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Turkish STEM Teachers' Opinions about the Scientist-Teacher-Student Partnership

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ABSTRACT
The main aim of this study is to investigate the opinions of Turkish STEM teachers about the Scientist-Teacher-Student Partnership (STSP). In order to provide extra insights about the STSP, a specifically designed questionnaire developed by Malaysian researchers was used. The study consists of data collected from 301 Turkish STEM teachers who have been working in the schools. As a result of the analysis of the data, it was found out that the teachers have positive opinions about the STSP. Looking at the differences between male and female teachers, it was found that there were significant differences in teachers' scores related to the roles of teachers, students, and scientists in the STSP. According to the teachers' experiences of working with scientists or not, the results showed that teachers who do not have experience of working with scientists have a more positive opinion of this collaboration process. Turkish STEM teachers showed greater appreciation of the value of working with a scientist, especially teachers who did not have working experience with a scientist. The outcomes of this study can be used to implement the STSP as a STEM education model.

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Introduction

As a result of the rapid changes in the field of science and technology, many countries have included the educating of individuals needed in the STEM field among the priority country policies (Sarı et al, 2020). It has given special importance to individuals who will work in the fields of science and technology of the future, especially with the changes that have been made in education policies. In this context, many countries have made serious changes and innovations in their science and technology education curricula and prioritized the creation of opportunities for students to actively learn in teaching and learning environments instead of classical learning settings. In addition to developing innovative teaching and learning methods that enable students to learn better in the fields of science and technology, increasing the motivation of students to pursue a career in the mentioned fields has also been among the priorities (Samsudin et al, 2020).

One innovative teaching and learning method of having students learn science is to involve them in a student-teacher-scientist partnership (STSP) that involves students in ongoing research programs (Barstow et al., 1996). Although the term, STSP, has no single definition, there is a widespread agreement that it focuses on the interaction among Scientist-Teacher-Student and it is foreseen that teachers, as well as students, will acquire the skills in 'real' scientific investigations from the scientists in this partnership (Fadzil et al., 2019; Houseal et al., 2014; Tanner et al., 2003; Ufnar & Shepherd, 2018). While this mutual learning appears to be ideal for science and science education, unfortunately, there are limited resources or mechanisms that support this cross-institutional partnership and understanding of how the partnership influences students' science learning. However, a wide range of international studies on STSP presents different approaches for teaching and learning environments. For example, Wormstead et al. (2002) focused on the GLOBE (Global Learning and Observations to Benefit the Environment) programme. This programme provided the opportunity for students to work with scientists. The researchers proposed recommendations to scientists about how they can get the most out of their research and teaching relationship with students and their teachers. At the end of this study, they identified and recommended a set of training material design criteria for implementation of STSP programmes (Guidelines for "components to include", "layout and organization of the materials", "writing the concept and skill-Building lessons and the instructions" and "Important issues to consider") in the elementary and middle school levels.

Although they are not as large as the GLOBE Program, it is seen that many studies have been done in this area. In many of these studies, it is seen that students take part in the research team of scientists in the process of solving a real science problem (Barab & Duffy, 2000; Barab & Hay, 2001; Bouillion & Gomez, 2001; McGinn & Roth, 1999; Richmond & Kurth, 1999; Richtie & Rigano, 1996; Kelley et al., 2020; Shanahan & Bechtel, 2020; Salame et al., 2020). Barab and Hay (2001) and Tinker (1997) indicate that students and teachers improve their content knowledge and scientific process skills in case of providing working environments with scientists. It has been shown that students who have the opportunity to work with scientists can create a scientific research question, design and manage their research, and analyze and report the data they obtain (Blumenfeld et al., 1998; Ledley et al., 2003). In addition, there are studies showing that STSP creates teacher content knowledge, and provide mutual respect for the work of both classroom teachers and scientists, and supports mechanisms that sustain teachers' efforts (Dresner & Starvel, 2004; Dresner & Worley, 2006). Peker and Dolan (2012) emphasize the common roles of teachers and scientists revealed that while scientists provide conceptual and epistemological support related to their scientific expertise, teachers play a critical role in ensuring students' access to this knowledge.

Fadzil et al. (2019) explored Malaysian Grade 10 students' perceptions of learning science through STSP. Eight science teachers and seven scientists from a university participated in the study. A survey questionnaire and interviews were used as data collection. The results from students showed that STSP helped them to enrich their learning experiences, they gained procedural skills through hands-on experiments, they used this opportunity to understand and explore emerging topics in science and finally they indicate various career opportunities in STEM-related fields. The researchers concluded that STSP can be used as a mechanism for educational reform in STEM.

There are also studies that reveal that there are great differences between the working principles of scientists shown in science education in schools and the contents of the studies that scientists have actually done in research centers (Rahm et al., 2003).

In the study conducted by Houseal et al. (2014), the effects of STSP on the development of content knowledge of teachers and students and their attitudes towards scientists were examined. In the related study, inquiry-based learning, which is a current approach for science teaching all over the world, was mentioned. It was emphasized that inquiry-based learning should be best taught with STSP. In this collaboration process, an experimental research design was applied in the study in which the changes and achievements of teachers in content knowledge, attitude, and pedagogical practices were investigated. The analysis of the study showed that there were significant positive changes in teachers' attitudes towards science and scientists and their pedagogical choices. In addition, it is stated that the students have important content knowledge acquisitions and positive attitudes regarding their perceptions towards scientists.

In some studies, it is shown that STSP connects students to the science experiences with working research scientists. Some researches emphasize that having active students in project-based classroom activities makes it easier to achieve learning goals (Krajicik et al., 1994) and learning is enhanced when a realistic context is provided (Abrams, 1998; Mullis & Jenkins 1988; Nainggolan et al., 2020; Sanchez et al., 2020; Hugerat et al., 2020).

According to Newell (2005), this kind of collaboration provides students with the flexibility to explore science topics that support the growth of students' interests while still focusing on the development of skills that are deeply covered in class. In another study that brought together scientists and middle school teachers to design and assess a project revealed that there was an improvement in students' problem-solving skills and interests (Wurstner et al., 2005).

Considering the benefits of STSP, it is seen that these are categorized under two groups: benefits for education and benefits for scientists. One of the most spectacular benefits in terms of education is authentic experiences (Donahue et al., 1998; Harnik & Ross 2003; Moss et al., 1998; Tinker, 1997; Yeung & Sun, 2021; Schwortz & Burrows, 2020) and these experiences give students increased understanding of the scientific research processes (Evans et al., 2001; Finarelli 1998; Harnik & Ross 2003; Wormstead et al, 2002; Ross et al., 2003; Wurstner et al., 2005; Poliseli, 2020; Flaherty, 2020).

In some researches, it is seen that STSP causes changes in students' attitudes towards science and has increased the content knowledge of teachers and the use of inquiry-based learning strategies (Caton et al., 2000; Comeaux & Huber, 2001; Ross et al., 2003; Wormstead et al., 2002; Wurstner et al., 2005).

Shein and Tsai (2015) underlined the importance of K-12 teachers and scientist collaborations. The report explains the 18-week high school science curriculum reform on environmental education in a public high school carried out by scientists and teachers. The authors also reported that mutual benefits are obtained by scientists and teachers at the end of the 18-week programme.

In the light of the above-mentioned studies, it is crystal clear that effective relationships among teachers, students, and scientists provide better science teaching and learning in schools. As an example of effective communication between teacher, student, and scientist, TÜBİTAK [The Scientific and Technological Research Council of Turkey] research competitions can be given in Turkey. TÜBİTAK, the state institution responsible for science and technological research, enables students, teachers, and scientists to come together in joint projects through the research competitions that are organized every year. For example, in research (Biology, Geography, Values Education, Physics, Chemistry, Mathematics, History, Technological Design, Turkish and Software) competitions among secondary schools, 15.661 project applications were prepared by a total of 20.960 students, 11.446 girls and 9.514 boys, from 3.123 different schools were received in 2020 (TÜBİTAK, 2020). These results show how important a mission for STSP can be established and implemented at the National level.
The current study aimed to analyze the details of the STSP from the perspective of teachers.

Methods

In this study, the survey method is chosen as a research approach to reach aims. The survey method has been used in many studies and it is defined as "the collection of information from a sample of individuals through their responses to questions" (Check & Schutt, 2012, p. 160). Survey research has historically included large population-based data collection. The primary purpose of this type of survey research was to obtain information describing characteristics of a large sample of individuals of interest relatively quickly (Ponto, 2015).

All schools have been closed due to the COVID-19 pandemic that emerged in 2020. Due to the prominence of distance education methods, data were collected through an online questionnaire. For the STSP model in this study, it is considered as students and teachers working in cooperation with scientists at universities within the scope of project studies in schools. The data in the study were collected from both teachers who collaborated and did not. The differences between the two groups of teachers were examined.

Research Question

To what extent do Turkish STEM teachers' STSP model opinions vary in terms of gender and working experience with scientists?

Sub - Research Questions

1. What are the general opinions of Turkish STEM teachers about the STSP?
2. What are the differences in the STSP opinions between Turkish STEM male and female teachers?
3. What are the differences in the STSP opinions of Turkish STEM teachers in terms of their working experiences with scientists?

In this paper "STEM teachers" is not used to make a reference to those teachers who are teaching in a transdisciplinary approach, rather it is used to refer to teachers who are teaching in the STEM content areas and using STEM education as a pedagogical tool that purposes the integration of STEM disciplines (science, technology, engineering, and mathematics).

Participants

The study consists of 301 Turkish STEM teachers (33% of them are male and 67% of them are female) who are working in state and private schools in Turkey. The age distribution and some of their demographic information are presented in Table 1 below.

Data Collection Tool

An online questionnaire was used to collect data from Turkish STEM teachers. The questionnaire was developed by Malaysian researchers from the University of Malaya in order to provide a meaningful explanation from teachers about the STSP. The results of this study will be used to compare the Malaysian data to see similarities and differences. A seven-point Likert type is used for data collection. In the Likert-type questionnaire, an item is simply a statement that the respondent is asked to evaluate by giving it a quantitative value on any kind of subjective or objective dimension, with the level of agreement/disagreement being the dimension most commonly used.

Table 1

Turkish STEM Teachers' Demographic Characteristics

Age	30 and below		between 31-40	between 41-50	51 and above	
n (%)	27 (9%)		105 (35%)	112 (37%)	57 (19%)	
Gender	Male			Female		
n (%)	98 (33%)			203 (67%)		
Teaching Experience	below 8 years		between 8-14	between 15-20	above 20 years	
n (%)	37 (12%)		73 (24%)	44 (15%)	147 (49%)	
Experience with scientists	Yes			No		
n (%)	108 (36%)			193 (64%)		
School Level	Middle School			High School		
n (%)	136 (45%)			165 (55%)		
Teachers' Branches	Computer	Biology	Science	Chemistry	Physics	Math
n (%)	22 (7%)	37 (12%)	72 (24%)	36 (12%)	29 (10%)	105 (35%)

The online questionnaire consists of nine sections that are defined below:
A- Demographic Profiles - 4 Items
This section includes questions about teachers' age, gender, teaching experience, working experience with scientists, school type, and teaching branches.
B - The Role of Teacher in the Collaboration - 15 Items
B Section of the questionnaire is designed to collect data from teachers about their role in bridging the gap between scientists and students from some aspects (e.g. knowledge and manipulative skills), their

needs (e.g. developing an activity that is appropriate with the students' ability) and their roles in science process skills implementation.

C - The Role of Student in the Collaboration - 8 Items

The C section of the questionnaire collects data from teachers about their students. Students' feedbacks in the eyes of teachers are asked in this section (e.g. students can provide feedback on the explanation given by the scientists)

D - The Role of Scientist in the Collaboration - 20 Items

This section tries to provide information about the role of scientists in the STSP model. Mentoring, affective and scientific contribution of scientists to students are questioned in this section.

E - Suitability of Time - 5 Items

This section is related to time management in the STSP model. How the best timing for this partnership is the main question of this section.

F - Support System - 8 Items

Support systems (management, financial, support staff, the lab assistant) for university level and school level are asked to teachers in this section.

G - Curriculum Related Activities - 6 Items

The instructional materials and their usage in this partnership are asked of teachers in this section.

H - Resources - 5 Items

Resources that are needed for teaching and learning facilities in this partnership are asked to teachers.

I - Commitment from All Parties - 9 Items

This section includes items about the commitments of teachers, scientists, and students. These items are asked to teachers to what extent they agree or disagree.

For the page limitation of this paper, only the A, B, C, and D sections of the questionnaire were analysed and reported in this paper.

Data Analysis

Likert scaling is a bipolar scaling method, measuring either positive or negative responses to a statement. Sometimes an even-point scale is used, where the middle option of "neither agree nor disagree" is not available. This is sometimes called a "forced choice" method since the neutral option is removed (Allen & Seaman, 2007). The neutral option can be seen as an easy option to take when a respondent is unsure, and so whether it is a true neutral option is questionable. A 1987 study found negligible differences between the use of "undecided" and "neutral" as the middle option in a five-point Likert scale (Armstrong, 1987).

In this study, a 7-point Likert scale is used. The percentage of answers given for each point was calculated. The first 3 points (1, 2, 3) were collected as "disagree". Point "4" is accepted as neutral and not included in the calculation. The remaining 3 points (5, 6, 7) were accepted as "agree" and collected. Then the Agreement index was calculated. For this, the Agree sum is subtracted from the Disagree sum. The following tables in the Findings section are prepared according to this approach.

Reliability and Validity for Evaluation

Expert opinion is important for the validity and reliability of the research when it is necessary to obtain evidence of the research. For that reason, expert opinions were taken for content validity and item analysis before implementation. In this study, the values of Cronbach Alpha for seven sections were found greater than 0.90. Only for one section Cronbach Alpha value is equal to 0.759 and this value can be considered acceptable as Muijs, (2011) and Jackson (2003) mentioned that the value has to be higher than 0.7 for a questionnaire to be internally consistent (Table 2).

Table 2

The Values of Cronbach's Alpha for the Evaluation of Questionnaire

Aspects of Questionnaire	Cronbach's Alpha
The Role of Teacher in the Collaboration	0.974
The Role of Student in the Collaboration	0.980
The Role of Scientist in the Collaboration	0.987
Suitability of Time	0.759
Support System	0.950
Curriculum Related Activities	0.930
Resources	0.957
Commitment from All Parties	0.942

Findings

In this study, teachers' opinions about the STSP were taken in terms of various variables. In the tables below, the statistical analysis is presented by considering 3 sub-problems [SP] which are defined as "SP1 What are the general opinions of Turkish STEM teachers about the STSP Model?"; "SP2 What are the differences in the STSP opinions between Turkish STEM male and female teachers?"; "SP3 What are the differences of STSP opinions of Turkish STEM teachers in terms of their working experiences with scientists?".

Findings for SP1: What are the general opinions of Turkish Teachers about the STSP Model?

Table 3

Statistical Analysis for the Role of Reachers in the Collaboration

Teachers play a role in bridging the gap between scientists and students from the aspects of:									
(%)	1	2	3	4	5	6	7	AI*	M**
Knowledge	4.32	3.32	9.63	6.98	13.62	19.60	42.52	58.47	6
Manipulative skill	2.66	4.65	9.97	5.98	12.29	23.59	40.86	59.47	6
Scientific ethics and values	3.65	4.32	9.63	8.97	11.63	23.26	38.54	55.81	6
Attitude towards Science subject	2.99	5.65	8.97	7.97	9.97	20.27	44.19	56.81	6
Simplified the scientific concepts for students to understand	1.99	5.98	8.31	8.31	9.63	19.93	45.85	59.14	6

** Agreement Index, ** Median*

Table 3 provides information on what the roles of teachers can be seen in this collaboration. Particularly, the aspects "Knowledge Manipulative skill, Scientific ethics, and values, Attitude towards Science subject, Simplified the scientific concepts for students to understand" indicates the extent to which teachers participate. When Table 1 is examined, it is seen that most of the teachers generally agree with the specified aspects. As stated in the methodology section, the difference between the summation of the first 3 categories and the summation of the last 3 categories is defined as an agreement index. When looking at the agreement indexes in this table, it is seen that the satisfaction of the teachers is higher than 55% in all aspects. The median value for all aspects was calculated as 6. Maximum agreement index was found for the aspect titled "Manipulative skill".

Table 4

Statistical Analysis for the Tole of Students in the Collaboration

Teachers need to:									
(%)	1	2	3	4	5	6	7	AI	M
Be involved in designing the instructional material with scientists	3.32	5.65	9.63	8.64	8.97	16.61	47.18	54.15	6
Develop activity that is appropriate with the students' ability	2.66	4.65	10.63	6.98	7.31	18.27	49.50	57.14	6
Design activity that is aligned with the current Science curriculum	2.66	3.65	11.96	9.63	5.32	22.59	44.19	53.82	6
Select materials that are suitable with the activity	1.99	3.99	11.30	8.31	7.31	22.92	44.19	57.14	6

The results related to the role of students in the STSP (in the eyes of teachers) are given in Table 4. The agreement indexes in all aspects in this part of the study are higher than 53% and the median values are also the same for all aspects and they are 6. In Table 4, teachers' needs in this collaboration were asked and most of the participants indicated that the aspects are their needs in this collaboration. While the maximum index was found for the items "Select materials that are suitable with the activity" and "Develop an activity that is appropriate with the students' ability", a minimum index was found for the item "Design activity that is aligned with the current science curriculum".

Table 5

Statistical Analysis for the Role of Scientists in the Collaboration

Teachers play a role in:									
(%)	1	2	3	4	5	6	7	AI	M
Making scientific terminology more comprehensible for the students	2.99	3.32	10.30	5.98	9.30	15.28	52.82	60.80	7
Aligning the terminologies used by the scientists and teachers during Science lessons	3.32	4.32	10.96	7.97	14.62	19.27	39.53	54.82	6
Modifying apparatus used during experiments	4.65	4.65	9.30	11.30	21.93	18.27	29.90	51.50	5
Modifying techniques used in conducting experiments	6.31	4.98	9.30	10.30	19.27	19.60	30.23	48.50	5
Enhancing experimenting skills among the students	1.33	4.98	7.97	7.31	8.31	18.94	51.16	64.12	7
Simplifying terminologies so that understandable by both students and scientists	2.33	5.98	8.31	6.64	13.62	22.92	40.20	60.13	6

Table 5 shows the statistical analyses for the role of scientists in the STSP in the eyes of teachers. The agreement index was found between the ranges of 48.50-64.12. While a maximum agreement index is reported for the aspect "Enhancing experimenting skills among the students", the minimum agreement index was found for the aspect of "Modifying techniques used in conducting experiments". Median values were in the range of 5-7. Min median values were found for the aspects of "Modifying apparatus used during experiments" and "Modifying techniques used in conducting experiments". On the other hand, the maximum median values were observed for the aspects of "Enhancing experimenting skills among the students" and "Making scientific terminology more comprehensible for the students".

Findings for SP2: What are the differences in the STSP perspectives between Turkish female and male STEM teachers?

Table 6

Statistical Analyses for the Role of Teachers in the Collaboration in Terms of Gender

Teachers play a role in bridging the gap between scientists and students from the aspects of:	Female N (203)			Male N (98)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Knowledge	13.8	79.8	66.0	24.5	67.3	42.9	0.026*
Manipulative skill	12.8	81.8	69.0	26.5	66.3	39.8	0.004*
Scientific ethics and values	14.3	78.8	64.5	24.5	62.2	37.8	0.020*
Attitude towards Science subject	13.8	79.8	66.0	25.5	63.3	37.8	0.010*
Simplified the scientific concepts for students to understand	13.3	79.8	66.5	22.4	66.3	43.9	0.040*

Table 6 shows the statistical analyses for the role of teachers in STSP depending on gender. It is very interesting to note that significant statistical differences ($p<0.05$) were found between the male and female teachers for all aspects. Agreement index scores were between 64.5 – 69.0 for female teachers and 37.8 – 43.9 for male teachers. It is found that female teachers have more positive opinions than male teachers.

Table 7

Statistical Analysis for the Role of Students in the Collaboration in Terms of Gender

Teachers need to:	Female N (203)			Male N (98)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Be involved in designing the instructional material with scientists	16.3	75.9	59.6	23.5	66.3	42.9	0.141
Develop activity that is appropriate with the students' ability	14.3	77.8	63.5	25.5	69.4	43.9	0.035*
Design activity that is aligned with the current Science curriculum	14.8	73.9	59.1	25.5	68.4	42.9	0.060
Select materials that are suitable with the activity	13.8	78.3	64.5	24.5	66.3	41.8	0.027*

Table 7 reveals the statistical analysis for the role of students in the STSP based on gender. From the results, it is seen that a significant difference ($p<0.05$) was found for the aspects titled "develop an activity that is appropriate with the students' ability" and "select materials that are suitable with the activity" between female and male teachers' opinions. On the other hand, no statistical difference (p>0.05) was observed for the aspects titled "Be involved in designing the instructional material with scientists" and "Design activity that is aligned with the current science curriculum".

Table 8

Statistical Analysis for the Role of Scientists in the Collaboration in Terms of Gender

	Teachers play a role in:						
	Female N (203)			Male N (98)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Making scientific terminology more comprehensible for the students	12.3	81.3	69.0	25.5	69.4	43.9	0.007*
Aligning the terminologies used by the scientists and teachers during Science lessons	15.3	76.4	61.1	25.5	67.3	41.8	0.052
Modifying apparatus used during experiments	14.8	72.4	57.6	26.5	65.3	38.8	0.035*
Modifying techniques used in conducting experiments	16.7	71.9	55.2	28.6	63.3	34.7	0.036*
Enhancing experimenting skills among the students	10.8	80.8	70.0	21.4	73.5	52.0	0.030*

Table 8 shows the role of scientists in STSP based on gender. While no statistical difference (p>0.05) was found for the aspect titled "Aligning the terminologies used by the scientists and teachers during Science lessons", significant differences (p<0.05) were observed for the rest of the items. When agreement indexes are examined, it was between 55.2 – 70.0 for female teachers, and 34.7 – 52.0 for male teachers. It can be interpreted that female teachers have more positive opinions than male teachers for all items.

Findings for SP3: What are the differences in STSP opinions of Turkish STEM teachers in terms of their working experiences with scientists?

Table 9

Statistical Analysis for the Role of Teachers in the STSP in Terms of Experience with Scientists

	Teachers play a role in bridging the gap between scientists and students from the aspects of:						
	Yes N (108)			No N (193)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Knowledge	22.3	69.9	47.7	8.3	86.1	77.8	0.003*
Manipulative skill	21.8	70.5	48.7	9.3	88.0	78.7	0.005*
Scientific ethics and values	22.3	67.9	45.6	9.3	83.3	74.1	0.005*
Attitude towards Science subject	22.3	69.4	47.2	9.3	83.3	74.1	0.006*
Simplified the scientific concepts for students to understand	20.2	69.4	49.2	9.3	86.1	76.9	0.011*

Table 9 shows the statistical analysis for the role of teachers in the STSP dependent on the experience with scientists. Statistically significant differences (p<0.05) were found for all the aspects studied in this section. The data in Table 9 reveals that teachers who do not have experience working with scientists have much more positive views than those who have working experience with scientists. The maximum agreement index was found as 78.7% (Knowledge) for teachers who do not have working experience with scientists. It was 49.2% (Simplified the scientific concepts for students to understand) for teachers who have experience with scientists.

Table 10

Statistical Analysis for the Role of Teachers in the STSP in Terms of Experience with Scientists

Teachers need to:	Yes N (108)			No N (193)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Be involved in designing the instructional material with scientists	23.3	67.9	44.6	10.2	81.5	71.3	0.007*
Develop activity that is appropriate with the students' ability	22.3	69.9	47.7	10.2	84.3	74.1	0.010*
Design activity that is aligned with the current Science curriculum	21.8	68.9	47.2	12.0	77.8	65.7	0.054
Select materials that are suitable with the activity	20.7	69.9	49.2	11.1	82.4	71.3	0.037*

Table 10 shows the statistical analyses for the role of students in the collaboration dependent on the experience with Scientists. There are statistically significant differences ($p<0.05$) for the items: "Be involved in designing the instructional material with scientists", "Develop an activity that is appropriate with the students' ability" and "Select materials that are suitable with the activity". However, no statistical difference ($p>0.05$) was found for the aspect "Design activity that is aligned with the current science curriculum". The maximum agreement index was found as 74.1% (Develop an activity that is appropriate with the students' ability) for teachers who do not have working experience with scientists. It was 49.2% (Select materials that are suitable with the activity) for teachers who have experience with scientists.

Table 11

Statistical Analysis for the Role of Teachers in the Collaboration in Terms of Experience with Scientists

Teachers play a role in:	Yes N (108)			No N (193)			
	Disagree	Agree	AI	Disagree	Agree	AI	Chi-Square
Making scientific terminology more comprehensible for the students	21.2	72.5	51.3	8.3	86.1	77.8	0.006*
Aligning the terminologies used by the scientists and teachers during Science lessons	22.8	69.9	47.2	11.1	79.6	68.5	0.022*
Modifying apparatus used during experiments	22.8	66.3	43.5	11.1	76.9	65.7	0.020*
Modifying techniques used in conducting experiments	24.4	64.8	40.4	13.9	76.9	63.0	0.035*
Enhancing experimenting skills	18.1	73.6	55.4	7.4	87.0	79.6	0.013*

among the students							
Simplifying terminologies so that understandable by both students and scientists	20.2	74.6	54.4	10.2	80.6	70.4	0.052

Table 11 shows the statistical analysis for the role of students in the collaboration dependent on the experience with scientists. While no statistical difference ($p>0.05$) was found for the aspect titled "Simplifying terminologies so that understandable by both students and scientists", there were significant differences ($p<0.05$) for the rest of the aspects studied. The maximum agreement index was found as 79.6% (Enhancing experimenting skills among the students) for teachers who do not have working experience with scientists. It was 55.4% ("Enhancing experimenting skills among the students" and "Simplifying terminologies so that understandable by both students and scientists") for teachers who have experience with scientists.

Discussion and Conclusion

In this study, the opinions of Turkish STEM teachers about the STSP were revealed through a questionnaire developed by the researchers. These perspectives have been evaluated in terms of various variables such as gender and whether or not having experience working with scientists.

This study contributes to the STEM Education field in terms of containing evidence showing how ready STEM teachers are for the STSP approach. The study reveals the necessity of enriching the STEM learning and teaching environments within the scope of STSP. In the STSP approach, dimensions such as gender, whether or not STEM teachers had previous experience of working with a scientist were examined and detailed analyzes were made. The study provides meaningful insights into the integration process of scientists into STEM education systems in different countries.

In the study, teachers were asked to evaluate their own roles in this collaboration process. The results revealed that teachers play important roles in building effective interaction between students and scientists on the issues such as knowledge gaining, developing manipulative skills, recognizing scientific ethics and values, developing a positive attitude towards science, and simplifying the scientific concepts. It is seen that inquiry-based learning has been developed as an important education policy in most of the countries in order to provide a more effective education (Harlen, 2010, Linn et al., 2014, Marth & Bogner, 2017, Rocard et al., 2007). Particularly in the European Union countries, as a result of the formation of open schooling policies and the importance of investments related to this action, the stakeholders are involved in the learning and teaching process as effective actors. In a study conducted by Blumenfeld et al (1991), it was revealed that teachers' inexperience in new technologies, necessary preparations, and classroom management causes them to feel uncomfortable about applying the inquiry-based learning method in schools. For that reason, the most important tasks go to teachers in achieving successful results of inquiry-based learning and open schooling processes. In the current study, it is revealed that Turkish teachers are aware that they have very important duties in establishing effective interactions, especially between students and scientists in terms of STSP.

One of the issues addressed in the current study is what the teachers' needs are for students to play active roles in this collaboration process. For this, teachers were asked how the contributions of their own and scientists should be in material design, in developing activities suitable for students' abilities, ensuring that activities are compatible with the curriculum, and selecting materials specific to the activities. Most of the teachers who participated in the study revealed that it is important for their students to play active roles in this collaboration process, and that they and scientists cooperate effectively on the above-mentioned issues. These results also support the findings of the study conducted by Peker and Dolan (2012). Peker and Dolan (2012) stated that the teachers played critical roles in ensuring that the students received all of this special information in the process of explaining scientific phenomena and the dimensions of the nature of science by scientists. In addition, the current study shed a light on the teachers' needs for their students. Their roles are crucial for students who interact with scientists before university education that have been largely unexplored (Peker and Dolan, 2012).

Another important issue investigated in this study is the evaluation of the roles that teachers should play for effective cooperation of scientists in terms of making scientific terminology more comprehensible for the students, aligning the terminologies used by the scientists and teachers during science lessons, modifying apparatus used during experiments, modifying techniques used in conducting experiments, enhancing experimenting skills among the students, simplifying terminologies so that understandable by both students and scientists. According to the results, most of the teachers participating in the study agree that the teachers should play important roles in the above-mentioned issues for scientists to make effective interactions in this cooperation process. There are not enough official documents that include guidelines about the participation of scientists in teaching and learning environments. This situation reflects the necessity that the ministries of education in each country should work and develop policies. The policy also should support STSP and should help scientists how they can show the dimensions of the nature of science to the students and for students to internalize these dimensions (Barstow et al., 1996).

This study also examined how teachers' opinions on the STSP differ in terms of gender. Findings show that female teachers are much more positive than male teachers. The extent of these variations is presented in Tables 4, 5, and 6. For example, there are significant differences found between male and female teachers' agreement index scores on the role of teachers in the collaboration (Table 4), the role of students in the collaboration (Table 5), the role of scientists in the collaboration (Table 6). The obtained results show that although there are some differences between the scores of male and female teachers regarding their own and students' roles in the STSP, it is seen that both gender groups agree on the roles of scientists in this collaboration. First of all, it is worth mentioning that the studies examining teachers' perspectives on the STSP in terms of gender are very few in the literature. The numbers of female teachers are statistically higher than those of male teachers in Turkey. This could be an advantage for the collaboration with the scientist because of their more positive opinions on the STSP collaboration. Mansour (2015) indicated that individual, contextual and cultural elements are very important and critical elements in establishing effective partnerships among students, teachers, and scientists. He continued to explain that gender, personality, power, the community, school, and classroom cultures were evident as factors affecting co-participation and dialogue. Nelson (2005) emphasized the need for research to examine gender factors and students' engagements to teaching science in the classroom. The current study will bring more insights into the teachers' approaches to the STSP in terms of gender. It is clear that the reasons for the changes mentioned above should be investigated by using qualitative research methods according to the gender of teachers.

One of the most important results of this research is the teachers' approach to the STSP according to their experience of working with scientists. The perspectives of the teachers in the collaboration process were discussed according to whether they have experience of working with scientists or not. The findings include interesting and striking results. In the part about the contributions of teachers with students and scientists in the collaboration process, it was found that teachers who do not have experience of working with a scientist are much more positive than teachers who have experience. When Table 7 is examined, more specifically, teachers who do not have experience of working with scientists are much more willing to work with scientists than teachers who have experience in working with scientists in the fields of "Knowledge, Manipulative skill, Scientific ethics and values, Attitude towards Science, Simplified the scientific concepts for students to understand". This clearly shows that Turkish teachers who have no experience of working with a scientist can easily collaborate if such an opportunity can be provided to those teachers. Table 8 presents what the needs of teachers are for students to play active roles in the STSP process. When

Table 8 is examined in detail, it is seen that teachers who do not have experience of working with scientists have significantly positive opinions compared to teachers who have experience working with scientists in the past. It was observed that there was no difference between both teacher groups in only one item and it is "Designing activity that is aligned with the current science curriculum". Table 9 shows the statistical analysis of some situations that teachers should do in order for scientists to play active roles in the STSP process, according to their experience of working with scientists. The data obtained again show that teachers who have no experience of working with scientists are significantly different from those who have. In only one item (Simplifying terminologies so that is understandable by both students and scientists), it was observed that the views of both teacher groups were not statistically different. In many studies (eg. Bolstad & Bull, 2013; Schuster & Carlsen, 2009; Willcuts, 2009), it is reported that the most important action in establishing relationships between scientific and school communities is explained as giving teachers the opportunity to work with scientists. In addition, in some studies (McLaughlin & MacFadden 2014; Dresner & Worsley 2006), it is concluded that providing the opportunity to teachers to work with scientists can easily change their perception about how science works. Anderson and Moeed (2017) conducted research on the effect of teachers' work with scientists within the scope of a program. As a result of this study, it has been revealed that there are effects on teachers especially about the value of scientific ways of thinking, deeper understanding of the nature of scientists' work, and how science and society influence each other. The conclusions drawn from these studies support the results of this study regarding teachers working experience with scientists.

From the results obtained from this study, STSP can be used as an efficient way to increase the maximum interaction among students, teachers, and scientists. Official guidelines should be created for the effective use of this model in STEM teaching and learning environments. This guideline, specially designed for scientists, should be integrated with school curricula so that each actor can play their role in this process. Finally, qualitative studies can be implemented to get more data to support STSP in the school STEM ecosystem.

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