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Views of STEM-trained Teachers on STEM Education in Türkiye

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Abstract

STEM education is important because it helps students learn about the world around them and how to solve problems. As enforcers of STEM, STEM-trained teachers have a unique point of view on this subject. This case study aims to reveal the views of STEM-trained teachers about STEM education in Türkiye. For this purpose, 61 teachers who had STEM training and STEM background participated in the study. Data were collected via a questionnaire consisting of multiple-choice and open-ended questions and analyzed with the content analysis procedure of qualitative methods. Results point out that STEM-trained teachers are aware of the interdisciplinary nature of STEM education and value daily life problems in activities. Despite being previously trained, the need expression for practical training on hands-on activities in STEM education is significant. Our suggestions for future research include more precise and activity-based teacher training, financial support on disposable materials and STEM-lab environments, and a cooperative perspective on different branches of teachers of the same school.

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Introduction

STEM education is an interdisciplinary approach to teaching and learning that integrates the disciplines of science, technology, engineering and mathematics which is designed to provide students with the skills and knowledge they need to succeed in a rapidly changing, technology-driven world (Yıldırım & Altun, 2015). One of the goals of STEM education is to prepare students for careers in fields that require a strong understanding of all four disciplines. STEM curriculum is designed to provide a comprehensive and well-rounded education in these areas. It is often interdisciplinary, incorporating elements of each discipline into the others (Çepni & Ormancı, 2017).

STEM education is essential for gaining students the skills they need to succeed in the ever-changing global economy. A strong understanding of STEM concepts is essential for students who want to pursue careers in fields such as engineering, computer science, and medicine. A strong STEM education can provide students with the foundation they need to be successful in any field they choose to pursue. STEM education helps students learn about the world around them and how to solve problems using critical thinking and problem-solving skills and also helps students develop necessary 21st-century skills such as collaboration, communication, and creativity (Sahin & Top, 2015). In recent years, there has been a push to increase the focus on STEM education in schools. This is in response to the growing demand for workers with STEM skills in the workforce (Ormancı, 2020). Many businesses and organizations have recognized the importance of STEM education and are working to support it.

As educators, teachers play an important role in shaping students' attitudes and beliefs about STEM. Studies have shown that teachers' attitudes and beliefs can influence students' academic achievement in STEM disciplines (Degenhart, 2009; Zhou et al., 2021). For example, teachers who have a positive attitude towards STEM are more likely to engage their students in active learning experiences, which can lead to increased student achievement (Rizki, 2018). In addition, teachers who believe that all students can be successful in STEM disciplines are more likely to foster a positive learning environment and provide adequate support to struggling students

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(Aykan & Yıldırım, 2022; Köse & Ataş, 2020; Yıldırım, 2018).

Given the importance of teachers' attitudes and beliefs on student achievement, teacher education programs should provide preservice teachers with opportunities to develop positive views about STEM (Aykan & Yıldırım, 2022; Cavas et al., 2021; Köse & Ataş, 2020). Teacher educators can promote positive teacher views about STEM by incorporating active learning experiences into their courses and by modelling positive attitudes and beliefs about STEM themselves (Zhou et al., 2021). In addition, it is essential to provide preservice teachers with opportunities to learn about and experience the use of technology in STEM classrooms (Chabalengula et al., 2012; Karademir & Yıldırım, 2021; Yıldırım et al., 2020).

There are several reasons why teacher views about STEM education need to be taken under advisement. First, teachers are generally the first point of contact for students when it comes to learning about STEM. This means that they have a significant influence on students' initial impressions of STEM (Aykan & Yıldırım, 2022; Meador, 2003; Thiagarajan et al., 1974). If teachers are negative or apathetic about STEM, students will be more likely to develop negative attitudes as well.

Second, teachers play a key role in providing students with the motivation to learn STEM subjects. If teachers are passionate about STEM, they are more likely to be able to engage and inspire their students. This can lead to increased interest and motivation in STEM, which can ultimately lead to better achievement (Bybee, 2006; Kelley & Knowles, 2016; Zhou et al., 2021).

Third, teacher views about STEM can impact the way that STEM is taught in the classroom. If teachers hold negative perceptions of STEM, they may be less likely to use effective teaching strategies or to integrate STEM into other subjects (Arslan, 2021; Paz et al., 2022). This may ultimately limit students' exposure to and engagement with STEM.

Overall, it is clear that teachers' views about STEM education are important as they can have a significant impact on students' attitudes, motivation, and achievement in STEM skills. It is therefore essential that teachers are positive and supportive of STEM education in order to ensure that students are able to benefit from it.

A survey of published literature was conducted to identify STEM teacher views related to the following:

- The definition of STEM teaching
- The goals of STEM teaching
- The challenges of STEM teaching
- The benefits of STEM teaching
- The importance of STEM teaching

According to the survey of published literature, there is a lack of a single well-established definition of STEM teaching. However, there are some common themes that emerge from the various definitions (Bybee, 2010; Paz et al., 2022; Tanın, 2021). Generally, STEM teaching is seen as a way of teaching that integrates the four main disciplines of science, technology, engineering and mathematics. STEM teaching is often seen as a way to prepare students for the future, with an emphasis on problem-solving, critical thinking and creativity and increases students' understanding of the way that things in real life work, as well as technology (Bybee, 2006, 2010; Duschl et al., 2007; Kelley & Knowles, 2016).

The lack of consensus on the exact definition of STEM education, leads to a variety of views of STEM teachers, constantly evolving as new research and technology become available. A few current views are that STEM teachers should have a strong knowledge of their content area, be able to effectively communicate with their students, and be able to engage their students in active learning (Aykan & Yıldırım, 2022; Cavas et al. 2021; Çınar et al. 2022; Duschl et al., 2007; Paz et al., 2022). STEM teachers should also be able to integrate technology into their teaching, as it is an important part of many STEM disciplines (Ghavifekr & Rosdy, 2015; Kelley & Knowles, 2016; Selvi & Yıldırım, 2017).

A recent study found that over 60% of surveyed STEM teachers said that they felt prepared to teach their subject (Beschorner & Kruse, 2016). However, many also noted that they would like more professional development opportunities, particularly in the area of technology integration (Beschorner & Kruse, 2016). These findings suggest that while most

STEM teachers feel prepared to teach, they would benefit from additional support in integrating technology into their instruction.

There is a lack of consensus among researchers as to what constitutes "best practices" in STEM teaching (Beschorner & Kruse, 2016; Bybee, 2010; Selvi & Yıldırım, 2017; Yıldırım & Selvi, 2017). However, there are some general themes that have emerged from the literature. First, effective STEM teaching must be inquiry-based, meaning that it should allow for and encourage student questions, explorations, and discoveries (Bybee, 2010; Duit, 2007). Second, effective STEM teaching should be interdisciplinary, incorporating concepts and skills from multiple disciplines in order to help students see the connections between them (Thibaut et al., 2018; Xie et al., 2015). Finally, effective STEM teaching should be hands-on and allow students to be actively engaged in their learning (Bybee, 2006; Duit, 2007).

From the literature, we can see that there are some studies on STEM education and teacher views, but the perspectives of STEM-trained teachers are overlooked. In this study, we aimed at exploring the views of STEM-trained teachers on STEM teacher training and reveal the shortcomings and their suggestions for future training programs. For this particular aim, answers to these questions are sought:

1. What is the definition of STEM-teacher education for STEM-trained teachers?
2. What is the reason for the importance of STEM-teacher education according to STEM-trained teachers?
3. What are the most important aspects or concepts of STEM-teacher education according to STEM-trained teachers?

Method

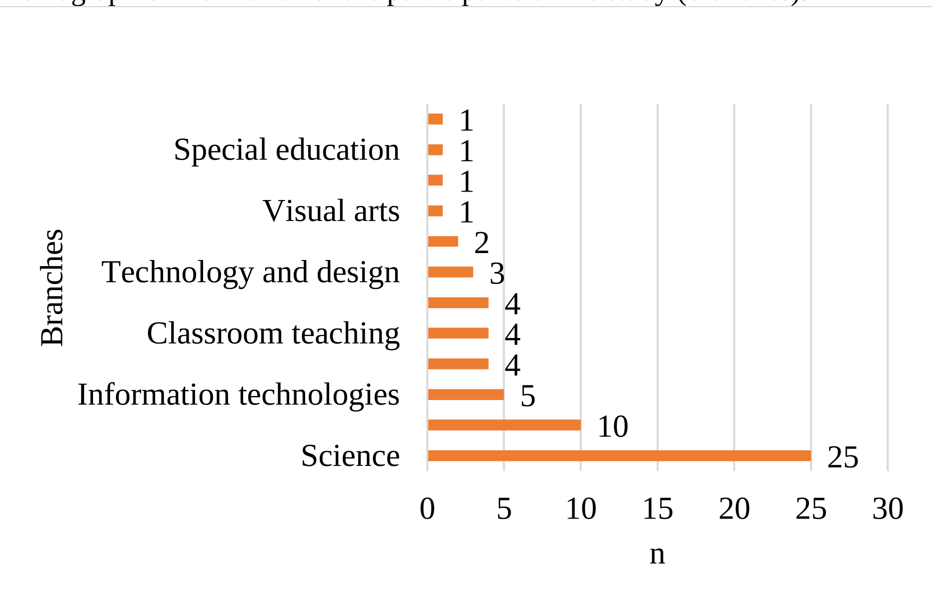
Research design

This study adopted a qualitative research methodology, in particular, a case study. Case studies are suitable for research in which a situation is tried to be revealed via open-ended questions or questionnaires. This study aims to reveal the current state of STEM teacher education. For this reason, we developed a questionnaire and asked the STEM-trained teachers' opinions on STEM-teacher education.

Study group

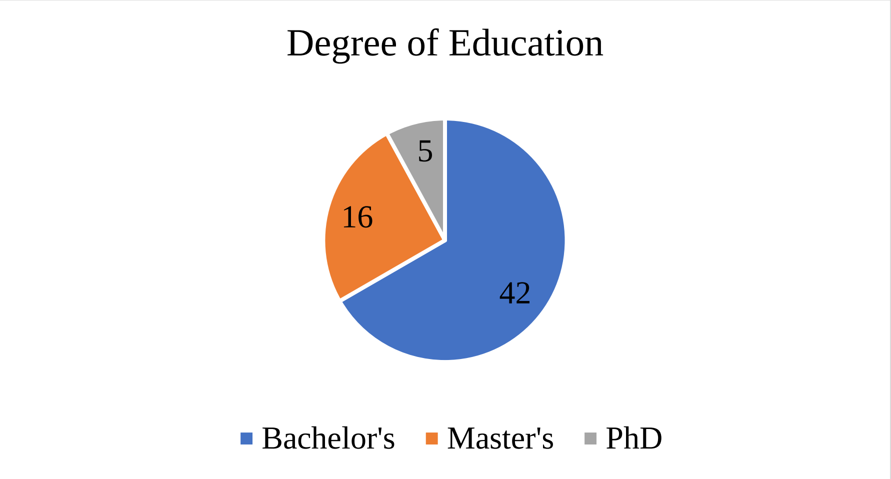
The participants of the study are 61 STEM teachers working in the Bursa province of Türkiye who previously participated in various STEM training and were certificated as STEM teachers. Demographic information about the participants is presented in Figures 1 and 2 below.

Figure 1.
Demographic information of the participants of the study (branches).



As seen in the figure, most participants are science teachers (n=25) and following them elementary mathematics teachers (n=10) which could be considered as the building blocks of the STEM education profession.

Figure 2.
Demographic information of the participants of the study (experience).



The participants are selected via purposive sampling among all STEM teachers working in Bursa according to their previous STEM training certificates and experiences. All the participants of the study had undertaken STEM training of at least 30-course hours and already working in the field as STEM educators.
As mentioned before, the STEM-trained teachers have participated in previous STEM training, which are presented in Table 1 below.

Table 1.
Content of the previous STEM training

Training places	Teachers	Examples	f
National Ministry of Education	T2-T4, T6, T8, T11, T14, T18, T19, T22, T23, T26, T35, T36, T38-T40, T53, T57, T60, T61	- *In-service STEM training* - *Beginner STEM training* - *Curriculum-based STEM educator training* - *New STEM approaches course* - *Bursa R&D STEM course* - *Designfils ve edusimsteam trainings* - *Osmangazi Arduino coding training in the Maker trainer project* - *Innovation and Educational Technologies General Directorate-STEM workshop*	21
Online Training	T3, T12, T21, T25, T34, T37, T42, T43, T47, T48, T50, T60	- *STEM learning scenarios preparation webinar* - *STEM lesson plan process and preparation within the scope of STEM teacher institutes training model* - *Design-fils Distance education project* - *Seminar program on YouTube* - *STEM education online seminar within the scope of the İstanbul volunteer educators' association teacher of the future program*	12
EU Projects	T6, T9, T10, T12, T13, T27, T28, T58	- *Scientix Bursa workshop* - *EU Schoolnet Academy- STEM is everywhere*	8

Workshops	T7, T8, T11, T20, T41	*- STEM workshops*	5
Conducting STEM Studies	T8, T9, T24, T29	*- Authorship in STEM books* *- Using STEM in educational environments and TUBITAK projects without any training* *- Instructor in STEM and Science centre*	4
Postgraduate Education	T1, T38, T45	*- Master's thesis* *- Taking STEM courses in a master's program*	3
eTwinning	T17, T31, T49	*- Online STEM education approach training* *- Values education and STEM course*	3
Tubitak Projects	T16, T30	*- Various projects* *- Kırıkkale University 4004 STEM training and physical programming camp with Arduino for teachers*	2
Erasmus+ teacher mobility	T1	*- Participating in STEM practices in Europe with Erasmus+ teacher mobility*	1
Others	T30, T37, T39, T42, T47, T48, T51, T54, T55, T57, T61	*- STEM introduction and hands-on activity presentation* *- STEM education practices with daily life materials 1 and 2* *- Bursa Science and Technology Center and BenMaker training* *- Robotic coding course* *- Lifelong Education Association - STEM education applications with building sets, measurement and evaluation in STEM education*	11
Not participating in any STEM Training	T5, T15, T24, T32, T33, T44-T46, T51, T52, T56, T59		12

As seen from Table 1, the teachers mostly joined the training programs such as in-service STEM training and Curriculum-based STEM educator training organized by the National Ministry of Education. Also, some teachers participated in online STEM education programs and EU projects. Few teachers stated that they attended workshops, Tubitak projects or Erasmus+ teacher mobility. On the other hand, 12 teachers have not participated in any STEM training program before.

Data collection tools

Data were collected via a questionnaire prepared by the researchers. The questionnaire was consisting of 9 open-ended questions in total: 5 questions for demographic information and 4 for views about a specific target. The four questions of analysis are:

1- How would you describe STEM-teacher education?
2- Why do you think STEM-teacher education should be given importance?
3- Which theoretical structure or concepts of STEM-teacher education do you think are the most important?
4- What are your expectations from STEM-teacher education?

The questionnaire was sent to the teacher via Google forms and the answers were collected online, in order to maximize attendance and validity. The teachers could reflect their views and reasoning in their own time and without any pressure of being judged.

Data analysis

Data collected were analyzed via content analysis and codes and themes for each question were formed. The analyses were conducted by two separate researchers and the codes and themes formed were compared. At the final stage of the analysis, the two researchers were in agreement about all the codes and themes formed from the data.

Findings

The findings obtained from the teachers' responses to the second question in which they were asked to define STEM education are presented in Table 2.

Table 2.
Teachers' STEM education definitions

Themes	Teachers	Explanation	f
Interdisciplinary Approach	T1-T6, T9-T12, T16-T18, T21, T23, T25, T26, T28, T31, T32, T35, T38-T41, T43, T45-T49, T51-T55, T58, T60	*- An educational model in which students combine and use science, technology, engineering and math skills* *- Producing solutions to problems from the perspective of science, technology, engineering and mathematics* *- Ensuring retention in learning with interdisciplinary gains* *- Integrating different disciplines* *- Developing new competencies by combining different disciplines with different skills* *- Multi-discipline learning and retention in learning* *- Preparing individuals for the future with interdisciplinary approaches* *- Linking at least two of the disciplines of science, technology, engineering and mathematics* *- Transferring gains in science, technology, engineering and mathematics with an integrated and interdisciplinary approach* *- Cross-curricular approach*	38
Transferring to Daily Life	T3, T10-T12, T16, T18, T19, T22-T24, T31, T35, T37, T41, T56, T61	*- Finding creative solutions to daily life problems* *- Transferring science to real life, adapting it, making it useful in practice* *- Producing solutions to daily problems with a science, technology, engineering and mathematics perspective*	16
Applied Processes	T17, T29-T31, T42, T46, T49, T51	*- Learning through experience* *- Avoiding rote-learning-based education* *- Transitioning of lessons from theory to practice* *- Concretization of learning* *- Through the scenarios, making sense of the theoretical knowledge learned at school through practice*	8
Product Oriented Studying	T1, T3, T13, T49, T59	*- The students search for answers to problems and needs by thinking and producing in all aspects* *- Students bring their own ideas to life* *- Product-based approach for the present and the future in the age of innovation*	5
Skills	T1, T3, T18, T24, T43, T45, T49	*- Use of scientific steps by students* *- Require and support 21st-century skills* *- Raising individuals who research, ask questions, think creatively and critically, produce, and produce solutions to the problems that come their way* *- Students demonstrate high-level knowledge and skills*	7
Project-based teaching	T2, T4, T36, T61	*- Aiming at project-based learning*	4
Problem Solving	T10, T13, T26, T32	*- Producing innovative and creative solutions* *- Finding concrete solutions to problems by students* *- Problem-solving skill*	4

Future	T34, T49, T50	*- Identifying the technologies of the future today* *- An education that will benefit students, their families, the country, the nation and humanity*	3
Learning Environments	T4, T6, T32	*- Thinking that the most suitable environment for STEM education is FCL (Future classroom lab)* *- The necessity of flexible learning environments for STEM* *- Collaborative education*	3
Social Benefits	T8, T24	*- The approach that enables the development of society in terms of science and technology* *- The keystone of education for countries trying to shape society through education*	2
Others	T2, T7, T9, T11, T14, T15, T20, T21, T26, T32, T44, T46, T51, T54, T57-T59, T61	*- A lesson to be learned and taught* *- A high-quality, creative and critical education* *- Being named STEM+A with the addition of the art field* *- Depth learning* *- Approaching information holistically* *- Allowing students to show their potential* *- Supporting processes such as research and responsibility*	18

As can be seen in Table 2, a significant amount of the teachers' responses are placed under the theme of the interdisciplinary approach. They emphasised that STEM education is an educational model combining science, technology, engineering and math. Besides, positive views on STEM education such as developing new competencies, retention in learning, and cross-curricular approach have emerged. The second notable theme is Transferring to daily life. The teachers focused on the reflections and contributions of STEM education to daily life problems. Apart from these, various definitions such as gain experience, product-based approach, improving skills and learning environment emerged in STEM.

The findings obtained from the third question, in which the importance of STEM education was questioned, are presented in Table 3.

Table 3.
The Importance of the STEM education

Themes	Teachers	Examples	f
21st Century Skills	T1-T3, T10, T11, T15, T17, T18, T21, T22, T26, T31, T33, T35-T37, T40, T42, T46-T48, T53-T55, T57, T60, T61	*- Developing 21st century skills* *- Problem-solving skills* *- Life and career skills* *- Learning and innovation skills (4C)* *- Information, media and technologies* *- Critical thinking skills* *- Creativity skills* *- Inquiry skills* *- Analytical thinking skills* *- Collaborative working skills*	27

Student Development	T1, T3, T6, T7, T27, T29, T31, T39, T40, T42-T44, T51, T54, T58, T60	*- Active participation of the students* *- Create a product* *- Developing the imagination* *- Raising scientifically literate individuals* *- Revealing the problems of the students* *- Improving academic success* *- Changing students' perspectives on the disciplines they have prejudice* *- Increasing children's self-confidence*	16
Associating with Daily Life	T12, T16, T18, T21, T23, T25, T32, T34, T42, T49, T56, T58, T61	*- Possibility of use in daily life* *- Enabling students to find solutions to daily life problems* *- Learning life skills by saving time*	13
Increasing Interest and Motivation	T3, T12, T13, T20, T21, T29, T30, T36, T39, T45, T61	*- Making the process enjoyable* *- Raising individuals who are interested in the fields, curious and willing to work in these fields* *- Increasing interest in science and mathematics lessons* *- Creating an effective and productive learning environment*	11
Interdisciplinary interaction	T4, T5, T8, T21, T22, T33, T37, T38, T40, T42, T46	*- An educational approach that allows collaboration with different disciplines* *- Providing a versatile study opportunity by being integrated into every lesson* *- Integrating four core disciplines (science, technology, engineering and mathematics) into a cohesive education* *- Solving problems with interdisciplinary knowledge* *- A cumulative system*	11
Contribution to Country Development	T3, T19, T24, T31, T34, T37, T43, T45, T50, T60	*- The STEM approach is the educational basis of every production and development-oriented country* *- Contribution to the PISA and TIMSS exams and the economy in the reports of the National Ministry of Education and independent institutions* *- STEM education has an important place in OECD countries* *- Increasing the country's development* *To be able to adapt to the requirements of the age and the developing world scientifically, technologically and economically*	10
Meaningfulness and retention in learning	T3, T18, T29, T37, T38, T47, T48, T49,, T59, T61	*- Meaningful structuring of knowledge* *- Ensuring retention in learning* *- Transition from theory to practice* *- Preventing rote learning* *- Ensuring conceptual and experiential unity*	10
Future Generations	T9, T10, T24, T26, T28, T37, T41, T43	*- Ensuring raising generations who question, research, produce and make discoveries* *- Raising multi-dimensional thinking generations* *- Raising generations who can keep up with the needs of the age* *- Preparing individuals for the jobs of the future*	8
Usage	T2, T3, T14, T17, T46, T52, T58	*- Not a lesson or topic, but training to think and apply* *- Learning by projects* *- Transforming knowledge into practice by the students* *- Teachers' guidance* *- One of the keystones of education*	7

Availability	T3, T6, T23, T33, T58	*- Being able to be shaped according to the individual competencies, abilities and interests of the students* *- Learning the subjects that meaningless on their own* *- Providing internalization of the subject* *- A useful approach for in-depth applications*	5
Others	T3, T22	*- Providing high-quality education* *- An approach that is still being worked on*	2

Teachers mostly explained the importance of STEM education through its positive effect on 21st-century skills. Also, they mentioned active participation, creating products, imagination and other valuable development of the students. Other significant themes are associating the knowledge with daily life, increasing interest and motivation towards the lessons and providing interdisciplinary interaction. Some teachers also pointed out the development of the country, retention in learning, future generations, usage and availability.

The findings obtained from the analysis of the responses given to the fourth question, in which the theoretical structures and concepts that are considered important in STEM education are investigated, are presented in Table 4.

Table 4.

The important theoretical structures and concepts in STEM education

Themes	Teachers	Examples	f
21st Century Skills	T9, T10, T15, T17-T19, T21, T22, T24-T26, T28, T31, T32, T36, T37, T39-T43, T45-T49, T51-T53, T55, T59	*- Higher-order thinking skills* *- Analytical thinking* *- Innovation* *- Problem-solving* *- Critical thinking* *- Creativity* *- Entrepreneurship* *- Reasoning* *- Idea generation* *- Design-based thinking* *- Productivity* *- Algorithmic thinking* *- Developing 21st century skills* *- Leadership*	31
Interdisciplinary interaction	T3, T4, T10, T11, T13-T15, T20, T23, T24, T26, T30, T32, T34, T35, T37, T38, T42, T45, T46, T49, T58, T60	*- Interdisciplinary interaction* *- Success in the integration of different disciplines is directly proportional to the success of education*	23
Prominent disciplines	T2, T5-T8, T10, T16, T17, T19, T27, T28, T33, T37, T50, T51, T55, T56, T59, T60, T61	*- Science (Literacy)* *- Art* *- Design* *- Maths* *- Technology (Literacy, Programming, Digitalization, Robotic coding)* *- Literacy in all disciplines* *- Engineering* *- Self-confidence and self-esteem* *- Change according to subject and achievements*	20

Teaching approaches and models	T1-T4, T11, T18, T22, T25, T29-T32, T35, T42, T43, T46, T52, T53	*- STEM applications carried out with the 5E model are more useful and applicable* *- Considering that Design Based Learning should be separated from STEM education* *- The importance of teaching the knowledge to be used in the product creation process* *- Active learning* *- Constructivism* *- Process-oriented training* *- Meaningful learning* *- Inquiry-based learning* *- Project-based learning* *- Collaborative learning*	18
Teaching process	T3, T4, T21, T22, T29, T36, T46, T55, T58	*- Allow students to practice* *- Progress from the abstract to the concrete, from the known to the unknown* *- Suitable for collaborative work* *- Learning by experiences* *- Real-time applications*	9
Learning environment	T6, T21, T54	*- Virtual laboratories* *- FLC place design thinking* *- Designing a flexible learning environment* *- Designing learning environments according to students' interests and age, and the economic situation of the school*	3
Teacher	T3, T6, T31	*- The ability of the instructor who will give STEM education to write original lesson plans* *- Continuity of educator training* *- Creativity and openness to innovation* *- The necessity for instructors to be aware of other disciplines' goals and scopes* *- Teacher's guidance*	3
Associating with daily life	T3, T35, T32	*- The necessity of daily life problems for STEM education* *- Associating with daily life*	3
Creating a product	T3, T11, T41	*- Creating an original product based on the gained knowledge* *- Using and integrating Engineering Design Processes in product creation* *- Using alternative assessment tools for product evaluation*	3
Others	T12, T17, T29, T44, T57	*- Scientific methods* *- Functionality* *- Being a maker*	5

As seen in Table 4, various responses emerged under the 21st-century skills theme. A significant amount of the teachers expressed that STEM education helps to improve the students' higher-order thinking skills, analytical thinking, innovation and problem-solving skills. Similar to the other questions, interdisciplinary interaction is one of the most important themes in this question. Teachers emphasized the integration of different disciplines such as art and design, as well as the main disciplines of STEM. Enhancing literacy in all subjects emerges as another important part of education. In addition, project-based learning, constructivism, inquiry-based learning, collaboration and active learning codes occurred under the theme of teaching approaches and models in STEM education. In addition to these themes, a few teachers also mentioned different issues such as the teaching process, learning environment and teacher in their responses.

The findings obtained from the fifth question, which investigated the expectations of teachers towards STEM teacher training, are presented in Table 5.

Table 5. Teachers' expectations towards STEM teacher training

Themes	Teachers	Examples	f
Professional development	T1, T3, T5, T7, T9, T11, T13, T14, T16-T21, T23, T24, T26, T28-T31, T33-T36, T39, T42-T49, T51, T53, T54, T56, T58-T60	*- Professional development* *- Ability to guide students* *- Carrying out studies that will contribute to the literature* *- Gain theoretical knowledge and experience* *- Being able to prepare lesson plans suitable for STEM education* *- Correcting missing and incorrect information* *- Following the changes and developments in STEM education* *- Learning different perspectives* *- Adapting to the age and technology* *- Understanding students' language* *- Multidimensional thinking* *- Understanding the language of science* *- Learning new skills* *- Learning techniques, methods and examples that can be used in different age groups* *- Development in assessment and evaluation* *- Contributing to the development of the country*	41
Gain experience in implementation	T2, T3, T8, T10, T12, T18, T23, T25, T27, T28, T32, T35, T36, T53, T54, T57	*- Gaining knowledge and experience in the field of application* *- Learning new approaches that can be applied in the classroom* *- Improvement in process management* *- Producing new projects*	16
Supporting student development	T6, T9, T19, T22, T26, T28, T40, T50, T52, T55, T59	*- Developing engineering skills* *- Raising awareness of students* *- Raising scientifically literate generations* *- Taking a more active role in daily life* *- Innovation and Creativity* *- Learning apps to help students make connections between their environment and the world* *- Supporting students to be individuals who question, research and produce* *- Contributing to concretizing the usage areas of mathematics in daily life*	11
Others	T8, T10, T12, T20, T23, T24, T29, T32, T33, T47, T48	*- Understanding STEM* *- Providing new STEM-related environments* *- Advanced STEM education* *- In-person training* *- Helping to disseminate the practices in the province*	11
Designing instructional processes suitable for STEM education	T6, T15, T21, T31, T32, T42, T55	*- Constructing science activities with a STEM education approach* *- Giving ideas about integration into courses* *- To be able to apply STEM education in schools with different conditions* *- Preparing activities suitable for the STEM approach* *- Learning new scenarios and methods*	7

Conducting interdisciplinary studies	T4, T17, T33, T37, T38, T61	*- Learning to collaborate with different disciplines* *- Carrying out projects with teachers interested in STEM education*	6

As can be seen in Table 5, teachers are open to professional development and new experiences. They emphasized especially being able to prepare STEM lesson plans, guide students in the process and learn different perspectives. Another remarkable theme is gaining application experience. One of the most important needs for teachers is gaining STEM application experience beyond theoretical knowledge. They believe that their professional development may bring the ability to support students' development and collaborate with different disciplines.

Discussion and Conclusion

In the study, teachers were asked to define STEM education and it was concluded that a significant part of the answers given by the teachers was under the theme of the interdisciplinary approach. Teachers emphasized that STEM education is an education model that combines science, technology, engineering and mathematics and its interdisciplinary nature. This situation shows parallelism with the definitions in the literature. This means that teachers could define STEM education using correct concepts and knows the definition of STEM. Akarsu et al. (2020) define the STEM approach as an educational approach which is not only product-oriented but also process and skill-oriented, which integrates science, technology, engineering and mathematics disciplines for the solution of real-life problems, facilitates the understanding of real-life problems with interesting and motivating experiences. Since the initials of STEM include science, technology, engineering and mathematics, it is expected that this is the most common expression by teachers. What is essential here is that the fields/branches are not expressed separately, but as a holistic expression as stated by the teachers. In our study, teachers presented their views on the reflections and contributions of STEM education to daily life problems. Karakaya et al. (2019) concluded in their study on student views that STEM activities are related to daily life problems. Altan and Üçüncüoğlu (2018) stated in their study with pre-service teachers that STEM activities are suitable for establishing relationships with daily life. When we examine the nature of STEM, the fact that it focuses on a situation or problem from daily life brings the concept of daily life to the fore when defining STEM by teachers. The fact that this situation is also stated by the teachers may be an indication that the teachers understand the logic of STEM education. Apart from these, teachers used various expressions related to the definition of STEM such as gaining experience, product-based approach, developing skills and learning environment. Karışan and Yurdakul (2017) understood that after the STEM activities they carried out in their studies, the students developed various engineering ideas and designed the solutions they found to the problems based on the examples given in the course. This supports the views of teachers. When the answers given by the STEM-trained teachers about the definition of STEM are examined in general, it is understood that many features of STEM are expressed by the teachers. This may be an indication that teachers are familiar with the concept of STEM. Especially the fact that the selected teachers are active in the field of STEM and receive the necessary training supports this situation.

Another dimension of the study is the importance of STEM education. Teachers mostly expressed the importance of STEM education with its positive effect on 21st-century skills. When the literature is examined, there are many studies on the positive effects of STEM education on 21st-century skills. Karışan and Yurdakul (2017) stated that students participating in STEM activities developed positive thoughts about 21st-century skills. In his study, Tanın (2021) concluded that STEM activities improved preschool teacher candidates' 21st-century skills positively. Bircan and Çalışıcı (2022) determined that STEM education has a significant effect on the 21st-century skills of primary school fourth-grade students. Because of the nature of STEM, students are expected to have positive effects on 21st-century skills, as they try to find a solution to a problem from daily life and use many skills in this process while applying their activities. It is an important conclusion that teachers focus on this situation the most. Other views expressed by the teachers in our study are associating the information with daily life, increasing interest and motivation in the lesson, and providing interdisciplinary interaction. In the studies in the literature, it has been concluded that STEM education associates information with daily life (Güder & Gürbüz, 2018; Kurtuluş et al., 2017; Ülger, 2019), increases interest and motivation in the lesson (Eroğlu & Bektaş, 2016), problem-solving (Astuti et al., 2021; Chen et al., 2019; Delahunty et al., 2020; Ülger, 2019; Roberts et al., 2022) and provides interdisciplinary interaction (Özbilen, 2018), which support the results of our study.

Another dimension in our study with teachers is the theoretical structures and concepts that are considered important in STEM education. A significant number of teachers stated that STEM education helps students develop higher-order thinking, analytical thinking, innovation and problem-solving skills. A similar view was emphasized by the teachers about the importance of STEM, which is the previous dimension. In addition, as in other questions, interdisciplinary interaction has been one of the most important themes in this question. Already in the literature, it is emphasized that STEM education is an interdisciplinary approach (Akarsu et al., 2020) and that it is effective in gaining an interdisciplinary perspective (Altan & Üçüncüoğlu, 2018). In this context, the concepts related to STEM education expressed by the teachers in our study show similarities with the literature. In addition, in our study, project-based learning, constructivism, inquiry-based learning, collaboration and active learning codes were formed under the theme of teaching approaches and models in STEM education. Similarly, in Yıldırım (2018)'s study, teachers emphasized that strategies and methods such as project-based learning, inquiry-based learning and problem-based learning should be used during STEM practices. However, in our study, it can be said that this situation is not among the main focus points of the teachers. Teachers need to know and be able to apply these models in order to apply the STEM approach in their lessons. Because each model serves different purposes and includes different steps. If teachers practice without knowing these models, they may encounter deficiencies or mistakes. At this point, it is recommended to talk about the models that teachers can use while giving STEM education and to apply them by giving the necessary examples.

In our study, it was understood that teachers are open to professional development and new experiences in the expectations for STEM teacher education, which is the last dimension. Teachers especially focused on preparing STEM lesson plans, guiding students in the process and learning different perspectives. In fact, the parts that teachers have the most difficulty with show parallelism with these answers. In the study of Alkılınç (2019), teachers stated that "not being able to prepare a lesson plan", "not being able to integrate STEM into the lesson", and "lack of materials related to STEM" among the reasons for not being able to apply STEM. Similarly, in Yıldırım (2020)'s study, teachers stated that they did not feel adequate about STEM education, had difficulties in preparing lesson plans and were not STEM literate. Parallel to these problems, it is natural that similar items occur in teachers' expectations for STEM education. When we look at the roles of teachers in the STEM approach, it is expressed as guiding students, creating a democratic learning environment and using collaborative learning (Bakırcı & Kutlu, 2018). Another point that draws attention to our study is that teachers want to gain practical experience. One of the most important needs of teachers is to gain STEM practice experience beyond theoretical knowledge. Science and mathematics teachers see the STEM education model as one of the indispensable cornerstones in their branches, but teachers are reluctant to implement the model due to reasons such as teacher competencies, lack of materials and cooperation (Özbilen, 2018). At this point, the importance of STEM education to be given to teachers emerges, and it is necessary to turn to practical training per the expectations of teachers to improve their competencies. As Eroğlu and Bektaş (2016) stated, the number of trainings on STEM and STEM-based course activities should be increased and the content/scope of the training should be expanded. Especially, as stated in our study, it is suggested that besides the theoretical lessons, examples of applications that will provide teachers with information about the process should be included and training should be given by holding workshops with teachers. Also, in order to resolve the issue of financial support, a teacher should be trained on how to write project proposals and fund their projects. Also, it is deemed important that the cooperation in STEM education among the teachers of different subjects in the same school is established.

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