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Examining Teachers' Views on STEM Education as an Interdisciplinary Approach

Nadir Aksoy[1,a,] , Hatice Yıldız[2,b,*]

[1] *Ministry of National Education, Sivas, Türkiye*
[2] *Faculty of Education, Sivas Cumhuriyet University, Sivas, Türkiye*
**Corresponding author*

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ABSTRACT

The aim of this research was to determine the opinions of teachers about STEM education. In order to address the issue with a holistic approach, the case study design, one of the qualitative research methods, was used in the research. The participants of the research consisted of 24 teachers, six teachers from each of the branches of Science, Information Technologies, Technology and Design, and Mathematics, working in secondary schools in the Central District of Sivas province. Data were collected through a semi-structured interview form. In the interview form, teachers were asked eight open-ended questions. The data obtained in the study were analyzed using content analysis technique. The findings derived from teachers' perspectives revealed that integrating STEM education as an interdisciplinary approach produced significant positive outcomes. It facilitated experiential and hands-on learning, promoted enduring comprehension, addressed real-world problems, and enhanced the acquisition of essential 21st-century skills such as critical, analytical, and creative thinking. Additionally, it increased student engagement and represented a product-oriented educational methodology. Lastly, teachers reported facing several challenges in implementing STEM activities, including lack of materials and workshop facilities, inadequacy of STEM lesson plans, time constraints due to dense curricula, and insufficient professional development opportunities provided to teachers.

Keywords: Science, Technology, Engineering, Mathematics (STEM), teacher, interdisciplinary.

Öğretmenlerin Disiplinler Arası Bir Yaklaşım Olarak STEM Eğitimine Yönelik Görüşlerinin İncelenmesi

**Sorumlu yazar*

Süreç
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ÖZ

Bu araştırmanın amacı alan öğretmenlerinin STEM eğitimi hakkındaki görüşlerini belirlemektir. Araştırmada konunun bütüncül bir yaklaşımla ele alınabilmesi amacıyla nitel araştırma yöntemlerinden durum çalışması deseni kullanılmıştır. Araştırmanın çalışma grubu Sivas ili Merkez ilçesindeki ortaokullarda görev yapan Fen Bilimleri, Bilişim Teknolojileri, Teknoloji ve Tasarım ve Matematik branşlarının her birinden altışar öğretmen olmak üzere toplam 24 öğretmenden oluşmaktadır. Araştırma verileri, yarı yapılandırılmış görüşme formu aracılığıyla toplanmıştır. Görüşme formunda öğretmenlere açık uçlu sorulardan oluşan 8 tane soru sorulmuştur. Araştırmada elde edilen veriler, içerik analizi tekniğiyle çözümlenmiştir. Araştırma sonucunda öğretmenlerin görüşlerinden; STEM eğitiminin disiplinler arası bir yaklaşım olarak kullanılmasının olumlu sonuçları olduğu, yaparak yaşayarak öğrenmeye fırsat tanıdığı, kalıcı öğrenmeyi sağladığı, günlük hayat problemlerine çözüm bulduğu, eleştirel düşünme, analitik düşünme ve yaratıcı düşünme gibi 21. yüzyıl becerilerini kazandırdığı, öğrencilerin ilgisini artırdığı, ürün odaklı bir yaklaşım olduğu anlaşılmıştır. Son olarak öğretmenler STEM etkinliklerini gerçekleştirmede malzeme ve atölye eksikliği, STEM ders planlarının yetersizliği, ders programlarından dolayı yaşanan zaman yetersizliği, öğretmenlere yeterli eğitimlerin verilmediği gibi sorunlarla karşı karşıya kaldıklarını ifade etmişlerdir.

Anahtar Kelimeler: Fen, Teknoloji, Mühendislik, Matematik (STEM), öğretmen, disiplinler arası.

[a] *nadiraksoy58@gmail.com* *https://orcid.org/0009-0008-9756-4326* | [b] *yildiz_htc@yahoo.com* *https://orcid.org/0000-0003-2365-6937*

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Introduction

In the 21st century, humanity is adapting to the advancements in technology, accompanying these changes dynamically (Çambay, 2024). These transformations directly influence the competitiveness among nations (NRC, 2015). The competitive environment emerging in the globalized world drives countries to prioritize the development of a highly skilled workforce (Huang et al., 2022). Therefore, the education system must adapt to these changes and prepare for future challenges (Çambay, 2024). To achieve this, equipping individuals with 21st-century skills through STEM education is considered crucial by policy makers, educators, and researchers (Huang et al., 2022). STEM, an acronym for Science, Technology, Engineering, and Mathematics, integrates the unique characteristics of each discipline while incorporating the shared skills and ideas that converge across STEM fields (Erdoğan et al., 2013).

The continuous advancement of technology and its integration into education present countless opportunities for future research and development endeavors. At this juncture, the demand for a highly qualified STEM workforce plays a critical role in ensuring the economic strength of nations (Vela et al., 2020). Interest in STEM education, which plays a vital role in driving economic growth and addressing global challenges (Widya et al., 2019), has significantly increased in recent years (Li et al., 2020). As the importance of STEM education becomes more widely recognized, researchers, educators, and curriculum developers, both domestically and internationally, are striving to promote the STEM approach (Şahin, 2024). It is a well-established fact that providing students with high-quality educational opportunities tailored to their developmental characteristics increases their likelihood of utilizing their interests, curiosity, and skills to succeed (Reynolds & Temple, 2008). Creating an inclusive classroom atmosphere where students feel valued and are encouraged to participate is crucial. Such an environment fosters the sharing of past experiences and challenges among students, enabling them to exchange insights and paving the way for effective and high-quality STEM education (Weiss et al., 2003).

The STEM education approach, which has become increasingly popular among the studies carried out by governments in order to increase the quality of education, is an important approach that should be implemented in school environments in terms of enabling the development of many attitudes and skills starting from preschool education (Soylu, 2016; Yıldırım & Altun, 2015). The significance of production efforts, particularly in the field of technology, is substantial for the economic growth of nations. Countries striving not to miss out on this contribution encourage their students to actively engage in engineering activities, aiming for them to derive valuable lessons from their failures and mistakes encountered during these endeavors. As a result of these practices, it is anticipated that individuals gaining career awareness will make significant contributions to science and the economy (Moore et al., 2014; Lacey & Wright, 2009).

There is a need for individuals who can utilize ideas generated through accessing and developing knowledge to solve problems and address both current and future challenges of the 21st century (Bybee, 2010). To meet this need, education systems emphasize STEM education (Kayan-Fadlelmula et al., 2022). STEM education not only provides students with theoretical knowledge in science, technology, engineering, and mathematics but also aims to develop them cognitively, affectively, and socially through skills such as problem-solving, critical thinking, communication, interaction (Şahin, 2024), interdisciplinary knowledge application, collaborative work, creative thinking (Burrows & Slater, 2015), arithmetic thinking, and metacognitive awareness (Papadakis et al., 2022). This objective supports the transition from traditional teaching methods to approaches incorporating research, inquiry, and collaborative learning (Quigley & Herro, 2016). The STEM approach emphasizes the importance of students actively processing knowledge and participating in hands-on activities, with inquiry-based learning—where students investigate questions and problems—serving as a powerful active learning strategy (Honey et al., 2014). Through this approach, students develop critical thinking skills and gain insights into scientific research methods (Joseph & Uzondu, 2024).

In STEM education, which seeks to empower students with 21st-century skills to address potential future challenges (Beers, 2011), teachers play a pivotal role. By utilizing a variety of methods and materials that cater to diverse learning styles, teachers can help uncover students' strengths and design instructional activities that are aligned with their needs and areas of interest (Basham et al., 2016). Teachers who guide their students by considering their individual characteristics during the learning process adapt effectively to the demands of contemporary developments (Şahin, 2024). It is evident that teachers require appropriate training to integrate STEM education into their lessons and address any misconceptions they may hold on the subject (Nadelson et al., 2013). In this regard, relevant authorities must focus on developing policies and programs related to STEM that emphasize the professional development of teachers (Marginson et al., 2013). Professional development is essential to ensure the successful implementation of best practices in STEM education (Joseph & Uzondu, 2024).

In recent years, STEM education has gained a prominent position within global education systems, as it is believed to encourage students to pursue careers in science, technology, engineering, and mathematics while equipping them with the skills necessary to address multidisciplinary and complex global challenges (Hsu & Fang, 2019). Providing students with early exposure to

STEM education by integrating engineering with physical sciences, mathematics, and technology can significantly enhance interest in careers within these fields (Ergün, 2019).

Honey et al. (2014) note that traditional education systems often separate disciplines, teaching content in isolation from one another. In contrast, STEM education represents a dynamic and integrated approach where disciplines are interconnected rather than kept distinct. Teachers facilitate instruction by integrating disciplines with one another (Urban et al., 2009). STEM education, which connects science, technology, engineering, and mathematics and enables students to recognize the interdisciplinary nature of these fields (Keller & Pearson, 2012), aids students in understanding the interconnections among diverse concepts and skills. This approach promotes addressing complex problems in a holistic manner (Joseph & Uzondu, 2024). Such integration contributes to deep learning, the development of higher-order thinking skills, and the attainment of greater academic achievement (Guzey et al., 2016).

STEM education, which emphasizes an interdisciplinary approach as its focal point, aims to foster meaningful and holistic learning by establishing connections across disciplines (Smith et al., 2000). STEM education makes a significant contribution to the cultivation of individuals equipped with these competencies by treating mathematics and science as an integrated whole and blending them with the disciplines of technology and engineering (Monsang & Srikoon, 2021). It is not necessary for all four disciplines to be present for an activity, practice, or project to be classified as "STEM." This inherent flexibility enables adaptations that integrate two or more fields to achieve specific learning outcomes (Halawa et al., 2024).

STEM education, which contributes to the creation of original products in educational activities by sparking students' curiosity and leveraging their sense of discovery (Altunel, 2018), places significant emphasis on the design of activities and instructional environments where disciplines are interconnected and interwoven. Given this emphasis, it is crucial for teachers to foster collaboration across disciplines (Rockland et al., 2010).

This research is significant in that it examines teachers' perspectives, attitudes, and perceptions regarding STEM education from an interdisciplinary perspective. Most studies in the literature on STEM focus on a specific discipline (e.g., only science or mathematics) and address the interaction between different disciplines in a limited way (Bybee, 2013; Honey et al., 2014). However, the interdisciplinary approach forms the basis of STEM education and plays a critical role in equipping students with 21st-century skills such as problem solving, creativity, and critical thinking (English, 2016; Marginson et al., 2013). In this context, there are only a limited number of studies in the literature that examine teachers' views on STEM from an interdisciplinary perspective. Studies show that STEM increases students' interest, especially at the middle school level, contributes to solving everyday problems, and supports lasting learning (Beers, 2011; Sanders, 2009). However, there are very few recent studies that comprehensively address teachers' views on STEM applications, the difficulties they encounter, and the reflections of interdisciplinary interaction. This study aims to fill this gap in the literature and present original findings on the interdisciplinary applicability of STEM education in the Turkish context by evaluating the experiences and perceptions of teachers from different disciplines together. In line with this purpose, the following questions were addressed:

What are the teachers' opinions on

1. their knowledge on STEM education?
2. the contributions provided by STEM education?
3. their participation in in-service training on STEM education and the adequacy of these activities?
4. their competencies within their own disciplines in the context of STEM education?
5. what they do in their lessons using STEM education?
6. how they utilize disciplines outside their own when incorporating STEM education in their lessons?
7. the significance of their own disciplines in terms of STEM?
8. the challenges they face in implementing STEM education in their schools and on potential solutions to these challenges?

Methodology

Research Design

This study was structured based on the qualitative research paradigm. It was planned and conducted using the case study design, one of the qualitative research approaches. A case study is a research design that aims to examine a specific phenomenon in a detailed and systematic manner (Yin, 2014). In this design, comprehensive data is collected, organized, and interpreted to reveal aspects of the current situation that will inform future research. The researcher aims to describe the phenomenon under investigation as it is, without any intervention (Yıldırım & Şimşek, 2021). A case study design was chosen for the research to examine teachers' experiences and views on STEM education in depth within their own context.

Participants

The criterion sampling method, one of the purposive sampling strategies, was used in selecting the participants. Since the research aimed to explore STEM education, teachers specializing in Science, Mathematics, Information Technologies, and Technology Design who had received STEM training were established as the selection criteria. Consequently, criterion sampling, which includes participants meeting predefined conditions relevant to the research (Patton, 2018; Yıldırım & Şimşek, 2021), was preferred. The criteria used to select participants were having participated in STEM education programs organized by the Ministry of National Education, universities, or other institutions, and having the ability to apply the training received in classroom lessons, projects, or school activities. To determine the teachers to be interviewed, preliminary interviews were conducted with teachers who had received STEM training and subsequently implemented it in their classes or schools and participated in projects or activities.

Accordingly, the participants consisted of 24 STEM-trained teachers working in various institutions in a city in the Central Anatolia Region of Turkey. Personal information about the participating teachers is presented in Table 1.

Data Collection Tool

In this study, a semi-structured interview form developed by the researchers was used. To uncover experiences and meanings related to case, it is essential to leverage the interaction, flexibility, and probing features that interviews offer to researchers (Yıldırım & Şimşek, 2021).

As a result of a detailed literature review, an 11-question interview form targeting teachers was prepared. To ensure content validity, the form was presented to two faculty members specializing in Educational Sciences for expert feedback. Based on their suggestions, four questions were merged into two, and one question was removed. Subsequently, a pilot study was conducted with three teachers to identify any unclear points in the interview form. No issues were encountered during this preliminary application.

The interview form consisted of two sections: the first included questions about participants' personal information, while the second contained eight questions aimed at determining their perspectives on STEM education. Ethical approval required for the implementation of the interview form was obtained. The form was then administered to teachers face-to-face, adhering to the principle of voluntarism. Each interview lasted approximately 20 minutes. Teachers were assured that the data would only be used for scientific purposes, and it was guaranteed that their identities would remain confidential. During the interviews, no guidance or influence was exerted on participants’ responses to the questions.

Data Analysis

The data obtained from the interviews were analyzed using the content analysis method. In content analysis, qualitative data are examined in depth, coded, and themes are created based on these codes. The frequency values of items related to the themes or sub-themes are also reported (Sönmez & Alacapınar, 2013). The coding process followed the steps outlined by Sağlam and Kanadlı (2020). Initially, the data were independently reviewed by two researchers, and unclear statements were excluded. Codes generated from the first round of analysis were defined based on the responses, and a code table was created. Subsequently, codes with the same meaning were grouped under a single label, and semantically similar code definitions were merged. The resulting codes were organized into themes. The codes and themes were then reviewed, and expert feedback was sought from a faculty member specializing in Educational Sciences. The findings were interpreted based on the defined data and were supported with direct quotations from the participants.

Validity and Reliability Studies

Ensuring validity and reliability is a critical aspect of research. Due to the distinct approaches, designs, and data used in qualitative studies, different criteria are applied for validity and reliability analysis (Büyüköztürk et al., 2021). In this context, to ensure validity, concepts such as transferability, credibility, and detailed reporting were prioritized. For reliability, consistency and confirmability were emphasized (Yıldırım & Şimşek, 2021).

To ensure the validity of the research in terms of credibility, a sense of trust was established by providing participants with information about the study before conducting interviews. Immediately after collecting the interview data, the researcher summarized the data and shared it with the participants, requesting their feedback regarding its accuracy, thus ensuring participant confirmation. Additionally, necessary revisions were made based on the feedback provided by an expert throughout all stages of the study.

Table 1. Personal information of the teachers

Variables		f	%
Gender	Female	10	41,7
	Male	14	58,3
Years of Professional Experience	1-5 years	3	12,5
	6-10 years	11	45,9
	11-15 years	7	29,1
	16 years and above	3	12,5
Educational Background	Bachelor’s Degree	11	45,9
	Non-thesis Master’s Degree	8	33,3
	Thesis-based Master’s Degree	5	20,8
Field	Science	6	25
	Information Technologies	6	25
	Technology and Design	6	25
	Mathematics	6	25

Furthermore, all phases of the research were presented in detail, and direct quotations from participant opinions were included. In this way, detailed descriptions were provided to support the external validity of the research.

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Moreover, to ensure identity confidentiality in the study, explanatory abbreviations specific to participants (e.g., "IT1-K") were used at the beginning of quotations. In the coding system, the participant's field and order were indicated, such as “S1” for Science-1, “IT3” for information Technology-3, “TD-4” for Technology and Design-4, and “M2” for Mathematics-2. The gender variable was also coded as “F” for Female and “M” for Male. To ensure the reliability of the research, the concept of confirmability was considered for external reliability. In this regard, a consistent approach was applied when asking questions to all participants during the interviews, and responses were recorded to prevent data loss. Additionally, interview forms, raw data, and the codes and themes generated through researchers' analyses are stored for review by interested parties.

Additionally, the reliability value of the study was calculated using the formula provided by Miles and Huberman (2016, p. 64):

$$reliability = \frac{number\ of\ aggrements}{total\ number\ of\ aggrements + disagreements}$$

The agreement between the researchers was found to be 91% (422/422+42). Miles and Huberman (2016, p. 64) state that a reliability value exceeding 90% is sufficient for ensuring the reliability of a study. To ensure internal reliability, the concept of consistency was considered, and expert opinions were sought from two faculty members specializing in Educational Sciences. The experts were asked to review the raw data and provide their feedback on whether the codes were consistent with the themes and categories. Based on the experts' suggestions, necessary revisions were made, and the coding was finalized.

Findings

Teachers' Opinions Regarding Their Knowledge about STEM Education

The findings obtained from teachers' responses regarding their knowledge of STEM education are presented in Figure 1.

Teachers' opinions regarding their knowledge of STEM education were categorized into 8 themes, ordered from the highest to the lowest frequency as follows: "An interdisciplinary approach" (f:21), "A product-oriented approach" (f:7), "A hands-on approach" (f:7), "An approach that fosters invention" (f:4), "An approach that promotes collaborative learning" (f:3), "An approach that develops problem-solving skills" (f:3), "A contemporary approach" (f:2), and "An approach that ensures permanent learning" (f:1). Examples of teachers' statements are provided below:

"STEM education is a method that aims to transform theoretical knowledge into practice, products, and innovative inventions. It enables students to perceive the knowledge they acquire in science, technology, engineering, and mathematics courses as parts of a whole." (S3-M)

"By utilizing the findings of science, the measurement and modeling tools of mathematics, and incorporating engineering skills and technology, STEM education is a product-oriented process of discovery, skill-building, production, and learning aimed at solving real-life problems. While it is fundamentally considered hands-on learning for permanent retention, factors such as students managing the process, the potential for improving products, the product development phase, teamwork, and a learning process enriched with positive emotions can elevate the contributions of STEM education far beyond permanent learning by allowing for deeper engagement." (M5-F)

"It is an interdisciplinary approach aimed at making educational activities more lasting. Through this approach, students' active participation in the process is ensured, leading to more permanent learning. Individuals recognize that knowledge learned in one discipline can also be applied and utilized in another, which allows them to enjoy the learning process, increases their motivation, and enhances their interest in lessons." (TD1-F)

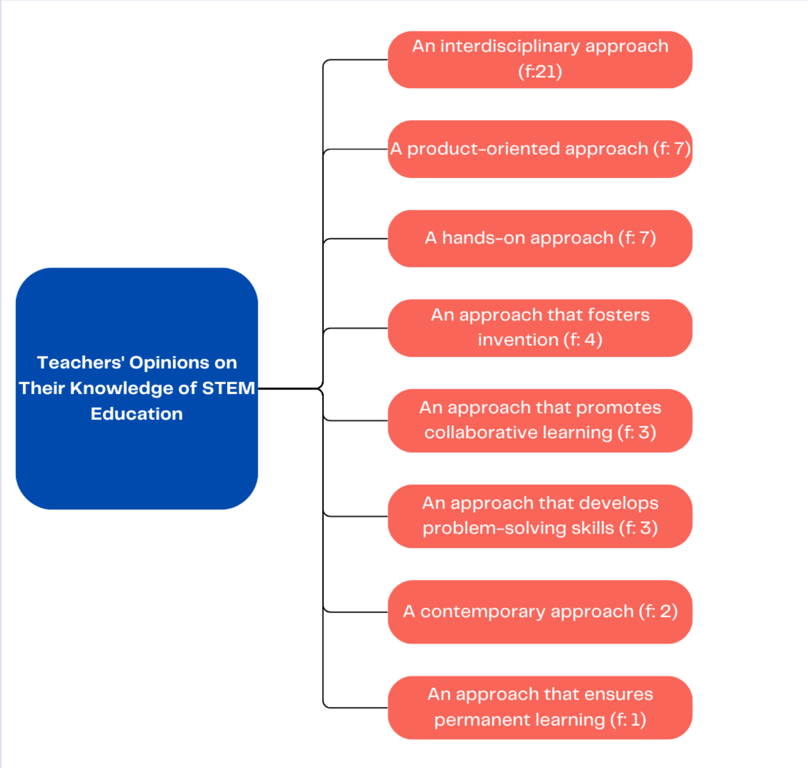

Figure 1. Teachers' opinions on their knowledge of STEM education

Teachers' Opinions on the Contributions of STEM Education

The findings obtained from teachers' responses regarding the contributions of STEM education are presented in Figure 2.

It is observed that teachers' perspectives on the contributions of STEM education are categorized into two main themes: **"Contributions to Students" (f:92)** and **"Contributions to Teachers" (f:2)**. The theme of contributions to students is further divided into three sub-themes: **"Cognitive Contributions" (f:74)**, **"Psychomotor Contributions" (f:11)**, and **"Affective Contributions" (f:7)**.

Within the **Cognitive Contributions** theme, contributions are divided into two subcategories: **"Learning" (f:54)** and **"Higher-Order Thinking" (f:20)**. The contributions related to Learning include: Facilitating learning through hands-on and experiential methods (f:17), Ensuring permanent learning (f:16), Promoting collaborative learning (f:7), Establishing interdisciplinary connections (f:6), Making learning enjoyable (f:3), Enabling knowledge transfer (f:2), Fostering scientific literacy (f:2), and Encouraging active learning (f:1). The contributions related to Higher-Order Thinking include: Problem-solving (f:9), Critical thinking (f:6), Developing creativity (f:4), and Self-regulation (f:1). Within the Psychomotor Contributions theme, the identified contributions are; Producing tangible outcomes (f:8), and Enhancing manual skills (f:3). The Affective Contributions theme includes: Increasing motivation (f:5), and Enhancing self-awareness (f:2). The Contributions to Teachers theme is divided into two subcategories: Facilitating professional development (f:1), and Enhancing motivation (f:1). Examples of teacher perspectives are provided below:

‘‘STEM education is important in terms of enabling students to achieve permanent learning. It not only benefits students but also provides an advantage for teachers to develop themselves. Teachers and students improve themselves by experiencing this process together. It offers significant motivational advantages for both parties.” (M3-M)

“It helps students become aware of real-life problems and fosters a critical perspective. It enhances the level of literacy in mathematics, technology, and science.” (S6-F)

“It contributes to raising entrepreneurial young individuals who solve their problems, are producers rather than consumers, are curious, questioning, and innovative.” (TD3-M)

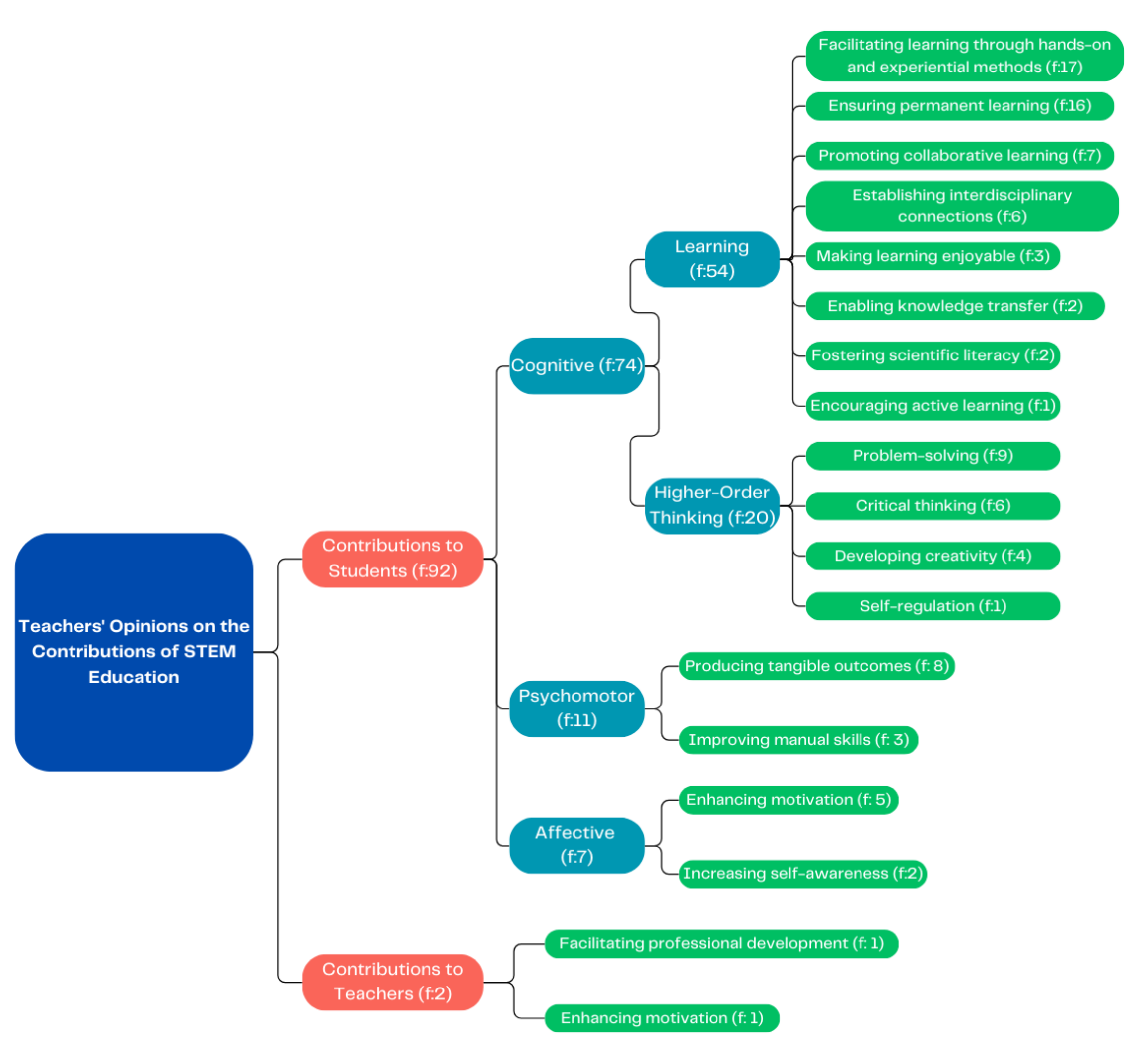

Figure 2. Teachers' opinions on the contributions of STEM education

Teachers' Participation in In-Service Training on STEM Education and Their Opinions on the Sufficiency of These Activities

The findings obtained from teachers' responses regarding their participation in in-service training on STEM education and their opinions on the adequacy of these activities are presented in Figure 3.

Teachers' participation in the course was categorized into two themes: "Participated" (f:14) and "Did Not Participate" (f:10). The views of teachers who indicated participation were further divided into three sub-themes regarding the adequacy of the activities: "Inadequate" (f:7), "Partially Adequate" (f:5), and "Adequate" (f:2). Teachers who rated the activities as inadequate expressed opinions such as "The course duration is insufficient" (f:6) and "I could not improve myself" (f:1). Those who found the activities partially adequate shared views such as "Not enough practice was done" (f:4) and "The course duration is insufficient" (f:1). Examples of teacher opinions that may have contributed to the formation of these themes are provided below.

"I attended the course and lessons. It is theoretically sufficient but lacks in practical aspects." (S5-M)

"I participated the course. I think it is partially adequate, but I believe the training should have been longer." (M1-F)

"I attended the course. STEM education is not an approach that can be fully acquired through one-week training sessions. We need to thoroughly internalize STEM education and continue developing ourselves in this area after the training." (IT2-M)

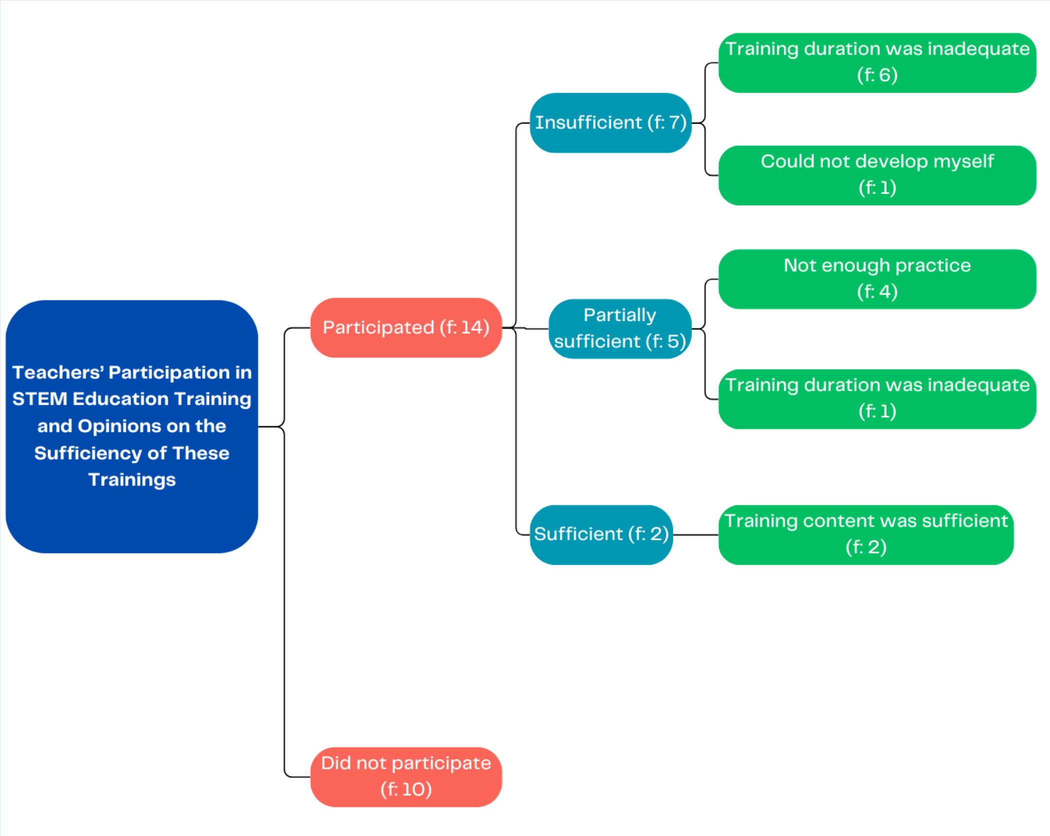

Figure 3. Teachers' participation in STEM education training and opinions on the sufficiency of these trainings

Teachers' Opinions Regarding Their Competencies in Their Own Disciplines in Terms of STEM Education

The findings obtained from the responses of teachers regarding their competencies in their own disciplines in terms of STEM education are presented in Figure 4.

It is observed that teachers' opinions regarding their competencies in their respective disciplines, in terms of STEM education, are categorized into three themes: **"Partially Adequate"** (f:12), **"Adequate"** (f:7), and **"Inadequate"** (f:5). The "Partially Adequate" theme is further divided into five sub-themes: **"I need STEM training"** (f:7), **"I constantly need to improve myself"** (f:2), **" I cannot sufficiently ensure permanent learning"** (f:1), **"I experience difficulties during implementation"** (f:1), and **"I am only competent in the technological field"** (f:1). The "Adequate" theme is divided into two sub-themes: **"I constantly improve myself"** (f:4) and **"I can use it in my lessons"** (f:3). The Inadequate" theme is also divided into two sub-themes: **"I need STEM training"** (f:4) and **"I have only basic-level knowledge"** (f:1). Examples of teachers' opinions are presented below.

"I believe that no one should be convinced of their knowledge sufficiency in this field and should constantly strive to improve themselves." (IT3-F)

"I can provide more support in terms of conceptual understanding and productivity. However, I believe that a teacher should have competency, even if not in-depth, in all STEM fields. Personally, I need to improve a bit more in coding and circuits. Having just ideas is not enough for producing an outcome." (S2-M)

"Since I have not received any training or participated in any work on this subject, I do not think I am sufficient or knowledgeable." (TD2-M)

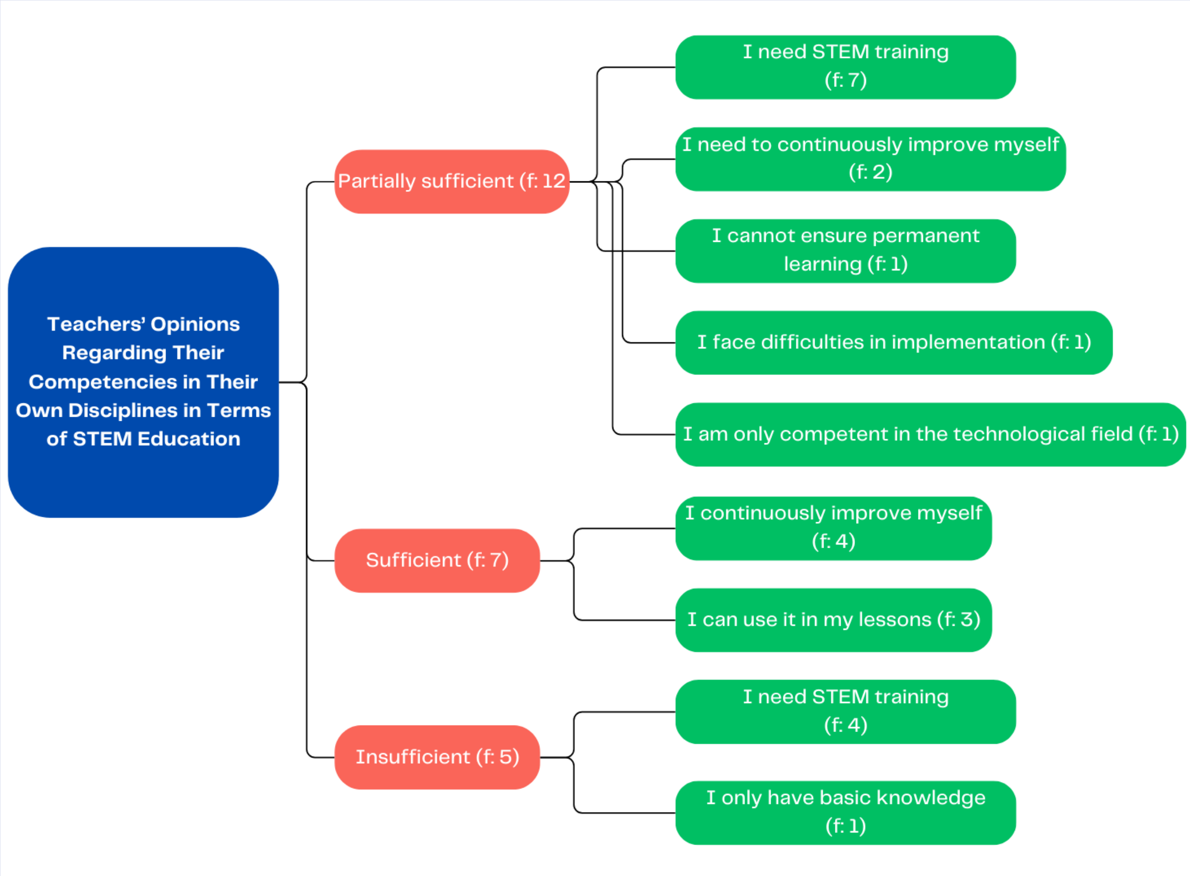

Figure 4. Teachers' opinions regarding their competencies in their own disciplines in terms of STEM education

Teachers' Opinions on What They Do Using STEM Education in Their Lessons

The findings obtained from teachers' responses regarding what they do using STEM education in their lessons are presented in Figure 5.

Teachers' opinions regarding what they do using STEM education in their lessons are categorized into seven themes: **"Designing"** (f:16), **"Performing mathematical calculations"** (f:9), **"Concrete representation of science topics"** (f:6), **"Conducting robotics coding activities"** (f:4), **"Conducting experiments"** (f:2), **"Problem solving"** (f:2), and **"Establishing connections between subjects"** (f:2). The **"Designing"** theme is further divided into five sub-themes: **"Designing with available materials"** (f:5), **"Designing with waste materials"** (f:4), **"Architectural design"** (f:3), **"Material design"** (f:2), **and "Model making"** (f:2). Examples of teachers' opinions are presented below.

"In classroom activities related to learning outcomes, I ask students to create designs, experiments, etc., that highlight their creativity. To help unleash their imagination, I let them design whatever they want with the materials they have, without giving them specific instructions." (S1-M)

"The Technology and Design course is a class where knowledge from other subjects is applied. In our lessons, science, mathematics, technology, and engineering topics are particularly emphasized. While students work on design and model projects, they benefit from this knowledge. For example, in the topic of transportation technologies, they design a transportation vehicle using simple materials that can travel the farthest, remain stable, and have a unique aesthetic appearance, all at minimal cost." (TD4-F)

"In the obstacle-avoiding robot activity, I utilize mathematical and design skills." (IT6-F)

Figure 5. Teachers' opinions on what they do using STEM education in their lessons

Teachers' Opinions on How They Benefit from other Disciplines While Using STEM Education in Their Lessons

The findings regarding teachers' opinions on how they benefit from disciplines outside their own while using STEM education in their lessons are presented in Figure 6.

Teachers' opinions on how they benefit from other disciplines have been categorized into four themes: **"Engineering"** (f:11), **"Mathematics"** (f:10), **"Science"** (f:7), and **"Technology"** (f:1). The **"Engineering"** theme is divided into two sub-themes: **"Design work"** (f:10), **"Area calculations"** (f:1). The **"Mathematics"** theme includes two sub-themes: **"Using mathematical calculations"** (f:9), **"Architectural design"** (f:1). The **"Science"** theme consists of one sub-theme: **"Providing examples for topics"** (f:7). The **"Technology"** theme contains one sub-theme: **"Using tools and equipment"** (f:1). Examples of teacher opinions contributing to the formation of these themes are presented below.

"Science classes are already integrated with mathematics, technology, and engineering. Since 'science' literally means 'nature,' all the knowledge used in nature forms the foundation of science. We use mathematics for calculations, engineering for designs, and technology for tools and equipment." (S3-M)

"In the Technology and Design course, topics such as transportation technologies, architectural design, energy transformation, and design are covered. I first remind students of the knowledge they have learned in science, mathematics, and other subjects, and then encourage them to work on design-oriented projects." (TD6-F)

"As an Information Technology teacher, I mostly benefit from mathematics and engineering. The activities we carry out generally require skills in design. Additionally, in many coding activities, I use mathematical operational operators." (IT4-M)

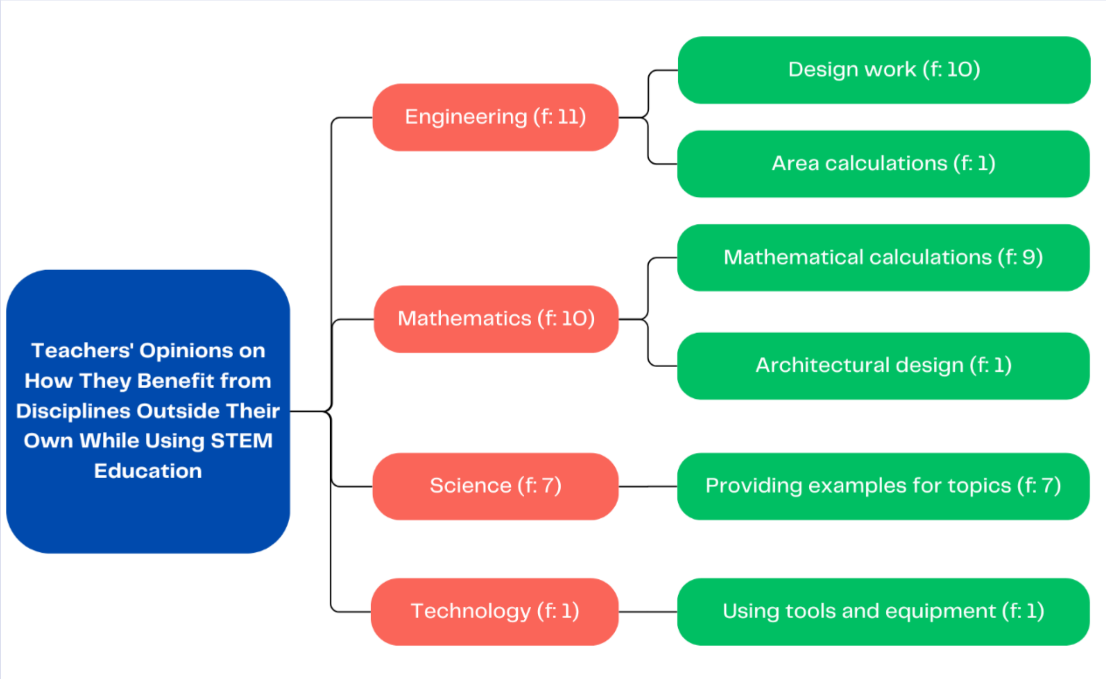

Figure 6. Teachers' opinions on how they benefit from disciplines outside their own while using STEM education

Teachers' Opinions on the Importance of Their Own Disciplines in Terms of STEM

The findings obtained from teachers' opinions regarding the importance of their own disciplines in terms of STEM are presented in Figure 7.

Teachers' opinions on the importance of their own disciplines in terms of STEM education are categorized into **"Technology Design"** (f:19), **"Science"** (f:14), **"Mathematics"** (f:14), and **"Information Technology"** (f:12). **Technology Design** teachers' views on the importance of their discipline in STEM education are divided into **6 sub-themes**: **"Necessary for design"** (f:5), **"An important part of STEM"** (f:4), **"Product-oriented"** (f:4), **"Promotes learning through discovery"** (f:2), **"Provides opportunities for practice"** (f:2), and **"Develops imagination"** (f:1). **Science** teachers' views on the importance of their discipline in STEM education are divided into **6 sub-themes**: **"Product-oriented"** (f:3), **"Promotes learning through discovery"** (f:3), **"Provides opportunities for practice"** (f:3), **"Develops problem-solving skills"** (f:3), **"An important part of STEM"** (f:1), and **"Develops creative thinking"** (f:1). **Mathematics** teachers' views on the importance of their discipline in STEM education are divided into **6 sub-themes**: **"An important part of STEM"** (f:3), **"Develops problem-solving skills"** (f:3), **"Mathematical calculations are used in almost all areas"** (f:3), **"Product-oriented"** (f:2), **"Develops higher-order thinking skills"** (f:2), and **"Promotes learning through discovery"** (f:1). **Information Technology** teachers' views on the importance of their discipline in STEM education are divided into 4 sub-themes: **"An important part of STEM"** (f:5), **"Develops programming skills"** (f:3), **"Provides opportunities for practice"** (f:2), and **"Prominence of robotics coding"** (f:2). Examples of teacher opinions are presented below.

"I believe that the mathematics discipline is extremely important for developing correct, practical, and rational thinking skills in many areas." (M2-F)

"Since the Technology and Design course is practice-oriented, I think it is very important for STEM education. By engaging students in hands-on applications, learning can become more permanent." (TD5-M)

"STEM activities play a crucial role in helping students gain meaningful experiences to better understand science classes. In this way, students not only achieve permanent learning by actively doing and experiencing but also create a product themselves, which helps them understand the importance of being an individual, build self-confidence, and experience the sense of accomplishment." (S4-F)

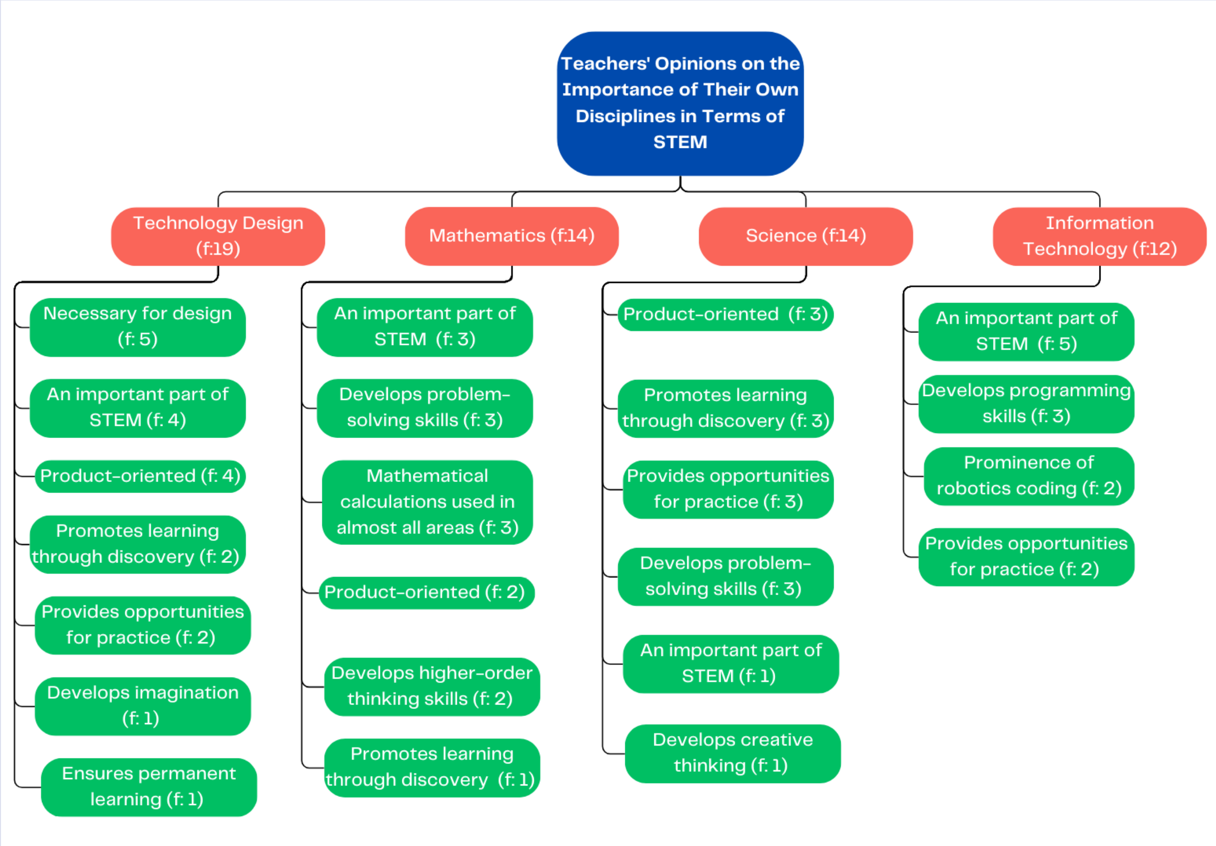

Figure 7. Teachers' opinions on the ımportance of their own disciplines in terms of STEM

Teachers' Opinions on Problems and Solutions While Implementing STEM Education in Their Schools

The findings obtained from teachers' responses regarding the problems they face while implementing STEM education in their schools are presented in Figure 8.

Teachers' perspectives on the challenges encountered in implementing STEM education are categorized into five main themes: **Program-Related** (f:25), **Physical Facilities** (f:24), **Teacher-Related** (f:15), **School-Related** (f:8), and **Student-Related** (f:2). The **Program-Related Issues** theme includes four sub-themes: "Insufficient course hours in the program" (f:13), "Lack of lesson plans" (f:7), "Overloaded curriculum" (f:3), "Limited to only four subject areas" (f:2). The **Physical Facilities** theme is divided into three sub-themes: "Lack of materials" (f:15), "Insufficient workshops" (f:5), "High costs" (f:4). The **Teacher-Related Issues** theme comprises four sub-themes: "Insufficient qualifications" (f:8), "Exam-oriented teaching" (f:4), "Communication problems" (f:2), and "Lack of motivation" (f:1). The **School-Related Issues** theme includes two sub-themes: "Scheduling conflicts" (f:4), "Overcrowded classes" (f:4) and lastly, the **Student-Related Issues** theme contains one sub-theme: "Insufficient skill level" (f:2). Examples of teachers' opinions are presented below.

"Our school has a workshop and a smartboard, which we use actively. However, we are insufficient in terms of materials. It would have been better if we could provide students with more diverse materials or if various design kits were available in our school. Additionally, I feel the need for a computer lab to support computer-aided topics." (TD6-F)

"The overlapping of class schedules and the opinions of administrators that STEM activities will not achieve academic success pose challenges. Although parents are willing in this regard, they prefer activities such as test-solving sessions, especially for students in their exam periods." (M6-M)

"The overemphasis on an exam-oriented perspective creates challenges in implementing STEM. First and foremost, achieving unity within the school is necessary. In the current school environment, a lack of time and overlapping class schedules prevent the realization of interdisciplinary activities." (S4-F)

Figure 8. Teachers' opinions on problems while ımplementing STEM education

The findings derived from teachers' responses regarding their solution proposals to the problems encountered in implementing STEM education in their schools are presented in Figure 9**.**

It is observed that the opinions of teachers regarding solutions to the problems they encounter in implementing STEM education in their schools are categorized into five main themes: **Physical Facilities** (f:25), **Teacher-Related** (f:20), **Program-Related** (f:17), **School-Related** (f:7), and **Student-Related** (f:3). The **Physical Facilities** theme is divided into two sub-themes: "Workshops should be established" (f:13), and "Material support should be provided" (f:12). The **Teacher-Related** theme includes two sub-themes: "In-service training should be provided" (f:13), and "Communication among teachers should increase" (f:7). The **Program-Related** theme consists of four sub-themes: "Time should be allocated for STEM activities" (f:7), "Educational programs should be revised" (f:5), "Lesson plans should be created for STEM" (f:3), and "Guidebooks should be prepared for STEM" (f:2), The **School-Related** theme includes three sub-themes: "Administrators should be made aware" (f:4), "School *STEM committees should be established" (f:2), and "Class schedules should be prepared carefully" (f:1). Lastly, the Student-Related theme consists of one sub-theme: "Students' interest should be increased" (f:3). Examples of teachers' opinions are presented below.*

"When I consider it within the context of my subject area, even conducting simple STEM activities requires a certain budget. School administrators need to give the necessary importance to STEM activities." (S3-M)

"For the implementation of STEM education, first and foremost, there is a need for proper STEM training in this area. Afterward, motivation and encouragement are essential. While tools and materials are important in STEM, any kind of resource can be utilized for this education. The most critical point is to introduce STEM effectively to teachers, students, and parents alike." (IT5-M)

"There is a need for curriculum revision, alignment of topics with other disciplines, financial resources, and of course, raising awareness among teachers." (M2-F)

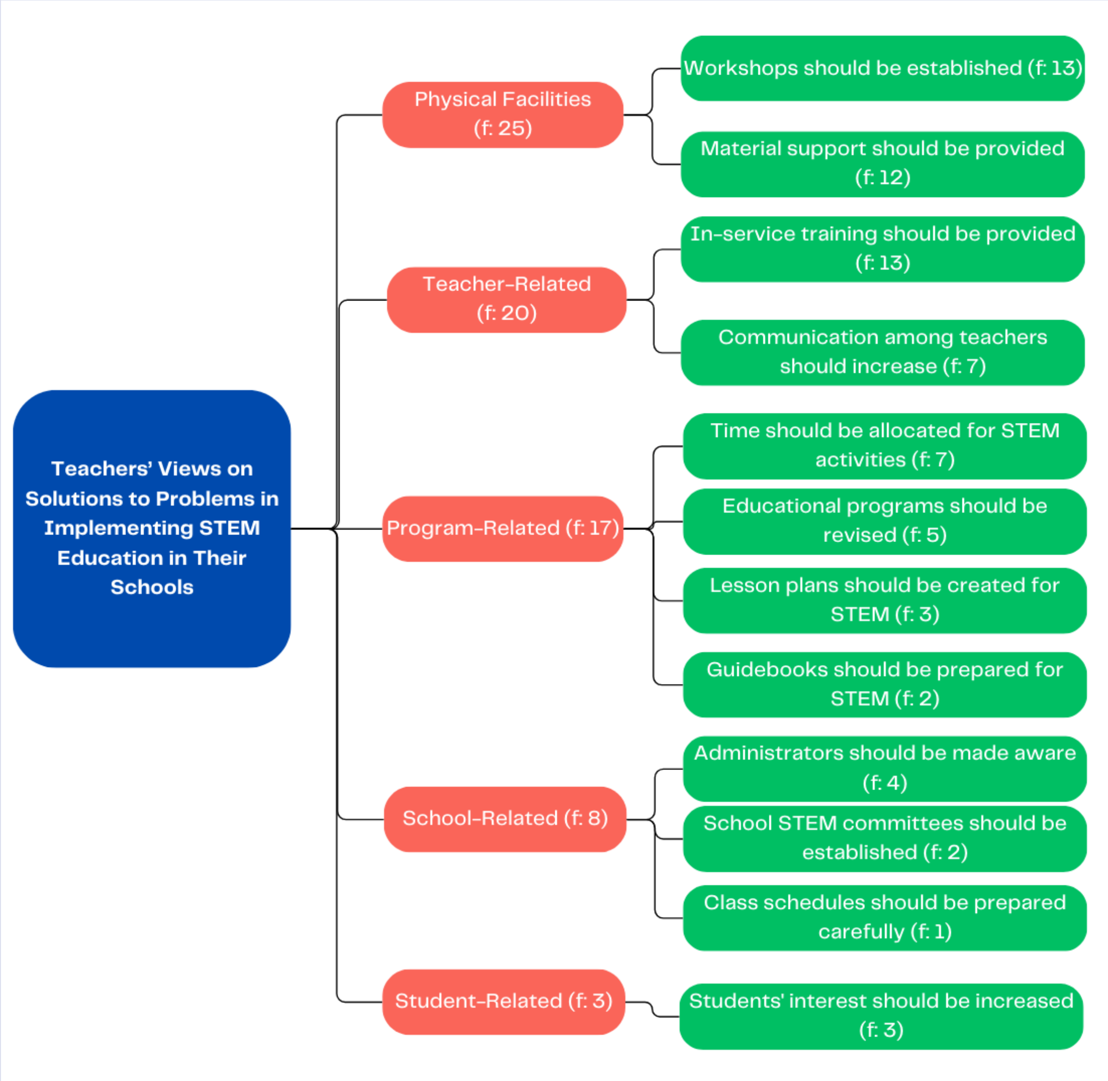

Figure 9. Teachers' views on solutions to problems in implementing STEM education in their schools

Discussion, Conclusion, and Recommendations

In this study, teachers' perspectives on STEM education as an interdisciplinary approach were examined, and the following conclusions were reached:

Initially, teachers participating in the study were asked about their knowledge of STEM education. Teachers described STEM as a contemporary approach that was interdisciplinary, product-oriented, practical, promoted invention, required collaborative learning, developed problem-solving skills, and ensured permanent learning. Consistent with these findings, Can and Sağır (2018), in their study examining classroom teachers' views on STEM applications, found that the majority of teachers were knowledgeable about STEM and defined it as an interdisciplinary approach aimed at creating products. Similarly, in Altunışık's (2024) research on the effectiveness of problem-based STEM applications in science teacher education, teachers described STEM as the integration of disciplines and a culture of production. These results are consistent with the existing literature and show that teachers understand STEM more in terms of its interdisciplinary and product-oriented aspects. However, the fact that some teachers view STEM as limited to the context of science or mathematics reflects the different perspectives in the literature. This difference can be attributed to teachers' pedagogical background in their own disciplines and their in-service training experiences. At this point, while emphasizing interdisciplinary integration, it can be said that teachers' discipline-based perceptions may pose a significant obstacle to the applicability of STEM.

When teachers were asked about the contributions of STEM education, they expressed that it provided various benefits to students in cognitive, psychomotor, and affective domains. The study concluded that the cognitive domain contributed in various ways, including facilitating experiential learning, ensuring lasting learning, promoting collaborative learning, and establishing interdisciplinary connections under the sub-theme of learning. Additionally, under the sub-theme of higher-order thinking, it supported skills such as problem-solving, critical thinking, and fostering creativity. In the affective domain, STEM education was noted to increase motivation and enhance self-awareness. In the psychomotor domain, the study observed to help students produce tangible outcomes and improve manual skills. Additionally, the study found that STEM education contributed to teachers' professional development and enhances their motivation. Supporting the findings of this study, the literature indicates that STEM education facilitates learning by doing and experiencing (Benzer & Kurt, 2022), ensures permanent learning (Can & Sağır, 2018), fosters collaboration (Akkor, 2024; Ecevit & Yıldız, 2024), and establishes interdisciplinary connections (Benzer & Kurt, 2022; Can & Sağır, 2018; Güleç Çiftçi, 2024). Furthermore, it develops problem-solving skills (Benzer & Kurt, 2022; Can & Sağır, 2018; Güleç Çiftçi, 2024; Kırmızıbiber, 2024; Mauch, 2001; Yıldırım & Selvi, 2016), critical thinking skills (Baydere, 2020; Benzer & Kurt, 2022), and creativity (Benzer & Kurt, 2022; Baydere, 2020; Güleç Çiftçi, 2024). It also raises student awareness (Güleç Çiftçi, 2024), enables product creation (Benzer & Kurt, 2022; Can & Sağır, 2018; Kırmızıbiber, 2024; Güleç Çiftçi, 2024), and enhances manual skills (Baydere, 2020; Güleç Çiftçi, 2024). Moreover, it supports teachers' professional development (Benzer & Kurt, 2022). These results largely correspond with findings in the literature and confirm the multidimensional contributions of STEM education. However, different studies show that psychomotor contributions are less emphasized, while cognitive and affective areas are more prominent. This difference is thought to be related to the variety of materials teachers have in their classroom practices and their lesson planning experiences. In this context, it can be said that this stems from teachers viewing STEM not only through cognitive contributions but also as a process that strengthens their professional motivation. In this respect, the results of this study offer a more comprehensive perspective compared to many studies in the literature.

The study concluded that the majority of the teachers participating in the study had previously attended STEM-related training, and most of them found the content of these trainings inadequate. Furthermore, the study determined that teachers considered themselves partially competent in STEM because they felt the need for training specific to their own disciplines. Supporting this finding, Can and Sağır (2018) concluded that teachers often do not feel adequate due to a lack of knowledge and practice regarding STEM, as well as frequent changes in the education system and curricula. Verdi (2024), in a study conducted with pre-service science teachers, found that their STEM competencies were at a high level. Similarly, Moh'd et al.(2021), in a study with mathematics teachers, concluded that teachers were pedagogically knowledgeable and well-equipped. These results show both similarities and differences when compared to studies in the literature. While most studies emphasize deficiencies in teachers' STEM competencies, some studies indicate that competency levels are high. This difference can be attributed to the context in which the studies were conducted, the sample groups, and the in-service or pre-service training opportunities available to teachers in STEM. Although teachers theoretically possess STEM awareness, it is thought that the perceived competence is limited by the perceived inadequacy of discipline-specific needs and educational content during the implementation phase.

The study determined that teachers, by integrating STEM education into their lessons, engaged in activities such as designing, performing mathematical calculations, concretizing scientific concepts, and conducting robotic coding exercises. Consistent with this finding, Can and Sağır (2018) reported in their study that teachers utilized measurement and calculations for product design in science lessons, taught using coding and Arduino, and employed technology and mathematics disciplines through mass and volume calculations. This result shows that STEM contributes to applied learning by integrating different disciplines, consistent with the literature. However, some studies indicate that teachers can only achieve limited integration in such applications because they lack sufficient materials and technical equipment. This difference is primarily due to infrastructure differences between schools and variations in teachers' technology skills. It can be said that teachers are eager to integrate STEM applications into their lessons, but the quality of these applications largely depends on hardware and supportive educational opportunities.

The study also found that teachers most frequently benefited from engineering and mathematics disciplines outside their own fields when conducting STEM activities in their lessons. Similarly, Benzer and Kurt (2022), in their research examining science teachers' perspectives on STEM applications, concluded that the science curriculum is most closely related to mathematics and engineering disciplines. Kızılay (2016), in another study, highlighted that engineering heavily incorporates science, mathematics, and technology, with mathematics being predominantly applied across other disciplines. These findings largely align with the literature and indicate that teachers are particularly focused on mathematical calculations and engineering-oriented design in their STEM applications. However, some studies also indicate that the integration of technology and science disciplines is more prominent. This difference varies depending on teachers' subject distribution, course content, and the equipment they have available. It can be argued that teachers emphasize mathematics and engineering because these fields can be more easily converted into measurable and tangible products, whereas technology and science fields may be limited to more abstract concepts.

The study revealed that teachers face several challenges when implementing STEM education in their schools, including a lack of materials, limited class hours in the curriculum, the absence of lesson plans, insufficient workshops, teachers' inadequacies in STEM-related topics, exam-oriented teaching approaches, and insufficient student preparedness. Consistent with this finding, Joseph and Nwankwo (2024) highlighted that one of the main challenges in implementing STEM education is the lack of adequate funding and resources. Supporting the current findings, Güleç Çiftçi (2024), in a study with school administrators, identified problems such as insufficient infrastructure and equipment, an overly intensive curriculum, the need for additional time, inadequate teacher proficiency, and lack of student interest. Similarly, Can and Sağır (2018) reported challenges such as students' lack of sufficient knowledge, teachers' lack of expertise, insufficient technology, a shortage of materials and equipment, and limited class time and duration. These results largely coincide with the literature and show that structural and pedagogical barriers are common in the implementation of STEM. However, some studies indicate that teachers can partially overcome these barriers through their individual creativity and efforts. This difference is thought to stem from infrastructure differences between schools, teachers' motivation levels, and the presence of administrative support. Teachers perceive exam-focused education and limited class hours as the biggest obstacles to STEM implementation; nevertheless, it is believed that these obstacles can be overcome with sufficient support and resources.

Teachers proposed several solutions to address the identified challenges, including establishing workshops, providing material support, offering in-service training for teachers, enhancing communication among teachers, raising awareness among administrators, allocating time for STEM activities in schools, and developing STEM education programs and lesson plans. Hsu et al. (2015) emphasize the necessity of reliable internet access and up-to-date technological equipment for effective STEM education. Honey et al. (2014) highlight that traditional education systems often divide subjects into separate units, making it challenging to implement integrated STEM programs that require a multidisciplinary approach. They stress the importance of schools adopting new curriculum models that promote the integration of science, technology, engineering, and mathematics. Sanders (2009) underlines the need for continuous training and support to help teachers stay updated with new technologies and teaching strategies. Similarly, Dolan (2016) points out that many teachers lack the necessary training and support to effectively integrate STEM practices into their classrooms. These results are consistent with the recommendations in the literature and reveal that the solutions proposed by teachers show similarities at a universal level. However, some studies also show that teachers use their individual creativity to produce lower-cost solutions based on local resources. This difference may be related to the economic resources of schools, regional support mechanisms, and teachers' openness to innovative approaches. It can be said that teachers' proposed solutions are mostly based on structural support, but individual and local initiatives also hold significant potential in STEM applications.

In general, this research reveals that STEM education is evaluated by teachers as an interdisciplinary, product-oriented approach that supports 21st-century skills; however, structural, pedagogical, and contextual limitations encountered during implementation hinder the full realization of this potential.

Based on the research findings, the following suggestions have been proposed:

- It may be beneficial to provide in-service training for teachers to effectively implement STEM education, considering the existing infrastructure and material conditions of schools during these training sessions.
- Raising awareness among school administrators and parents about the importance of STEM activities in an exam-focused system could help garner their support and understanding.
- Establishing interdisciplinary committees in schools, comprising teachers from relevant fields, might facilitate collaboration and enable the planning of dynamic activities throughout the academic term.
- Providing material support required for conducting STEM activities could enhance their effectiveness.
- Researchers might consider developing resources, such as activity examples and lesson plans based on an interdisciplinary approach, to assist teachers interested in conducting STEM-related studies.

Genişletilmiş Özet

Giriş

Eğitimde kalitenin arttırılması amacıyla devletlerin yaptığı çalışmalar arasında son dönemde popülerliği giderek artan STEM eğitimi yaklaşımı okul öncesi eğitimden itibaren bir çok tutum ve becerinin geliştirilmesine olanak sağlaması bakımından okul ortamlarında uygulanması gereken önemli bir yaklaşımdır (Soylu, 2016; Yıldırım ve Altun, 2015). Öğrencilerin 21.yüzyıl becerilerini kazanarak gelecekte karşılaşabilecekleri sorunlara çözüm bulmalarını hedefleyen STEM eğitiminde (Beers, 2011) öğretmenlere de görevler düşmektedir. Öğretmenlerin mesleki gelişimi, STEM eğitiminde en iyi uygulamaların başarılı bir şekilde uygulanmasını sağlamak için gereklidir (Joseph & Uzondu, 2024). Bu araştırma öğretmenlerin STEM ve tasarım süreçlerine bakış açılarını, tutumlarını, bilgilerini, algılarını incelemeye yönelik mevcut durum analizi çalışması yapılması bakımından önem arz etmektedir. Bu sebeple disiplinlerarası bir yaklaşım olarak STEM uygulamalarında branşlar arası etkileşimin önemi araştırmada vurgulanan önemli bir noktadır. Bu araştırmanın amacı öğretmenlerin disiplinlerarası bir yaklaşım olarak STEM eğitimine yönelik görüşlerini ortaya koymaktır.

Yöntem

Araştırma, nitel araştırma yaklaşımlarından olgu bilim desenine göre planlanmış ve yürütülmüştür. Çalışma grubunun seçiminde amaçlı örnekleme yöntemlerinden ölçüt örnekleme yöntemi kullanılmıştır. Araştırmanın çalışma grubu Sivas ili Merkez ilçesindeki ortaokullarda görev yapan Fen Bilimleri, Bilişim Teknolojileri, Teknoloji ve Tasarım ve Matematik branşlarının her birinden altışar öğretmen olmak üzere toplam 24 öğretmenden oluşmaktadır. Araştırma verileri, yarı yapılandırılmış görüşme formu aracılığıyla toplanmıştır. Görüşme formunda öğretmenlere açık uçlu sorulardan oluşan 8 tane soru sorulmuştur. Araştırmada elde edilen veriler, içerik analizi tekniğiyle çözümlenmiştir.

Sonuç

Öncelikle araştırmaya katılan öğretmenlere STEM eğitimi hakkındaki bilgileri sorulmuştur. Öğretmenler STEM'i; disiplinlerarası, ürün odaklı, uygulamalı, buluş yapmayı sağlayan, işbirlikli öğrenmeyi gerektiren, problem çözme becerisi kazandıran, kalıcı öğrenmeyi sağlayan çağdaş bir yaklaşım olarak tanımlamıştır.

Öğretmenlere STEM eğitiminin sağladığı katkılara ilişkin görüşleri sorulduğunda öğrencilere bilişsel, psikomotor ve duyuşsal boyutta çeşitli katkılarının olduğunu ifade etmişlerdir. Bilişsel boyutta, öğrenme temasında yaparak yaşayarak öğrenmeyi sağlama, kalıcı öğrenmeyi sağlama, işbirlikli öğrenmeyi sağlama, disiplinlerarası ilişki kurma gibi; üst düzey düşünme temasında problem çözme, eleştirel düşünme, yaratıcılığı geliştirme gibi katkılarının olduğu sonucuna ulaşılmıştır. Duyuşsal boyutta motivasyonu arttırma, kendine yönelik farkındalığı arttırma; psikomotor boyutta ise ürün ortaya koyma ve el becerisini geliştirme şeklinde öğrencilere katkılarının olduğu tespit edilmiştir. Ayrıca öğretmenlerin mesleki gelişimini sağlama ve motivasyonu arttırma gibi katkılarının olduğu sonucuna ulaşılmıştır.

Araştırmaya katılan öğretmenlerin çoğunluğunun daha önce STEM ile ilgili eğitimlere katıldığı ve katılan öğretmenlerin çoğunluğunun da bu eğitimlerin içeriğini yetersiz bulduğu anlaşılmıştır. Ayrıca öğretmenlerin STEM açısından kendi disiplinlerinde eğitimlere ihtiyaç duydukları için kendilerini kısmen yeterli gördükleri tespit edilmiştir.

Öğretmenlerin derslerinde STEM eğitimini kullanarak tasarım yapma, matematiksel hesaplamalar yapma, fen konularını somutlaştırma, robotik kodlama etkinlikleri yapma gibi çalışmalar gerçekleştirdikleri belirlenmiştir.

Öğretmenlerin derslerinde STEM etkinliklerinde kendi disiplinleri dışında en çok mühendislik ve matematik disiplininden faydalandıkları anlaşılmıştır.

Araştırma sonucunda öğretmenlerin okullarında STEM eğitimini gerçekleştirirken malzeme eksikliği, programda ders saatinin az olması, ders planlarının olmaması, atölye yetersizliği, öğretmenlerin STEM konusundaki yetersizlikleri, sınav odaklı ders işlenmesi, öğrenci seviyesinin yetersiz olması gibi sorunlarla karşılaştıkları tespit edilmiştir. Bahsedilen sorunlara ilişkin öğretmenlerin atölyeler kurulması, malzeme desteği sağlanması, öğretmenlere hizmetiçi eğitim verilmesi, öğretmenler arasında iletişimin arttırılması, idarecilerin bilinçlendirilmesi, okullarda STEM için etkinlik zamanı olması, STEM eğitim programlarının ve ders planlarının hazırlanması gibi önerilerde bulundukları tespit edilmiştir.

Tartışma

Araştırmaya katılan öğretmenlerin STEM hakkında yaptıkları tanımlardan STEM'e ilişkin gerçekçi bilgilerinin olduğu anlaşılmıştır. Can ve Sağır (2018) tarafından yapılan araştırmada öğretmenlerin büyük çoğunluğunun STEM hakkında bilgi sahibi olduğu ve mevcut çalışmayı destekler nitelikte STEM'i disiplinlerarası ve ürün ortaya konulmasına yönelik bir yaklaşım şeklinde tanımladıkları görülmüştür. Benzer şekilde Altunışık'ın (2024) araştırmasında öğretmenler STEM'i disiplinlerin birleştirilmesi ve üretme kültürü şeklinde tanımlamıştır.

Öğretmenler STEM eğitiminin bilişsel, psikomotor ve duyuşsal boyutta bir çok katkısı olduğunu düşünmektedir. Mevcut çalışmayı destekler nitelikte literatürde yer alan çalışmalarda STEM eğitiminin yaparak ve yaşayarak öğrenmeyi sağlama (Benzer & Kurt, 2022), kalıcı öğrenmeyi sağlama (Can & Sağır, 2018), işbirliğini geliştirme (Akkor, 2024; Ecevit & Yıldız, 2024), disiplinlerarası ilişki kurma (Benzer & Kurt, 2022; Can & Sağır, 2018: Güleç Çiftçi, 2024), problem çözme becerilerini geliştirme (Benzer & Kurt, 2022; Can & Sağır, 2018; Güleç Çiftçi, 2024; Kırmızıbiber, 2024; Mauch, 2001: Yıldırım & Selvi, 2016), eleştirel düşünme becerisi kazandırma (Baydere, 2020: Benzer & Kurt, 2022), yaratıcılığı geliştirme (Benzer & Kurt, 2022; Baydere, 2020; Güleç Çiftçi, 2024), öğrenciye farkındalık kazandırma (Güleç Çiftçi, 2024), ürün ortaya koyma (Benzer & Kurt, 2022; Can & Sağır, 2018; Kırmızıbiber, 2024; Güleç Çiftçi, 2024), el becerisini geliştirme (Baydere, 2020; Güleç Çiftçi, 2024), öğretmenlerin mesleki gelişimine katkı sağlama (Benzer & Kurt, 2022) gibi katkılarının olduğu belirlenmiştir.

Araştırmaya katılan öğretmenlerin çoğunluğu daha önce STEM ile ilgili eğitimlere katılmakla birlikte bu eğitimlerin içeriğini yetersiz bulmaktadır. Bu sonucu destekler nitelikte Can ve Sağır (2018) STEM hakkında bilgi ve uygulama eksikliği, eğitim sistemi ve programdaki sık değişiklikler gibi nedenlerden dolayı çoğunlukla öğretmenlerin kendilerini yeterli hissetmedikleri sonucuna ulaşmıştır.

Öğretmenler derslerinde STEM eğitimini kullanarak tasarım yapma, matematiksel hesaplamalar yapma, fen konularını somutlaştırma, robotik kodlama etkinlikleri yapma gibi çalışmalar gerçekleştirmektedir. Bu sonuçla tutarlı olarak Can ve Sağır'ın (2018) araştırmasında, öğretmenlerin fen bilimleri dersinde ürün tasarlamada ölçüm ve hesaplamalardan yararlanılması, kodlama ve Arduino ile öğretim, kütle ve hacim hesaplamaları yaparak teknoloji ve matematik disiplinini kullandıkları sonucuna ulaşılmıştır.

Öğretmenlerin derslerinde STEM etkinliklerinde kendi disiplinleri dışında en çok mühendislik ve matematik disiplinlerden faydalandıkları sonucuna ulaşılmıştır. Benzer ve Kurt (2022) da fen öğretmenlerinin STEM uygulamalarına yönelik görüşlerini incelediği araştırmada fen bilimleri dersinin en çok matematik ve mühendislik disiplinleri ile arasında ilişki bulunduğu sonucuna ulaşmıştır.

Araştırma sonucunda öğretmenlerin okullarında STEM eğitimini gerçekleştirirken malzeme, atölye eksikliği gibi bir çok sorun yaşadıkları anlaşılmıştır. Bu sonuçla tutarlı olarak Joseph ve Nwankwo (2024) STEM eğitiminin uygulanmasındaki başlıca zorluklardan birinin yeterli finansman ve kaynak sağlamak olduğunu belirtmiştir. Mevcut araştırma sonuçlarını destekler nitelikte Güleç Çiftçi (2024) okul yöneticileri ile yaptığı araştırmada yeterli altyapı ve donanım olmaması, müfredat yoğunluğu olması, ayrıca zaman gerekmesi, öğretmen yeterliliği olmaması, öğrenci ilgisizliği gibi sorunların olduğu sonucuna ulaşmıştır.

Öğretmenler belirttikleri sorunların çözümüne ilişkin olarak fiziksel imkanların iyileştirilmesine yönelik önerilerde bulunmuşlardır. Benzer şekilde Hsu vd. (2015) güvenilir internet erişimi ve güncel teknolojik ekipmanın etkili STEM eğitimi için gerekli olduğunu vurgulamaktadır.

Öneri

Elde edilen bulgular doğrultusunda STEM eğitimlerinin etkili bir şekilde gerçekleştirilmesi için öğretmenlere hizmetiçi eğitimler verilmesi, STEM etkinliklerinin gerekliliği hakkında okul idarecileri ve velilere farkındalık kazandıracak çalışmalar gerçekleştirilmesi önerilmiştir.

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Interview Form

1. What do you think about STEM education?
2. What do you think about the contributions of STEM education?
3. Have you attended any events regarding STEM education (such as seminars, courses, congresses, panels, conferences, etc.)? If so, what do you think about the adequacy of these trainings?
4. What do you think about your competencies in your own discipline in terms of STEM education?
5. What do you do using STEM education in your classes? Can you give an example?
6. How do you benefit from other STEM disciplines outside of your own in your classes?
7. What do you think about the importance of your own discipline in terms of STEM education?
8. What are the problems you have experienced while implementing STEM education and what are your suggestions for solving these problems?