

Content Analysis of the Studies Examining the Opinions of Teachers and Teacher Candidates on STEM Education

The aim of this study is to analyze the content of the studies examining the opinions of teachers and teacher candidates on STEM education, which will shed light on the future. This study is a qualitative study and theses and articles were analyzed with content analysis, one of the qualitative research methods. For this purpose, content analysis was performed on the studies examined according to the purpose, method, study group, data collection tools, data analysis, results, and suggestions. For this study, a research has been conducted using the keywords "opinion on STEM education", "STEM", "teacher candidates", "attitude", "awareness". Identified 23 studies were examined and seven questions were determined and the data tried to be answered to these questions were presented in tables and their frequency distributions were determined. The result with the highest frequency was the positive attitudes of teachers and teacher candidates and opinions towards STEM. Based on the results obtained from the research, the following suggestions can be made: STEM activities can be carried out in teacher education programs to increase the tendency towards STEM education. STEM education can be included in teacher education programs as an applied lesson.

Keywords: *Teachers and teacher candidates, STEM education opinions, content analysis*

Introduction

STEM education emerged at the beginning of the 21st century as a concept including the integration of science, technology, engineering and mathematics disciplines among themselves, contributing to the deep and permanent learning of individuals, and providing life and professional skills required by the era (Akgündüz et al., 2015; Akyıldız, 2014; Bybee, 2013). In order to meet the needs of this era, which is called the age of technology, individuals with the knowledge and experience defined as 21st century skills are needed. From a universal perspective, these capabilities must be used to develop in the 21st century and to lead civilizations. According to Kılıç and Ertekin (2017), STEM education is a new paradigm put forward to train the human resources needed by the new economy, which is increasingly based on engineering and technology.

Contribution of STEM education to students according to the literature can be summarized as in the following: (1) it increases the skills of observation, experimentation and determining variables by enabling the education programs to be comprehended deeply and functionally (Yamak, Bulut & Dündar, 2014), (2) it enables students to understand the sociocultural

1 perspective of the studied subjects and to choose STEM fields while setting
2 their career goals (Moore, 2014), (3) by supporting students to produce
3 projects on any subject they encounter, to provide them with creative and
4 applicable solutions to problems (Rogers & Porstmore, 2004), (4) it is seen
5 that it contributes to scientific process skills (Strong, 2013), (5) it allows more
6 careful solution to any problem (Wang, 2012), (6) it allows to adapt to future
7 professions (Thomas, 2014).

8 According to Çorlu, Capraro, and Capraro (2014), STEM education has a
9 strategically important location for Turkey's economic competitiveness in the
10 global arena. People who have the qualifications to work in the STEM fields
11 are needed for economic developments feeding with innovation (TÜSİAD,
12 2017). STEM education, which increases its importance every day, is an
13 integrated approach that makes individuals adopt creative problem solving
14 techniques (Akgündüz et al., 2015; Gülhan & Şahin, 2016). For this reason,
15 STEM education is of great importance for countries to make progress in
16 economic and scientific fields. Şahin, Ayar and Adıgüzel (2014) state that
17 STEM education should be supported by the countries and awareness about
18 STEM should be increased in order for countries to develop and maintain
19 scientific and economic development.

20 As a necessity of the period we live in, we need to structure the
21 information with our previous knowledge by researching and querying.
22 Raising individuals with research and inquiry skills is among the aims of the
23 curriculum. In order for students to learn information meaningfully and
24 permanently, classroom, in-school, and out-of-school learning environments
25 are designed according to the inquiry-based learning strategy. (MEB, 2018). It
26 can be said that STEM education has been included in education programs
27 since 2017. With the inclusion of STEM education in the curriculum, it has
28 become important to investigate the STEM teaching tendencies of teacher
29 candidates because the implementers of the curriculum are today's teacher
30 candidates. Therefore, STEM education has an important place in raising
31 qualified individuals. For this reason, it is important to determine the STEM
32 teaching tendencies of teacher candidates during their education.

33 There are various studies aimed at determining the views of teachers and
34 teacher candidates on STEM education. It is thought that gathering these
35 studies under common headings and evaluating their findings together will be
36 a useful study in understanding the opinions of teachers and teacher candidates
37 on STEM education better, seeing the studies done in the field as a whole, and
38 seeing the shortcomings in the field. For this reason, the aim of the study is to
39 analyze the content of the studies about the opinions of teachers and teacher
40 candidates on STEM education. For this purpose, it was tried to answer the
41 following questions about the studies examined:

- 42
- 43 1. What are the aims of the studies addressing the opinions of teachers
44 and teacher candidates on STEM education?

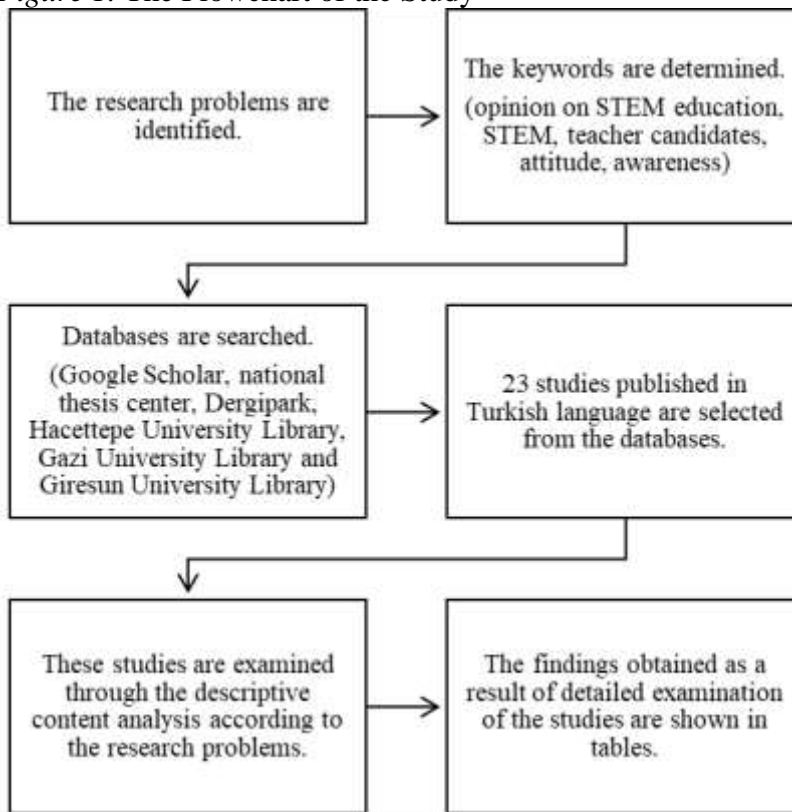
- 1 2. Which methods have been used in studies addressing the opinions of
- 2 teachers and teacher candidates on STEM education?
- 3 3. What are the samples in the studies addressing the opinions of teachers
- 4 and teacher candidates on STEM education?
- 5 4. Which data collection tools have been used in studies addressing the
- 6 opinions of teachers and teacher candidates on STEM education?
- 7 5. Which data analysis techniques have been used in studies addressing
- 8 the opinions of teachers and teacher candidates on STEM education?
- 9 6. What results have been achieved in studies addressing the opinions of
- 10 teachers and teacher candidates on STEM education?
- 11 7. Which suggestions have been included in studies addressing the
- 12 opinions of teachers and teacher candidates on STEM education?

13 14 15 **Methodology**

16
17 This study is a qualitative study and the theses and articles included in the
18 study were analyzed by content analysis, one of the qualitative research
19 methods. For this purpose, content analysis was performed on the studies
20 according to the purpose, method, study group, data collection tools, data
21 analysis, results, and suggestions. Content analyzes are research syntheses that
22 play an important role in disseminating researched knowledge and shaping
23 future research, policies, practices and public perception (Suri & Clarke,
24 2009). In general, these are divided into three as meta-analysis, meta-synthesis
25 (thematic content analysis) and descriptive content analysis. This study was
26 prepared as a descriptive content analysis study. Descriptive content analysis is
27 a systematic study that includes studies on a specific subject and evaluating the
28 trends and research results in a descriptive dimension (Çalık, Ünal, Coştu &
29 Karataş, 2008; Ültay, Dönmez Usta & Durmuş, 2017; Ültay, Akyurt & Ültay,
30 2021). In other words, qualitative and quantitative studies conducted
31 independently of each other are examined and organized and general trends in
32 the field are determined (Selçuk, Palancı, Kandemir & Dündar, 2014). Thus, it
33 is shown what the general tendency is to researchers who work in the relevant
34 field and want to do it (Cohen, Manion & Morrison, 2007; Selçuk et al., 2014).

35 For this study, a search was carried out using the keywords "opinion on
36 STEM education", "STEM", " teacher candidates", "attitude", "awareness."
37 Google Scholar, national thesis center (YÖK), Dergipark, Hacettepe
38 University Library, Gazi University Library and Giresun University Library
39 databases were searched and 23 studies published in Turkish language were
40 selected from the resources. The flowchart of the study is shown in Figure 1.

41
42

1 *Figure 1. The Flowchart of the Study*

2
3
4 The obtained findings are presented in tables in the section of Findings.

5 6 7 **Findings**

8
9 In this section, the findings obtained as a result of detailed examination of
10 the studies selected for research are included. The data obtained for the
11 research questions are summarized in the tables below.

12
13 (1) *The aims of the studies addressing the opinions of teachers and teacher*
14 *candidates on STEM education*

15
16 Table and explanations regarding the aims of the studies conducted to
17 examine the opinions of teachers and teacher candidates on STEM education
18 are given below.

19
20

1 *Table 1. The Aims of the Studies*

Aims	Studies	<i>f</i>
Examining the awareness of teachers and teacher candidates about STEM	S2, 8, 12, 15, 16, 17, 18, 22	8
Determination of teachers' and teacher candidates' opinions on STEM education	S4, 5, 11, 13, 15, 16, 23	7
Analysis of teachers' and teacher candidates' teaching tendencies on STEM education according to different variables	S6, 7, 14, 19, 21	5
Determination of teachers' and teacher candidates' attitudes towards STEM education	S5, 9, 20, 21	4
Determining the teaching tendencies of teachers and teacher candidates for integrated STEM teaching	S1, 3, 18, 19	4
Determining teachers' and teacher candidates' self-efficacy regarding STEM education	S5, 20	2

2

3 When Table 1 is examined, it is seen that the study with the highest
4 frequency has the purpose of “examining the awareness of teachers and teacher
5 candidates about STEM.” The aim of the study with the closest frequency to
6 this is to “determination of teachers and teacher candidates’ opinions on
7 STEM education.” The frequencies of the studies conducted with the aim of
8 “determination of teachers and teacher candidates’ attitudes towards STEM
9 education” and “determining the teaching tendencies of teachers and teacher
10 candidates for integrated STEM teaching” are four and equal to each other.
11 The study conducted with the aim of “determining teachers' and teacher
12 candidates' self-efficacy regarding STEM education” is the one with the lowest
13 frequency.

14

15 (2) *Methods of the studies addressing the opinions of teachers and teacher*
16 *candidates on STEM education*

17

18 Tables and explanations regarding the methods used in studies conducted
19 to examine the opinions of teachers and teacher candidates on STEM
20 education are given below.

21

22 *Table 2. The Methods of the Studies*

Methods	Studies	<i>f</i>
Quantitative	S1, 2, 5, 6, 7, 10, 12, 14, 15, 17, 18, 19, 21, 22	15
Qualitative	S4, 5, 11, 13, 16, 23	6
Mixed	S3, 8, 9, 20	4

23

24 As can be seen in Table 2, studies were mostly carried out with
25 quantitative research methods. Qualitative research was the method with the
26 second highest frequency used in this study. The least preferred method in the
27 studies examined was the mixed method. The mixed method can be defined as
28 a model that examines the research subject in more detail and from different

1 angles (Çepni, 2014). For this reason, more detailed data could be obtained by
2 using it more.

3
4 (3) *The samples of the studies addressing the opinions of teachers and*
5 *teacher candidates on STEM education*

6
7 Tables and explanations regarding the samples preferred in studies
8 conducted to examine the opinions of teachers and teacher candidates on
9 STEM education are given below.

10
11 *Table 3. The Samples of the Studies*

Sample Studies	Science education	Primary education	Mathematics	Computer and Instructional Technologies	Preschool education	Technology Design	Chemistry education	Biology education	Physics education
S1	X	X		X	X				
S2					X				
S3	X								
S4	X								
S5	X								
S6	X	X	X		X				
S7	X	X	X						
S8								X	
S9				X					
S10	X		X	X			X	X	X
S11	X								
S12	X						X	X	X
S13							X		
S14	X	X	X						
S15		X							
S16	X		X			X			
S17									
S18	X								
S19	X								
S20	X								
S21	X		X						
S22		X	X						
S23									X

12
13 When Table 3 is examined, it is seen that the most preferred sample in the
14 studies is Science Education. The second preferred sample is Mathematics
15 Education. The reason for this may be related to the presence of these two
16 branches in STEM. The table shows that Computer and Instructional
17 Technologies, Preschool, Chemistry, Biology, and Physics education branches

1 are preferred in the same number of studies. The least preferred branch is
 2 Technology Design. In S17, no branch is specified and defined. S10 is the
 3 study in which the most different types of sample was used. In this study, data
 4 were collected from a total of six branches.

5
 6 *(4) Data collection tools of the studies addressing the opinions of teachers
 7 and teacher candidates on STEM education*

8
 9 Tables and explanations regarding the data collection tools preferred in
 10 studies conducted to examine the opinions of teachers and teacher candidates
 11 on STEM education are given below.

12
 13 *Table 4. The Data Collection Tools of the Studies*

Methods	Studies	<i>f</i>
Questionnaire	S1, 2, 3, 5, 6, 7, 9, 10, 12, 14, 15, 17, 18, 19, 20, 21, 22, 23	18
Interview	S3, 4, 5, 8, 9, 11, 16	6
Information Form	S2, 7, 17	3
Reflective Diary	S3, 13	2
Survey	S9	1
Word Association Test	S3	1

14
 15 When Table 4 is examined, it is seen that the most used data collection
 16 tool is questionnaire. "Attitude Related to STEM Education" and "Self-
 17 Efficacy Scale Related to STEM Education", "Attitude Scale towards
 18 Technology" and "Integrated STEM Teaching Orientation Scale" can be given
 19 as examples for questionnaire. The use of questionnaire is suitable for the
 20 purpose of these studies. In the studies obtained in this research, it is seen that
 21 different data collection tools are mostly used in S3. The least preferred data
 22 collection tools are surveys and word association tests.

23
 24 *(5) Data analysis techniques of the studies addressing the opinions of
 25 teachers and teacher candidates on STEM education*

26
 27 Tables and explanations regarding the data analysis techniques preferred
 28 in studies conducted to examine the opinions of teachers and teacher
 29 candidates on STEM education are given below.

30
 31 *Table 5. The Data Analysis Techniques of the Studies*

Methods	Studies	<i>f</i>
Statistical Package Programs	S1, 2, 3, 7, 10, 12, 14, 17, 18, 19, 21, 22	12
Content Analysis	S3, 4, 8, 11, 13, 14, 15, 23	8
Descriptive Analysis	S5, 6, 9, 11, 13	5
Comparative Analysis	S5, 13	2
Explanatory Factor Analysis	S20	1

1 When Table 5 is examined, statistical package programs were preferred to
 2 provide the analysis of the data such as SPSS. The second highest frequency of
 3 data analysis method is content analysis. At least, the use of explanatory factor
 4 analysis was preferred.

5
 6 (6) *Results of the studies addressing the opinions of teachers and teacher*
 7 *candidates on STEM education*

8
 9 Tables and explanations regarding the results of the studies conducted to
 10 examine the opinions of teachers and teacher candidates on STEM education
 11 are given below.

12
 13 *Table 6. The Results of the Studies*

Results of the Studies	Studies	<i>f</i>
It has been revealed that teachers and teacher candidates display positive attitudes and opinions towards STEM.	S1, 3, 5, 6, 7, 8, 9, 11, 12, 14, 15, 19, 20, 21, 23	15
It was stated that they found STEM education beneficial in terms of improving learning.	S1, 4, 5, 7, 8, 20, 21	7
It was observed that gender had no effect on the attitude and awareness towards STEM education.	S2, 7, 15, 19, 21, 22	6
It was observed that the STEM teaching tendencies of the female teacher candidates was higher than the male teacher candidates.	S6, 10, 12, 17, 18	5
The teachers and teacher candidates associated STEM education with related disciplines.	S4, 5, 7, 13, 15	5
They stated that STEM practices could be negatively affected by infrastructural and financial problems.	S3, 9, 13, 16	4
High STEM awareness of graduate teachers and 4th grade teacher candidates will enable the transfer of new educational approaches to students more efficiently.	S7, 12, 18, 22	4
It was seen that there was a significant difference in favor of Science Education in the attitude and awareness levels regarding STEM compared to other branches.	S7, 16, 22	3

14
 15 When Table 6 is examined, it is seen that the results of the study are
 16 collected in eight different categories. The frequency distributions of the
 17 categories are very close to each other. The result with the highest frequency
 18 was “It has been revealed that teachers and teacher candidates display positive
 19 attitudes and opinions towards STEM.” The result with the lowest frequency
 20 was “It was seen that there was a significant difference in favor of Science
 21 Education in the attitude and awareness levels regarding STEM compared to
 22 other branches.” This result coincides with the fact that Science Education is
 23 given more weight in the branches chosen for the sample in the 23 studies
 24 discussed in this study. There are many different results about the relationship

1 of gender with STEM. For example some studies reached the result of “It was
2 observed that the STEM teaching tendencies of the female teacher candidates
3 was higher than the male teacher candidates.” while some reached that “It was
4 observed that gender had no effect on the attitude and awareness towards
5 STEM education.” There are studies in the literature that have found many
6 different results about the relationship of gender with STEM.

7
8 (7) *Suggestions of the studies addressing the opinions of teachers and teacher*
9 *candidates on STEM education*

10
11 Tables and explanations regarding the suggestions of the studies
12 conducted to examine the opinions of teachers and teacher candidates on
13 STEM education are given below.

14
15 **Table 7.** *The Methods of the Studies*

Suggestions of the Studies	Studies	f
Pre-service and in-service trainings can be organized to improve teachers 'and teacher candidates' awareness, knowledge, and skills regarding STEM education.	S2, 4, 5, 8, 9, 10, 12, 13, 15, 16, 18, 20, 21, 23	14
STEM education can be included in teacher education programs as an applied lesson.	S1, 4, 5, 6, 7, 8, 10, 11, 12, 18, 20, 22	12
More studies on this subject are recommended in order to increase STEM teaching tendencies of teachers and teacher candidates.	S3, 6, 8, 10, 11, 14, 15, 19, 21, 22	10
In order for the STEM approach to be applied effectively, infrastructure problems should be eliminated and the necessary budget should be provided.	S3, 4, 9, 12, 20	5

16
17 When Table 7 is examined, the most used suggestion in the studies is “It is
18 useful to organize pre-service, in-service trainings, and science camps that will
19 improve STEM awareness. In addition, practices that will improve the
20 knowledge and skills of teachers and teacher candidates about STEM
21 education can be included in-school and out-of-school learning environments
22 such as field trips, projects, laboratory applications, and workshops.” The
23 second suggestion with the highest frequency that follows "STEM education
24 can be included in teacher education programs as an applied lesson." The same
25 recommendations appear to be included in many studies. No suggestions were
26 specified in S17.

27
28
29 **Discussion**

30
31 The aim of this study is to analyze the content of the studies examining the
32 opinions of teachers and teacher candidates on STEM education. It was

1 observed that the studies examined mainly aimed at “examining the awareness
2 of teachers and teacher candidates about STEM.” The reason of this can be
3 that STEM education is still new for Turkish educational system. Therefore,
4 the researchers may try to reveal the real implementers’ (teachers and teacher
5 candidates) awareness and opinions about STEM education and try to reveal
6 the negative and positive opinions/sides of STEM education.

7 In these studies, it is seen that the quantitative approach is mostly used as
8 a method. Quantitative research is a type of research that presents facts and
9 events in an observable, measurable, and numerically expressible way.
10 Because qualitative research takes much more times and effort, the researchers
11 may have wanted to use quantitative research types to close the lack of
12 research on this subject in Turkish context. Due to the fact that quantitative
13 research is highly preferred, different studies have been recommended by using
14 other methods in the recommendations section of some studies.

15 When the results of the studies are examined, it is revealed that the
16 teachers and teacher candidates have/show positive attitudes and opinions
17 towards STEM. This result is compatible with the other studies in the
18 literature. It is stated in these studies that information technologies, science,
19 preschool and primary school teachers have positive attitudes towards STEM
20 (Çevik, Daniştay, & Yağcı, 2017; Karahan, Canbazoğlu Bilici, & Ünal, 2015;
21 Knop et al., 2017; Ültay & Ültay, 2020). It was stated that in this research,
22 some studies found STEM education effective at improving learning by doing,
23 making learning permanent, directing research and inquiry, in the development
24 of problem solving skills, making learning enjoyable, and being successful in
25 learning subjects. In the study of Altan, Yamak and Kırıkkaya (2016), science
26 teacher candidates stated that they found STEM education useful and effective
27 for the same reasons. Similar studies on the impact of STEM education on
28 success in learning have also been existed in the literature (i.e Cotabish,
29 Dailey, Robinson, & Hughes, 2013; Herdem & Ünal, 2018; Park & Yoo,
30 2013).

31 Considering the sample of the studies, teachers and teacher candidates
32 were included in the studies from 9 different branches for 23 studies. Studies
33 with Science Education teachers and teacher candidates mostly took place in
34 the studies. The reason of this can be science is one of the main components of
35 STEM. In STEM activities, at least two components of four disciplines should
36 be existed (Aydın-Günbatar, 2019). It is seen that the studies about STEM
37 education comprises of science or mathematics as the main component and
38 then the other disciplines are preferred as supplementary disciplines (i.e Altan,
39 Yamak & Kırıkkaya, 2016; Gülhan & Şahin, 2016; Hacıoğlu, 2017).

40 When the suggestions regarding the studies are examined, the most
41 presented suggestion is “It is beneficial to organize pre-service and in-service
42 trainings to improve teachers 'and teacher candidates' awareness, knowledge,
43 and skills regarding STEM education.” In addition, practices that will improve
44 the knowledge and skills of teachers and teacher candidates about STEM
45 education can be included in in-school and out-of-school learning

1 environments such as field trips, projects, laboratory applications and
2 workshops.

3 4 5 **Conclusions and Recommendations**

6
7 Overall, it can be stated that the general trend in Turkey regarding STEM
8 is to reveal the attitudes and opinions of teachers and teacher candidates.
9 However, they mostly display positive attitudes and opinions, to implement
10 STEM education in schools is quite difficult for Turkey because it requires
11 revising and/or re-designing the Turkish educational system. To accomplish
12 this revision is required too many infrastructural changes and financial support.
13 Thus, STEM education is in progress in particular activities in Turkey.

14 This study provides a comprehensive view of STEM education from the
15 perspectives of teachers and teacher candidates. It will be especially useful for
16 researchers and educators who want to study STEM. It hints at which subject /
17 field they should concentrate on or which studies they should pursue. Based on
18 the results of the research, the following suggestions can be made:

- 19
- 20 • STEM activities can be conducted in teacher education programs to
 - 21 increase the tendencies towards STEM education.
 - 22 • STEM education can be included in teacher education programs as an
 - 23 applied lesson.
 - 24 • These studies can be carried out in all branches and at all grade levels,
 - 25 which can both raise awareness and contribute to literature studies.
- 26
27

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