World Journal on Educational Technology: Current Issues

Volume 10, Issue 1, (2018) 052-060

www.wj-et.eu

Opinions of secondary school science and mathematics teachers on STEM education

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Suggested Citation:
Yıldırım, B. & Türk, C. (2018). Opinions of secondary school science and mathematics teachers on STEM education. *World Journal on Educational Technology: Current Issues. 10*(1), 052-060.

Received date; 11 October 2017 revised date; 23 November 2017 accepted date 28 December 2017
Selection and peer review under responsibility of Prof. Dr. Steven Ross, John Hopkins University, United States.

Abstract

In this study, the opinions of middle school science and mathematics teachers towards STEM (science, technology, engineering and mathematics) education were examined. The research was carried out for 30 hours with 28 science and mathematics teachers who were working in Istanbul during the spring semester of 2016–2017 academic year. 75% of these teachers are female while 25% are male. The study was conducted by the case study method among qualitative research methods. To determine the opinions of the secondary school science and mathematics teachers, 'STEM interview form for teachers' consisting of eight questions was created. As a result of the analysis, the teachers emphasised that they did not feel sufficient about STEM education and that a good STEM teacher should have STEM knowledge, pedagogy knowledge and the 21st century skill knowledge. However, it was found that after the STEM training, teachers had positive changes in their opinions towards engineering and technology.

Keywords: STEM, teacher, science, mathematics.

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1. Introduction

The dizzying effect of science and technology has directly affected all areas, as well as education. Countries need individuals who memorise the knowledge they learn, and individuals with collaborative, creative, effective in communication, critical thinking and problem-solving skills rather than individuals who cannot survive in the 21st century business world (Akaygun & Aslan-Tutak, 2016; Partnership for 21st Century Learning, 2018). Countries are constantly renewing and changing their curricula, so that they can meet these needs and compete with other countries. Over the next 50 years after World War II, countries have gone through changes in science and mathematics curriculum. However, the fact that changes in science and mathematics are not sufficient has led to the addition of curriculum design and technology since 1990 (Banks & Barlexs, 2014). With the introduction of curriculum design and technology, approaches to science and mathematics have begun to be emphasised.

STEM (science, technology, engineering and mathematics) is one of the education approaches (Gonzalez & Kuzenzi, 2012). Although STEM education consists of an abbreviation, it actually has a much broader meaning in terms of the meaning and the content it contains. In other words, STEM education is an educational approach in which science, technology, engineering and mathematics are integrated, and these disciplines are linked to everyday life and supported by the 21st century skills. Today, many countries are implementing STEM education in formal and informal learning environments (Yildirim, 2017a). STEM education develops many qualifications of individuals such as critical thinking, creativity, collaborative work, empathy, enables individuals to interdisciplinary work and enables them to associate the obtained knowledge with everyday life (Childress, 1996; Cotabish, Dailey, Robinson & ve Hunghes, 2013; Elliott, Oty, McArthur & Clark, 2001; Schiavelli, 2008). Through STEM training, individuals who have won these qualifications will be able to survive and compete in the 21st century business world. Good teacher training on STEM education is required for individuals to gain these qualifications, for countries to be strong in terms of economy and innovation, and also, for STEM applications to be used in classrooms. It is important for teachers who will give STEM education to have sufficient experience and accumulation in STEM education. In this context, the teachers will be given STEM training and after the STEM training, they will be asked about their opinions about STEM education. For this purpose, 'What are the opinions of middle school science and mathematics teachers towards STEM education?' problem culminated.

2. Method

This section will include the research model, study group, data collection tool, analysis of data and implementation steps.

2.1. Research method

Within the scope of the research, it was tried to determine what are the opinions of the secondary school science and mathematics teachers towards STEM education. For this purpose, the case study method of qualitative research methods was used in the research. According to Creswell (2003), a case study is a qualitative research approach in which the researcher's in-depth study of one or more limited situations within a given time frame defines the contexts and theme of the situation. The nature of the case study allows an in-depth and thorough examination of a state of research. In other words, all dimensions of a situation are examined in detail. Within the scope of this study, all dimensions of STEM education for teacher training will be tried to be examined starting from the opinions of teachers.

2.2. Study group

The study group is composed of 28 teachers who were working in Istanbul during the spring semester of the 2016–2017 academic year. In order to make sure the names of the teachers in the working group are kept unknown, they are given codes as O1, O2, ..., O27, O28 in the direction of ethical rules. Information on the teachers in the study group is given in Table 1.

Table 1. An example of a table

Theme	Code	*f*	%
Gender	Female	21	75
	Male	7	25
Experience	0–4 years	14	50
	5–9 years	9	32.14
	10+ years	5	17.86
Branch	Science Teacher	19	67.86
	Mathematics Teacher	9	32.14

When Table 1 is examined, 75% of the teachers who had STEM training are composed of female teachers while 25% are male teachers. When the experience of the teachers participating in the training is examined, it is seen that 50% of the teachers' experience has not passed 4 years, 32.14% varies between 5 and 9 years and 17.86% has 10 years and more experience. Besides, it is also seen that the majority of the teachers who participated in the training are teachers of science.

2.3. Data collection tools

A semi-structured interview form consisting of 10 questions was created by the researcher to determine the opinions of secondary school science teachers and mathematics teachers (STEM interview form for teachers [OSGF]). The following steps were followed during the creation of this semi-structured interview form for teachers. These steps are:

1. Firstly, the studies on the effects of STEM education on teachers were scanned.
2. As a result of the scanning, the interview form for the teachers was examined.
3. A semi-structured interview form consisting of 10 questions was created as a result of the interview forums.
4. Opinions were obtained from the experts for 10 question OSGF.
5. Based on the opinions of the experts, two questions were extracted from the semi-structured interview form. The questions about the extracted questions are given in the following section.
6. Editing have been made on the semi-structured interview form in the light of expert opinions. After the editing, a pilot study for the interview form was carried out by applying on a volunteer teacher who was teaching in a public school.
7. As a result of the pilot work, the interview form was finalised.

2.4. Data analysis

Semi-structured analysis of data obtained as a result of qualitative data and data obtained by interview form were evaluated according to content analysis. As a result of the analyses, the codes were given to the individuals to pay attention to the scientific ethic and to keep the names of the individuals. These codes continue as O1, O2, O3, …, O28.

Example:

O1: The first student to participate in the interview.

O2: The second student to participate in the interview.

3. Figures

This section contains findings from the qualitative data analysis. The findings obtained from the analysis of the data are shown in the tables respectively.

When Table 2 is examined, it is seen that the importance of STEM education in the direction of teacher opinions are given under the themes of '21st century skills, teaching–learning processes and benefits of STEM education'. The prominence of STEM education has been expressed by teachers as 'creative thinking and imagination', and 'critical thinking and problem solving' skills in the 21st century skill theme. The most important aspect of STEM education is stated as 'Applied learning' and 'Learning by doing-living' by the teachers under 'Teaching–learning process'. When the STEM education is under the benefit of the teachers, the teachers mostly emphasised 'Economic development and innovation' and 'Self-confidence development'.

Table 2. The answers given to the question 'Why is STEM education important?'

Themes	Codes	*f*
21th century skills	Creative thinking and imagination	11
	Critical thinking and problem solving	10
	Communication - collaboration	9
	Leadership and responsibility	2
Teaching-learning process	Applied learning	7
	Learning by doing-living	7
	Inquiry/research-based learning	5
Benefits of STEM education	Economic development and innovation	10
	Self-confidence development	3
	Interdisciplinary	2
	Association with everyday life	2
	Meaningful and permanent learning	2
	High-level thinking skills	2
	Entertaining and appealing	2
	Responsibility	2
	Vocational education	1

When Table 3 is examined, the vast majority of teachers feel insufficient about STEM education. However, while some of the teachers see themselves partially sufficient, only one teacher felt sufficient.

Table 3. The answers given to the question: 'Do you feel sufficient about STEM education?'

Theme	Codes	*f*
STEM education knowledge	Sufficient	1
	Partially sufficient	7
	Insufficient	20

When Table 4 is examined, it is understood that the teachers felt insufficient especially about engineering and application knowledge in STEM education. In addition, teachers feel themselves weak in science and technology knowledge. These answers are followed by lack of time management, coding and mathematics knowledge respectively.

Table 4. The answers given to the question: 'If you feel insufficient about STEM education, in what way do you think you are insufficient?'

Theme	Codes	*f*
Lack of knowledge	Engineering knowledge	10
	Application knowledge	7
	Science field knowledge	6
	Technology knowledge	6
	Time management	5
	Coding knowledge	4
	Mathematics knowledge	3

When Table 5 is examined, most of the teachers stressed that STEM content knowledge, pedagogy knowledge and integration knowledge are the qualifications that should be taught in order to teach STEM education well. This was followed by the 21st century skill knowledge and context knowledge respectively.

Table 5. Answers given to the question: 'What are the qualifications that a teacher should have in order to teach STEM education in an effective way?'

Theme	Codes	*f*
Teacher opinions	STEM content knowledge	27
	Integration knowledge	13
	Pedagogy knowledge	13
	Context knowledge	7
	21st century skill knowledge	11

When Table 6 is examined, the problems that may be encountered during STEM education are given under the themes of 'Teacher-originated problems', 'Student-originated problems', 'Programme-originated problems' and 'Physical problems'. When teachers' opinions are examined, under the title of 'Teacher-focused troubles' they point out that they cannot use the most time effectively and cannot establish an interdisciplinary relationship. Under student-originated problems, they shared the ideas of the student readiness and inappropriacy to the student's level. It is stated that the programme is not appropriate for the curriculum and engineering under programme-originated problems. Under physical problems theme, material deficiencies and excessive student number are mentioned as problems.

Table 6. Answers given to the question: 'What are the problems that can be encountered during STEM education?'

Theme	Codes	*f*
Teacher-originated problems	Lack of time	19
	Inability to establish an interdisciplinary relation	9
	Classroom management	2
	Inability to form groups	1
Student-originated problems	Readiness	3
	Student level appropriacy	3
Programme-originated problems	Curriculum appropriacy	8
	Appropriacy of engineering	3
	Inappropriacy with exam system	1
	Inability to associate with real-life	1
Physical problems	Material deficiencies	13
	Excessive student number	11
	Unsuitable classroom environment	6

When Table 7 is examined, teachers expressed that the programme should be focused on practice, less in-depth learning, interdisciplinary, and include engineering and technology in order to be able to apply STEM education. These opinions were followed by parallel programmes, which should be appropriate for project-based learning, and should enable the process and result-oriented assessment respectively.

Table 7. Answers given to the question: 'What are the features that should be included in the programme so that STEM education can be implemented?'

Theme	Codes	*f*
Programme features	Practice focused	8
	Less in-depth learning	6
	Interdisciplinary	6
	Design and technology	6
	Parallel with the programme	4
	Project based learning	4
	Process and result-oriented evaluation	3
	Associated with everyday life	3
	Inquiry learning	2
	Spiral (circular)	2
	Collaborative	2
	Equipped with the 21th century life skills	1
	Guide book	1

When Table 8 is examined, it is seen that majority of the teachers' opinions on engineering and technology changed positively. However, two teachers were found to have no change in their opinions.

Table 8. Answers given to the question: 'Have your opinions on technology and engineering changed after STEM training?'

Theme	Codes	*f*
Change on the opinions	Changed	26
	Not changed	2

When Table 9 is examined, it is seen that engineering is not difficult and complicated for the teachers after STEM education, and that they are conscious about engineering and technology. Thus, they will increase their will to study technology and engineering after this training. It is also seen that STEM education has enabled teachers to work on engineering and reduced the bias against engineering.

Table 9. Answers given to the question: 'How did your opinion on technology and engineering change?'

Theme	Codes	*f*
Opinions on technology and engineering	Engineering is not difficult and complicated	6
	Interest and curiosity increased in technology and engineering	3
	Understanding engineering and technology	2
	Conscious about engineering and technology	2
	Will to study and research on engineering and technology	2
	Lost bias towards engineering	2
	Thought engineering and technology were not related	1
	Had negative thoughts against engineering	1
	Realised that you can produce something	1

	If you study engineering, you will succeed	1
	Science and mathematics are necessary for engineering	1

4. Discussion and conclusions

In this study, the teachers' opinions for STEM education have tried to be analysed in all aspects.

Within the scope of the study, the importance of STEM education has been emphasised in the direction of teacher opinions. When teacher opinions are analysed, it is emphasised that STEM education is important because it contributes to creative thinking and creativity, and also, it contributes to critical thinking and problem-solving skills, enables to learn by practicing, doing and living, and most importantly contributes to the development of innovation and economic development. When reviewing the literature about STEM education, it is emphasised that STEM education is important because of its many benefits for society, economy and the individuals (Banks & Barlex, 2014; Riskowski, Todd, Wee, Dark & Harbor, 2009; Thomas, 2013). The body of literature about STEM education supports this work.

Within the scope of the study, it has been examined whether the teachers feel enough about STEM education or not. According to the interview results with teachers, it has been understood that teachers does not feel enough about themselves. Similar results have been obtained in many studies in which the opinions of teachers about STEM education were examined (Shin & Han, 2013; Thomas, 2013; Wang, 2012; Yildirim, 2016b). Yildirim (2016) has examined the opinions of teachers about STEM education in his study. As a result of the examination, it has been determined that the teachers have felt insufficient about STEM education. Moreover, within the scope of the study, teachers expressed that they feel themselves insufficient in engineering, application, science and technology knowledge.

Within the scope of the study, the features of what should be included in the programme in order to be able to apply for STEM education have been examined following the teacher opinions. As a result of the examination, it has been emphasised that the programme should be focused on practice, should include less topic but in-depth knowledge and should be interdisciplinary, design and technology-oriented. In addition, it has been emphasised that the programme should include project-based learning related to daily life. The curriculum changes made by the Ministry of National Education supports the teachers' opinions (Ministry of National Education, 2016). These results can be a guide for programme changes which will be made about STEM education. Therefore, it is deducted that this study will shed light on studies related to programme development.

In addition, within the scope of the study, what problems might be encountered during STEM education have been discussed. As a result of the teacher's views, many problems such as difficulties in interdisciplinary, material deficiencies, lack of time, appropriacy to the student's level, physical environment of the class have been emphasised during STEM education applications. In addition, teachers have stated that many problems, especially based upon the programme, for STEM education. Yildirim and Selvi (2015) have studied the opinions of pre-service teachers in his work. Yildirim and Selvi (2015) studied the opinions of prospective teachers in his work. As a result of the study, the researchers emphasised that there are some difficulties in time, possibility and group formation about STEM education. Similarly, Morrison (2006) has emphasised that the classroom environment for STEM education should be appropriate in his study.

Within the scope of the study, the characteristics that should be found in a good teaching in order to teach STEM education in a good way have been studied. As a result of the interview with the teachers, it has been emphasised that a good STEM teacher should have STEM knowledge, pedagogy knowledge, integration knowledge, context knowledge and 21st century skills knowledge. When the body of literature has been examined, especially STEM field knowledge, pedagogy knowledge, the

21st century skill knowledge and integration knowledge have been well noted (Benuzzi, 2015; Hudson, English, Dawes, King & Baker, 2015; Rogers, Winship & Sun, 2015; Stohlmann, Moore & Roehrig, 2012; Yildirim, 2017).

Finally, in the scope of the study, it has been studied whether there have been any changes in the teachers' opinions on engineering and technology after STEM education. As a result of opinions from the teachers after the STEM training, it has been determined that the teachers' opinions on engineering and technology have been changed positively. In addition, it has been examined how the opinions of the teachers about engineering and technology have changed. As a result of the review, it has been found that engineering is not difficult and complicated for the teachers, their interest on the engineering and technology increases, and they get more conscious and also the bias towards these areas decrease. In the light of these results, it shows that STEM education has positively changed teachers' opinions on engineering and technology. When the body of literature is examined, there are many studies that STEM education has changed the opinions on technology and engineering positively (Elam, Donham & Soloman, 2012; Nadelson & Callahan, 2011; Tseng, Chang, Lou & Chen, 2011; Yildirim, 2016a).

5. Limitations of the study and suggestions

The study was conducted with 28 teachers, who were working in Istanbul during the spring semester of 2016–2017 academic year for 30 hours. New studies can be carried out with larger and different groups of teachers for longer periods of time.

In this study, the opinions of the teachers who are in different branches about STEM education have been examined within the scope of qualitative research. In new studies, studies can be carried out using a mixed research method or a quantitative research method.

Within the scope of the study, teachers were found insufficient about STEM education. In-service trainings can be organised to overcome the deficiencies of teachers on STEM education. In addition, courses can be added for STEM education within the faculties of education.

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