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Evaluation of STEM Education by Turkish Science Teachers

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Abstract

STEM education has been adopted all around the world to educate individuals that meet the requirements of the changing workforce. Currently, efforts to integrate STEM education into mainstream education are being made in Turkey as well, and it is critical to review them. Therefore, the aim of the current study is to obtain an evaluation of the developing STEM education in Turkey by science teachers. For this purpose, the surveying method, one of the quantitative research methods, was used. 128 science teachers working in Diyarbakır province participated in the study. The "Criteria for Quality STEM" scale, adapted to Turkish by the researchers, was used as the data collection tool in the study. Based on the results, it was concluded that young teachers have higher score averages in improving relations between school, society and business world. It was also found that teachers who practice STEM in science education by spreading them over a period of time have higher averages in terms of creating a STEM culture and climate and establishing the connection between school, society and business world. It was determined that teachers who read academic studies have higher averages in integration of academic knowledge and providing school, community and cooperation compared to those who do not. It was determined that the teachers who previously took part in projects related to STEM education have higher averages in creating the STEM culture and climate in schools. In the light of these results, it is suggested that future research is needed to help science teachers learn how to implement STEM education in their classes so that they can use it effectively and successfully.

Keywords: Evaluation, Science Teachers, STEM education

A. Introduction

All over the world, progress in the field of education develops the industry, and developments in the industry force education to change. Industry, technology and education, which are in close relationship with each other, are among the most important issues on a global scale. From this point of view, it is expected that all individuals will have the skills required by our age, which are also defined as 21st century skills, and it is important that education practices are designed to build on the acquisition of these skills. While designing curriculum, it is important that the approaches to gain these skills are at the centre. One of the most important of these approaches is STEM (Science, Technology, Engineering, and Mathematics) education in which science, technology, engineering and mathematics are integrated. Therefore, it is essential to educate students who can conduct scientific research in schools (Dugger, 2010). As highlighted in the Rising Above the Gathering Storm report published by the National Academies, students must acquire skills such as adaptability, complex communication, social skills, non-routine problem-solving, self-management, and systems thinking to compete (Bybee, 2010). Considered as an interdisciplinary subject in schools, STEM is generally defined as the integration of science, technology, engineering and mathematics into a new world. STEM study presents information and practices about the world we live in a holistic way, rather than teaching them in a piecemeal fashion (Dugger, 2010). STEM education includes knowledge, skills and beliefs that emerge with the integration of science-technology-engineering-mathematics disciplines (Çorlu, Capraro and Capraro, 2014). The pedagogical foundations of STEM education are built on the idea of integrating disciplinary-specific knowledge and skills into programs where real-life problems are addressed in the context of engineering (Bybee, 2013).The aim of STEM is to relate the study areas of education stages with real life topics and to actively use STEM topics in the daily life of learners and empowering individuals who can compete in the economic fields that are the determinant of happiness, adapt to scientific innovations, make scientific and creative changes, and play an active role in the globalizing world (Sanders, 2009). With STEM education, students are aimed to become innovative individuals who are better problem solver, self-confident, logical thinker, science and technology literate (Morrison, 2006). In addition, students can more easily adapt to the world of technology and be technically better equipped for their careers (Czerniak, Weber, Sandman and Ahern, 1999). By acting in coordination with all the disciplines it contains, STEM educates students who are innovative, questioning, decision-making, producing effective solutions to problems, forward-thinking, able to communicate effectively and disciplined students and brings these students to life (Capraro et al., 2005). Additionally, with STEM education, students are qualified to use the knowledge they have gained for production using their imagination (Czerniak, Weber, Sandman and Ahern, 1999). All countries need an innovative STEM workforce to compete in the 21st century. Therefore, ensuring that all students have access to effective STEM education is vital to the competitiveness of nations. Therefore, many countries are competing to find the right approaches to successfully implement STEM education in schools (Thomas & Watters, 2015). It is very important that teachers, as the key actors of education, are well-trained to adopt the interdisciplinary STEM education approach (Wang, 2012).

B. Literature Review

When the MoNE (Ministry of National Education) curricula are examined in Turkey, it can be seen that research and projects related to STEM education have been under way since 2000. However, these projects and studies have not been not fully efficient and effective, because Turkey is in the last place among 34 leading countries in the field of STEM in the 2017 Education Overview report by the OECD (OECD, 2017). Examining the STEM studies in Turkey, various institutional projects for STEM education integration draw attention. As in many countries in the world, some STEM education outcomes were added to the science curriculum in 2018 in Turkey (IETGD, 2018a). Trainings are carried out in different regions of Turkey by STEM education groups under the Provincial Directorates of National Education (Değirmenci, 2020). Teachers are offered STEM trainings as part of various ongoing projects carried out through university-business cooperation (TUSIAD, 2019). The STEM Maker Lab initiative is also trying to popularize STEM education by organizing festivals in different cities (TUSIAD, 2019). In addition, the STEM Education Teacher's Handbook was published by the Ministry of Education, Innovation and Educational Technology General Directorate of Turkey (IETGD). This book presents the theoretical and practical framework necessary for teachers to reflect their STEM understanding in their lessons (IETGD, 2018b). In addition, the HAREZMI Education Model put into practice by the Ministry of National Education in Turkey draws attention. Istanbul was chosen as the pilot province for the HAREZMI education model, and education and training applying this model began to be offered in certain schools of Istanbul. When the HAREZMİ education model is examined in terms of the methods and techniques used, it is observed to be an education model based on the STEM approach (Bolat, 2021). One of the factors that increase the quality of teaching results is that teachers use different methods and techniques in their classroom activities. In this process, teachers evaluate their own abilities and progress and constantly improve themselves. Only then will the quality of education increase. A "Design Skills Workshop" (TBA) was established by the Ministry of National Education for all education levels to allow teachers and students to develop and acquire skills appropriate for their age. In addition, many in-service training courses for teachers strive to achieve this goal (IETGD, 2018b). The Turkish higher education system aims to educate students who are sensitive to the needs of society and economy, are determined, innovative, creative, entrepreneurial, product designers, self-sacrificing, and globally competitive whose qualifications fit in with the latest technological needs. To achieve this, STEM Education Report in 2016, STEM Teacher Education Handbook in 2017 and Curriculum in 2018 were published and some important steps were taken (IETGD, 2018b).

With the adoption of the STEM education approach by many countries and incorporating it into the education system, research in this field has gained momentum. Reviewing the STEM education methods research literature, it can be observed that the highest number of studies include K-12 students and teachers. Many studies show the problems teachers face when applying STEM education in the classroom. Some teachers report having difficulties in terms of time, materials and instructions and not being adequately informed about STEM education (Eroğlu & Bektaş, 2016). Therefore, for STEM education to be effective, it is crucial for teachers to carry STEM practices to their classrooms. As such, teachers are expected to have the necessary STEM teaching and application skills to be able to raise creative thinkers who can transfer 21st century knowledge and skills, who are knowledgeable in science, technology and engineering, competent in science, engineering, mathematics, and scientific processes to deliver high-quality education. Science teachers must continue to develop their expertise in the field of STEM education to help the education system to succeed. For this reason, it is very important to evaluate STEM education by considering all its dimensions by science teachers and to organize STEM education adaptations in schools accordingly in order for STEM education to achieve its goals. Thus, the current study aims to evaluate STEM education through the perspective of science teachers, and seeks the answers to the following questions:

1. What is the average of the answers given by the science teachers to the items in the scale?
2. Is there a significant gender-based difference between science teachers in their evaluation of STEM education?
3. Is there a significant age-based difference between science teachers in their evaluation of STEM education?
4. Is there a significant difference between science teachers in their evaluation of STEM education depending on the type of school?
5. Is there a significant difference between science teachers in their evaluation of STEM education depending on how often they apply STEM education in their teaching?
6. Is there a significant difference between science teachers in their evaluation of STEM education depending on whether they follow academic publications on STEM education?
7. Is there a significant difference between science teachers in their evaluation of STEM education depending on whether they have participated in STEM education projects?

C. Research Methodology

1. Research Design

The survey, one of the quantitative research designs, was used in this study. Survey research is defined as the collection of information from a sample of individuals through their responses to questions (Check & Schutt, 2012). Surveys are capable of obtaining information from large samples of the population.

2. Participants

In the study, simple random sampling method was used. Simple random sampling is the random withdrawal of sampling units from the created universe list. The sample of the study consisted of 128 science teachers who voluntarily agreed to participate in the research. All teachers were teaching 5th, 6th, 7th and 8th grade science classes in state and private schools during 2021/2022 academic year. The participants included 71 female and 57 male science teachers who had different teaching experience from one year to over two years.

3. Data Collection Technique

The Criteria for Quality STEM/STEAM scale was developed by Mark et al. (2015) was used as the data collection tool. The scale was chosen because it offers a versatile evaluation of STEM education. The scale was translated into Turkish by the researchers and then, it was proofread by a Turkish teacher together with an English teacher who has a very good knowledge of this scale. In order to get expert opinion, a professor in the field of biology education, who is fluent in English, was asked to make comparisons between the original English scale and the scale translated into Turkish, and to correct any deficiencies. The scale items were revised by considering the criticism and suggestions from the experts. Afterwards, the scale was administered to two science teachers working at a state secondary school in the Kayapınar district of Diyarbakır province. In order to discuss the suggestions from the science teachers, a meeting was held with a team of experts consisting of two education professors and an associate professor, and the items were discussed one by one. After the meeting, the items were corrected and the scale was given again to the same science teachers. A second meeting was held with the expert team, taking into account the feedback received from the teachers. At the end of the second online meeting, difficult to understand or incorrectly expressed items were corrected and all the items were made clear, understandable and consistent. As such, the scale form, which includes demographic information and consists of four sub-dimensions, was given its final form. The scale is a 4-point Likert type, with 1. "Never", 2. "Rarely", 3. "Sometimes", 4. "Always". The STEM education evaluation scale used in the study consists of 4 dimensions and 73 items. The scale has 42 items in the Integrating of the Academic Content (IAC) dimension, 11 items in the STEM Climate and Culture (SCC) dimension, 13 items in the Collaboration Among School, Community and Industry (CSCI) dimension, and 7 items in the Connections with College and Career Readiness (CCCR) dimension. The Cronbach alpha coefficient of the scale used in the study was calculated as *.949* for the IAC dimension, *.879* for the SCC dimension, *.956* for the CSCI dimension, *.838* for the CCCR dimension, and *.962* for the entire scale. The results of the factor analysis performed to ensure the construct validity of the adapted scale are shown in Table 2.

In the factor analysis, the KMO (KaiseMeyer-Olkin Measure of Sampling Adequacy) value, which indicates the suitability of the data for factor analysis, must be greater than 0.50 and the degree of Sphericity (Bartlett's Test of Sphericity) which indicates that significant factors will emerge from the data obtained, must be ($p<.05$) (Tabachnick &

Fidell, 2013). In addition, in the explanatory factor analysis, items with an Eigen value greater than 1 and a factor load over 0.30 can be included in the factor. According to the table, the KMO value was 0.819 and the Bartlett test result was significant at the p= 0.000 level. Therefore, it can be said that the data are suitable for factor analysis. The analysis revealed four factors with an eigen value of 1 and above. As can be seen in Table 2, the variance explanation rates are 30.060% for the first factor, 7.418% for the second factor, 6.810% for the third factor, and 5.534% for the fourth factor. The total variance explained by the four factors is 49.823%.

4. Data Analysis Techniques

Kolmogorov-Smirnov normality test was used to determine the normality distribution of the data collected, and it was determined that the data did not have a normal distribution. For this reason, Mann-Whitney U test was used in paired group comparisons and Kruskal Wallis H test was used in group comparisons of three or more. The intervals used to interpret the averages of the scale used in the research are given below.

Always: 3,25-4,00
Often: 2,50-3,24
Seldom: 1,75-2,49
Never: 1,00-1,74

D. Findings

In this section, the tables created on the basis of the analysis of the data obtained in the research are given.

Table-1. Science Teachers' Item Averages in the Academic Context Integration Dimension

	Item	$\overline{X}$
IAC 1	At our school, students have the opportunity to engage in learning experiences with STEM education.	2,12
IAC 2	At our school, students solve everyday problems using information they have learned.	2,83
IAC 3	At our school, students have the opportunity to take part in performance-oriented STEM activities.	2,27
IAC 4	At our school, students participate in STEM assessment activities.	2,02
IAC 5	At our school, students have the right to choose their own learning activities.	2,45
IAC 6	At our school, students have the right to choose the content of the subject to be learned.	2,30
IAC 7	At our school, students have the right to choose their teaching method.	2,36
IAC 8	At our school, students have a say in the planning of the lesson.	2,22
IAC 9	The science education in our school has standards that are suitable for students' STEM practices.	2,13
IAC 10	At our school, students interact with one another through conversation.	3,69
IAC 11	At our school, students interact with their teachers through conversation.	3,76
IAC 12	At our school, students interact with one another through listening.	3,40
IAC 13	At our school, students interact with their teachers through listening.	3,51
IAC 14	At our school, students interact with one another through writing.	2,75

IAC 15	At our school, students interact with their teachers through writing.	2,57
IAC 16	At the school I teach, students have the opportunity to work collaboratively in groups.	3,02
IAC 17	At the school I teach, students have the opportunity to collaborate in groups to answer questions.	3,00
IAC 18	At the school I teach, students have the opportunity to collaborate to build understanding through group work.	2,95
IAC 19	At our school, students have the opportunity to collaborate to solve problems through group work.	2,95
IAC 20	At the school I teach, students have the opportunity to collaborate in group work projects.	2,94
IAC 21	At the school I teach, students have adequate access to information technologies (internet, smart board, e-books, computer simulations, etc.).	2,50
IAC 22	At the school I teach, teachers have adequate access to information technologies (internet, smart board, e-books, computer simulations, etc.).	2,59
IAC 23	At the school I teach, school administrators have sufficient access to information technologies (internet, smart board, e-books, computer simulations, etc.).	2,65
IAC 24	At our school, teachers have access to reliable and consistent support for IT innovation.	2,55
IAC 25	At our school, teachers have access to reliable and consistent support to maintain their IT.	2,67
IAC 26	At our school, students have access to reliable and consistent support for IT innovation.	2,56
IAC 27	At our school students have access to reliable and consistent support to maintain their information technology.	2,49
IAC 28	At our school, leadership for the adoption of educational technology as a shared vision among education stakeholders is limited.	2,50
IAC 29	At our school, there are efforts to support the effective application of technology to carry out the STEM activities added to the science curriculum.	2,41
IAC 30	At our school, science teachers perform their teaching activities based on ISTE (International Educational Technologies Society) standards.	2,39
IAC 31	At our school, students are used to demonstrate their understanding of digital citizenship, technological operation.	2,32
IAC 32	At our school, students use technology to think critically.	2,43
IAC 33	At our school, students use technology to solve problems.	2,55
IAC 34	At our school, students use technology to collaborate.	2,60
IAC 35	At our school, students use technology to communicate.	2,80
IAC 36	At our school, students use technology to produce in STEM activities.	2,34
IAC 37	At our school, students use technology to create STEM activities.	2,36
IAC 38	The teachers of our school receive professional development training in STEM.	2,26
IAC 39	Our school administrators receive professional development training in STEM.	2,30
IAC 40	At our school, professional development in the STEM field is part of the teaching professional development.	2,37
IAC 41	At our school, STEM professional development involves a small number of teachers.	2,50
IAC 42	Our school administrators develop STEM professional learning communities to align with our school's STEM practices.	2,14

As shown in Table 1, students rarely have opportunities to experience learning through STEM education ($\overline{X}$=2,12). Furthermore, students rarely participate in performance-oriented STEM activities ($\overline{X}$=2,27) and participate in evaluation activities in STEM activities ($\overline{X}$=2,02). Students rarely have the right to determine the content of the subject ($\overline{X}$=2,30), plan the lesson ($\overline{X}$=2,22), choose the teaching method ($\overline{X}$=2,36) and learning activities ($\overline{X}$=2,45). Similarly, it was found that science education is rarely ($\overline{X}$=2,13) at the level of study standards needed for STEM practices. It was also determined that students communicate with each other and with their teachers at all times through speaking ($\overline{X}$=3,69; $\overline{X}$=3,76) and listening ($\overline{X}$=3,40; ($\overline{X}$=3,51), and students frequently communicate with each other ($\overline{X}$=2,75) and with their teachers ($\overline{X}$=2,57) through writing. Students frequently have opportunities to work in groups for collaborative study ($\overline{X}$=3,02), answering questions ($\overline{X}$=3,00), solving problems ($\overline{X}$=2,95), project development ($\overline{X}$=2,94) and understanding ($\overline{X}$=2,95) (Table 1). Students $\overline{X}$=2,50), teachers ($\overline{X}$=2,59) and school administrators ($\overline{X}$=2,65) have frequent access to ICT technologies. It was also found that students and teachers often have access to consistent support for upgrading ($\overline{X}$=2,56; $\overline{X}$=2,55) and maintaining ($\overline{X}$=2,49; $\overline{X}$=2,67) ICTs. The science teachers stated that the STEM approach activities added to the science curriculum and efforts made to support the effective application of technology ($\overline{X}$=2,41) and teaching activities based on ISTE (International Educational Technologies Society) standards ($\overline{X}$=2,39) are rare. Students use technology for problem solving ($\overline{X}$=2,55), cooperation ($\overline{X}$=2,60) and communication ($\overline{X}$=2,80) frequently, while they rarely ($\overline{X}$=2,43) use technology for critical thinking. It was also found that students rarely used technology in STEM activities to produce ($\overline{X}$=2,34) and create ($\overline{X}$=2,36). On the other hand, teachers ($\overline{X}$=2,26) and school administrators ($\overline{X}$=2,30) rarely receive professional development training in STEM.

Table-2. Science Teachers' Item Averages in the STEM Climate and Culture Dimension

	Item	$\overline{X}$
SCC 1	Our school organizes events to celebrate and showcase student work in the STEM field.	1,95
SCC 2	Our school organizes events to celebrate and showcase teacher work in the STEM field.	1,98
SCC 3	The innovations that teachers in our school make in their work are not appreciated.	1,81
SCC 4	The innovations that students in our school make in their studies are not appreciated.	1,81
SCC 5	STEM studies carried out in our school are shared with the society using communication tools.	2,30
SCC 6	Our school has guidelines focused on increasing participation in STEM activities.	2,25
SCC 7	Our school has practices focused on increasing participation in STEM activities.	2,29
SCC 8	Few students in our school participate in STEM activities.	2,32
SCC 9	The STEM activities that the students in our school perform outside of school are independent from the school.	2,05
SCC10	Teachers at our school have access to the necessary resources to engage students in STEM learning.	2,21
SCC11	In our school, a space has been created for the display of STEM education products.	2,04

As can be seen in Table 2, the activities organized to celebrate and exhibit student and teacher work in the STEM field ($\overline{X}$=1,95; $\overline{X}$=1,98) are rare. Furthermore, the innovations made by teachers and students ($\overline{X}$=1,81; $\overline{X}$=1,81) are rarely appreciated. The level of sharing of STEM work with the society through communication tools ($\overline{X}$=2,30) was also found to be rare. Schools rarely have STEM guidelines ($\overline{X}$=2,25) and practices ($\overline{X}$

=2,29). Participation of students in STEM activities ($\bar{X}$=2,32) and performing STEM activities independently from school ($\bar{X}$=2,05) were determined to be rare as well. In addition, teachers' access to STEM education resources ($\bar{X}$=2,21) was determined to be rare. Creation of an area for the exhibition of STEM education products in schools is also rare ($\bar{X}$=2,04).

Table-3. Science Teachers' Item Averages in the Dimension of Cooperation between School, Society and Business World

	Items	$\bar{X}$
CSCI 1	Our school develops a STEM plan in line with the strategies aligned with the program objectives.	2,07
CSCI 2	Our school allocates financial resources to ensure that STEM goals are attainable.	1,94
CSCI 3	Our school administrators know about the STEM goals.	2,41
CSCI 4	Our school teachers know about the STEM goals.	2,41
CSCI 5	The parents of our students know about the STEM and its goals.	1,94
CSCI 6	The business people of our city (employers in the city) know about the STEM goals.	2,23
CSCI 7	Our school aims to partner with non-governmental organizations to achieve a quality STEM plan.	2,14
CSCI 8	Our school seeks to partner with other schools to implement a quality STEM plan.	2,17
CSCI 9	Our school seeks to partner with universities to implement a quality STEM plan.	2,11
CSCI 10	Our school seeks to collaborate with businesses to implement a quality STEM plan.	2,11
CSCI 11	Our school participates in partners/stakeholder meetings that set strategies for maintaining STEM programs.	2,20
CSCI 12	Students at our school interact with STEM partners/stakeholders (universities, employers, nonprofits).	2,02
CSCI 13	Teachers at our school interact with their STEM partners/stakeholders (universities, employers, nonprofits).	2,16

As shown in Table 3, schools rarely develop a STEM plan ($\bar{X}$=2,07) in line with the strategies compatible with the curriculum goals and allocate financial resources ($\bar{X}$=1,94) to ensure that STEM goals are attainable. The science teachers who participated in the study stated that school administrators ($\bar{X}$=2,41), teachers ($\bar{X}$=2,41), parents ($\bar{X}$=1,94) and employers ($\bar{X}$=2,23) rarely knew the aims of STEM education. Similarly, schools rarely aim to establish partnerships with non-governmental organizations ($\bar{X}$=2,14), other schools ($\bar{X}$=2,17), universities ($\bar{X}$=2,11), and businesses ($\bar{X}$=2,11) to implement a quality STEM plan.

Table-4. Science Teachers' Item Averages in the Dimension of Connection with Universities and Career Readings

	Item	$\bar{X}$
CCCR 1	At our school, information about secondary school STEM programs is shared with teachers.	2,01
CCCR 2	At our school, information about secondary school STEM career topics is shared with teachers.	2,04
CCCR 3	At our school, career-related courses in STEM are available in the science curriculum.	2,35

CCCR 4	Our school students have opportunities to explore their STEM careers.	2,16
CCCR 5	Our school's STEM-educated students come together to discuss their post-secondary education careers.	1,96
CCCR 6	Our school's students who have received STEM education come together to plan their post-secondary education careers.	2,05
CCCR 7	Secondary school students of our school have access to the visual arts course as an elective course.	2,48

As can be seen in Table 4, the information about STEM programs ($\overline{X}$=2,01) and STEM career topics ($\overline{X}$=2,04) in the schools where science teachers work is rarely shared with teachers. It was also found that students rarely had opportunities ($\overline{X}$=2,16) to explore their STEM careers. Similarly, students who have received STEM education rarely come together to discuss ($\overline{X}$=1,96) and plan ($\overline{X}$=2,05) their after-school education careers.

Table-5. Mann-Whitney-U Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Gender Variable

	Gender	N	Rank Average	Total Rank	U	p
IAC	Female	71	68,60	4870,50	1732,5	,163
	Male	57	59,39	3385,50		
SCC	Female	71	66,20	4700,00	1903,0	,563
	Male	57	62,39	3556,00		
CSCI	Female	71	68,06	4832,00	1771,0	,225
	Male	57	60,07	3424,00		
CCCR	Female	71	65,21	4630,00	1973,0	,808
	Male	57	63,61	3626,00		
	Male	57	58,69	3345,50		

Looking at Table 5, no significant difference by the gender of science teachers can be observed in the IAC dimension (U=1732.5, p>.05), SCC dimension (U=1903.0, p>.05), CSCI dimension (U=1771.0, p>.05) and CCCR dimension (U=. 1973.0, p>.05).

Table-6. Kruskal Wallis H Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Age Variable

	Age	N	Rank Average	sd	X^2	p	Significant Difference
IAC	(1) 20-25	8	90,06	4	10,795	,029*	1>3 1>4 2>3 2>4
	(2) 26-30	35	75,41				
	(3) 31-35	55	57,04				
	(4) 36-40	19	53,53				
	(5) 41 and over	11	67,45				
SCC	(1) 20-25	8	94,94	4	8,673	,070	
	(2) 26-30	35	70,64				
	(3) 31-35	55	61,17				

	(4) 36-40	19	55,87				
	(5) 41 and over	11	54,36				
CSCI	(1) 20-25	8	83,25	4	10,906	,028*	2>3 2>4
	(2) 26-30	35	78,17				
	(3) 31-35	55	58,76				
	(4) 36-40	19	50,92				
	(5) 41 and over	11	59,50				
CCCR	(1) 20-25	8	70,19	4	1,861	,761	
	(2) 26-30	35	62,26				
	(3) 31-35	55	68,53				
	(4) 36-40	19	58,82				
	(5) 41 and over	11	57,18				
	(2) 26-30	35	76,17				
	(3) 31-35	55	57,95				
	(4) 36-40	19	51,32				
	(5) 41 and over	11	62,00				

Looking at Table 6, a significant age-related difference is observed in the IAC dimension (X^2=10.795, p<.05) and the CSCI dimension (X^2=10.906, p<.05). It was determined that the significant difference in IAC dimension was in favor of teachers between the ages of 20-25 (1>3; 1>4) and those between the ages of 25-30 (2>3; 2>4) (p<.05). Significant results were obtained in favour of teachers in the 25-30 (2>3; 2>4) age group in the CSCI sub-dimension (p<.05). In the SCC dimension (X^2=8.673, p>.05) and in the CCCR dimension (X^2=1.861, p>.05) no significant age-based difference was found.

Table-7. Mann-Whitney-U Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Variable of School Type They Worked

	Type of school	N	Rank Average	Total Rank	U	p
IAC	State	120	62,64	7517,00	257,0	,028*
	Private	8	92,38	739,00		
SCC	State	120	63,24	7589,00	329,0	,136
	Private	8	83,38	667,00		
CSCI	State	120	63,33	7599,00	339,0	,164
	Private	8	82,13	657,00		
CCCR	State	120	63,83	7660,00	400,0	,428
	Private	8	74,50	596,00		
	Private	8	90,75	726,00		

Table 7 shows that there is a significant difference in favour of science teachers working in private schools in IAC dimension (X^2=11,969, p<.05). No significant difference could be found in the dimensions of SCC (X^2=5,330, p>.05), CSCI (X^2=5,077, p>.05) and CCCR (X^2=3,181, p>.05) according to the type of school the teachers work in.

Table-8. Kruskal Wallis H Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Variable of Frequency of Applying STEM Education

	Application Frequency	N	Average Rank	Sd	X^2	p	Significant Difference
IAC	(1) Never	52	57,85	4	5,719	,221	
	(2) Every week	16	60,44				
	(3) Once in a month	9	56,94				
	(4) Every two months	42	72,80				
	(5) in a period	9	79,00				
SCC	(1) Never	52	54,64	4	20,712	,000*	1<4 1<5 2<4 2<5 3<4 3<5
	(2) Every week	16	53,50				
	(3) Once in a month	9	42,00				
	(4) Every two months	42	79,65				
	(5) in a period	9	92,78				
CSCI	(1) Never	52	55,52	4	15,198	,004*	1<4 1<5 2<4 2<5
	(2) Every week	16	50,81				
	(3) Once in a month	9	57,39				
	(4) every two months	42	76,20				
	(5) in a period	9	93,22				
CCCR	(1) Never	52	61,48	4	2,794	,593	
	(2) Every week	16	65,69				
	(3) Once in a month	9	50,89				
	(4) Every two months	42	70,74				
	(5) in a period	9	64,33				
	(2) Every week	16	55,00				
	(3) Once in a month	9	54,78				
	(4) Every two months	42	77,00				
	(5) in a period	9	90,00				

Examining Table 8, a significant difference can be seen in terms of the frequency of teachers' use of STEM in the SCC (X^2=20,712, p<.05) and CSCI (X^2=15,198, p<.05) dimensions.

Thus, there is a significant difference in both dimensions in favor of science teachers who use STEM education for science teaching once a semester and once every two months. No significant difference could be detected in terms of the frequency of teachers' use of STEM in the IAC (X^2=5,719, p>.05) and CCCR (X^2=2,794, p>.05) dimensions.

Table-9. Mann-Whitney-U Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Variable of Academic Study Follow-up

	Academic Study Follow-up	N	Average Rank	Total Rank	U	p
IAC	Yes	57	72,86	4153,00	1547,0	,022*
	No	71	57,79	4103,00		
SCC	Yes	57	69,83	3980,50	1719,5	,144
	No	71	60,22	4275,50		
CSCI	Yes	57	73,07	4165,00	1535,0	,019*
	No	71	57,62	4091,00		
CCCR	Yes	57	65,96	3759,50	1940,5	,689
	No	71	63,33	4496,50		
	No	71	58,11	4125,50		

Looking at Table 9, it is clear that teachers who follow academic studies have significantly higher scores than those who do not in the dimensions of IAC (U=1547,0, p<.05) and CSCI (U=1535,0, p<.05). No significant difference could be detected in the dimensions of SCC (U=1719,5, p>.05) and CCCR (U=1940,5, p>.05) according to teachers' academic pursuit of work.

Table-10. Mann-Whitney-U Test Results Regarding the Difference between the Mean Scores of the Teachers Participating in the Study According to the Variable Working on the Project

	Working on the project	N	Average Rank	Total Rank	U	p
IAC	Yes	20	75,85	1517,00	853,0	,136
	No	108	62,40	6739,00		
SCC	Yes	20	81,10	1622,00	748,0	,029*
	No	108	61,43	6634,00		
CSCI	Yes	20	78,33	1566,50	803,5	,069
	No	108	61,94	6689,50		
CCCR	Yes	20	71,23	1424,50	945,5	,375
	No	108	63,25	6831,50		
	No	108	62,03	6699,00		

As can be seen in Table 10, compared to those who do not work in STEM projects, there are significant differences in favour of science teachers working in STEM projects in the SCC (U=748,0, p<.05) dimension. However, no significant difference could be found based on the working status of science teachers in STEM projects in the dimensions of IAC (U=853,0, p>.05), CSCI (U=803.0, p>.05), and CCCR (U=945.5, p>.05).

E. Discussion

Our study in which science teachers evaluated STEM education in schools found that students have very few opportunities to get actively involved in learning through STEM education, to take part in performance-oriented STEM activities, to participate in assessment activities in STEM activities, and to choose their own learning activities. It was also determined that students rarely have a right to determine the content of the subject to be learned, the teaching method and the planning of the lesson, which shows that there are some shortcomings in the implementation of STEM education in classrooms. The majority of the science teachers were found not to work under standards suitable for STEM practices in the schools where they work. The majority of the science teachers participating in the study reported that their students have the opportunity to communicate with each other and with their teachers through speaking, listening and writing. The vast majority of the teachers point out that their students have the opportunity to work collaboratively, answer questions, create understanding in group work, solve problems, and produce projects. The science teachers participating in the research were found to have easy access to ICTs (internet, smart board, e-book, computer simulations, etc.) in the schools they work. However, teachers have little access to reliable and consistent support to update and maintain students' ICTs, which means that teachers and students do not have the support they need while using new technologies. Few of the science teachers participating in the research reported that the leadership performed is sufficient for the adoption of educational technology as a common vision among the education stakeholders in the schools where they work. Most of the science teachers participating in the research do not think that the activities carried out to support the effective application of technology to carry out the STEM approach activities added to the science curriculum in the schools where they work are adequate. In addition, the science teachers stated that the level of performing teaching activities in their schools based on ISTE standards is low. Moreover, the use of digital citizenship by the students to show that they understand technology is very low. The students' use of technology for critical thinking, problem solving, producing in STEM activities and creating content in STEM activities is also low. Considering the results of the research, the technology components, which are indispensable in our age and whose integration into education are becoming increasingly important, are not adequately integrated into STEM education. Using technology in STEM education requires keeping up with the pace of organizational change, acquiring new skills, having the core competency of the industry, and applying interdisciplinary knowledge (Connor, Karmokar, & Whittington, 2015). Therefore, integration of technology in STEM education is critical. In today's education system, teachers are expected to create an effective learning environment by integrating their subject knowledge and pedagogical knowledge with technology knowledge (Koehler &

Mishra, 2009) because the success of STEM education depends on teachers who can integrate science, mathematics, technology and engineering skills (Epstein & Miller, 2011). As a matter of fact, Kelley (2010) points out that there are many examples of efforts to apply technology education to multidisciplinary or interdisciplinary fields in history, but these efforts leave much to be desired. Similarly, El-Deghaidy and Mansour (2015) emphasize that teachers do not sufficiently understand the integration of technological applications in STEM education. In the current study, most students were found to use technology to communicate and collaborate, which can be attributed to the fact that the young generation use social media actively. It was also determined that science teachers and school administrators have insufficient professional development training on STEM. Similarly, Akyıldız (2020) draws attention to the fact that school administrators' level of receiving STEM education is low. In addition, science teachers participating in the research point out that there is an inability to see professional development in the field of STEM as a part of the field of teaching professional development in the schools where they work. In addition, many science teachers participating in the research stated that the school administrators they work with are insufficient in developing STEM professional learning communities so that their schools can be compatible with STEM practices. All these results indicate quite a few shortcomings in academic STEM education integration at schools. One of these shortcomings is that STEM education remains at the program level (Kang, 2019; Ramli et al., 2017; Akgündüz et al., 2015). Indeed, Brown et al. (2011) emphasize that there is little evidence that STEM education exists in schools. This lack of evidence stems from the lack of knowledge, skills, resources, materials, interest and training related to STEM education (Ramli & Talib, 2017). Williams (2011) lists the difficulties encountered in the academic integration of STEM education as the economic differences between schools, unplanned implementation, unequal opportunities between students, examination-oriented education systems, difficulties experienced by teachers in STEM applications, lack of support to overcome the difficulties, not performing the necessary STEM education inspections, lack of awareness that STEM education is a need, creation of an imaginary STEM perception to market to school to parents, and lack of evaluation of STEM education in schools. Likewise, Drake & Burns (2004) list the difficulties encountered in STEM education as lack of time, insufficient examples for teachers, teachers' lack of STEM knowledge due to inadequate training, lack of materials, difficulties experienced by the teachers in other disciplines other than their specialization, the resistance experienced in adapting to new trends and change, and insufficient moral support.

It was also found that the science teachers participating in the research do not organize activities in their schools to exhibit the STEM works and that they do not share their STEM activities with the society by using communication tools. It was also determined that the science teachers participating in the research do not have directives and practices that focus on increasing their participation in STEM activities in the schools they work. Furthermore, it was found that these teachers do not have access to the resources needed to engage students in STEM learning. Moreover, it was found that there was no space to exhibit the STEM education products at the schools where the science teachers worked. However, the science teachers were appreciated for the innovations they made. Because these results show that STEM education does not affect the climate at the school even if it takes place in the classrooms, they reveal the necessity of accelerating the work to create a STEM culture and climate at schools.

It was determined that the schools' level of developing STEM education plans and creating financial resources for STEM is very low. It was also found that school administrators, teachers, parents and employers know the aims of STEM education at a low level. It is observed that schools rarely aim to establish partnerships with non-governmental organizations, other schools, universities and businesses to implement STEM plans. Similarly, it was found that schools rarely attend the meetings of partners who set the strategies for maintaining their STEM programs. In addition, students and teachers rarely interacted with STEM partners. These results reveal that STEM education is weak in terms of establishing relationships with school, society and the business world.

It was determined that information about STEM programs and STEM career topics in schools is rarely shared with teachers and career-related courses in STEM education are rarely included in the science curriculum. It was also found that students rarely have opportunities to explore their STEM careers and students who take STEM education rarely meet to discuss and plan their post-secondary education careers. Furthermore, secondary school students rarely have the visual arts course as an elective course. These results show that the connection with universities and STEM education career readings are also quite weak. To help students receive effective STEM education and to give them the opportunity to choose a career in this field in the future, science teachers who guide students should be experienced in STEM education. However, the results of our research reveal that science teachers do not receive adequate training on STEM education. When the reports published on STEM education in Turkey are examined, it is clear that the efforts for the development of STEM education continue (Akgündüz et al., 2015), but are not sufficient (IETGD, 2018b). With STEM education, which is one of the most important educational reforms of recent years, it is very important to develop students' knowledge and skills in science and mathematics, to enable them to design technology and engineering, and to develop positive perspectives on science, mathematics, technology and engineering (Akgündüz et al., 2015). Thus, teachers, school management, universities and the business world need to work together in order for STEM education to be delivered at schools.

No significant difference was found in any dimensions of the scale for science teachers' evaluation of STEM education by their gender. However, significant results were obtained in favour of young teachers by the age variable in the IAC dimension and CSCI dimension of the scale for science teachers' evaluation of STEM education. With the introduction of STEM education in Turkey in the early 2000s, the *Interdisciplinary Science Teaching* and *Applications of Science in Technology* courses added to the Higher Education Science Teacher Training Program helped recent graduates to have more information about the integration of academic knowledge about STEM. In addition, it is not surprising that young teachers have higher averages in the integration of academic knowledge in

STEM education, due to the fact that technological development has become more intense and young teachers are very familiar with technology. As a matter of fact, Akgündüz et al., (2018) point out that teachers over the age of 30 face challenges in applying STEM education without adequate content knowledge and competence in STEM teaching at universities, without professional interaction, and without adequate learning. Young teachers are more active in the CSCI dimension because they have more knowledge about STEM.

It was determined that the teachers working in private schools had significantly higher averages in the ABE dimension than the teachers working in public schools. Rini & Syadih (2020) found that teachers working at good schools have positive beliefs and perceptions about STEM education, while their beliefs and perceptions are negative in schools with poor school facilities and equipment. Therefore, the fact that the physical equipment of private secondary schools in Turkey is better and that many private schools have STEM laboratories lead to the conclusion that science teachers working in these schools have keener awareness of the integration of the academic context. Park et al. (2017) point out that one of the barriers to teachers' STEAM implementation is the lack of financial support. Therefore, better financial resources of private schools support this result. Johnson (2006) points out that teachers do not have sufficient resources for STEM education, and emphasizes that eliminating these difficulties can facilitate the implementation and success of STEM programs.

In our study, a significant difference was found in the SCC and CSCI dimensions by the science teachers' frequency of using STEM education for science purposes. A significant difference in both dimensions was found in favour of the teachers who applied STEM education in their classes once and twice a month. Considering that there are science teachers who have not received STEM education in the research sample, their tendency to focus on short-term results when planning STEM education is not surprising. Köksal (2002) emphasizes that one of the weakest aspects of STEM education in Turkey is trying to fit this education only into the course hours. However, STEM education requires a long implementation process (Scott, 2009). Indeed, the creation of a STEM culture in the schools of the teachers who have carried out STEM education throughout the entire semester can also be considered as a result of the continuity of STEM education in schools. With STEM education, students are able to collaboratively produce solutions to problems in daily life while turning their knowledge into practice, meet the needs of the business world, and the quality of education increases (Proudfoot, Green, Otter & Cook, 2018; Yang & Baldwin, 2020). The development of STEM literacy, the cooperation of schools, society and the business world, and the ability of teachers to compete in the global economy are among the factors that directly contribute to the development of countries (Barakos, Lujan, & Strang, 2012). In this respect, it is only natural that teachers who succeed in making STEM education a part of science education have higher averages in establishing the connection between their school, society and the business world.

We also found that science teachers who follow academic research on STEM education have significantly higher averages in ABE and OTI dimensions than those who do not. This is not particularly surprising for the ABE dimension because it is inevitable for teachers who follow academic studies to have more academic knowledge about the STEM education practices. It is just normal that they use this knowledge for the academic integration of STEM education at their schools. Again, it is inevitable for science teachers who follow academic studies to better understand and develop the relationship between the school, society and business world. Trilling & Fadel, (2009) point out that STEM education plays an important role in preparing children for the future, which leads to the conclusion that science teachers should perform their STEM education practices more professionally. Thus, science teachers need to follow the research publications on STEM education. As a matter of fact, Arslan ve Arastaman (2021) stresses the need to adopt a holistic approach including academic integration where stakeholders such as family, industry, NGOs, universities, research centers, and local governments all acknowledge each other, and they have no communication problems. We also found that science teachers who had the opportunity to work in a project related to STEM education had higher averages in creating STIs in their schools, which means that science teachers who have gained the working culture in the project can integrate this culture into the school culture they work in because STEM education calls for processes such as projects that cover a long period of time and require detailed planning, cooperation and production. The science teachers who took part in the project made better sense of the STEM education processes and could integrate them into their lessons better due to this practice opportunity.

F. Conclusion

Turkish science education curriculum was revised in 2018 and learning outcomes for STEM was added to the new curriculum. Additionally, various projects have been carried out to help for spreading STEM education in Turkey. Despite these efforts studies have documented that there is still a long way to go in terms of incorporating STEM activities in learning instructions. The current study revealed that the participant science teachers found themselves sufficient in terms of the academic integration of STEM education. However, they emphasized the need to overcome the lack of cooperation between school, society and business world which is essential for a successful STEM education. In addition, science teachers claimed that STEM climate and culture are not sufficient in schools. Similarly, the inadequacy of further study and career guidance by schools in the context of STEM education was emphasized by the participant science teachers.

G. Suggestions

In light of the findings of the study, the following suggestions can be made:

1. Adding courses that will improve the practical dimension of the *Interdisciplinary science teaching* theoretical course integrated into science teacher training programs
2. Providing in-service training to improve the knowledge and practice status of science teachers about STEM teaching
3. Opening STEM teacher training programs at the undergraduate level

4. Opening specialized STEM teacher programs at the graduate level
5. Providing the STEM education materials needed by schools
6. Involving science teachers as stakeholders in academic research
7. Encouraging science teachers to take part in STEM projects
8. Seminars on STEM-career relationship can be organized by the Ministry of National Education for students, parents and teachers.

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