Content Analysis of STEM-Oriented Studies in Science Education: 2017–2021

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ABSTRACT

Recently, the number of studies oriented to multidisciplinary science education is becoming more widespread with the increasing prevalence of 21 century-based applications. It is necessary to determine the subjects that are focused on educational research and the subjects that are studied frequently or rarely in order to draw a framework. Identifying science, technology, engineering, and mathematic (STEM) -oriented studies in science education with systematic content analysis accelerates researchers working in this field and gives them clarity about the subjects, samples, and a variety of variables. Therefore, the aim of this study is to examine STEM-oriented studies in science education between 2017 and 2021 with systematic content analysis in terms of different variables in Turkey. The study was conducted according to certain criteria. Scopus, Web of Science, and Google Scholar databases and indexes were examined. the number of publications made in Turkish is greater than the number of publications in English. One of the striking findings in the data obtained is that the number of publications with two authors is the highest compared with the distribution of the number of other authors. The journal that has published the most articles is Science Activities-Projects and Curriculum Ideas. The most used sample is composed of secondary school students, and the most preferred range as the sample type is between 11 and 30. There is an almost equal ratio between the research methods (quantitative and qualitative) used in the studies. It is seen that the tools classified as alternative evaluations are used the most in the studies, whereas concept maps are the least used data collection tool. It is thought that the study will guide researchers who will conduct STEM-oriented studies in science education and will help with popular trend topics that have been widely discussed recently in Turkey.

Keywords:[1]
STEM, STEM education, content analysis, science education, Turkey

Introduction

Science education prioritizes active learning approaches and enables individuals to realize meaningful learning through experimental series in the problem-solving process. In the practice of gaining skills in science education, the need for personal solutions is considered a priority. One of the most important tasks of science teaching is to provide individuals with an understanding and ability to use scientific process skills in the stages of problematic designs. Science process skills include observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, and communicating (Vitti & Torres, 2006). Science teaching explains ways of using scientific laws and theories with mathematical relations. With the acquisition of these skills, individuals can acquire the qualifications to deal with the solution of real problems in the real world. It is also necessary to explain that real-life problems have been reshaped in line with technology applications, expectations, and needs of the 21st century. Social needs have changed because scientific developments, new applications in learning approaches, and needs have been differentiated (MoNE, 2018).

The rapid progress of scientific and technological developments steers the perceptions in today's world, and the characteristics that individuals and societies should have in order to keep up with the times change in parallel with these developments (Yıldırım & Gelmez-Burakgazi, 2020). Many technologies and engineering-based applications such as special space vehicles, digital revolution, online education technologies, widespread robotic applications, drone technology, artificial intelligence, virtual reality, and so many more have been integrated into our lives.

Since all these new age practices require multidimensional thinking and practice, the necessity of using different disciplines together has emerged. Science, technology, engineering, and mathematics (STEM) is one of the most common and current examples of the usage of different disciplines together in designs that require multitasking.

STEM disciplines and STEM education are often confused. While the word STEM is an abbreviation, STEM education is a pedagogical approach that includes the integrated use of these disciplines (Akgündüz, 2018). There are many definitions for the concept of STEM (Kara, Tonin, Vlassopoulos, 2021). The National Research Council-NRC (2005) explains STEM as the foundation for discovery and technological innovation. Similarly, in the previous period, NRC (2005) defined STEM as topics and issues that include physical and

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natural sciences, technology, engineering, mathematics, and computer science disciplines (including environmental science, environmental stewardship, and cybersecurity).

STEM-related concepts sometimes refer to a learning model (project-based, problem-based and inquiry-based learning), sometimes to a person (E.G., Maker), or to sub-components of engineering and mathematics (mathematical modelling, computational thinking, design thinking), and sometimes tools and methods that can be used during the implementation of education (robotic, coding), which are components of STEM education (Akgündüz, 2018).Experienced developments cause changes in the roles and responsibilities undertaken in science education, and even the curriculum is periodically revised in line with the needs.

According to Korkmaz (2018), STEM is an educational approach that includes the simultaneous learning of science, technology, engineering, and mathematics by supporting each other and covers all school periods. It is noteworthy that there has been a development in the recently renewed science curriculum, especially in the application of interdisciplinary subjects. The use of different disciplines together has increased interest in the concept of STEM. In terms of education, STEM education is a very new concept. In 2005, the initial step for integration was taken with the 'Science and Technology' lesson educational program; STEM education has become a part of the Science Educational Program, and the pilot application was carried out in 2017. STEM has become its place in our educational system with 'Science, Engineering and Entrepreneurship Implementation,' in the 2018 educational program in Turkey. (Ergün & Kıyıcı, 2019). These changes continued in the following years. Considering the vision of the science curriculum updated in 2017 and 2018, it is noteworthy that although the programs used structurally have similar contents, there has been a change in the functioning process (Bektaş & Aslan, 2019).

STEM education, which has become effective in recent years, has an important role in increasing the level of skills, supporting creativity, innovation, and sustainability, ensuring transition between professions, and gaining skills appropriate to the professions that have developed in the last 10 years in the twenty-first century (Ministry of National Education [MoNE], 2018). In STEM education, students go through the processes of identifying a real problem situation and analyzing it, then finding alternative solutions, trying the design and eliminating the deficiencies. In this way, the student gains 21st century skills such as creativity, critical thinking, and problem-solving cooperation, together with STEM education(Bozan & Anagün, 2019).

A true STEM education should increase students' understanding of how things work and improve their use of technologies. STEM education should also introduce more engineering during pre-college education (Bybee, 2010). STEM education attempts to create learning environments that enable students to solve real-life problems involving more than one discipline and establish interdisciplinary relationships. In these learning environments, students are expected to work collaboratively and develop competencies for each discipline's field (Çavaş & Çavaş, 2020).

In the engineering and design process, students put forward their solution proposals for a problem together with the research and questioning processes and test their suggestions to reach the best possible solution proposal. This process enables students to learn concepts related to science and technology in a meaningful and permanent way while improving their engineering skills (Şahin & Kabasakal, 2021).

In recent years, there has been an increase in the number of studies on STEM application development, the effects of the STEM model in practice, scale development to measure STEM skills, and teacher and student views in our country (Özbilen, 2018).The learning experiences in science education, interdisciplinary teaching emerges as a teaching process that supports inquiry-based individual learning, with a complex structure of different disciplines in the process, and has become increasingly widespread nowadays. Studies in Turkey have focused on the effects of STEM-oriented models and activity designs (Güven, Selvi & Benzer, 2018; Çakır &Güven, 2019; Buber & Çoban, 2020; Hiğde, Keleş, & Aktamış, 2020; Sırakaya, Alsancak Sırakaya & Korkmaz, 2020). In addition, studies on augmented reality applications, digital game designs (Hacıoğlu & Dönmez, 2020), robotic applications (Çakıroğlu & Elbir, 2017; Çınar, 2020; Şen, Ay & Kıray 2021; Üçgül & Altıok, 2021; Yalçın & Akbulut, 2021), and three-dimensional printer technology, which prioritize engineering and technology (Ergün & Kıyıcı, 2019; Ekiz-Kıran & Aydın-Günbatar, 2021), have drawn attention. Career choices are among the subjects studied within the scope of the occupational need for the STEM field, which has increased recently (Bircan & Köksal, 2020). In addition, there are many classroom practices in the current literature that examine the effects of STEM measurement tool development processes on STEM and affective variables (Kızılaslan, Zorluoglu, & Sözbilir, 2019). There are also studies evaluating the research in the field of STEM, especially covering the last years (Çevik, Şanlıtürk & Yağcı 2017; Tezel & Yaman, 2017; Ergün, 2029;

Kaya, 2020; Yıldırım & Gelmez-Burakgazi, 2020; Cumhur, Masalimov, Rostovtseva, Shindryaev, Kryukova, 2021; Duran & Sarı, 2021).

Recently, the number of STEM-oriented studies in science education has become increasingly widespread in the international arena, with the increasing prevalence of 21 century-oriented technology and engineering-based applications. In general, it is important to examine the research on education in Turkey to reveal the current situation. It is necessary to determine the subjects that are focused on educational research and the subjects that are studied frequently or rarely in order to draw a framework. Identifying STEM-oriented studies in science education with a systematic content analysis accelerates researchers' work in this field and gives them clarity about the subjects, samples, and a variety of variables.

The content-analytical procedure is to count certain elements in the material and compare their frequency with the occurrence of other elements. It aims to extract a certain structure from the material (Bikner-Ahsbahs, Knipping, Presmeg, 2015). Studies in which engineering applications are shaped by scientific schemes have become increasingly widely used. The better the understanding of how these contents are formed and their dimensions, the faster they will be used in educational studies. The category system constitutes the central instrument of analysis. It also contributes to the inter-subjectivity of the procedure, making it possible for others to reconstruct or repeat the analysis (Bikner-Ahsbahs et al; 2015).

When the literature on studies conducted in Turkey is examined, it is seen that there are many STEM-oriented studies in science education between 2017 and 2021. (Tezel & Yaman, 2017; Yıldırım & Türk, 2018; Batdi, Talan & Semerci, 2019; Sönmez & Özgün-Koca, 2020; Özrili, 2021; Öztürk, 2019). Certain studies have been conducted in this field, but it is noteworthy that there are not many STEM-focused studies in science education that include current content analysis between 2017 and 2021 in Turkey.

The purpose of this study is to analyze the studies about science, technology, engineering, and mathematics (STEM) oriented studies in science education in the last five years (2017-2021) in Turkey using the content analysis method in terms of different variables and to reveal the trends in the field. For this purpose, answers were sought for the following research questions.

1) What is the distribution of the identified publications by years and publication language?
2) What is the number of authors of the identified publications?
3) What is the distribution of the identified publications by the journals?
4) What are the commonly used samples in the identified publications?
5) What are the commonly used sample sizes in the identified publications?
6) What are the research methods used in the identified publications?
7) What are the commonly used data collection tools in the identified publications?

METHOD

In this section, the design of the study, the participants, the data collection tools, and the techniques used in data analysis are described.

Research Design

The research methodology used in this study is descriptive content analysis, which is a qualitative research method that uses a set of procedures to classify and offers many potential benefits (Weber, 1990; Short & Palmer, 2008). Content analysis classifies textual material, reducing it to more relevant and manageable bits of data (Weber, 1990). The aim of this study was to present a detailed review of articles on STEM-focused science education between 2017 and 2021 in Turkey. The study was conducted according to certain criteria. Scopus, Web of Science, and Google Scholar databases and indexes were examined. Because of the reasonable availability of search filters, both databases were preferred to access articles on STEM-focused science education-based topics. Similar articles were found among the articles obtained from Google Scholar, Web of Science, and Scopus databases. These publications have been carefully sorted. Necessary controls were made in case the same publication was published in different indexes.

In the process of compiling the articles, the following criteria were considered:

- Having at least one of the concepts of STEM or STEAM with science education in the keywords, in the title or abstract of the publications between the years 2017 and 2021.
- Articles such as editorial, mini-review, and conference papers are excluded.
- Research Report and Review type of articles were selected.
- In databases such as Web of Science and Scopus, the location filter is determined to be Turkey.

Data collection and analysis

The publications identified through systematic analysis were entered into the MS Excel software. The journals and the number of articles between the years 2017 and 2021 were analyzed using the MS Excel program and formed with "STEM-Oriented Research Review Form". Necessary precautions have been taken to consider the risks that may reduce the validity and reliability of the research. Observational reliability as an indicator of internal reliability means that more than one researcher measures a phenomenon or event in the same way over the same period (Yıldırım & Şimşek, 2013). The classification of the articles with the determined criteria was analyzed independently by two different coders from the research team for coding reliability at the same time. These two analyses were then compared. According to Yıldırım and Şimşek (2013), the percentage of agreement is the ratio of the number of items agreed upon by the observers or evaluators to the total number of evaluations or observations. 20 publications randomly selected from 237 studies were coded by two researchers from the research team. The title categories for the Research Review Form coded by the researchers were highly consistent with each other.

Finally, 237 articles on STEM-focused science education in the last 5 years were examined. The STEM-Oriented Research Review Form was identified according to the following titles:

- Publication Years
- The Language of the Publications According to Years
- Number of Authors in Publications
- Journals of Publications
- Sample Type of Publications
- Sample Size of Publications
- Data Collection Tools of Publications
- Research Methods of Publications

FINDINGS

In this section, the findings of the articles on STEM-focused science education with different variables are presented between 2017 and 2021 in Turkey. A total of 237 articles published in Turkey between 2017 and2021 were reached. These articles focus on STEM-oriented science education and meet the criteria determined within the scope of the research.

Demographic Information Distribution of Publications

In this section, according to research questions, the studies on STEM-oriented science education in Turkey between 2017 and 2021 are examined in terms of demographic variables explained below.

- Publication Years and Language of the Publications According to Years
- Number of Authors in Publications
- Journals of Publications

The findings regarding the distribution of the identified articles by year and publication language are presented in Table 1.

Table 1. Distribution of publications by years and language

Language	English		Turkish		Total	
Year	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
2017	13	13.8	24	16.8	37	15.6
2018	11	11.7	21	14.7	32	13.5
2019	16	17.04	19	13.3	35	14.8
2020	22	23.4	43	30.1	65	27.4
2021	32	34.06	36	25.1	68	28.7
Total	94	100	143	100	237	100

According to Table 1, the types of written language of publication used in the most STEM-oriented studies in the last 5 years are English and Turkish. While 13 (13.8%) of the 37 studies conducted in 2017 were written in English, 24 (16.8%) were in Turkish. To speak for 2018, 11 (11(11.7%) of the 32 studies conducted

were written in English, for 21 (14.7%) were in Turkish. In addition, while 16 (%17.04) of the 35 studies conducted in 2019 were written in English, the remaining 19 (13.3%) were in Turkish. The table shows that 22 (23.4%) of the 65 studies conducted were written in English and the remaining 43 (30.1%) were written in Turkish in 2020. Finally, 32 (34.06%) of the 68 studies conducted in 2021 were written in English and 36 (25.1%) were in Turkish.

The findings regarding the distribution of the number of authors are given in Table 2.

Table 2. Distribution of the Number of Authors

Number of Authors	Number of Articles (f)	Percentage (%)
1	46	19,4
2	117	49,36
3	52	21,94
4	18	7,59
5 or more	4	1,68
Total	237	100%

Table 2 shows the number of authors of the 237 studies examined. The number of authors is categorized as 1, 2, 3, 4, and 5 or more. According to Table 2, 46 (19.4%) of 237 publications are single-authored. It is seen that 117 (49.36%) of the publications have 2 authors, while 52 (21.94%) of them have 3. The remaining 18 (7.59%) publications have four authors, while four (%1.68) publications have 5 or more authors in the last five years.

The findings regarding the articles published by journals on STEM-oriented science education in the last 5 years are given in Table 3.

"Distribution of Authors' Institutions of Publications" was removed from this section according to the review

Table 3. Distribution of Journals in which Articles were Published

Number of articles published by journals	Frequency (f)	Percentage (%)
Science Activitie, Projects, and Curriculum Ideas in STEM Classrooms	10	4.23
Pamukkale University Journal of the Faculty of Education	8	3.38
Journal of Baltic Science Education	6	2.53
Yüzüncü Yl University Journal of the Faculty of Education	6	2.53
Boğaziçi University Journal of Education	5	2.12
Cumhuriyet International Journal of Education	5	2.12
International Journal of Education in Mathematics, Science, and Technology	5	2.12
Kastamonu Education Journal	5	2.12
Ihlara Journal of Educational Research	4	1.70
Journal of Education and Instruction	4	1.70
Trakya University Journal of the Education Faculty	4	1.70
Ağrı İbrahim Çeçen University Journal of the Social Sciences Institute	3	1.26
Education and Science	3	1.26
Hacettepe University Journal of the Faculty of Education	3	1.26
International Journal of Technology and Design Education	3	1.26
Istanbul Aydn University Journal of the Faculty of Education	3	1.26
Journal of Science Education and Technology	3	1.26
Journal of STEAM Education	3	1.26
Mediterranean Journal of Educational Research	3	1.26
Necatibey Faculty of Education Journal of Electronic Science and Mathematics Education	3	1.26
Turkish Journal of Education	3	1.26
International Association of Educational Researchers	3	1.26
Asian Journal of Instruction	2	0.85
Abant İzzet Baysal University Journal of the Faculty of Education	2	0.85
Academia Journal of Educational Research	2	0.85
Muş Alparslan University Journal of Social Sciences (Anemon)	2	0.85
Journal of inquiry-based activities	2	0.85
Atatürk University Kazm Karabekir Journal of the Faculty of Education	2	0.85
ukurova University Faculty of Education Journal	2	0.85
Journal of Education Theory and Practical Research	2	0.85
Eurasian Journal of Educational Research	2	0.85
Journal of Science, Mathematics, Entrepreneurship, and Technology Education	2	0.85
Journal of the Gazi Faculty of Education	2	0.85
Interactive Learning Environments	2	0.85
Journal of Turkish Science Education	2	0.85
Mehmet Akif Ersoy University Journal of the Education Faculty	2	0.85
Mustafa Kemal University Journal of the Social Sciences Institute	2	0.85
Problems of Education in the the 21st Century	2	0.85
Research in Science Education	2	0.85
Sakarya University Journal of Education	2	0.85
Journal of STEM Education	2	0.85
Journal of History School (JOHS)	2	0.85
Technology Knowledge and Learning	2	0.85
Turkish Studies and Educational Sciences	2	0.85
Universal Journal of Educational Research	2	0.85
Journal of the Turkish Chemical Society, Section C: Chemical Education	2	0.85
Journal of Education in Eskisehir Osman Gazi University Turkish World Apply and Research Center (ESTÜDAM)	2	0.85
*……	1	0.42
Total	237	100

*There are 92 journals that published one article on STEM-focused science education.

In Table 3, 139 journals that published studies on STEM-oriented science education in Turkey between 2017 and 2021 were reached. While the journal Science Activities-Projects and Curriculum Ideas in STEM Classrooms published 10 (%4.23) articles, Pamukkale University Journal of the Faculty of Education published 8 (%3.38) articles. The Journal of Baltic Science Education and Yüzüncü Yıl University Journal of the Faculty of Education have both published 6 articles in the last five years on STEM-oriented science education. According to Table 3, the journals that published five articles in the last five years are Boğaziçi University Journal of Education, Cumhuriyet International Journal of Education, International Journal of Education in Mathematics Science and Technology, and Kastamonu Education Journal. There are 3 journals that publish 4 articles in the related field: Ihlara Journal Educational Research, Pegem Journal of Education and Instruction, and Trakya University Journal of Education Faculty. Ağrı İbrahim Çeçen University Journal of Social Sciences Institute, Education and Science, Hacettepe University Journal of the Faculty of Education, International Journal of Technology and Design Education, stanbul Aydn University Journal of the Faculty of Education, Journal of Science Education and Technology, Journal of STEAM Education, Mediterranean Journal of Educational Research, Necatibey Faculty of Education, Journal of Electronic Science and Mathematics Education, Turkish Journal of Education, and International Association of Educational Researchers have published 3 (1.26%) articles between 2017 and 2021 on STEM-oriented science education in Turkey. Twenty-

five journals have published 2 (0.85%) articles on STEM-oriented science education in the last 5 years. There are 92 journals with 1 (0.42%) publication on STEM-oriented science education.

Methodological Information Distribution of Publications

According to the research questions, the studies on STEM-oriented science education between 2017 and 2021 are examined in terms of the methodological variables explained below.

- Sample Type of Publications
- Sample Size of Publications
- Research Methods of Publications
- Data Collection Tools of Publications

The findings regarding the commonly used samples in the identified publications are presented in Table 4.

Table 4. Distribution of Sample Types Used in the Studies

Sample Type	Frequency (f)	Percentage (%)
Primary School Students (1-4)	2	0.86
Secondary School Students (5-8)	98	41.4
High School Students (9-12)	8	3.3
Gifted and Talented Students	6	2.6
Primary Inservice School Teacher (1-4)	1	0.43
Primary Pre-Service Mat Teachers (1-4)	2	0.86
Primary Pre-Service School Teachers (1-4)	1	0.43
Pre-service school counselor (1–4)	1	0.43
In-service Science Teachers (5–8)	17	7.1
Pre-service science teachers (5–8)	42	17.7
In-service Social Studies Teacher (5–8)	1	0.43
In-service ICT teachers (5–8)	1	0.43
In-service Science Teachers (9–12)	1	0.43
Pre-service chemistry teachers (9–12)	2	0.86
Teacher of Science and Art Centres Institution (BILSEM)	1	0.43
No Sampling	31	13.08
Mixed Groups	21	8.8
Dean of the Faculty of Education	1	0.43
Total	237	100

Table 4 includes the sample types used in studies on STEM-oriented science education in Turkey in the last 5 years. According to Table 4, when 98 (41.4%) articles included middle school students, 42 (17.7%) articles were conducted with pre-service teachers. In addition, 31 (13.08%) articles did not have a sample and 21 (8.8%) articles were conducted with mixed groups.

The findings regarding the commonly used sample sizes in the identified publications are presented in Table 5.

Table 5. Distribution of Sample Size Used in the Studies

Sample size	Frequency (f)	Percentage
0-10	19	8.0
11-30	53	22.3
31-60	46	19.4
61–100	26	10.9
101–500	39	16.4
›500	21	8.8
No Sampling	33	13.9
Total	237	100

The sample sizes used in studies on STEM-oriented science education in Turkey in the last 5 years are given in Table 5. The sample size used in 19 (8.0%) of 237 articles varies between 0 and 10 (Table 6). In addition, according to the findings, 53 (22.3%) samples vary between 11 and 30. While there are 46 (19.4%) publications

with a sample size between 31 and 60, the sample size of 26 (10.9%) publications varies between 61 and 100. It is understood that the sample size of 21 (8.8%) articles is 500 or more. In addition, it is seen that the sample size of 39 (16.4%) publications is between 101 and 500. There are no samples in 33 (13.9%) studies.
The findings regarding the research methods used in the identified publications are given in Table 6.

Table 6. Distribution of Research Methods Used in the Studies

Method of the Article	Frequency (f)	Percentage (%)
Quantitative	102	43,04
Qualitative	100	42,20
Mixed	35	14,76
Total	237	100

The research methods used in studies on STEM-oriented science education in the last 5 years are given in Table 6. The methods used were categorized as quantitative, qualitative, and mixed. According to Table 6, 102 (43.04%) of 237 studies were quantitative and 100 (42.20%) of them were qualitative, while 35 (14.76%) were prepared using a mixed research method.
The findings regarding the commonly used data collection tools in the identified publications are presented in Table 7.

Table 7. Distribution of Data Collection Tools Used in the Studies

Data Collection Tool		Frequency (f)	Percentage (%)
Survey	Likert	64	17
Achievement Test	Multiple Choice	22	5.7
Attitude Tests		41	10.7
Perception Tests		5	1.3
Alternative Tests (Science process skills, Self-Efficacy Beliefs, STEM Teaching Intention…etc)		47	12,4
Motivation test		5	1.3
Interview	Semi-structured	83	22
	Unstructured	4	1.1
Observation		4	1.1
Alternative Evaluation	Concept Map	1	0.3
	Document	15	4
	Inventory	4	1.1
	Worksheet	6	1.5
	Diaries	7	2
	Video Records-Pictures	6	1.5
	Portfolios -Products	14	3.7
	Field notes	5	1.3
	Case Study	45	12
Total		378	100

Table 7 shows the distribution of data collection tools used in studies on STEM-oriented science education in the last 5 years. According to Table 7, 378 data collection tools are available. While 64 (17%) of the data collection tools were surveys, 22 (5.7%) were achievement tests. In addition, attitude tests were used in 41 (10.7%) studies, perception tests were used in 5 (1.3%) studies, and alternative tests (Science process skills, Self-Efficacy Beliefs, STEM Teaching Intention…) are used in 47 (12.4%) studies. However, it is seen that there are 5 (1.3%) motivation tests. In addition, as a data collection tool, a total of 87 interviews were conducted as semi-structured (f:83) and unstructured (f:4). The number of studies with observation as a data collection tool was 4 (1.1%). It is also seen that there are alternative evaluations (f:103). Alternative assessments were obtained

as concept map (f:1), document (f:15), inventory (f:4), worksheet (f:6), diaries (f:7), video record, pictures (f:6) portfolios -products(f:14), field notes f:(5) and case study (f:45).

RESULT AND DISCUSSION

When the number of publications written in English and Turkish between 2017 and 2021 is examined, similar results are obtained for 2017, 2018 , and 2019 (Table 1). However, in 2020 and 2021, it is noteworthy that there is an increase in the number of publications. These findings can be explained by the increase in the use of technology applications that support STEM education recently. With the right blend of technology, pedagogy, and knowledge, many technological tools can be used in science teaching. The use of many tools such as simulations, animations, data collection and editing tools, sensors, presentation tools, virtual laboratories, augmented reality applications, mobile applications, measurement and evaluation tools, and online discussion groups in science teaching is becoming increasingly common (Akgündüz, 2019, Chapter 3, p.65). In addition, web 2.0 technologies, developed in line with the needs of the user, are rapidly finding themselves in every field today. The dissemination of situations in which such technologies are used based on good examples helps to share successful examples on one hand and to create new proposals on the other (Akgündüz, 2019, Chapter 7, p.143). Çavaş, Ayar, Turuplu, and Gürcan (2020) reviewed 45 theses and 52 articles on STEM education in Turkey between 2010 and 2018. Similarly, it has been stated that the number of studies conducted recently has gradually increased. Durak, ankaya, Nacak, and Baysal (2021) reviewed 117 theses on STEM education in Turkey during the last five years. They found that the number of studies from 2011 to 2019 increased, but there was a graphical decrease in 2020. This can be associated with the fact that the pandemic process has caused a decrease in the number of studies that require active studies.

According to the data obtained, the number of publications made in Turkish is more than the number of publications in English when the general data are examined in the studies on STEM-oriented science education in Turkey in the last 5 years. In the study by Ergün (2020), 83 postgraduate theses were examined, and the distribution of theses according to language was examined. Similarly, 74 Turkish and 9 English studies were conducted.

When STEM-oriented science education studies in Turkey were examined in the last 5 years, 237 publications meeting the determined criteria were reached. The publications were examined according to the distribution of the number of authors. According to Table 2, one of the striking findings in the data obtained is that the number of publications with two authors (f:117) is the highest compared with the distribution of the number of other authors. One of the remarkable findings reached in this study is that the number of studies with two (f=117) 49.36% and three authors (f=52) 21.94% was proportionally higher in the publications examined on STEM Education between 2017 and2021. In the study of Agile by Lang (2017), in the content analysis of 34 articles on STEM Education conducted between 2014 and 2016, similar results were reached with a maximum of two (f=11) 32.4% and three authors (f=9) 26.5%. Studies on the number of authors (Daşdemir, Cengiz & Aksoy, 2018; Ecevit, Yıldız & Balcı, 2015) in the literature emphasize the importance of studies with multiple authors for an integrated and coordinated order. Although the number of publications with a single author is dominant (Rousseau, 1994) in the literature, STEM-oriented studies in science education have mostly emerged in the form of publications with two authors. Besides, it has been known for a long time that the number of authors per article is increasing. Consequently, the phenomenon of multiple authorship has drawn considerable attention and has become an important topic in the sociology of science (Rousseau, 1994). There are similar studies in the literature regarding the proportional increase in the number of publications (Rao, 2012; Çevik, Şanlıtürk &Yağcı, 2017) with two authors. Another remarkable situation according to the data obtained is the proportional similarity of the number of publications with a single author (f:46) and with 3 authors (f:52). Another remarkable point is that publications with 5 or more authors (f:4) are at the bottom of the list. One of the reasons for this situation may be the scoring system for academic encouragement. According to the academic scoring criteria, as the number of authors increases, the percentage of points per author decreases. While the author receives full points in single-authored publications, the score decreases as the number of authors increases. This may explain the low number of publications with 5 or more authors in order of preference.

This study investigated the distribution of journals in which STEM-oriented publications in science education in Turkey were published between 2017 and2021. The findings show that the journal that has published the most articles in this field in the last 5 years is "Science Activities-Projects and Curriculum Ideas in STEM Classrooms" (Table 3). As it can be understood from the name of the journal, it has a theme based on

STEM-oriented studies. This situation has been effective in taking the first place among the journals in which science-oriented studies in STEM education are published. The purpose of this journal is to publish innovative articles that will provide teachers and educators with classroom-tested experiments and curriculum ideas that encourage inquiry into science through active learning experiences. the journal progresses in line with its aims and includes many STEM-oriented studies in the international arena, as well as STEM-oriented science education studies conducted in Turkey. When the studies in the field are examined, Pamukkale University Journal of the Faculty of Education ranks second with 8 articles (3.38%) among 139 journals (Table 3). When the Pamukkale University Journal of the Faculty of Education is examined in terms of its scope, it maintains studies that support teacher education, combining technology with practice, in its focus and scope. the reason for the journals' high ranking agrees with its focus and scope.

Among the journals in which STEM-oriented science education studies are published the most in Turkey, there are 2 journals in the third place with six (2.53) publications each. These journals are "Journal of Baltic Science Education" and "Yüzüncü Yl University Journal of the Faculty of Education" (Table 3). The Journal of Baltic Science Education (JBSE) publishes original scientific research articles in the field of Natural Science Education and related areas for all educational levels. In particular, recent studies on the nature of science education have focused on the STEM field, which has been instrumental in making the publications published in JBSE more STEM-oriented. Yüzüncü Yl University Journal of Education aims to contribute to several education fields from preschool education to higher education and adult education by establishing qualified links between theory and practice from a national and international perspective in the field. In addition, in the study conducted by Çolakoğlu and Gökben (2017), it is understood that Yüzüncü Yl University stands out with the number of faculty members who have done their doctoral studies in the field of STEM education and the presence of a laboratory for STEM education. We found that (Table 3) at least one article was published in 47 journals (61.18%), and in 92 journals, we found at most 1 article (38.82%). The mentioned journals are popular and have qualified publications in their field. The low number of STEM-oriented studies in science education in these journals may be because they include many studies in different fields and are multidisciplinary.

The sample types used in studies on focused science education in Turkey between 2017 and 2021 were examined. In the articles examined, 18 different sample types were obtained. According to the findings in Table 4, the most used sample in the studies on STEM-oriented science education in the last five years was secondary school students. In 98 (%41.4) of the 237 studies examined, the sample type is middle school students. 2018 science teaching program, which will cover 3 and 8 grade levels, includes engineering and design skills among its main objectives (MoNE, 2018). In terms of the strategies and methods adopted, the importance of STEM-oriented studies for students is emphasized in the curriculum. According to Table 4, when STEM-oriented science education studies are examined, it is seen that while the number of mixed group sample types in which more than one group is included in the study is 21, the number of studies conducted with only science teachers in a lower order is 17. While pre-service science teachers take second place with 42 (17.7%) studies, there are studies without samples with 31 (13.08%) articles in third place. Similarly, in the compilation of postgraduate theses by Ergün (2020), between 2012 and 2018, middle school students were in the sample order, while pre-service science teachers were in the second place and science teachers were in the third place. In addition, in the studies of Ültay, Balaban and Ültay (2021), which included the views of teachers and prospective teachers on STEM education, most pre-service science teachers were studied. In addition, with the 8 (%3.3) article high school students covering grades 9-12 and with 6 (%2.6) article gifted and talented students draw attention in the ranking. The findings show that the number of studies on STEM-focused science education with gifted and talented students has been low in the last 5 years in Turkey. Kanl and Özyaprak (2016) state that we require various models and a more structured and deliberate framework for progress, especially for specific interventions such as STEM education for gifted students.

The sample sizes used in STEM-oriented studies in science education in Turkey between 2017 and 2021 were examined. According to the findings, the most preferred range as the sample type is between 11 and 30 with a rate of %22.3 (Table 5). This rate is followed by the sample size between 31 and 60 with %19.4. This finding is similar to the study of Sırakaya and Alsancak-Sırakaya (2020). It is stated that quantitative methods were the most common in these studies. The fact that the common sample size was 31–100 may be related to the use of quantitative (experimental) methods in studies. In addition, the intervals specified in STEM education, which generally focuses on classroom work and applications, are similar to the average sample size

used in classroom studies. However, it draws attention as one of the least number of studies with a sample size of over 500 with a rate of %8.8. It can be said that a sample size of over 500 is not preferred much due to possible problems in terms of data collection and cost due to the increase in the number of samples.

The distribution of research methods used in STEM-oriented studies in science education in Turkey in the last 5 years has been examined. According to Table 6, out of 237 studies, 100 were qualitative and 102 were quantitative. According to the data obtained, there is an almost equal ratio between the research methods used in the studies. In the remaining 35 studies, both quantitative and qualitative research methods were used together. As can be seen from the findings obtained from the study, different data collection and analysis techniques, both quantitative and qualitative, are used in educational studies (Sırakaya & Alsancak- Sırakaya 2020). Quantitative methods are generally associated with numerical (quantifiable) data, particularly numerical data analysis. Qualitative methodscollect non-numerical data (Spens & Kovacs, 2006). The two research techniques mentioned here cannot be separated from each other by certain lines. However, collecting quantitative data does not necessarily imply quantitative data analysis and includes open-ended questions already for data collection (Spens & Kovacs, 2006). The research methods and data collection tools used in the next research question are explained in detail.

Data collection tools used in studies on STEM-oriented science education in the last 5 years were examined. According to the findings, the tools classified as alternative evaluations (concept map, document, inventory, worksheet, diaries, video records-pictures, portfolios-products, field notes and case study) were used the most (f:103) in the studies (Table 7). The case study (f:45) stands out among alternative evaluations. Case studies have the potential for further development by specializing in a combination of technical methodology strategies or theories (Johansson, 2007). The reason why case studies are preferred more frequently than alternative assessment methods can be explained by the conveniences and advantages described above. After the alternative evaluations, the most preferred data collection tool is the interview. In particular, it is understood that the semi-structured (f:83) interview technique is used more than the unstructured interview. The reason for this situation may be that the semi-structured interview technique is more advantageous for the researcher as it follows a certain instruction. The semi-structured interview technique provides important convenience to the researcher. Because the interview is conducted in accordance with a pre-prepared interview protocol, it can provide more systematic and comparable information (Balcı, 2005). Survey (f:64) is third as a data collection tool. Survey is a data collection tool frequently used in educational research. There may be different reasons for the use of surveys, depending on the subject and characteristics of the research. Web surveys have several advantages, including shorter transmitting time, lower delivery cost, more design options, and less data entry time (Fan & Yan, 2010).

CONCLUSIONS AND IMPLICATIONS

The aim of this research is to determine the status of STEM-oriented studies in science education in Turkey between 2017 and 2021. In accordance with this purpose, 237 studies meeting the specified criteria were reached. The reviewed studies present a detailed content analysis of the studies on STEM-oriented science education in Turkey with different variables. There are many studies that try to reveal the current situation of STEM education in Turkey. However, the study draws attention to present the latest advantages, challenges, and limitations by covering various sub-questions and focusing on science education.

Duran and Sar (2021) draw attention to the fact that although STEM education has been seen as a popular subject in Turkey in recent years, the international trend has continued for many years. Therefore, the necessity of increasing the number of studies conducted in Turkey comes to the fore. At this point, there is a need for holistic studies in which more in-depth and large samples will be involved in examining STEM education contextually, rather than small samples and applications made in limited time.

When the national literature is examined, it can be seen that the number of studies on STEM and content analysis on STEM (Daşdemir, Cengiz and Aksoy, 2018; Çevik, 2017) has increased over the years in Turkey. Considering that STEM education can lead to a paradigm shift in education, the number of articles on STEM education in all journals will increase over the years.

According to the MONE STEM Education Report (2016), while adapting STEM education to the Turkish education system, it should aim to enable students to simultaneously transform theoretical knowledge from the field of science into practice in the field of engineering. It is important to be able to use mathematical coding

while using technology. In addition, students are expected to question throughout the process and develop products by gradually creating answers. Students in Turkey have the energy, opportunity, and competence to acquire many of these skills. These opportunities need to be made more widespread and accessible to all grade levels.

Declarations

Conflict of Interest

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