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An Investigation of Science And Mathematics Teachers' Thoughts on STEM Education

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This study examines the views of high school physics, chemistry, biology, and mathematics teachers on STEM education. The research uses a phenomenological research design. The sample involved three public high schools and eight teachers. Participants had prior experience and knowledge of STEM education. The experience of the participating teachers ranged from approximately 9 to 30 years. Data for the study were collected using a semi-structured interview form. The interview form consists of eight questions. As a result of the analysis of the interviews, 8 themes and 67 codes were categorized. Results reveal that the implementation of STEM will greatly contribute to the development of students and teachers. Many teachers think that STEM applications will be extremely effective in creating an environment where teachers can be motivated, develop projects and discover their students' talents. Results show that many teachers do not get enough information about STEM seminars held at universities. In addition, it reveals that teachers have problems with time, equipment and classroom control during STEM practices.

KEYWORDS: High School, Qualitative Study, STEM Education

Introduction

STEM (Science, Technology, Engineering, and Mathematics) education is an interdisciplinary and holistic teaching approach model (Breiner et al., 2012; Bybee, 2010; Cheng & So, 2020). STEM education is an instructional model that supports student-centered education rather than teacher-centered education. In reality, STEM education has led to a restructuring of the existing teaching system in the fields and courses of science, technology, engineering, and mathematics (Gok, 2021a, 2021b). Therefore, STEM education is mostly referred to

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as integrated STEM education (Gok, 2022a; Yaki et al., 2019).

Teachers and students play an important role in implementing STEM education. They can apply STEM education inside and/or outside the classroom by creating a synergy. STEM education is needed today to equip teachers and students with 21st-century skills (Gok, 2021a; Hacioglu, 2021; Mcdonald, 2016; Stehle & Peters-Burton, 2019). The 21st-century skills include problem-solving, critical thinking, analytical thinking, solution orientation, working in teams and groups, creativity and a spirit of discovery, openness to innovation and change, a sense of responsibility, and openness to communication (Huang et al., 2022). The 21st-century skills are also important for teachers to innovate and keep up with innovations (Shernoff et al., 2017).

Teachers play a crucial role as practitioners of STEM education. It is of great significance to carefully examine the positive and negative aspects that teachers encounter during the implementation of STEM to shape the future of STEM education. In this study, gathering the perspectives of teachers in STEM education is deemed essential for several reasons (application and experience, shaping education policies, needs analysis, professional development, students' academic performance, etc.). Teachers function as the primary executors of STEM education, providing guidance and instruction to students. Consequently, their perspectives offer valuable insights into the practical application of STEM teaching methods and their impact on students. The feedback obtained from teachers holds the potential to shape educational institutions at the school, regional, and even national levels, influencing educational policies. Thus, leveraging the viewpoints of teachers in STEM education becomes instrumental in refining the efficacy of educational systems. Teachers' opinions play a crucial role in identifying challenges, success stories, and requirements within STEM education. Such analyses are pivotal in the development of resources such as educational materials, programs, and support systems. By considering teachers' perspectives, we can gain insights into their professional development needs, thereby facilitating the design of specialized training programs aimed at enhancing their proficiency in STEM subjects. The viewpoints of teachers in STEM education are closely linked to student success. Understanding which teaching methods prove more effective allows for the improvement of the overall student learning experience. Consequently, seeking the opinions of teachers in STEM education becomes paramount in the development of more effective, tailored, and student-centered educational strategies.

Review Of Related Literature

Research (Fernandez-Cezar et al., 1490; Fung et al., 2022; Landicho, 2020) on STEM education has found that teaching has a positive effect on students'

academic performance and motivation. The results of these studies suggest that STEM education is important for all levels of education. Because students in higher education have higher levels of readiness, they can complete STEM-based activities more easily and quickly than students in other educational settings. However, applying STEM-based activities at the primary level can be challenging for teachers given student readiness. Therefore, school administrators should provide regular professional development courses and seminars for teachers working at this level. To support teachers and provide them with different perspectives, instructional materials and programs should be prepared for different levels and grades. In this regard, schools should be brought to the level where they can conduct STEM-based activities, and the physical infrastructure and conditions should be provided.

When teaching STEM-based activities, teachers can use project inquiry-based instruction, problem-based instruction, collaborative instruction, technology-enhanced instruction, and other approaches instead of traditional approaches. These approaches have been shown to have a positive impact on student academic achievement (Blatt et al., 2020; Chang et al., 2022; Siregar et al., 2020; Wahono et al., 2020). Teachers can choose instructional approaches based on students' cognitive levels when conducting STEM-based activities. These instructional approaches can positively contribute to students' motivation, identify their interests, discover their talents, and demonstrate their creativity.

When selecting STEM-based activities, teachers should make sure that students can solve problems they encounter in their daily lives using scientific methods. These problems may include social problems related to the environment in which students live. With this approach, the projects developed can contribute both to students' academic success and to solving a problem in society (Li et al., 2020). When students are left alone with a problem, they naturally look for new solutions to solve it. Under the guidance of teachers, students can use engineering practices and various technologies (such as 3D printers, virtual reality, animation, simulations, coding, etc.) to solve problems.

When teachers assign project-based activities based on STEM, they should provide open-ended problems that encourage student creativity (Poonsin & Jansoon, 2021; Siew et al., 2015). In addition, teachers should carefully consider the relationship between the project topic and mathematics, engineering, technology, and science, as well as its applicability and potential to foster students' discovery skills. To ensure that students can overcome any difficulties that may arise during the project, teachers must prepare the project in advance according to certain criteria and standards. In addition, during the project, teachers should collaborate with other subject teachers and college teachers who specialize in the relevant areas. Teachers should encourage students to work in teams on STEM-based projects. Because students may not be accus-

tomed to this instructional approach, their motivation may decrease over time, and they may not achieve the desired level of success in the work process. Their interest may also decrease after some time. In this regard, teachers should continuously support their students and keep motivating them throughout the project.

To implement STEM-based activities in the classroom, it may be necessary to make some changes to the curriculum. The results of many studies have also shown the need for a STEM-based curriculum (Kim & Bolger, 2017; Tunc & Bagceci, 2021). For STEM-based activities to be implemented, teachers should be flexible in lesson planning because both students and teachers need a lot of time to complete these activities. Teachers may encounter some problems when implementing STEM-based activities in their classrooms (Hasanah, 2020; Leung, 2020). One of the biggest problems they face is the need to implement the curriculum. Another problem is obtaining the necessary tools and equipment for the laboratory. In addition, teachers also face some problems in applying STEM. Some of these problems (material support, computers, internet, etc.) are solved by the school administration, while others (classroom management during STEM applications, excessive time spent on project work, etc.) are solved by the teachers' efforts. To be successful in STEM, school administrators, teachers, and students must work together as a team (Bruce-Davis et al., 2014; Gok, 2022a).

The Rationale Of The Study

The principal objective of this research is to elucidate the perspectives held by seasoned high school educators concerning matters encompassing the practical application and experiential aspects of STEM education. This inquiry specifically focuses on the teachers' insights into shaping educational policies, conducting needs analyses, addressing professional development, and assessing the correlation between these factors and students' academic performance. STEM education stands out for its potential benefits, such as enhancing teacher motivation, contributing to students' cognitive, social, and emotional development, and promoting project-based learning. However, the lack of sufficient studies (Aslan & Bektas, 2019; Brown & Bogiages, 2019; El-Deghaidy et al., 2017; Gok, 2022b; Karakaya & Yilmaz, 2022; Nguyen et al., 2020; Rahman et al., 2022) in this area is noteworthy.

The rationale of this study is to address the gap by exploring the perspectives of experienced teachers on STEM education and contribute to the existing research in this field. The research brings forth the teachers' viewpoints on the factors that stakeholders, including teachers, students, and school administrators, may encounter in the implementation of STEM education. Consequently,

the findings of this study hold the potential to serve as a guiding framework for future research endeavours in the field of STEM education.

By aiming to fill the knowledge gap and gain insights into teachers' perspectives, the rationale of this study seeks to contribute to the research conducted in the field of STEM education.

Research Methodology

This study used a phenomenological research design (Creswell & Creswell, 2017). This research design supports a qualitative study that examines profound phenomena that we encounter in our lives but may not know about in detail or have thought about in depth (Yildirim & Simsek, 2016). The purpose of this study was to explore the knowledge, experience, and thoughts of high school teachers (physics, chemistry, biology, and mathematics) concerning STEM education.

Sample for the Study

In this research, the purposive sampling method was preferred as an appropriate and accessible sampling method. The participants were teachers who already had experience and knowledge about STEM education. The teachers who had previous experience with STEM education were trained in seminars organized by the provincial or district directorates of national education in Turkey. In addition, many of the teachers who participated in the research had implemented the seminar training they had received in their classes.

This research was conducted in three different state high schools in Izmir province during the 2018-2019 school year. Compulsory education in Turkey extends over 12 years. The initial four years are dedicated to primary education, succeeded by four years of secondary education, culminating in a final four-year phase of high school education. A pivotal aspect involves the transitional juncture from secondary to high school, mandating the successful completion of a nationwide standardized examination, culminating in the establishment of a national ranking. Depending upon their examination scores, students can matriculate into diverse specialized high schools, spanning fields such as science, health, sports, vocational studies, and other domains. It is noteworthy that a predominant inclination among students is evident towards public educational institutions. High school education typically encompasses a comprehensive array of subjects, including Turkish language, mathematics, natural sciences, social sciences, foreign languages, Turkish literature, history, geography, philosophy, and other fundamental disciplines. The overarching goal of these subjects is to furnish students with a broad cultural and knowl-

edge foundation. The necessary legal permissions were obtained from the Governor of Izmir and the Izmir Provincial Directorate of National Education to conduct the research. Izmir is the third biggest city in Turkey.

Eight teachers with experience in STEM education participated in the research. In general, there are no information technology teachers working in public high schools in Turkey. As a result, the research in question was conducted with a group of high school-level physics, chemistry, biology and mathematics teachers. It should also be noted that there is no curriculum covering engineering subjects in high school education. The teaching responsibilities of high school teachers include students aged 14-18. The professional experience of the participating subject teachers ranged from approximately 9 to 30 years. The subjects and genders of the teachers are listed in Table 1. Considering the Personal Data Protection Act, each teacher was assigned an alphabetical code instead of his or her real name.

Table 1

Subject and Gender of the High School Teachers.

Teacher	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Gender	F	M	F	M	F	M	F	M
Subject	PHY	PHY	CHM	CHM	BIO	BIO	MATH	MATH

Note: F: Female; M: Male; PHY: Physics; CHM: Chemistry; BIO: Biology; MATH: Mathematics

Data Analysis

Data for the research were collected using a semi-structured interview form. Each interview with the participating subject teachers lasted approximately 20 minutes. Based on the literature reviews conducted (Eroglu & Bektas, 2016; Ozbilen, 2018), the questions for the interview form were formulated. Then, five experts from the academic field and two physics teachers who had experience in teaching STEM were interviewed to obtain their opinions on the suitability and comprehensibility of the interview form. As a result of the expert opinions received, some questions in the interview form were modified to make them clearer and easier to understand. Based on the assessments made, the interview sheet consisted of eight questions.

Before the research, participating teachers were informed about the research. Then, the dates, locations, and times for the interviews were set according to their class schedules. The interviews with the teachers were recorded with their consent and at the end of the interviews, the audio recordings were transcribed verbatim. The statements were read to the teachers for

confirmation to ensure the accuracy of their statements. Teachers' statements from the informal interviews were quoted in the results section without modification or interpretation. Data analysis involved a content analysis in which two academic experts examined the research data to identify similar themes and codes based on the data.

Results Of The Study

As a result of the analysis of the research data, 8 themes and 67 codes were identified related to the didactic approach, the implementation of STEM education, the importance of STEM education, the impact of STEM education on students' academic achievement, the impact of STEM education on teachers' professional experiences, the role of school administrators in the implementation of STEM education, information about STEM education, and teachers' opinions about STEM education. Some of the identified codes shared common characteristics with different themes. In identifying the codes, long expressions were used for some codes to ensure clarity and comprehensibility of the research. The identified themes and codes were explained in bullet points according to the interview questions.

1. Can you define STEM education?

The themes and codes of the teachers' responses to the first interview question are shown in Table 2.

Table 2

STEM Education Definition Explained by Teachers.

Themes	Codes
Didactic approach	Interaction between different scientific fields Integration of knowledge and skills in related scientific fields Practical applicability of knowledge in real-life situations Interdisciplinary learning environment A more active learning process

Many subject teachers defined STEM education as an educational model or teaching approach. Teachers emphasized the importance of STEM teaching in terms of creating a common product between related disciplines and linking acquired knowledge to real life.Some teachers' remarks on the definition of STEM education were given as follows:

CHMF described *"STEM is the process of applying science, technology, mathematics, and engineering fields in a practical manner that is related to real-life situations rather than just theoretical concepts."*

MATHM defined *"STEM as an instructional approach that integrates science and technology into teaching mathematics and engineering, creating a collaborative and interdisciplinary learning environment."*

BIOF described *"STEM as a teaching and learning model that involves working with other disciplines to engage students in a more active and experiential learning process."*

2. Have you implemented STEM instruction in your classes? If so, how did you implement it?

The themes and codes of the responses teachers gave to the second interview question are shown in Table 3.

Table 3

The Implementation Topics of STEM Education.

Theme	Codes
The Implementation of STEM Education	Energy conversation
	Pascal's principle
	Projectile motion
	Arduino circuits with coding support
	Pressure
	Fermentation
	The physical interpretation of the derivative
	Electric and magnetic field
	Electrolysis
	Projectile motion
	Geometry
	Derivative

Physics, chemistry, biology, and mathematics teachers have applied STEM to simple and applicable topics. For STEM, teachers have preferred topics that require physical equipment, are inexpensive, and do not require much time to implement. Teachers generally implemented STEM-based practices for robotics coding and project studies. Some teacher statements regarding the implementation of STEM were given as follows:

PHYF explained *"Certain activities, such as designing Arduino circuits with coding support, have been carried out in the context of subjects such as electric and*

magnetic fields."

MATHM stated, *"We transformed the physical interpretation of derivatives and mathematical and engineering courses into an enjoyable experience using the Scratch software for parabolas."*

3. Do you think STEM education is important to your subject? If you answered yes, why do you think it is important?

Table 4 shows the subject and codes of the responses given by teachers to the third interview question.

Table 4

The Importance of STEM Education for Teachers.

Theme	Codes
The Importance of STEM Education	Problem-solving
	Enabling analytical thinking
	Enabling active learning
	Developing projects
	Alternative solutions
	Relating topics to everyday life

Teachers stated that the implementation of STEM education would especially contribute to students' skills in problem-solving, critical thinking, and analytical reasoning. In addition, teachers pointed out that STEM education would help students learn by questioning and interpreting information rather than memorizing it. Some teachers' opinions about the importance of STEM instruction are presented below:

PHYM stated, *"In physics, emphasizing project development for STEM education is of great importance."*

BIOM expressed *"Students can make their knowledge more permanent by conducting experiments related to the topics they learn. It is important to convert theoretical knowledge into practice. Also, I find it important in terms of being able to concretize the subjects."*

MATHF explained *"Mathematics has recently been perceived as a more feared and less understood subject. I believe that STEM will overcome this perception. Thus, students will have opportunities to implement their knowledge in real life. The classic question from students is, "Where will we use this in our daily lives, teacher?" The STEM approach will be very beneficial for our teachers in this regard."*

4. Do you think STEM education will contribute to student success? If your answer is yes, could you please explain the contribution to student success?

The themes and codes of the responses given by teachers to the fourth interview question are shown in Table 5.

Teachers expressed that the implementation of STEM education would have many positive effects on students, such as allowing them to learn by questioning information, learning by doing and experiencing, discovering their interests and talents, developing projects, and sharing their thoughts freely.

Table 5

The Impacts of STEM Education on the Students' Academic Achievement.

Theme	Codes
The Impact of STEM Education on Students' Academic Achievement	Problem-solving Project-based learning Group work Creative solutions Self-confidence Communication skills Self-improvement Taking responsibility Production-oriented skills Cooperation with the group

The following are some opinions of teachers on the impact of STEM teaching on students' academic achievement:

CHEMM explained *" STEM teaching approach will develop students' project-based learning skills, problem-solving skills, increase the importance of teamwork and responsibility. It will be useful for children, especially at an early age, to gain production-oriented skills and develop creative solutions for problem-solving. Additionally, I believe that it will enable students to develop in the areas of preparing for the workforce."*

BIOF expressed that *"it will increase students' interest in the course. I firmly believe that it will increase success and develop teamwork and team spirit in group work. Of course, I also think that it will contribute to communication skills, cooperation within the group, self-improvement, self-confidence building, and research."*

MATHF stated *"Students will participate more in classes, and permanent learning will be provided. Since it will develop the ability to apply what they have*

learned, the internalization of the subjects will be provided, and as a result, success will increase."

5. Do you think STEM education will have a positive impact on teachers' professional experiences? If your answer is yes, could you explain the contribution to teachers' professional experiences?

The themes and codes of the responses teachers gave to the fifth interview question are shown in Table 6. Teachers indicated that integrating the STEM teaching approach into their classrooms contributed greatly to their professional development. Specifically, teachers indicated that they use STEM-based teaching approaches such as problem-solving, project-based learning, problem-based learning, and collaborative learning instead of traditional teaching methods in their classes. STEM-based teaching approaches have increased teachers' motivation and provided them with alternative perspectives.

Table 6

The Impacts of STEM Education on the Teachers' Experiences.

Theme	Codes
The Impact of STEM Education on Teachers' Professional Experiences	Problem-solving skills Critical thinking Self-confidence Communication skills Interdisciplinary collaboration Creativity Motivation

The following are some of the opinions of teachers on the impact of STEM on teachers' professional experiences:

PHYF expressed *"It will increase personal development, enhance communication skills, and make teachers more competent in their fields. It will also provide teachers with interdisciplinary collaboration, creativity, and problem-solving skills."*

BIOM explained *"Spending more time in a laboratory environment can enhance our skills. I believe that teachers collaborating can contribute to our accumulation of knowledge. STEM education can be beneficial in developing teachers' creativity, research skills, problem-solving abilities, and collaboration with other teachers. It increases professional motivation and job satisfaction while improving communication among teachers."*

MATHM stated *"Changing our perspective on the lesson can positively impact our teaching process. Teachers' positive interactions with each other can lead to positive outcomes. It eliminates the memorization of information to some extent. Additionally, it enables teachers to have more knowledge about the practical application of the subject they teach."*

6. What do you expect from your administrators in implementing STEM education?

The themes and codes of the responses teachers gave to the sixth interview question are shown in Table 7.

Table 7

The Role of School Administrators Regarding the Implementation of STEM Education.

Theme	Codes
The role of school administrators in the implementation of STEM education	STEM seminars More resources Flexible working program Sufficient equipment Advanced and equipped laboratories Effective curriculum program

Teachers' expectations of school administrators include attending professional development courses and seminars on STEM, organizing seminars for teachers regularly, and adapting classrooms and laboratories for teaching STEM. Teachers' opinions on what they expect from their school administrators are presented below:

PHYM explained *"Developing laboratories and creating workspaces to carry out projects are essential. Additionally, for physics classes, more time should be allocated for practical applications by increasing the number of class hours in the school schedule. Also, administrators should create a suitable infrastructure for implementing this approach. STEM laboratories should be established, and in-service training on STEM should be provided to teachers. Supporting teachers' projects can help them fulfill their responsibilities."*

CHEMF stated *"It is important to organize necessary in-service training and to provide all kinds of support during the application of STEM. Creating flexible workspaces, to the extent that conditions allow, that are suitable for STEM is also important. Physical conditions should be made suitable for STEM, to the extent possible."*

BIOF expressed *"It is necessary to provide the required materials and resources. The laboratory and curriculum programs should be adjusted to be suitable for STEM. The exam system and evaluation criteria should be completely changed, and the curriculum program should be re-evaluated. Both students and teachers should be supported in terms of both classes and materials for practical applications. Institutional competence should be established."*

MATHF explained *"steps should be taken to support practical applications, such as providing a flexible working program and equipment. The curriculum programs should be adjusted to be suitable for STEM studies. STEM seminars should be conducted by field experts."*

7. Are you able to get information about STEM seminars organized by provincial and district directorates of national education or state/private universities?

The topics and codes of the answers given by teachers to the seventh interview question are shown in Table 8.

Table 8

The Announcement of STEM Seminars to Teachers.

Theme	Codes
Information about STEM Education	Official letter of the Provincial/District Directorate of National Education Informing through the official web page via social media Obtaining information by individual effort

Teachers expressed that they were not sufficiently informed about the seminars, conferences, and trainings that were organized for STEM. In addition, they were not able to attend these in-service trainings regularly due to the heavy workload of their weekly classes. Teachers mentioned that they learned about the seminars from STEM and other information through official letters sent by provincial and/or district national education directorates. In addition, teachers did not receive information about the STEM educational seminars organized by universities.

8. Could you share more thoughts on STEM education?

The themes and codes of the responses given by teachers to the eighth interview question are shown in Table 9. Teachers have some positive and negative

thoughts about STEM education. Many teachers stated that the implementation of STEM will have a positive effect on the motivation of teachers and students. Teachers explained that teaching STEM will increase students' interest in the course, make them participate in the project work with enthusiasm and curiosity, and develop their spirit of discovery. In addition, teachers expressed that the process of implementing STEM education across the board will take time, that creating a physical infrastructure will be an economic challenge, and that there may be difficulties in implementing the curriculum. The positive and negative opinions of some teachers about STEM education are presented in Table 9.

Table 9

The Opinions of Teachers about STEM Education

Theme	Codes
Teachers' Opinions about STEM Education	Critical thinking
	Creative thinking
	Allocating time
	Self-confidence
	Problem-solving skills
	Collaborative work
	Physical conditions
	The number of students
	The exam system
	Learn by doing
	Interdisciplinary relationships
	Curriculum and class hours
	In-service training
	Ability to access information
	The use of media and technology
	Time management
	Communication skills

PHYM stated *"I believe that STEM education approach will contribute to the development of students' critical thinking and creativity. The density of the curriculum can prevent us from spending time on other studies. In addition, inadequacies in implementation can have a negative impact on the implementation of STEM education."*

CHEMF stated *"I believe that this approach will enable our students to move away from memorization and develop thinking, research, interpretation, and synthesis skills and gain confidence. This approach is very beneficial to students when it comes to critical thinking, problem-solving, creative thinking, and collaboration. The physical*

conditions also need to be improved, the number of students in the classroom needs to be reduced, and the exam system needs to be regulated accordingly."

BIOM explained *"I believe that this method will increase students' interest in the class and enhance the permanence of their knowledge. I also believe that it will contribute to students' social and mental development. However, due to limited resources in state schools and overcrowded classrooms, there may be difficulties in implementing this method. Therefore, the education system (schools, curriculum, class schedules, working areas, etc.), especially teacher training institutions, needs to be reorganized according to STEM. To achieve this, we must accept a long-term process and implement the system in practice."*

MATHF stated *"I think it will increase student participation in classes, and improve their understanding of the subject matter, problem-solving skills, and communication skills. I believe that the interaction of mathematics with other sciences and the teaching of mathematics through application will bring more success in the long term. However, the current education system's structure may not allow for much emphasis on STEM due to the need for students to solve many questions during class. Additionally, university entrance exams, school exams, and the curriculum are not suitable for STEM, making it difficult to implement it effectively in Turkey."*

Conclusions

When the results of the interviews were evaluated in general according to the interview questions, it can be said that the implementation of STEM education will contribute greatly to the development of both students and teachers. The results of similar studies (Aslan-Tutak et al., 2017; Fung et al., 2022; Gok, 2022a; Landicho, 2020) supported the results of this research.

Since teachers had experience and knowledge about STEM education, it was not difficult for them to define STEM education. Many teachers received STEM education through in-service training organized by the Ministry of National Education. Many teachers learned about STEM education seminars through official letters from the Ministry of National Education. However, many teachers expressed that they did not receive enough information about the STEM educational seminars organized at universities. Similar results were found in the studies of Eroglu and Bektas (2016) and Ozbilen (2018). It was found that it is important to establish an official communication network for healthy implementation and announcement of information about STEM educational seminars to teachers. Many teachers stated that STEM education is important for their subject area.

As a result of the discussions, teachers expressed the need for teaching models that focus on students and encourage their active class participation, such as STEM, instead of traditional teaching methods. In this regard, STEM

education is important to create an environment where teachers can be motivated, develop projects, and discover the talents of their students.

Teachers indicated that implementing STEM education improves students' problem-solving skills, contributes positively to their critical and analytical thinking processes, helps them discover their interests and talents, develops their social skills in groups, and ensures their attendance in class. These findings were supported by the results of previous studies by Blatt et al. (2020), Chang et al. (2022), Fung et al. (2022), Gok (2021a) and Gok (2021b). When the teacher and student components of STEM education are combined, it becomes clear once again how necessary and important STEM education is for both teachers and students. STEM education will contribute greatly to teacher professional development and experience.To implement STEM education, teachers have certain expectations of school administrators. These expectations include the establishment of a flexible work schedule, legal permissions to conduct STEM-based activities outside of class time, the provision of well-equipped laboratories and workshops for the effective and efficient implementation of STEM-based activities, regular seminars, and in-service training.

Overall, the research findings reveal that STEM education has a positive impact on both teachers and students. It enhances teacher motivation, facilitates project development, and contributes to students' cognitive, social, and emotional development. However, some areas need improvement, such as providing teachers with adequate information about STEM educational seminars at universities and addressing logistical challenges. To ensure successful implementation, it is crucial to establish effective communication networks and provide necessary support to teachers and administrators in implementing STEM education. Thus, it can be concluded that the objectives of the study have been achieved.

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