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Thematic content analysis of STEM studies published in the field of science education in Türkiye

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Abstract

Purpose: This study aims to thematically analyze STEM studies published in the field of science education in Türkiye from 2013 to 2022.

Design and Methodology: The thematic content analysis research method was used in the study. The identified journals in SSCI and ERIC indexes were searched with the criteria of focusing on science education and conducted in Türkiye. 70 articles were analyzed with parameters such as aims, dependent variables, learning models integrated with STEM, research methods, sample groups, sample sizes, data collection tools, number of data collection tools, duration of instruction, data analysis methods, and results.

Results: The findings revealed that the majority of the studies aimed to determine opinions and the effect on skill development. Moreover, it was determined that achievement, attitudes, scientific creativity, and critical thinking were utilized as dependent variables and STEM was predominantly integrated with project-based learning. Additionally, it was established that the majority of studies employed a case study approach, utilized secondary school students as a sample population, included between 11 and 50 participants, employed interview methods for data collection, utilized a singular data collection instrument, four weeks as instructional duration, and content analysis as data analysis method in STEM studies. Moreover, the findings revealed that the proportion of dependent variables exhibiting positive effects of STEM education was 86.49%, while 13.51% did not demonstrate a positive effect.

Implications & Suggestions: Researchers engaged in studies within the STEM field were provided with recommendations regarding the study.

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1. INTRODUCTION

Nowadays, it is evident that there are rapid and significant changes and developments in science and technology. Competition among countries has increased as a result of these changes. It is essential for countries to have scientifically literate people who can use information effectively, think creatively and critically, solve problems, and have scientific process skills to keep up with and contribute to this rapid change and to compete with other countries in science and technology (Akgündüz et al., 2015; Ceylan, 2014; Çiftçi, 2006). Furthermore, the importance of integrating science, technology, engineering, and mathematics (STEM) across disciplines to promote scientific and technological progress has been recognized by nations around the world (Akgündüz et al., 2015). In this context, countries aim to update and improve their education policies and to develop and renew their curricula (Irkıçatal, 2016).

In 2001, STEM emerged in the United States of America (USA) as an interdisciplinary education model. STEM is an acronym for Science, Technology, Engineering and Mathematics (Bybee, 2010; Sanders, 2009). The acronym STEM has been defined in academic literature as an interdisciplinary approach that does not adhere to the traditional, subject-specific learning that deals with science, technology, engineering, and mathematics disciplines in isolation. Instead, it integrates four or more disciplines with an overarching teaching and learning paradigm (Ejiwale, 2013; Morrison, 2006). STEM education aims to equip students at all levels, from preschool to higher education, with the ability to identify problems using an interdisciplinary approach and to develop appropriate solutions (Altunel, 2018). STEM education aims to develop students' literacy in science, technology, engineering, and mathematics, fostering creativity, collaboration, problem-solving, and competitiveness, while promoting the acquisition of 21st century skills. 21st Century Skills are some skills individuals need to have to keep up with rapid 21st century innovation and succeed. These skills were identified as creativity and innovation, communication and collaboration, critical thinking and problem-solving, and information, communication, and technology literacy (Partnership for 21st Century Learning [P21], 2015). STEM is to equip students with the requisite skills to thrive in the 21st century global economy (English, 2016). According to Thomasian (2011), STEM education has two primary objectives: firstly, to expand the number of students who have professional choices among these disciplines in higher education, and secondly, to improve students' fundamental knowledge levels in STEM disciplines, thereby enabling them to develop innovative solutions to problems related to these disciplines in their daily lives.

The STEM approach, which has gained considerable traction globally, was first introduced in Türkiye in the 2014 report published by the Turkish Industry and Business Association (TÜSİAD). The report states that there is a need for individuals trained in STEM fields and with 21st century skills. It therefore recommends the creation of employment opportunities in STEM fields, an increase in the number of students receiving STEM education, and an enhancement of STEM skills at all levels of education (Akgündüz et al., 2015; TÜSİAD, 2014). Furthermore, Türkiye's consistently low performance in international examinations such as PISA, TIMMS and PIAAC has highlighted the necessity for innovative approaches to educational reform (MoNE, 2016). As a consequence, the STEM approach was incorporated into the 2018 science curriculum as a discrete element, designated as "Science, Engineering, and Entrepreneurship Applications" (MoNE, 2018).

A review of existing literature reveals a considerable body of work analysing the current state of STEM education within Türkiye (Aydın-Günbatar & Tabar, 2019; Bolat & Saltan, 2020; Ceylan, 2021; Çalışkan & Okuşluk, 2021; Daşdemir et al., 2018; Duran & Sarı, 2021; Elmalı & Balkan Kıyıcı, 2017; Eren & Dökme, 2022; Ergün, 2020; Gökçen, 2021; Gülhan, 2022; Kalemkuş, 2020; Kaya & Ayar, 2020; Kızılay, 2018; Mandev & Yavuz, 2022; Ormancı, 2020; Özcan & Karabaş, 2019; Püsküllü, 2019; Sarica, 2020; Ültay et al., 2021; Yaman, 2020; Yıldırım & Gelmez Burakgazi, 2020; Yıldırım, 2016; Yılmaz et al., 2018). Some of these studies seek to identify trends in specific areas of STEM education. For instance STEM studies with students in the fourth and fifth grades (Duran & Sarı, 2021), STEAM studies (Gülhan, 2022), STEM studies about opinions of teachers and teacher candidates (Ültay et al., 2021), postgraduate theses on STEM (Ceylan, 2021; Çalışkan & Okuşluk, 2021; Ergün, 2020; Ormancı, 2020), STEM studies on teacher education (Kızılay, 2018), experimental research on STEM education (Kalemkuş (2020); STEM studies in science education (Eren & Dökme, 2022; Püsküllü, 2019), and STEM studies in science and mathematics education (Gökçen, 2021).

In examining these studies, it became evident that there were fewer instances of studies utilizing the method of meta-synthesis (thematic) content analysis than those employing descriptive content analysis (Kaya & Ayar, 2020, Ormancı, 2020; Sarica, 2020; Yıldırım & Burak Gelmezgazi, 2020; Yılmaz et al, 2018). Upon examination of these studies, Kaya and Ayar (2020) sought to elucidate the patterns of STEM studies by analyzing 50 qualitative articles published in the ULAKBİM database in Türkiye between 2016 and 2019. The study examined the evolution of STEM studies within the context of publication year, research topic, research method, sample group, and research findings. The study primarily utilized teachers as its sample population, with the majority of studies published in 2018. The case study method was the most prevalent research method employed. Additionally, it was determined that opinions on STEM education were the most extensively researched topic, with the findings indicating that STEM education has the potential to enhance students' 21st-century skills. In a related study, Yıldırım and Burak Gelmezgazi (2020) conducted a review of 12 qualitative studies conducted in Türkiye between 2014 and 2019. The studies were identified through an examination of the ERIC, Scopus and Web of Science databases. The analysis revealed that the studies examined focused on the results of STEM applications carried out inside or outside the school, the current situation at the cognitive level regarding STEM education, and prospective teachers' relationships between STEM disciplines. In contrast to the aforementioned studies, Sarica (2020) and Ormancı (2020) conducted thematic content analysis of postgraduate theses in the field of STEM education in Türkiye. Furthermore, Yılmaz et al. (2018) used thematic content analysis and document analysis together and examined 20 articles about STEM education in Türkiye that were placed in the ULAKBİM database between 2010 and 2017. A review of these studies reveals that studies in STEM fields conducted up to 2020 have been the subject of the majority of research. Furthermore, the studies that have been examined are not solely focused on science but also encompass other disciplines, including mathematics and engineering.

In this study, it was aimed to conduct a thematic content analysis of STEM studies conducted in only science field in Türkiye and included in journals with Turkish addresses accessed in Social Sciences Citation Index (SSCI) and Education Resources Information Center (ERIC) databases. SSCI is a reliable source of the most significant journals in the international humanities and social sciences (Chen & Du, 2015). ERIC is one of the international field indexes (Ültay & Ültay, 2018). In thematic content analysis, a limited number of studies are examined to gain a deeper understanding of the general framework of the subject under investigation (Çalık & Sözbilir, 2014). Accordingly, it was deemed appropriate to scan the journals of Türkiye origin included in these SSCI and ERIC indexes and to examine the studies of STEM education published in these journals. The problem of this study is to determine the general trend in STEM education research in Türkiye. The sub-problems related to this problem are as follows:

1. What were the aims of STEM studies?
2. What dependent variables were employed in STEM studies?
3. What learning models were integrated with STEM in these studies?
4. Which methods did STEM studies employ?
5. What sample groups did STEM studies utilize?
6. Which sample sizes did STEM studies exploit?
7. What data collection tools did STEM studies utilize?
8. How many data collection tools did STEM studies utilize?
9. What instructional duration did STEM studies prefer?
10. What data analysis methods did STEM studies employ?
11. What were the results of STEM studies?

2. METHOD

2.1. Method

This study utilized the thematic content analysis (meta-synthesis) method, which is a qualitative research approach. Thematic content analysis involves synthesizing and interpreting research on the same subject from a critical perspective within the framework of themes or templates (Çalık & Sözbilir, 2014; Finfgeld, 2003; Walsh & Downe, 2005). Thematic content analysis enables a comprehensive understanding of the structure of the subject under investigation (Au, 2007). In addition, for researchers, teachers, and policymakers who may not have access to all the studies, the synthesis of the common and similar aspects of the different studies on the topic through thematic content analysis could be a valuable reference (Çalık et al., 2005; Gül & Sözbilir, 2015). As thematic content analyses are qualitative, it is common for the number of studies analyzed to be limited (Çalık & Sözbilir, 2014; Gül & Sözbilir, 2015).

2.2. Data Collection

This study examined STEM studies in the field of science education, which were published in educational science journals predominantly from Türkiye, indexed in the SSCI and/or ERIC databases, and published between 2013 and 2022. A review of academic journals reveals that there is only one Turkish-addressed and SSCI-indexed journal: Science and Education. A total of 23 journals, predominantly from Türkiye, were examined in the ERIC database. STEM studies were found in 14 of these journals. A total of 98 studies on STEM were identified in Science and Education and 14 journals. Following the research criteria, 70 studies conducted exclusively in the field of science education (including those related to the environment, physics, chemistry, and biology) were included in the study scope (Appendix A). The journals included in the study are listed in Table 1.

The studies were selected using criterion sampling, one of the purposive sampling methods. In criterion sampling, all situations that meet a set of pre-determined criteria are studied (Yıldırım & Şimşek, 2018). The following criteria were used to define the scope of the research:

- The studies were published in a journal included in the SSCI index or ERIC index,
- The studies were only focused on science education (including environment, physics, chemistry, and biology),
- The studies were conducted in Türkiye.

Table 1. *The Journals and Their Indexes*

Journals	Index	f
Education and Science	SSCI	3
Educational Sciences: Theory & Practice	ERIC	3
Eurasia Journal of Mathematics, Science & Technology Education	ERIC	1
Eurasian Journal of Educational Research	ERIC	7
European Journal of Educational Research	ERIC	2
International Journal of Curriculum and Instruction	ERIC	7
International Journal of Education in Mathematics, Science and Technology	ERIC	7
International Journal of Instruction	ERIC	1
International Journal of Research in Education and Science	ERIC	1
International Online Journal of Education and Teaching	ERIC	7
Journal of Education in Science, Environment and Health	ERIC	7
Journal of Pedagogical Research	ERIC	1
Journal of Turkish Science Education	ERIC	15
Participatory Educational Research	ERIC	7
The Turkish Online Journal of Educational Technology	ERIC	1
Total		70

f= frequency

The journals within the scope of the study were searched until 31 May 2022. The index information of the journals is applicable for the 2022 year. The publication years and frequencies of the studies obtained as a result of the screening are listed in Table 2.

Table 2. *Frequency of the STEM Studies According to Years*

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Frequency (f)	1	1	2	16	4	7	6	14	15	4

2.3. Data Analysis

The 70 studies have been numbered from A1 to A70. The matrix prepared by the researchers was used to analyze and interpret the data. Firstly, the codes corresponding to each category were determined and the articles within the scope of the study were coded according to their content characteristics, and the studies with common characteristics were classified under the same code. Then, categories and themes were formed by bringing together the appropriate codes. Frequency and percentage values were calculated for the codes, and categories.

2.4. Validity and Reliability

In order to ensure the reliability of the study, the researchers employed a two-step coding process. First, they separately coded the variables. Second, they compared the resulting codes. The consistency between the codes was quantified using the formula put forth by Miles and Huberman (1994) (Common codes / (total number of common and non-common codes) x 100), resulting in a value of 96.4%. In accordance with the recommendations of Miles and Huberman (1994, p.64), a 70% degree of concordance between two distinct coders is considered a sufficient threshold for the dependability of qualitative data analysis. The 96.4% of similar data indicates the validity of the analysis. Furthermore, a consensus was reached due to the few discrepancies between the coding and exchange of ideas among the coders, thus reinforcing the reliability of the findings.

Sandelowski and Barroso (2006) identified four categories of validity that are essential to guarantee the validity of thematic content analysis studies (p. 228). To ensure the reliability of the study, the research was conducted following the established criteria for each of the four validity types. The following section outlines the criteria and the procedures carried out in the study for each criterion.

1. Descriptive validity refers to the factual accuracy of the data. It implies that all relevant studies have been included in the research and that the information from each study is accurately defined.
2. Interpretive validity refers to the full and fair representation of the understanding and perspectives of the researchers.
3. Theoretical validity refers to the reliability of the researchers' interpretations.
4. Pragmatic validity refers to the usefulness and transferability of knowledge.

Sandelowski and Barroso (2006) delineated the process of optimizing validity in thematic content analysis studies (p.232). The methodology employed to ensure the validity of this study is presented in Table 3. All actions performed are marked with a cross sign (×).

Table 3. *Types of Validity Provided in the Study*

Validity Type	Descriptive	Interpretive	Theoretic	Pragmatic
Utilize all available communication channels for searching	x			
Consultation with experts in research synthesis			x	
Independent search by at least two persons	x			
Independent assessment of each report by at least two persons	x	x		
Exchange ideas about changes in the process and the results achieved, and document the whole process	x	x	x	x

3. RESULTS / FINDINGS

The aims of the STEM studies in the scope were examined. The frequencies and percentages of the aim category and related codes are presented in Table 4. The studies are presented in the table with their respective codes.

Table 4. *Frequencies and Percentage of the Aims of STEM Studies*

Category	Codes	Studies	f	%
Aim	Determining opinions about STEM education	A6, A15, A18, A19, A21, A31, A32, A43, A44, A45, A54, A55, A58, A59, A68, A70	16	16.33
	Determining the effect of teaching on skill development	A4, A12, A14, A16, A17, A24, A28, A34, A37, A39, A47, A50, A56, A57, A58, A69	16	16.33
	Determining the effect of teaching on affective behaviours	A4, A10, A16, A23, A30, A37, A39, A44, A50, A53, A56, A57, A58, A60	14	14.29
	Affective behavior detection	A5, A8, A11, A20, A27, A31, A33, A61, A66	9	9.18
	Curriculum review	A3, A25, A26, A35, A62, A63, A65	7	7.14
	Content analysis of STEM studies	A13, A22, A42, A51, A64	5	5.10
	Determining the effect of teaching on cognitive behaviours	A36, A37, A52, A53, A57	5	5.10
	Socio cultural and gender studies	A5, A7, A48	3	3.06
	Psychomotor behavior/ Scientific process skills determination	A5, A20, A27	3	3.06
	Metaphor detection	A40, A41	2	2.04
	STEM career choice	A2, A48	2	2.04
	Teacher candidate education	A10, A50	2	2.04
	Instructional material design	A29, A32	2	2.04
	Measurement tool development-adaptation	A49, A67	2	2.04
	Education system and policies	A7, A46	2	2.04
	Environmental education	A54	1	1.02
	In-service training	A16	1	1.02
	Mind map detection	A54	1	1.02
	Misconception detection	A52	1	1.02
	STEM prerequisite determination	A9	1	1.02
	STEM cognitive structure detection	A38	1	1.02
	Use of distance education	A55	1	1.02
	The nature of STEM concepts	A1	1	1.02
Total			98	100

** A study may comprise more than one aim*
f=frequency, %= percentage

Table 4 reveals that the majority of publications in the field of STEM in the SSCI and ERIC index from Türkiye focus on equally two aims: the determination of opinions about STEM education (16.33%) determining the effect of teaching on skill development (16.33%). The analysis revealed that the most frequent aims were, in order, determining the effect of teaching on affective behaviors (14.29%), affective behavior detection (9.18%), curriculum review (7.14%), content analysis of STEM studies (5.10%) and determining the effect of teaching on cognitive behaviors (5.10%), respectively. However, Table 3 indicates that one study each was conducted on the following topics: in-service training (A16), misconception detection (A52), mind map detection (A54), nature of STEM concepts (A1), STEM prerequisite detection (A9), STEM cognitive structure detection (A38), use of distance education (A55) and environmental education (A54).

In the meantime, it is understood that some studies researched more than one subject. To illustrate, the study coded A54 investigated the subjects of opinion determination towards STEM, environmental education and mind mapping; the study coded A5 investigated the subjects of affective behavior determination, psychomotor behavior/scientific process skill determination, socio-cultural and gender; and the study coded A4 investigated the subjects of the effect of instruction on affective behavior and the effect of instruction on skill development.

The dependent variables in the STEM studies were analyzed within the scope of the research. The frequencies and percentages of the dependent variables category and related codes are presented in Table 5. The studies are presented in the table with their respective codes.

Table 5. *Frequencies and Percentage of the Dependent Variables of STEM Studies*

Category	Codes	Studies	f	%
	Achievement	A36, A37, A53	3	8.11
	Attitude towards STEM	A50, A52, A53	3	8.11
	Scientific creativity	A28, A34, A47	3	8.11
	Critical thinking	A4, A39, A51	3	8.11
	STEM perception	A39, A51	2	5.41
	STEM awareness	A10, A58	2	5.41
	Science process skills	A56, A58	2	5.41
	21 century skills	A12, A14	2	5.41
	Ability to prepare lesson plan	A17	1	2.70
	Ability to design STEM learning and teaching processes	A63	1	2.70
	Attitude towards science	A52	1	2.70
Dependent Variables	Attitude towards science and technology	A44	1	2.70
	Conceptual change	A52	1	2.70
	Daily life problem solving	A36	1	2.70
	Engineering perception	A60	1	2.70
	Innovative thinking skills	A69	1	2.70
	Intrinsic motivation	A4	1	2.70
	Reflective thinking skills	A37	1	2.70
	Research skills	A69	1	2.70
	Problem solving perception	A4	1	2.70
	Psychomotor skills	A37	1	2.70
	STEM career interest	A30	1	2.70
	STEM profession interest	A56	1	2.70
	STEM semantic perceptions	A50	1	2.70
	STEM teaching tendency	A10	1	2.70
Total			37	100

** A study may include more than one dependent variable. f=frequency, %= percentage*

Table 5 illustrates that the dependent variables on which the impact of STEM education has been most extensively researched were achievement, attitude towards STEM, scientific creativity, and critical thinking, with an equal percentage (8.11%). The subsequent dependent variables used were STEM perception, STEM awareness, science process skills, and 21st-century skills, which have equal percentage (5.41%). Moreover, an analysis of the studies according to the number of independent variables revealed that the studies in which only a single independent variable was examined were the most common, while the studies in which three independent variables were examined were the least common. A single independent variable was examinedin 12 studies (A12, A14, A17, A28, A30, A34, A44, A47, A52, A58, A60, A63). In eight studies, two independent variables were examined. These were A4, A36, A39, A50, A51, A53, A56 and A69. In only two studies, three independent variables were examined. These were A37, A50 and A60.

The learning models integrated with STEM were investigated in the STEM. Table 6 shows the findings related to the teaching methods and practices integrated with STEM in the analyzed studies. The studies are presented in the table with their respective codes.

Table 6 demonstrates that in 20 studies, STEM education was implemented in conjunction with various learning models. Among these learning methods, STEM education was most commonly implemented with the project-based learning method (20.0%). Then it was followed by inquiry-based learning, out-of-school learning, the socio-scientific method, and engineering design-based learning with an equal percentage (10.0%).

Table 6. *Frequencies and Percentage of the Learning Models Integrated with STEM*

Category	Codes	Studies	f	%
Learning Model	Project-based learning	A10, A12, A19, A24	4	20
	Engineering design-based learning	A39, A56	2	10
	Inquiry-based learning	A27, A47	2	10
	Out-of-school learning	A11, A30	2	10
	Socio-scientific method	A14, A15	2	10
	Cooperative learning	A1	1	5
	Argumentation	A37	1	5
	Digital game-technology oriented learning	A29	1	5
	Game-based learning	A4	1	5
	Mathematical modelling	A46	1	5
	Robotic applications	A70	1	5
	Simulation supported learning	A58	1	5
	Virtual reality	A68	1	5
Total			20	100

f=frequency, %= percentage

The research approach, design, and method used in the analyzed studies were investigated. The frequencies and percentages of the methodology/design category a are presented in Table 7. The studies are presented in the table with their respective codes.

Table 7. *Frequencies and Percentage of the Methodology/Design in STEM Studies*

Category	Sub-category	Codes	Studies	f_{code}	$\%_{code}$	f_{sc}	$\%_{sc}$
Methodology/ Design	Quantitative	Quasi-experimental	A28, A37, A47	3	4.29	20	28.57
		Pre-experimental	A10, A12, A52, A60	4	5.71		
		Descriptive	A2, A55, A66	3	4.29		
		Correlational	A20	1	1.43		
		Survey	A5, A8, A18, A29, A33, A49, A61, A67	8	11.43		
		Meta-analysis	A57	1	1.43		
	Qualitative	Culture analysis	A7	1	1.43	37	52.86
		Phenomenology	A1, A19, A38, A40, A41, A43, A70	7	10.00		
		Case-study	A6, A9, A11, A15, A16, A17, A21, A23, A27, A32, A39, A45, A48, A54, A59, A68	16	22.86		
		Action research	A44	1	1.43		
		Individual- self research	A31	1	1.43		
		Document analysis	A35, A62	2	2.86		
		Review	A46, A65	2	2.86		
		Concept analysis	A26	1	1.43		
		Content analysis	A3, A22, A25, A42, A51, A64	6	8.57		
	Mixed	Explanatory	A4, A13, A24, A36, A53, A56, A58	7	10.00	13	18.57
		Exploratory	A34	1	1.43		
		Triangulation	A50, A69	2	2.86		
		Embedded	A14, A30	2	2.86		
		Multiphase	A63	1	1.43		
Total				70	100		

**f_{code}: Frequency of code, $\%_{code}$: Percentage of code, f_{sc}: Frequency of sub-category, $\%_{sc}$: Percentage of sub-category*

In Table 7, the category presents the research approaches, the sub-category presents the research designs, and the codes present the research methods. As evidenced by Table 6, studies within the STEM disciplines are predominantly qualitative in terms of research methodology (52.86%) and interactive in terms of research design (34.29%). Case study has been identified as the most prevalent research method employed in STEM studies (%22.86). It is observed that phenomenology and explanatory research methods share second place with equal percentages (10.0%). Nevertheless, Table 7 indicates that correlational, meta-analysis, cultural analysis, action research, individual-self research, concept analysis, exploratory, and multiphase research methods are the least favored research approaches in STEM studies.

The sample levels of the STEM studies were examined. The frequencies and percentages of the sample level category is presented in Table 8. The studies are presented in the table with their respective codes.

Table 8. *Frequencies and Percentage of the Sample Levels in STEM Studies*

Category	Codes	Studies	f	%
Sample Level	Pre-school	A19, A27	2	2.86
	Primary school	A4	1	1.43
	Secondary school	A5, A7, A11, A14, A28, A29, A30, A33, A36, A37, A39, A40, A41, A44, A45, A47, A49, A52, A53, A56, A59, A60, A66, A69	24	34.29
	High school	A12, A34, A48	3	4.29
	Undergraduate	A1, A6, A8, A10, A15, A17, A20, A21, A23, A24, A32, A38, A43, A50, A54, A58, A61, A63, A70	19	27.14
	Teacher	A9, A16, A18, A31, A55, A67, A68	7	10.00
	Document	A2, A3, A13, A22, A25, A35, A42, A51, A57, A62, A64	11	15.71
	No sample size	A26, A46, A65	3	4.29
Total			70	100

f=frequency, %= percentage

Table 8 shows that the most preferred sample level used in STEM studies was secondary school (34.29%). It can be seen that the undergraduate level was in second place (24.14%) and the document was in third place (15.71%). Furthermore, Table 6 shows that the least used sample level was pre-school (2.86%) and three studies did not specify the sample level.

The sample sizes of the STEM studies were investigated. The frequencies and percentages of the sample sizes category are illustrated in Table 9. The studies are presented in the table with their respective codes.

Table 9. *Frequencies and Percentage of the Sample Sizes in STEM Studies*

Category	Codes	Studies	f	%
Sample Size	1-10	A3, A9, A31, A35, A55, A62, A68	7	10.00
	11-50	A1, A4, A11, A12, A13, A14, A15, A16, A17, A19, A21, A22, A23, A27, A30, A32, A36, A37, A39, A42, A43, A44, A45, A50, A51, A52, A53, A54, A56, A57, A58, A59, A60, A63	34	48.57
	51-100	A7, A25, A28, A40, A41, A47, A64	7	10.00
	101-200	A6, A10, A20, A24, A33, A34, A38, A61, A69	9	12.86
	201-500	A5, A8, A18, A48, A66, A70	6	8.57
	501-1000	A29, A67	2	2.86
	Over than1000	A2, A49	2	2.86
	No sample size	A26, A46, A65	3	4.29
Total			70	100

f=frequency, %= percentage

Table 9 shows that between 11 and 50 sample size was the most preferred in STEM studies (48.57%). Moreover, it presents that sample sizes between 201 and 500 and between 501 and 1000 were the least preferred sample sizes in STEM studies, with the same percentage (2.86%). In addition, Table 8 also presents that three studies did not specify the sample size.

Data collection tools used in STEM studies were examined. The frequencies and percentages of data collection tools category is illustrated in Table 10. The studies are presented in the table with their respective codes.

Table 10. *Frequencies and Percentage of Data Collection Tools in STEM Studies*

Category	Codes	Studies	f	%
Data Collection Tool	Questionnaire/Form	A9, A10, A11, A16, A18, A22, A23, A24, A32, A33, A36, A40, A41, A48, A50, A51, A63, A64, A70	19	15.83
	Achievement/Concept test	A24, A28, A34, A36, A37, A47, A52, A53, A56, A58	10	8.33
	Scale	A4, A5, A8, A10, A12, A14, A20, A30, A37, A39, A44, A49, A50, A52, A53, A56, A58, A60, A61, A66, A67, A69	22	18.33
	Interview	A4, A6, A7, A9, A12, A14, A15, A19, A21, A27, A30, A31, A38, A39, A43, A44, A45, A53, A54, A55, A56, A58, A59, A63, A68, A69	26	21.67
	Observation	A4, A6, A7, A27, A31, A69	6	5.00
	Field notes	A6, A7, A14, A15, A44, A59, A69	7	5.83
	Alternative tools	A4, A9, A23, A24, A25, A29, A37, A38, A44, A54	10	8.33
	Document	A1, A2, A3, A7, A9, A13, A16, A17, A24, A31, A35, A44, A53, A57, A59, A62	16	13.33
	No data collection	A26, A42, A46, A65	4	3.33
Total			113	100

** A study may include more than one type of data collection tool*
f=frequency, %= percentage

Table 10 indicates that interview was mostly preferred data collection tools in STEM studies (21.67%). It is seen that the scale was in second place (18.33%) and the questionnaire/form was in third place (15.83%). Furthermore, Table 10 indicates that observation was the least preferred data collection tool, and in four studies used any data collection tool.

Table 11. *Frequencies and Percentage of Number of Data Collection Tools in STEM Studies*

Category	Codes	Studies	f	%
Number of Data Collection Tool	1	A1, A2, A3, A11, A13, A17, A18, A19, A21, A22, A25, A28, A29, A32, A33, A34, A35, A40, A41, A43, A45, A47, A48, A51, A55, A57, A60, A61, A62, A64, A67, A68, A70	33	47.14
	2	A5, A8, A10, A15, A16, A20, A23, A27, A36, A38, A49, A54, A63	13	18.57
	3	A6, A12, A31, A37, A39, A50, A52, A56, A58, A59, A66	11	15.71
	4	A7, A30, A53	3	4.29
	5	A14, A24, A44	3	4.29
	6	A4, A69	2	2.86
	7	A9	1	1.43
	No number	A26, A42, A46, A65	4	5.71
Total			70	100

f=frequency, %= percentage

The number of data collection tools employed in STEM studies was examined. The frequencies and percentages of the number of data collection tools category are presented in Table 11. The studies are presented in the table with their respective codes.

Table 11 indicates that the majority of STEM studies employed a single data collection tool (47.14%). Moreover, it is seen that the least of STEM studies used seven data collection tools (1.43%). In addition, the frequency and number of data collections appear to be inversely proportional.

The instructional durations of STEM studies were analyzed. The frequencies and percentages of the instructional duration category are presented in Table 12. The studies are presented in the table with their respective codes.

Table 12 shows that the instructional duration of 29 studies varied between one week to 24 weeks. It seems that the most commonly preferred instructional duration was four weeks (17.24%). Table 11 also shows that 6 weeks, 8 weeks, and 14 weeks with instructional duration shared second place in STEM studies, with equal percentages (13.79%).

Tablo 12. *Frequencies and Percentage of STEM Studies' Instructional Duration*

Category	Codes	Studies	f	%
Instructional duration	1 week	A30	1	3.45
	2.5 week	A52	1	3.45
	3 week	A11, A36	2	6.90
	4 week	A1, A12, A27, A32, A54	5	17.24
	5 week	A39	1	3.45
	6 week	A28, A45, A47, A69	4	13.79
	8 week	A4, A59, A60, A68	4	13.79
	9 week	A23	1	3.45
	10 week	A58	1	3.45
	12 week	A34	1	3.45
	13 week	A9, A17	2	6.90
	14 week	A15, A31, A44, A63	4	13.79
	15 week	A56	1	3.45
	24 week	A14	1	3.45
Total			29	100

f=frequency, %= percentage

Data analysis methods of STEM studies were investigated. The frequencies and percentages of data analysis category are presented in Table 13. The studies are presented in the table with their respective codes.

Table 13. *Frequencies and Percentage of Data Analysis in STEM studies*

Category	Sub-category	Codes	Studies	f_{code}	$\%_{code}$	f_{sc}	$\%_{sc}$
Data Analysis	Quantitative	Descriptive statistics with tables	A2, A4, A5, A8, A10, A14, A18, A25, A28, A29, A30, A34, A37, A39, A48, A50, A52, A53, A60, A61, A66, A69	22	17.19	73	57.03
		Figure/graphic	A2, A13, A57, A67	4	3.13		
		t-test	A4, A5, A8, A14, A25, A28, A30, A34, A39, A50, A52, A53, A61, A69	14	10.94		
		Correlation	A5, A8, A20, A24, A25	5	3.91		
		ANOVA/ANCOVA	A10, A30, A61, A66, A69	5	3.91		
		Factor analysis	A49, A67	2	1.56		
		Regression	A8	1	0.78		
		Non-parametric	A12, A18, A20, A25, A36, A37, A39, A44, A47, A53, A56, A60, A63, A66	14	10.94		
		Effect size	A13, A34, A39, A52, A57, A58	6	4.69		
	Qualitative	Content analysis	A1, A3, A4, A11, A12, A13, A14, A15, A16, A19, A21, A22, A25, A27, A30, A31, A32, A33, A34, A35, A36, A40, A41, A42, A43, A44, A45, A50, A51, A53, A54, A55, A58, A62, A63, A64, A68, A70	38	29.69	55	42.97
		Descriptive analysis	A6, A8, A9, A15, A16, A17, A23, A24, A33, A36, A38, A39, A44, A56, A59, A69	16	12.50		
		Constant- comparative	A7	1	0.78		
Total				128	100		

** A study may include more than one data analysis method*
f_{code}:=frequency of code, $\%_{code}$:= percentage of code, f_{sc}= frequency of sub-category, $\%_{sc}$= percentage of sub-category

Table 13 indicates that quantitative analysis methods were employed with greater frequency than qualitative data analysis methods in STEM studies. However, Table 13 shows that content analysis was the first place, descriptive analysis with tables was the second place, t-test, and non-parametric analysis were the third places with equal percentages. However, regression and constant-comparative were the least used as data analysis methods with equal percentages in STEM studies.

The results related the effects of STEM education on dependent variables were examined. The frequencies and percentages of the result category are presented in Table 14. The studies are presented in the table with their respective codes.

Table 14. *Results on the Effect of STEM Education on Variables*

Category	Sub-category	Codes	Studies	f_{code}	$\%_{code}$	f_{sc}	$\%_{sc}$
Result	A positive effect was found	Attitude towards STEM	A50, A52, A53	3	8.11	32	86.49
		Scientific creativity	A28, A34, A47	3	8.11		
		Achievement	A37, A53	2	5.41		
		Critical thinking	A39, A51	2	5.41		
		Scientific process skills	A56, A58	2	5.41		
		STEM awareness	A10, A58	2	5.41		
		STEM perception	A39, A51	2	5.41		
		21-st century skills	A12, A14	2	5.41		
		Ability to prepare lesson plan	A17	1	2.70		
		Attitude towards science and technology	A44	1	2.70		
		Competence to design the learning-teaching process according to STEM	A63	1	2.70		
		Conceptual change	A52	1	2.70		
		Daily life problem solving	A36	1	2.70		
		Engineering perception	A60	1	2.70		
		Innovative thinking skills	A37	1	2.70		
		Intrinsic motivation	A4	1	2.70		
		Psychomotor skills	A37	1	2.70		
		Reflective thinking	A37	1	2.70		
		Research skills	A69	1	2.70		
		STEM career interest	A30	1	2.70		
		STEM profession interest	A56	1	2.70		
		STEM teaching tendency	A10	1	2.70		
	A positive effect was not found	Achievement	A36	1	2.70	5	13.51
		Attitude towards science	A52	1	2.70		
		Critical thinking	A4	1	2.70		
		Problem-solving perception	A4	1	2.70		
		STEM semantic perception	A50	1	2.70		
Total				37	100		

f=frequency, %= percentage

Table 14 indicates that STEM education had a statistically significant positive effect on the dependent variables, with a percentage of 86.49%. Table 13 also indicates that the dependent variables exhibiting the most positive effects were scientific creativity and attitude towards STEM, with equal percentages (8.11%). Conversely, STEM education did not have a statistically significant positive effect on the dependent variables, with a percentage of 13.51%. As can be seen in a positive effect was not found sub-category, the dependent variables, achievement, attitude toward science, critical thinking, problem-solving perception, and STEM semantic perception had the same percentage (2.70%).

4. DISCUSSION and CONCLUSION

This study sought to ascertain the general trajectory of STEM studies in Türkiye over the past decade. To this end, 70 STEM studies published in 15 educational science journals and indexed in the SSCI or ERIC database between 2013 and 2022 were subjected to analysis. The aforementioned studies were subjected to a thematic content analysis employing parameters including the studies' stated aims, dependent variables, learning models that integrate with STEM, research methods, the composition of sample groups, sample sizes, data collection tools, number of data collection tools, instructional durations, data analysis methods, and results.

Upon examination of the aims of the study, it was observed that the aims of opinion determination towards STEM education and the effect of teaching on skill development were the most extensively studied, followed by the effect of teaching on affective behaviors. This result is comparable to that obtained by Kaya and Ayar (2020). Kaya and Ayar (2020) identified the most studied topics in STEM education studies in Türkiye as opinions towards STEM education, attitudes towards STEM education, and skills towards STEM education, respectively. Sarica (2020) found that the most studied topic was skill development, followed by opinion formation. The high number of studies whose aim or purpose is to determine opinions is thought to be due, at least in part, to the desire to collect more detailed information from the sample group through interviews or open-ended surveys after STEM education. Moreover, It has been demonstrated that there is a dearth of studies about in-service training, misconception detection, mind mapping detection, the nature of STEM concepts, STEM prerequisite determination, STEM cognitive structure detection, the utilization of distance education in STEM education, and environmental education in STEM education.

The study revealed that the dependent variables in which the effect of STEM education was most extensively examined as an independent variable were achievement, attitude towards STEM, scientific creativity, and critical thinking, with equal percentages. The results appear to be in close alignment with those of several previous studies in the literature, including those by Aydın-Günbatar & Tabar (2019), Çavaş et al. (2020), Ecevit et al. (2022), and Gülhan (2022). For instance, Çavaş et al. (2020) observed that in the postgraduate theses and articles in the field of STEM education in Türkiye between 2010 and 2018, skills were predominantly examined as dependent variables, followed by attitude and achievement. Ecevit et al. (2022) found that the most frequently studied dependent variables in graduate theses and articles in the field of STEM education between 2014 and 2020 in Türkiye were attitude, achievement and problem-solving skills, respectively.

This study revealed that the most integrated approach to STEM education was project-based learning. This result was also found in the study conducted by Zulaikha et al. The reason why the project-based learning model is more integrated with STEM education is that they are similar in many ways. Furthermore, project-based teaching can facilitate the acquisition of numerous 21st-century skills, which is one of the fundamental objectives of STEM education (Katz & Chard, 2000, p.161). Furthermore, the present study revealed that, following project-based learning, STEM education became more integrated with inquiry-based learning, out-of-school learning, socio-scientific learning, and engineering design-based learning.

The case study method was identified as the most frequently employed research method in the publications examined in the current study. Similarly, studies in the literature have indicated that the case study method is the most frequently employed research method in STEM education studies (Aydın-Günbatar & Tabar, 2019; Çavaş et al., 2020; Kızılay, 2018; Özcan & Karabaş, 2019). Furthermore, in the studies examined, it was observed that after the case study method, survey, phenomenology, and explanatory research methods were used more frequently. In addition correlational, meta-analysis, culture analysis, action research, concept analysis, and exploratory research methods were used very rarely in STEM studies.

The sample groups most commonly employed in STEM studies were examined, with the results indicating that studies conducted with secondary school students were found to be the most prevalent. Similar findings were identified in many studies within the literature (Daşdemir et al., 2018; Eren & Dökme, 2022; Ergün, 2020; Gülhan, 2022; Kalemkuş, 2020; Mandev & Yavuz, 2022; Özcan & Karabaş, 2019; Sarica, 2020; Püskullü, 2019). It is hypothesized that the incorporation of STEM education into the 2018 Science Curriculum, encompassing Science, Engineering, and Entrepreneurship Practices, has been effective in increasing the number of STEM education studies, particularly at the secondary school level. Furthermore, it was determined that the most frequently studied sample group after secondary school students was undergraduate students, while the least frequently studied sample groups were preschool and primary school students.

In addition, the most frequently studied sample sizes were also examined in STEM studies. It was determined that the most commonly used sample size was between 11 and 50. In the study conducted by Ormancı (2020), the most frequently used sample size was found to be in a similar range (between 31 and 50) to the current study.

In this study, the interview was identified as the principal data collection tool in STEM studies. Some studies have reached similar findings in the literature (Çalışkan & Okuşluk, 2021; Kızılay, 2018; Püsküllü, 2019). However, it was concluded that observation was the least used data collection tool in this study. Furthermore, it was found that the majority of studies employed a single data collection tool, with the number of studies decreasing as the number of data collection tools used increased. It is notable that no study in the literature can be related to this data.

This study revealed that the instructional duration employed varied considerably between one and 24 weeks. The most frequently used instructional duration was four weeks, followed by six, eight, and 14 weeks, each of which occurred at equal rates. Kalemkuş (2020) determined that the most common instructional duration was six to 10 weeks. In the study conducted by Aydın-Günbatar and Tabar (2019), the most common instructional duration was observed to be between one and two months (4-8 weeks). The findings of this study indicate that one of the most common aims of STEM studies is to determine the effect of teaching on skill development. It is reasonable to assume that skill development will not be achieved in a relatively short period. Therefore, it is deemed appropriate that the instructional duration should be extended to a minimum of four weeks or more.

Upon examination of the data analysis methods employed in the studies, it was found that quantitative data analysis methods were utilized more frequently than qualitative data analysis methods. However, it appears that the majority of the data was analyzed using content analysis. Ecevit et al. (2022) and Sungur Gül et al. (2022) defined content analysis as the most frequently used data analysis method.

The results of the studies examining the effect of STEM education on the dependent variables were analyzed. The findings demonstrated that STEM education had a statistically significant, positive effect on the dependent variables at a rate of 86.49%, whereas the effect was not statistically significant for the remaining 13.51%. The analysis revealed that the dependent variables exhibiting the most positive effects were scientific creativity and attitude toward STEM. The number of studies examining the results of STEM education in the literature is relatively limited (Duran & Sarı, 2021; Ültay et al., 2021). In Duran and Sarı's (2021) study, it was found that STEM education had the most positive effect on academic achievement. Ültay et al. (2021) categorized the results of all STEM education studies they examined. In this study, it was found that there was a positive tendency according to STEM, with a positive opinion that STEM education increased students' attitudes and interest towards science courses.

Consequently, it has been established that the number of studies on STEM education conducted in Türkiye and published in SSCI or ERIC-indexed journals has gradually increased over the past decade. The majority of studies included in this review were conducted with secondary school students. The qualitative research approach and the case study method were the most frequently employed research methods, while content analysis was the most prevalent method used for data analysis. Furthermore, the results of these studies indicated that STEM education had the most positive effect on attitudes towards STEM and scientific creativity. Furthermore, the effect of STEM education on academic performance, critical thinking, scientific creativity, and attitudes towards STEM was investigated. The findings suggest that STEM education has a predominantly positive effect on scientific creativity and attitudes towards STEM.

4.1. Suggestions

The analysis of the studies revealed that only a small number of studies were focused on specific objectives, including metaphor determination, career choice for STEM disciplines, pre-service teacher education, instructional material design, measurement tool development and improvement, education system and policies, in-service training, misconception determination, mind map determination, prerequisite and cognitive structure determination related to STEM, and distance education and environmental education. It can be concluded that there is a need for further studies to be conducted on these objectives.

It has been observed that variables such as self-efficacy, self-confidence, and scientific literacy etc. are not included as dependent variables in STEM studies. These variables may be included as dependent variables in future STEM studies.

A review of the literature revealed a paucity of studies that integrated STEM education with a range of pedagogical approaches, including cooperative learning, argumentation, technology-supported teaching, mathematical modeling, game-based learning, and simulation-supported research learning methods. However, there is potential for further research in this area, with studies being conducted in this field integrating STEM education with models such as problem-based learning, the 5E model, the REACT model, and others.

The studies observed were predominantly conducted using qualitative research methods, with mixed methods employed in the lowest percentage. Consequently, there is scope to expand the body of literature utilizing this approach. The case study was the method employed in most of the studies, although only a few employed other methods, including correlational, meta-analysis, cultural analysis, action research, concept analysis, and exploratory research. There is a potential for further studies to employ these research methods within the context of STEM education.It has been observed that the number of studies involving primary school, pre-school, and high school students as a sample is very low. It is therefore recommended that studies on STEM education involving students at these educational levels be emphasized. It was observed that the sample size of the analyzed studies was mostly between 11-50. However, studies with sample sizes outside this range can be conducted.

As observation and field notes were seldom employed as data collection instruments in the studies analyzed, further research utilizing these techniques could be conducted. The findings revealed that a significant majority of studies employed a single data collection instrument, with a markedly lower proportion utilizing four or more. Therefore, it is recommended that the number of data collection instruments be augmented in future studies.It has been observed that regression analysis is rarely employed in studies within the STEM disciplines. However, there is potential for the use of regression analysis in the future to inform educational practice within this field.

This study focused on analyzing only those studies published in SSCI or ERIC-indexed journals to determine the status of STEM education in Türkiye. It is recommended that this study be expanded in the future by examining STEM studies conducted in Türkiye and scanned in other international indexes.

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Declaration of Conflicting Interests and Ethics

In terms of the ethical standards that govern research, the approval of an ethics committee is not a prerequisite for this study.

Authorship Contribution Statement

İnanç Kösen: Conceptualization, Investigation, Methodology, Analysis, Writing e original draft.
Hülya Dede: Conceptualization, Supervision, Validation, Writing e review, and editing.

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APPENDIX A. STEM Studies in the Scope of the Research

Codes	STEM Studies
A1	Akaygun, S., & Aslan-Tutak, F. (2016). STEM images revealing stem conceptions of pre-service chemistry and mathematics teachers. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 56-71.
A2	Akgunduz, D. (2016). A Research about the placement of the top thousand students placed in STEM fields in Turkey between the years 2000 and 2014. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(5), 1365-1377.
A3	Aktürk, A. A., Demircan, H. Ö., Şenyurt, E., & Çetin, M. (2017). Turkish early childhood education curriculum from the perspective of STEM education: A document analysis. *Journal of Turkish Science Education*, *14*(4), 16-34.
A4	Asigigan, S. I. & Samur, Y. (2021). The effect of gamified STEM practices on students' intrinsic motivation, critical thinking disposition levels, and perception of problem-solving skills. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, *9*(2), 332-352.
A5	Atabey, N. & Topcu, M.S. (2021). The relationship between Turkish middle school students' 21st century skills and STEM career interest: Gender effect. *Journal of Education in Science, Environment and Health (JESEH)*, *7*(2), 86-103.
A6	Ayar, M. C. (2015). First-hand experience with engineering design and career interest in engineering: An informal STEM education case study. *Educational Sciences: Theory & Practice*, *15*(6), 1655-1675.
A7	Ayar, M.C. & Yalvac, B. (2016). Lesson learned: Authenticity, interdisciplinarity, and mentoring for STEM learning environments. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 30-43.
A8	Gürler, S. A. (2021). State of prediction of the critical thinking dispositions of primary school teacher candidates through their self-efficacy for STEM practices. *Participatory Educational Research*, *9*(3), 62-81.
A9	Aydin, G. (2020). Prerequisites for elementary school teachers before practicing STEM education with students: A case study. *Eurasian Journal of Educational Research*, *20*(88), 1-40.
A10	Aydogan Yenmez, A., Gökce, S., Aydede, M.N. & Çelik, T. (2021). Investigation of pre-service teachers' awareness of STEM and STEM teaching intention. *International Online Journal of Education and Teaching (IOJET)*, *8*(1). 250-260.
A11	Baran, E., Canbazoglu Bilici, S., Mesutoglu, C. & Ocak, C. (2016). Moving STEM beyond schools: Students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 9-19.
A12	Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st century skills. *Journal of Turkish Science Education*, *18*(4), 798-815.
A13	Batdi, V., Talan, T., & Semerci, C. (2019). Meta-analytic and meta-thematic analysis of STEM education. *International Journal of Education in Mathematics, Science and Technology (IJEMST)*, *7*(4), 382-399.
A14	Benek, I., & Akcay, B. (2021). The effects of socio-scientific STEM activities on 21st century skills of middle school students. *Participatory Educational Research*, *9*(2), 25-52.
A15	Bozkurt Altan, E., Ozturk, N. & Yenilmez Turkoglu, A. (2018). Socio-scientific issues as a context for STEM education: A case study research with pre-service science teachers. *European Journal of Educational Research*, *7*(4), 805-812.
A16	Altan, E. B., & Ercan, S. (2016). STEM education program for science teachers: perceptions and competencies. *Journal of Turkish Science Education*, *13*(special), 103-117.
A17	Altan, E. B., & Ucuncuoglu, I. (2019). Examining the development of pre-service science teachers' STEM-focused lesson planning skills. *Eurasian Journal of Educational*

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A18 Çavaş, B., Çapar, S., Çavaş, L., & Yahşi, Ö. (2021). Turkish STEM Teachers' Opinions about the Scientist-Teacher-Student Partnership. *Journal of Turkish Science Education (TUSED), 18*(4), 622-637.

A19 Çetin, A. (2020). Examining project-based STEM training in a primary school. *International Online Journal of Education and Teaching (IOJET), 7*(3). 811- 825.

A20 Çetin, A. (2021). Investigation of the relationship between the STEM awareness and questioning skills of pre-service teachers. *International Journal of Research in Education and Science (IJRES), 7*(1), 65-81.

A21 Cetin, A., & Balta, N. (2017). Pre-service science teachers views on stem materials and stem competition in instructional technologies and material development course. *European Journal of Educational Research, 6*(3), 279-288.

A22 Çevik, M. (2017). Content analysis of STEM-focused education research in Turkey. *Journal of Turkish Science Education, 14*(2), 12-26.

A23 Çınar, S., Pırasa, N., Uzun, N., & Erenler, S. (2016). The Effect of Stem Education on Pre-Service Science Teachers' Perception of Interdisciplinary Education. *Journal of Turkish Science Education (TUSED), 13*(Special Issue), 118-142.

A24 Corlu, M.A. & Aydin, E. (2016). Evaluation of learning gains through integrated STEM projects. *International Journal of Education in Mathematics, Science and Technology, 4*(1), 20-29.

A25 Corlu, M. S. (2013). Insights into STEM education praxis: An assessment scheme for course syllabi. *Educational Sciences: Theory & Practice, 12*(4), 2477-2485.

A26 Corlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers in the age of innovation. *Science and Education, 39*(171), 74-85.

A27 Dilek, H., Tasdemir, A., Konca, A.S. & Baltaci, S. (2020). Preschool children's science motivation and process skills during inquiry-based STEM activities. *Journal of Education in Science, Environment and Health (JESEH), 6*(2), 92-104.

A28 Dogan, A., & Kahraman, E. (2021). The Effect of STEM Activities on the Scientific Creativity of Middle School Students. *International Journal of Curriculum and Instruction, 13*(2), 1241-1266.

A29 Donmez, I., Tekce, M. & Kirmit, S. (2020). Using digital games in technology oriented STEM education: The examination of the students' game designs. *Journal of Education in Science, Environment and Health (JESEH), 6*(2), 77-91.

A30 Donmez, I. (2021). Impact of out-of-school STEM activities on STEM career choices of female students. *Eurasian Journal of Educational Research, 91*, 173-203.

A31 Dönmez, İ., & Taşar, M. F. (2020). A self-study on the values and beliefs of science teachers and their science, technology, engineering and mathematics (STEM) applications. *Participatory Educational Research, 7*(1), 59-79.

A32 Ercan, S., Bozkurt altan, E., Taştan, B., & Dağ, İ. (2016). Integrating GIS into science classes to handle STEM education. *Journal of Turkish Science Education (TUSED), 13*(Special Issue), 30-43.

A33 Ergun, A., & Balcin, M. D. (2019). The perception of engineers by middle school students through drawings. *Eurasian Journal of Educational Research, 19*(83), 1-28.

A34 Eroglu, S. & Bektas, O. (2022). The effect of STEM applications on the scientific creativity of 9th-grade students. *Journal of Education in Science, Environment and Health (JESEH), 8*(1), 17-36.

A35 Yapıcıoğlu, A. E. (2021). An analysis of the outcomes of the Turkish science curriculum in terms of science process skills, nature of science, socio-scientific issues, and STEM: An analysis of the outcomes of the Turkish science curriculum. *International Journal of Curriculum and Instruction, 13*(2), 925-949.

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A37 Gülen, S. & Yaman, S. (2019). The effect of integration of STEM disciplines into Toulmin's argumentation model on students' academic achievement, reflective thinking, and psychomotor skills. *Journal of Turkish Science Education, 16*(2), 216-230.

A38	Hacıoğlu, Y., Yamak, H., & Kavak, N. (2016). Pre-service science teachers' cognitive structures regarding science, technology, engineering, mathematics (STEM) and science education. *Journal of Turkish Science Education*, *13*(special), 88-102.
A39	Hacioglu, Y. & Gulhan, F. (2021). The effects of STEM education on the students' critical thinking skills and STEM perceptions. *Journal of Education in Science, Environment and Health (JESEH)*, *7*(2), 139-155.
A40	Idin, S. & Donmez, I. (2018). A metaphor analysis study related to STEM subjects based on middle school students' perceptions. *Journal of Education in Science, Environment and Health (JESEH)*, *4*(2), 246-257.
A41	İdin, Ş. (2019). The metaphors of Turkish, Bulgarian and Romanian students on STEM disciplines. *International Journal of Curriculum and Instruction*, *11*(2), 147-162.
A42	Kanadlı, S. (2019). A meta-summary of qualitative findings about STEM education. *International Journal of Instruction*, *12*(1), 959-976.
A43	Karademir, A., & Yıldırım, B. (2021). A Different perspective on preschool STEM education: Preschool STEM education and engineering for preservice teachers. *Journal of Turkish Science Education*, *18*(3), 338-350.
A44	Karahan, E., Canbazoglu-Bilici, S., & Unal, A. (2015). Integration of media design processes in science, technology, engineering, and mathematics (STEM) education. *Eurasian Journal of Educational Research*, *60*, 221-240.
A45	Karakaya, F., Alabaş, Z.E., Akpınar, A., & Yılmaz M. (2020). Determination of middle school students' views about stem activities. *International Online Journal of Education and Teaching (IOJET)*, *7*(2), 537-551.
A46	Kertil, M. & Gurel, C. (2016). Mathematical modeling: A bridge to STEM education. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 44-55.
A47	Kırıcı, M. G., & Bakırcı, H. (2021). The effect of STEM supported research-inquiry-based learning approach on the scientific creativity of 7th grade students. *Journal of Pedagogical Research*, *5*(2), 19-35.
A48	Kizilay, E., Yamak, H., & Kavak, N. (2020). Analysis of the female student profiles who consider choosing STEM careers. *International Journal of Curriculum and Instruction*, *12*(2), 164-175.
A49	Koyunlu Unlu, Z., Dokme, I., & Unlu, V. (2016). Adaptation of the science, technology, engineering, and mathematics career interest survey (STEM-CIS) into Turkish. *Eurasian Journal of Educational Research*, *63*, 21-36.
A50	Mirici, S., Gencer, İ., & Gündüz, S. (2019). The impact of STEM project writing education on candidate female teachers' attitudes, their semantic perceptions and project writing skills towards STEM education. *International Journal of Curriculum and Instruction*, *11*(2), 255-272.
A51	Ormancı, Ü. (2020). Thematic content analysis of doctoral theses in STEM education: Turkey context. *Journal of Turkish Science Education*, *17*(1), 126-146.
A52	Ozdemir, Benli, E. (2021). The impacts of stem supported Science teaching on 8th grade students' elimination of misconceptions about "solid, fluid and gas pressure", and their attitudes towards Science and STEM. *International Online Journal of Education and Teaching (IOJET)*, *8*(1), 205-228.
A53	Özcan, H., & Koca, E. (2019). The impact of teaching the subject "pressure" with STEM approach on the academic achievements of the secondary school 7th grade students and their attitudes towards STEM. *Science and Education*, *44*(198), 201-227.
A54	Sümen, Ö. Ö., & Çalisici, H. (2016). Pre-service teachers' mind maps and opinions on STEM education implemented in an environmental literacy course. *Educational sciences: Theory and practice*, *16*(2), 459-476.
A55	Ozdemir, E. B. (2021). Views of science teachers about online STEM practices during the COVID-19 period. *International Journal of Curriculum and Instruction*, *13*(1), 854-869.
A56	Özkul, H., & Özden, M. (2020). Investigation of the effects of engineering-oriented STEM integration activities on scientific process skills and STEM career interests: A mixed methods study. *Science and Education*, *45*(204), 41-63.
A57	Saraç, H. (2018). The effect of science, technology, engineering and mathematics-STEM

educational practices on students' learning outcomes: A meta-analysis study. *Turkish Online Journal of Educational Technology-TOJET, 17*(2), 125-142.

A58 Sarı, U., Duygu, E., Şen, Ö. F., & Kırındı, T. (2020). The effect of STEM education on scientific process skills and STEM awareness in simulation based inquiry learning environment. *Journal of Turkish Science Education, 17*(3), 387-405.

A59 Akdağ, F. T., & Güneş, T. (2016). Assessment of STEM applications in terms of students' opinions. *Participatory Educational Research*, *4*(1), 161-169.

A60 Akdağ, F. T., & Güneş, T. (2016). The effect of STEM applications on students' science-engineering perceptions. *Participatory Educational Research*, *4*(1), 195-207.

A61 Tekerek, B., & Karakaya, F. (2018). STEM education awareness of pre-service science teachers. *International Online Journal of Education and Teaching (IOJET), 5*(2), 348-359.

A62 Tofur, S., & Gökkaya, Y. (2020). Examining the pre-school curriculum in terms of the STEM approach. *International Online Journal of Education and Teaching (IOJET), 7*(3), 1189-1203.

A63 Turk, N., Kalayci, N., Yamak, H. (2021). Evaluation of the effectiveness of science, technology, engineering and mathematics (STEM) curriculum designed and implemented for undergraduate programs of faculty of education. *International Online Journal of Education and Teaching (IOJET), 8*(3), 1401-1428.

A64 Ulger, B. B. & Çepni, S. (2020). Gifted education and STEM: A thematic review. *Journal of Turkish Science Education, 17*(3), 443–466.

A65 Yalçın, N., Kılıç, B., & Atatay, Ç. (2016). A model suggestion for STEM activity design within the scope of the curriculum. *Participatory Educational Research*, *4*(1), 95-107.

A66 Yerdelen, S., Kahraman, N., & Taş, Y. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. *Journal of Turkish Science Education*, *13*(special), 59-74.

A67 Yıldırım, B. (2018). Adapting the teachers' efficacy and attitudes towards STEM scale into Turkish. *Journal of Turkish Science Education (TUSED)*, *15*(2), 54-65.

A68 Yildirim, B., Sahin-Topalcengiz, E., Arikan, G., & Timur, S. (2020). Using virtual reality in the classroom: Reflections of STEM teachers on the use of teaching and learning tools. *Journal of Education in Science, Environment and Health (JESEH), 6*(3), 231-245.

A69 Yılmaz, A., & Yanarateş, E. (2022). The effect of STEM activities developed within the scope of a science course on 7th grade students' inquiry and innovative thinking skills: The effect of STEM activities. *International Journal of Curriculum and Instruction*, *14*(1), 274-303.

A70 Yuksel, T., Delen, I., & Ilhan Sen, A. (2020). In-service and pre-service teachers' views about STEM integration and robotics Applications. *Eurasian Journal of Educational Research*, *90*, 243-268.