEM in my future lessons." (P3)
	Conditional usage	P4, P5, P6, P8	"As long as the right environment, materials and time are provided, it can be used in the classroom". (P4)
Reasons for using STEM	Develop ciritical skills	P2	"I will definitely use it [STEM]. Project-based education promotes both creativity and productivity." (P2)
	Support meaningful learning	P5	"When the appropriate environment and necessary conditions are provided, receiving STEM-based education will help students produce knowledge on their own, using their own methods and approaches, rather than being passively prepared with information."(P5)
	Increase interest	P7	"Yes, I will use it. If I use the STEM approach in science lessons, students' interest in the lesson will increase." (P7)
	Support use of technology	P6	"I definitely want to use this [STEM] approach. Because technology has become a part of our lives, and I think it would be beneficial to use this technology that is so integrated into our lives in our education system". (P6)

As can be seen in Table 9, all teacher candidates who expressed their views indicated that they planned to use the STEM approach in science education. Teacher candidates coded P1, P2, P3, P7, P9, P10, and P11 most often stated that they would prefer to use the STEM approach in their future teaching, indicating that they believe it can be used in science education. The remaining participants coded P4, P5, P6 and P8 stated that they would consider using the STEM approach if certain physical conditions such as an appropriate environment, necessary materials and time were provided. Having established the teacher candidates' propensity to use the STEM approach, the reasons for their propensity were also observed. In this regard, the participants explained their reasons for using the approach as follows: project-based learning, promoting creativity and fostering productive individuals (P2), providing meaningful learning (P5), increasing interest in the classroom (P7), and integrating technology into the education system (P6).

4. Discussion and Conclusion

The aim of the study was to investigate the STEM awareness of pre-service science teachers based on their responses to a scale and semi-structured interview questions. The results showed that the participants were aware of the benefits of STEM education for students, teachers and the classroom. For a new teaching approach such as STEM education to be implemented, teachers must be aware of its positive and negative aspects and be convinced to use it. Therefore, for the STEM approach to be successfully implemented in teaching, it is essential that pre-service teachers are aware of the positive aspects of the STEM approach and are willing to integrate it into their teaching. The results of this study show that the pre-service teachers involved in the study have this awareness. Discussions of the critical findings and related literature are provided below.

4.1. STEM for Students

The study reveals that pre-service science teachers perceive STEM as highly beneficial for students, fostering higher-order thinking skills, confidence, motivation, active participation, sustained learning and the development of productive individuals (Aslan & Bektaş, 2019; Bakırcı & Kutlu, 2018; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019; Türk & Korkmaz, 2023). Teachers play a pivotal role in shaping students' perceptions of STEM careers, and inadequate guidance may limit students' exposure to opportunities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). Teachers are undoubtedly the most important factor influencing student success. In order to increase the capacity of the STEM workforce, teachers need to shape their students' beliefs about future careers and occupational fields. If teachers do not inform students about career options, students will have little knowledge about many STEM career opportunities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). In order for teachers to show students how science is useful for future careers, they need to use this approach in their teaching.

Studies confirm that STEM enhances science education by promoting creativity and hands-on learning (Bakırcı & Kutlu, 2018; Özdemir & Cappellaro, 2020). However, challenges include time constraints, lack of materials, comprehension difficulties due to inexperienced teachers, disinterest among some students, and anxiety about product creation (Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). Addressing these issues requires classroom adaptations for group work and access to equipped laboratories (Doğan, Savran Gencer & Bilen, 2017; Bakırcı & Kutlu, 2018). Overcoming these barriers is crucial for the role of STEM in skills development and economic contribution (Kartopu & Duran, 2023).

4.2. STEM for Teachers

Pre-service science teachers demonstrate high STEM awareness, aligning with literature findings of elevated awareness among teachers and pre-service teachers (Yaman & Aşılıoğlu, 2022; Özdemir, 2019). This awareness is essential for integrating STEM into education and guiding students toward STEM careers (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016). Benefits for teachers include personal growth, facilitating meaningful learning, assessing higher-order skills, integrating technology, and nurturing productive generations (Aslan & Bektaş, 2019; Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019). STEM training boosts awareness, with studies noting improvements among participants in STEM-focused activities (Angle, Colston, French, Gustafson, O'Hara & Shaw, 2016; Dönmez, 2020; Holland, Knowles & Kelley, 2018; Şahin, 2019). Additional studies emphasize a productive, enjoyable teaching atmosphere and increased motivation (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). In conclusion, the study aligns with existing literature and underscores STEM's contributions to assessing higher-order learning and developing productive individuals, indicating prospective teachers' readiness to implement STEM in their future practice.

Some challenges, such as time constraints, access to materials, classroom management and student guidance, were also identified by participants as making it difficult for teachers to implement STEM education. These findings are in line with the existing literature that identifies similar disadvantages such as material scarcity, high costs, time-intensive activities, and classroom management difficulties, especially in large classes (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020). However, in contrast to this study, other research suggests additional challenges for teachers lacking STEM training, such as knowledge gaps and a tendency to view STEM as a tool rather than a goal (Aslan & Bektaş, 2019; Eroğlu & Bektaş, 2016; Özdemir & Cappellaro, 2020; Özcan & Koştur, 2018). Some studies point to knowledge gaps among untrained teachers (Özcan & Koştur, 2018), highlighting the need for robust training.

4.3. STEM for Teaching

Pre-service science teachers express their readiness to adopt STEM in their teaching, valuing its project-based approach, creativity and enhancement of meaningful learning (Özdemir & Cappellaro, 2020; Doğan & Saraçoğlu, 2019; Eroğlu & Bektaş, 2016). While some studies report moderate awareness of the impact of STEM education due to limited experience (Yaman & Aşılıoğlu, 2022; Yaşar, 2021; Çevik, Danıştay & Yağcı, 2017; Dadacan, 2021; National Academies [NA], 2014), this study finds positive attitudes without uncertainty ($\bar{x}$: 3.78). As noted by Yaman and Aşılıoğlu (2022), a possible reason for the medium level of awareness of the impact of STEM on teaching in this study could be the lack of practical classroom experience of the pre-service science teachers involved. This lack of real classroom experience and lack of practical experience in delivering STEM-based lessons could explain the moderate level of awareness in this dimension.

The participants defined STEM as interdisciplinary and application-focused, which is in line with the literature that emphasises integration across disciplines (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Eroğlu & Bektaş, 2016; Hacıoğlu, Karslı Baydere, Kocaman & Şahin Çakır, 2021; Uğraş, 2017). The value of STEM lies in fostering thinking skills, technical competence and real-world applications (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Bybee, 2010). Practical experience gaps may limit implementation (Özdemir & Cappellaro, 2020), suggesting the need for enhanced teacher training with STEM courses and hands-on practice to improve effectiveness (Aktürk & Çalışkan, 2024; Çevik, 2018).

One of the themes reflecting pre-service science teachers' perspectives on STEM is their views on its importance. The pre-service science teachers' perspectives on the importance of the STEM approach, emphasising its role in developing higher-order thinking skills, teaching modern technological skills, linking theoretical knowledge to everyday life, promoting diverse problem solving, and changing negative attitudes towards science. These views are consistent with the existing literature, which similarly highlights the impact of STEM on higher-order thinking (Bölükbaşı & Arı, 2019; Bakırcı & Kutlu, 2018; Erdoğan & Çiftçi, 2017; Özcan & Koştur, 2018; Uğraş, 2017). Teachers' emphasis on practical application, multiple solutions and attitude change is also reflected in the research findings. For example, Bakırcı and Kutlu (2018) found that STEM enhances science education by making learning concrete, encouraging hands-on experience, enabling tangible product design, increasing engagement, and supporting long-term retention.

Suggestion The study investigated the STEM awareness of pre-service science teachers and their views on the STEM approach. The results show that the participants generally have a high level of STEM awareness and positive views of STEM. Based on the findings of the study, the following suggestions are made to guide future research in this area and to support educators.

The findings of this study indicate that participants perceive some contextual difficulties, such as lack of infrastructure and materials, and classroom-related difficulties, such as classroom management challenges and heavy teaching loads, as barriers to the implementation of STEM. Therefore, schools should ensure that necessary laboratory technologies, infrastructure and equipment are provided to both teachers and students to support STEM activities. In addition, collaboration with teachers from other disciplines could be a viable solution to classroom-related barriers. Schools should ensure that the necessary infrastructure and coordination are in place to support such collaboration.

Effective implementation of STEM requires teachers to have certain competencies. In the literature, the necessary competencies for teachers are discussed under the concept of STEM literacy, which includes STEM integration knowledge, pedagogical knowledge, 21st century skills and contextual knowledge. Supporting the STEM literacy of future teachers is essential for the success of STEM applications. In addition, ensuring the availability of the necessary infrastructure and technological resources in schools and in the wider educational context is equally important to enable STEM-literate teachers to implement the approach effectively in their teaching. In this context, activities and training focused on developing STEM literacy should be provided to prospective teachers to ensure their preparedness. Teachers should be trained to develop STEM lesson plans. This includes activities related to organising lessons, providing materials and preparing the classroom environment for STEM teaching.

The study found that participants believed that STEM activities require advanced materials, creating a perception that a lack of materials hinders the implementation of STEM. To address this perception, teacher candidates should experience STEM activities that can be carried out with simple and accessible materials, demonstrating that effective STEM teaching does not always require high-level resources.

5. References

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M. S., Öner, T., & Özdemir, S. (2015). *STEM eğitimi Türkiye raporu: Günün modası mı yoksa gereksinim mi?* [A report on STEM education in Turkey: A provisional agenda or a necessity?] [White paper]. Aydın Üniversitesi. https://doi.org/10.13140/RG.2.1.1980.0801

Aktan, C. C., & Tunç, M. (1998). Bilgi toplumu ve Türkiye. *Yeni Türkiye Dergisi, 4*(19), 118–134.

Aktürk, A. O., & Çalışkan, G. (2024). Öğretmen adaylarının teknoloji hakkındaki metaforları. *Necmettin Erbakan Üniversitesi Ereğli Eğitim Fakültesi Dergisi, 6*(1), 265–291.

Angle, J. J., Colston, N. M., French, D. P., Gustafson, J. E., O'Hara, S. E., & Shaw, E. I. (2016). Addressing the call to increase high school students' STEM awareness through a collaborative event hosted by science and education faculty: A how-to approach. *Science Educator, 25*(1), 43–50.

Aslan, F., & Bektaş, O. (2019). Fen bilgisi öğretmen adaylarının STEM uygulamaları hakkında görüşlerinin belirlenmesi. *Maarif Mektepleri Uluslararası Eğitim Bilimleri Dergisi, 3*(2), 17–50. https://doi.org/10.46762/mamulebd.646318

Aydeniz, M. (2017). *Eğitim sistemimiz ve 21. yüzyıl hayalimiz: 2045 hedeflerine ilerlerken, Türkiye için STEM odaklı ekonomik bir yol haritası* [Our education system and our 21st century dream: A STEM-focused economic roadmap for Turkey as we move towards the 2045 goals]. University of Tennessee, Knoxville. https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1019&context=utk_theopubs

Bakırcı, H., & Kutlu, E. (2018). Fen bilimleri öğretmenlerinin FeTeMM yaklaşımı hakkındaki görüşlerinin belirlenmesi. *Turkish Journal of Computer and Mathematics Education, 9*(2), 367–389. https://doi.org/10.16949/turkbilmat.417939

Bayram, N. (2004). *Sosyal bilimlerde SPSS ile veri analizi*. Ezgi Kitabevi.

Bozkurt Altan, E., Buluş Kırıkkaya, E., & Yamak, H. (2015). FeTeMM eğitim yaklaşımının öğretmen eğitiminde uygulanmasına yönelik bir öneri: Tasarım temelli fen eğitimi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 6*(2), 212–232.

Bölükbaşı, G., & Arı, A. G. (2019). Fen bilimleri öğretmenlerinin FeTeMM eğitimi ve etkinliklerine yönelik görüşleri. *Academic Perspective Procedia, 2*(1), 47–56. https://doi.org/10.33793/acperpro.02.01.11

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher, 70*(6), 5–9.

Buyruk, B., & Korkmaz, Ö. (2016). FeTeMM farkındalık ölçeği (FFÖ): Geçerlik ve güvenirlik çalışması. *Türk Fen Eğitimi Dergisi, 13*(2), 61–76. https://doi.org/10.12973/tused.10179a

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2010). *Bilimsel araştırma yöntemleri* (4th ed.). Pegem Akademi.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30–35.

Creswell, J. W. (2013). *Steps in conducting a scholarly mixed methods study*. DBER Speaker Series.

Creswell, J. W. (2017). *Araştırma deseni: Nitel, nicel ve karma yöntem yaklaşımları* (S. B. Demir, Trans. Ed., 3rd ed.). Eğiten Kitap.

Çepni, S. (2021). *Araştırma ve proje çalışmalarına giriş* (9th ed.). Celepler Matbaacılık.

Çevik, M. (2017). Ortaöğretim öğretmenlerine yönelik FeTeMM farkındalık ölçeği (FFÖ) geliştirme çalışması. *Journal of Human Sciences, 14*(3), 2436–2452. https://doi.org/10.14687/jhs.v14i3.4673

Çevik, M. (2018). Impacts of the project based (PBL) science, technology, engineering, and mathematics (STEM) education on academic achievement and career interests of vocational high school students. *Pegem Eğitim ve Öğretim Dergisi, 8*(2), 281–306. https://doi.org/10.14527/pegegog.2018.012

Çevik, M., Danıştay, A., & Yağcı, A. (2017). Ortaokul öğretmenlerinin FeTeMM (fen-teknoloji-mühendislik-matematik) farkındalıklarının farklı değişkenlere göre değerlendirilmesi. *Sakarya University Journal of Education, 7*(3), 584–599. https://doi.org/10.19126/suje.335008

Çorlu, M. S. (2018). STEM bütünleşik öğretmenlik: Yaparak öğrenmeden üreterek öğrenmeye. *Harvard Business Review, 7*, 102–108. https://www.academia.edu/37080082

Dadacan, G. (2021). *Öğretmen adaylarının STEM öğretimiyle ilgili özyeterlik farkındalık ve yönelimlerinin çeşitli değişkenler açısından incelenmesi* [Unpublished master's thesis]. Hacettepe Üniversitesi.

Deveci, İ. (2018). Fen bilimleri öğretmen adaylarının sahip oldukları FeTeMM farkındalıklarının girişimci özellikleri yordama durumu. *Kastamonu Education Journal, 26*(4), 1247–1256. https://doi.org/10.24106/kefdergi.356829

Doğan, E., & Saraçoğlu, S. (2019). Fen bilimleri öğretmenlerinin STEM temelli fen eğitimi hakkındaki görüşleri. *Journal of Hasan Ali Yücel Faculty of Education, 16*(2), 182–220. https://doi.org/10.5152/hayef.2019.19016

Doğan, H., Savran Gencer, A., & Bilen, K. (2017). Science and engineering implementation: A case study on edible and renewable car activity. *Journal of Inquiry Based Activities, 7*(2), 62–85.

Dönmez, M. C. (2020). *Robotik uygulamaların aday öğretmenlerin STEM farkındalıkları, fen öğretmeye yönelik öz yeterlikleri ve STEM'e yönelik tutumları üzerine etkileri* [Unpublished master's thesis]. Kırşehir Ahi Evran Üniversitesi.

Erdoğan, I., & Çiftçi, A. (2017). Investigating the views of pre-service science teachers on STEM education practices. *International Journal of Environmental and Science Education, 12*(5), 1055–1065.

Eroğlu, S., & Bektaş, O. (2016). STEM eğitimi almış fen bilimleri öğretmenlerinin STEM temelli ders etkinlikleri hakkındaki görüşleri. *Eğitimde Nitel Araştırmalar Dergisi, 4*(3), 43–67. https://doi.org/10.14689/issn.2148-2624.1.4c3s3m

Eysenbach, G., & Köhler, C. (2002). How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. *BMJ, 324*(7337), 573–577. https://doi.org/10.1136/bmj.324.7337.573

Fletcher, L. B., Schoendorff, B., & Hayes, S. C. (2010). Searching for mindfulness in the brain: A process-oriented approach to examining the neural correlates of mindfulness. *Mindfulness, 1*(1), 41–63. https://doi.org/10.1007/s12671-010-0006-5

Heo, H. (2000). Theoretical underpinnings for structuring the classroom as self-regulated learning environment. *Educational Technology International, 2*(1), 31–51.

Karslı Baydere, F., Şahin Çakır, Ç., Hacıoğlu, Y., & Kocaman, K. (2021). Lisansüstü öğrencilerinin STEM eğitimi ile ilgili görüşleri: İki üniversite örneği. *Trakya Eğitim Dergisi, 11*(2), 568–587. https://doi.org/10.24315/tred.623999

Kartopu, S., & Duran, S. Ş. (2023). Tasarım atölye eğitiminde disiplinlerarası uygulamalar. *Necmettin Erbakan Üniversitesi Ereğli Eğitim Fakültesi Dergisi, 5*(1), 93–118.

Keleş, Ö. (2007). *Sürdürülebilir yaşama yönelik çevre eğitimi aracı olarak ekolojik ayak izinin uygulanması ve değerlendirilmesi* [Unpublished doctoral dissertation]. Gazi Üniversitesi.

Knowles, J. G., Kelley, T. R., & Holland, J. D. (2018). Increasing teacher awareness of STEM careers. *Journal of STEM Education, 19*(3), 47–55.

Koyunlu Ünlü, Z., & Dere, Z. (2019). Okul öncesi öğretmen adaylarının FeTeMM farkındalıklarının değerlendirilmesi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi, 21*(1), 44–55. https://doi.org/10.17556/erziefd.481586

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Sage Publications.

Ministry of National Education. (2013). *İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı*. Talim ve Terbiye Kurulu Başkanlığı.

Ministry of National Education. (2018). *Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar)*. Talim ve Terbiye Kurulu Başkanlığı.

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. https://twin-cities.umn.edu/

Murat, A. (2018). *Fen bilgisi öğretmen adaylarının 21. yüzyıl becerileri yeterlik algıları ile STEM'e yönelik tutumlarının incelenmesi* [Unpublished master's thesis]. Fırat Üniversitesi.

National Academy of Engineering and National Research Council. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. The National Academies Press. https://doi.org/10.17226/18612

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. https://doi.org/10.17226/13165

Özcan, H., & Koştur, H. İ. (2019). Fen bilimleri dersi öğretim programı kazanımlarının özel amaçlar ve alana özgü beceriler bakımından incelenmesi. *Trakya Eğitim Dergisi, 9*(1), 138–151. https://doi.org/10.24315/tred.469584

Özdemir, A. U. (2019). *Sınıf öğretmenlerinin FeTeMM farkındalıkları ve FeTeMM eğitimi uygulamalarına yönelik görüşleri* [Unpublished master's thesis]. Akdeniz Üniversitesi.

Özdemir, A. U., & Cappellaro, E. (2020). Sınıf öğretmenlerinin FeTeMM farkındalıkları ve FeTeMM eğitimi uygulamalarına yönelik görüşleri. *Fen Bilimleri Öğretim Dergisi, 8*(1), 46–75.

Öztürk, M. (2017). *İlköğretim 4. sınıf öğretmenleri ve öğrencilerinin FeTeMM eğitimine dair yeterlik inançları ve tutumlarının incelenmesi* [Unpublished master's thesis]. Ege Üniversitesi.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Sage Publications.

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER), 2*(1), Article 4. https://doi.org/10.5703/1288284314653

Şahin, B. (2019). *STEM etkinliklerinin fen öğretmeni adaylarının STEM farkındalıkları, tutumları ve görüşleri üzerine etkisinin belirlenmesi* [Unpublished master's thesis]. Bartın Üniversitesi.

Türk, E. F., & Korkmaz, Ö. (2023). Eğitsel robot setleri ile gerçekleştirilen STEM etkinliklerinin etkililiği: Deneysel bir çalışma. *Ahmet Keleşoğlu Eğitim Fakültesi Dergisi, 5*(1), 92–118. https://doi.org/10.38151/akef.2023.46

Uğraş, M. (2017). Okul öncesi öğretmenlerinin STEM uygulamalarına yönelik görüşleri. *The Journal of New Trends in Educational Science, 1*(1), 39–54.

Yaman, F., & Aşılıoğlu, B. (2022). Öğretmenlerin STEM eğitimine yönelik farkındalık, tutum ve sınıf içi uygulama özyeterlik algılarının incelenmesi. *Milli Eğitim Dergisi, 51*(234), 1395–1416. https://doi.org/10.37669/milliegitim.845546

Yaşar, Z. (2021). *Okul öncesi öğretmenlerinin FeTeMM farkındalık düzeylerine ve FeTeMM etkinliklerine ilişkin görüşleri* [Unpublished master's thesis]. Fırat Üniversitesi.

Yıldırım, A., & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* (9th ed.). Seçkin Yayıncılık.

APPENDIXES

Appendix 1. Semi-structured interview quations

1. Which disciplines are related to science?
2. What is the relationship between science, technology, engineering, and mathematics?
3. How would you define STEM or its Turkish adaptation, FeTeMM?
4. Have you ever received STEM education? If yes, where and what kind of training did you receive? What are the benefits of the STEM education you received?
5. Do you think STEM-based science teaching can be used to strengthen science lessons in middle school?
6. What are the advantages of using STEM-based activities in science lessons from a teacher's perspective?
7. What are the advantages of using STEM-based activities in science lessons from a student's perspective?
8. What are the disadvantages of using STEM-based activities in science lessons from a teacher's perspective?
9. What are the disadvantages of using STEM-based activities in science lessons from a student's perspective?
10. during the implementation of STEM-based activities?