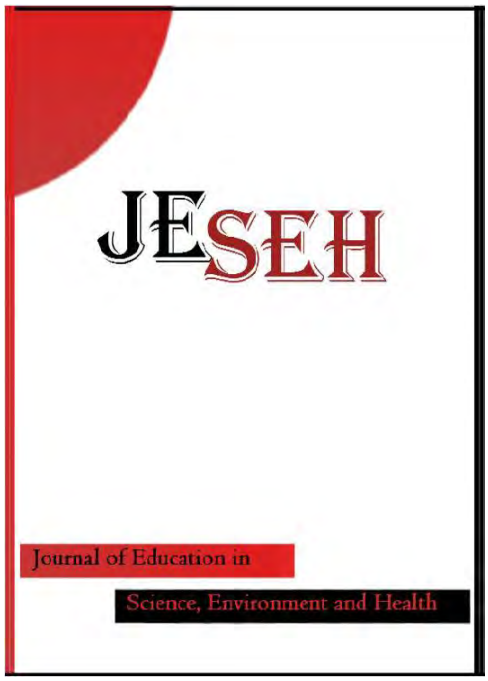

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A Systematic Review of Experimental Studies on STEM Education

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Abstract

This research systematically examines the experimental articles on STEM education (science, technology, engineering, and mathematics education). In this direction, experimental articles with the Social Sciences Citation Index on the Web of Science were analyzed within the scope of research questions, taking into account the guidelines of PRISMA. The research was carried out using the systematic review method. In the first search made in this line, the results listed 17,482 studies. Then, this number was reduced to 34 by applying the inclusion and exclusion criteria. Finally, the studies were examined in detail, and 12 articles that were not suitable were excluded from the scope. Thus, this research was carried out on 22 articles. In line with research problems, articles were categorized by publication year, country, method, study group and number, data collection tools, data analysis methods, topics covered, and experimental methods. The research results infer that the number of articles increases every year, and Turkey and China are the pioneering countries in this sense. It is noteworthy that mixed methods and quasi-experimental methods are generally preferred in the literature. Contrary to the literature, another result obtained from the research is that teachers are preferred in variable numbers as the study group. Scales, tests, and interviews are the most frequently used measurement tools by researchers. Besides, t-tests and content analysis are used in data analysis. Additionally, various topics are covered in the articles. One of the results obtained from the research is that the effect of STEM education on various skills and achievements is examined more. In line with these results, some suggestions were made by discussing the studies in the literature.

Introduction

Scientific and technological changes affect societies. Changes are inevitable as a result of this interaction. There is a need for a workforce that can use science and technology effectively for many countries that compete with one another (Kennedy & Odell, 2014). Countries that want to develop by adapting to this change make innovations and reforms in various fields to ensure that their workforce has the knowledge and skills required by age (Bybee, 2010). As a matter of fact, developing science and technology, decreasing energy resources, and global economic competition have changed the knowledge and skills that today's people must have (Roehrig et al., 2012). One of the key roles in acquiring this knowledge and skills is education.

Being a country that makes a difference in many fields today is possible with the 21st-century skills of the people of that country, such as critical thinking, innovation, cooperation, communication, problem-solving, creativity, and technology literacy (Partnership for 21st Century Learning [P21], 2015). One of the ambitious educational approaches to gaining these skills is STEM (science, technology, engineering, and mathematics) education (Bybee, 2010). STEM education is an innovative educational approach aimed at raising individuals equipped with the competencies of the age and ready for the world of the future (Güllü & Akçay, 2022). Today, STEM education is on the agenda of countries leading the world in many fields, and significant investments are being made (Banks & Barlex, 2014; Caprile et al., 2015; Corlu et al., 2014; So et al., 2018; US Department of Education, 2018).

The interest in STEM education in the world started in the 2000s and through the 2010s; however, it gained momentum and continued to increase (Yager & Brunkhorst, 2014). The importance of studies in the literature that report the general situation of studies on STEM education, which many researchers have been working on and which has a significant impact on education systems, is of great importance. There are studies conducted in this context in the literature (Arshad, 2021; Irwanto et al., 2022; Li et al., 2020; Martín-Páez et al., 2019; Matsuura & Nakamura, 2021; Wan et al., 2021). These studies are mainly carried out as traditional and systematic reviews. Hence, this study systematically examines the SSCI-indexed articles on STEM education.

Theoretical Framework

STEM Education

STEM education is an up-to-date approach that places students at the center from preschool to higher education, prioritizes collaborative learning, covers formal and informal education, emphasizes 21st-century skills, and ensures the realization of multidimensional learning by integrating science, technology, engineering, and mathematics disciplines. (Gonzalez & Kuenzi, 2012; Herschbach, 2011; Israel et al., 2013; Sainsbury, 2007; Smith & Karr-Kidwell, 2000). The main objective of STEM education is to educate individuals with the skills required by the age (Thomas, 2014). Although the aims of STEM education differ in various research and reports, they have some common goals. Some of those contribute to a country's economy by raising individuals with STEM literacy and those who can work in future business areas. STEM education also aims to keep a country's economy strong as well as skills and success (Deming & Noray, 2020; McGunagle & Zizka, 2020).

STEM education is an educational approach that encourages, motivates students, makes them achieve their dreams, has ethical values, can think systematically, and mediates them to transfer their knowledge and skills to different and new problem situations (Bybee, 2010; Dugger, 2010; Morrison, 2006). This allows STEM students to make plans, comments, and evaluations on ideas as well as solve the problems they encounter in daily life (Tseng et al., 2013). It is only possible for countries to achieve such developments with well-equipped individuals trained in STEM disciplines who are innovative and have science and technology literacy (Miaoulis, 2009).

Systematic Review

Systematic reviews are scientific studies in which the findings are analyzed by scanning the original scientific research on a particular subject in detail and using exclusion and inclusion criteria (Aslan, 2018). This concept is used as a *systematic review, systematic compilation, review,* and *literature review* in the literature. This research uses the "systematic review" term. Systematic reviews (Yılmaz, 2021), which are frequently encountered in studies in the field of health sciences (Medicine, nursing, etc.), are also used in fields such as business administration, psychology, sociology, educational sciences, and educational administration (Zawacki-Richter, 2020).

Karaçam (2013) suggests that review studies are in three different forms (Moule & Goodman, 2009; Gerrish & Lacey, 2010): (1) Traditional / narrative / literature / descriptive review, (2) Systematic review, (3) Meta-analysis. Yılmaz (2021) also states that systematic review and similar studies are basically content analysis studies. The most important guide to guide systematic reviews is PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). PRISMA has a detailed checklist and flow diagram for systematic review studies (Liberati et al., 2009).

Since certain criteria determine the studies to be used in systematic reviews, they are more objective than traditional reviews. Other researchers can repeat systematic reviews as they are carried out according to a certain protocol and have a clear method. However, this is not the case in traditional reviews, which prevents possible prejudices (Yılmaz, 2021).

Reviews on STEM Education

The literature on STEM education shows that there are traditional reviews (Brown, 2012; Hasanah, 2020; Martín-Páez et al., 2019; Mizell & Brown, 2017; Minichiello et al., 2018) and systematic reviews (Arshad et al., 2021; Ibáñez, & Delgado-Kloos, 2018; Irwanto et al., 2022; Jin, 2021; Kayan-Fadlelmula et al., 2022 Li et al., 2020) on this topic. There is also content analysis (Kaya & Ayar, 2020; London, 2018), meta-analysis (Jeong et al., 2019; Wang et al., 2022), and bibliometric analysis (Ha et al., 2020; Marín-Marín et al., 2021; Talan, 2021) studies.

The number of review and systematic review studies on STEM education in the international literature is gradually increasing. The widespread use of systematic review studies in educational sciences has attracted the attention of many researchers. In the literature, systematic review studies that deal with STEM education from various perspectives generally intensified in 2018 and beyond.

Systematic reviews of STEM education generally focus on augmented reality (Ibáñez & Delgado-Kloos, 2018; Yu et al., 2022), distance education (Alangari, 2022; Gamage et al., 2022), engineering design processes (Hafiz & Ayop, 2019), game-based learning (Gao et al., 2020), robotics (Ferrada-Ferrada et al., 2020; Hussin et al., 2019), special education (Ehsan et al., 2018; Kolne & Lindsay, 2020; Schreffler et al., 2019), computational thinking (Wang et al., 2021), mobile learning (Khaokhajorn et al., 2020), project-based learning (Imaduddin et al., 2021), measurement and evaluation (Mahanan et al., 2021), and artificial intelligence (Zawacki-Richter et al., 2019).

Some of the systematic review studies on STEM education are summarized below. Li et al. (2020) systematically analyzed 798 articles published in 36 journals between 2000 and 2018. (Gao et al. (2020)) systematically examined 30 articles between 2010 and 2019 within the scope of mobile game-based learning in STEM education. Wan et al. (2020) researched 24 experimental studies on STEM education in early childhood. Articles published in (Irwanto, 2022) and (Journal of Science Education and Technology, Research in Science Education, Journal of Science Teacher Education, International Journal of Science Education, Journal of Research in Science Teaching, and Science Education) journals were analyzed in another study. Arshad et al. (2021) systematically examined the remaining 17 articles after search strategies out of 1480 articles reached using Scopus, Wiley, and Google Scholar. Jin (2021) reviewed 24 experimental studies to support indigenous students in STEM education between 2011 and 2020. Ibáñez & Delgado-Kloos (2018) analyzed 28 articles they accessed using ERIC, Scopus, and Springer databases. Gamage (2022) used the 4-step PRISMA-P process to identify 155 eligible journal articles from 104 journals in 55 countries from 2015 to 2021.

Purpose of the Research

Experimental design is frequently used in studies on STEM education (Lin et al., 2019). To this end, reviews on STEM education are carried out with a general perspective (Arshad et al., 2021; Li et al., 2020). Considering the application dimension of STEM education, it is thought that the importance of experimental studies in this field is great. This research can accelerate researchers who want to conduct a meta-analysis. As a matter of fact, giving a general view of experimental studies facilitates the work of researchers. Studies in this direction in the literature are quite limited (Jin, 2021; Kalemkuş, 2019; Wan et al., 2020). Additionally, examining these studies in distinguished indexes such as WoS is significant in guiding current studies in this field. In this context, this research systematically examines the experimental studies on STEM education in the SSCI category on WoS. In this direction, the study seeks answers to the following research questions:

1. What is the distribution of studies on STEM education by year and country?
2. What are the methods and designs used in studies on STEM education?
3. What are the sample group and sample size in studies on STEM education?
4. What are the types of data collection tools and data analysis methods in studies on STEM education?
5. What are the trends in the topics covered in studies on STEM education and applied STEM activities?

Method

This research was carried out through the systematic review method. The systematic review method of the research was structured according to the PRISMA decision principles. With a checklist of over 20 items and a flow diagram, PRISMA principles ensure that literature review studies are carried out transparently (Liberati et al., 2009).

Search Strategy

All the data within the scope of the research were taken from the official website of the Web of Science (WoS). In the first search made with "Advanced Search," some keywords containing the research topic were used (Table 1).

Table 1. Search strategy

WoS Query	(TI=(STEM OR STEAM OR science, technology, engineering, and mathematics) AND TS=(EXPERIMENTAL OR PRE-TEST OR POST TEST))
Last Retrieved	13.08.2022

The last search was done on 13.08.2022. As a result of the search, 17,482 studies were reached. Research data were obtained from articles on this date. All articles that met the criteria determined by the expert opinions collected by the researcher were included in the research.

Database and Selection Criteria

WoS index is frequently preferred in meta-analysis, bibliometric analysis, and systematic reviews. The criteria for inclusion and exclusion of studies were formulated and applied to ensure that the included studies were closely related and of high reliability. The inclusion and exclusion criteria are shown in Table 2.

Table 2. Selection criteria

Inclusion Criteria	Exclusion Criteria
• Published in the WoS • Article • Written in the English • Open Access • Research areas: Education, Educational Research • WoS categories: Education, Educational Research • SSCI • Experimental method	• Not published in the WoS • Review article, book chapter / review, proceeding paper, etc. • Not written in the English • Descriptive, Correlational, Comparison, Historical method • Duplicate studies • ESCI, SCI-EXPANDED, CPCI-S, etc. • Research areas outside of education and WoS categories • Article unavailable in full text

The articles in the field of education, which were written in English with the SSCI index and adopted the open-access experimental method, were evaluated by taking them into the scope of the research. Unlike many studies, no year range was given in this study.

Publication Selection

PRISMA Flow Diagram was used to determine the studies within the scope of the research (Figure 1). Firstly, 17,482 studies were reached by using the search terms in Table 1. Then, studies that were not suitable were excluded using the inclusion and exclusion criteria (For example, the term STEM has a different meaning in the medical literature, types of studies other than the article, etc.).

Table 3. Filter strategies of articles

Category	Category
Access Type	Open Access
Document Type	Article
Research Area	Education Educational Research
Language	English
WoS Categories	Education Educational Research
WoS Index	SSCI
*https://www.webofscience.com/wos/woscc/summary/b3e501c0-4419-4bb1-81b8-e59439b7cdd6-4d5448da/relevance/1	

As a result of the filtering process in Table 3, the studies to be examined were collected in a folder. Then, it was checked whether there were repeated search results. At this stage, the number of articles decreased to 34. Then, data were collected through the "Article Classification Form," which was created to examine the articles easily. At this stage, 12 more articles that were not the focus of this research were excluded (due to scale development, use of STEM expression outside of education, etc.). Thus, the final number of articles to be analyzed in the systematic review was obtained (Appendix). The PRISMA Flow Diagram showing the process is shown in Figure 1.

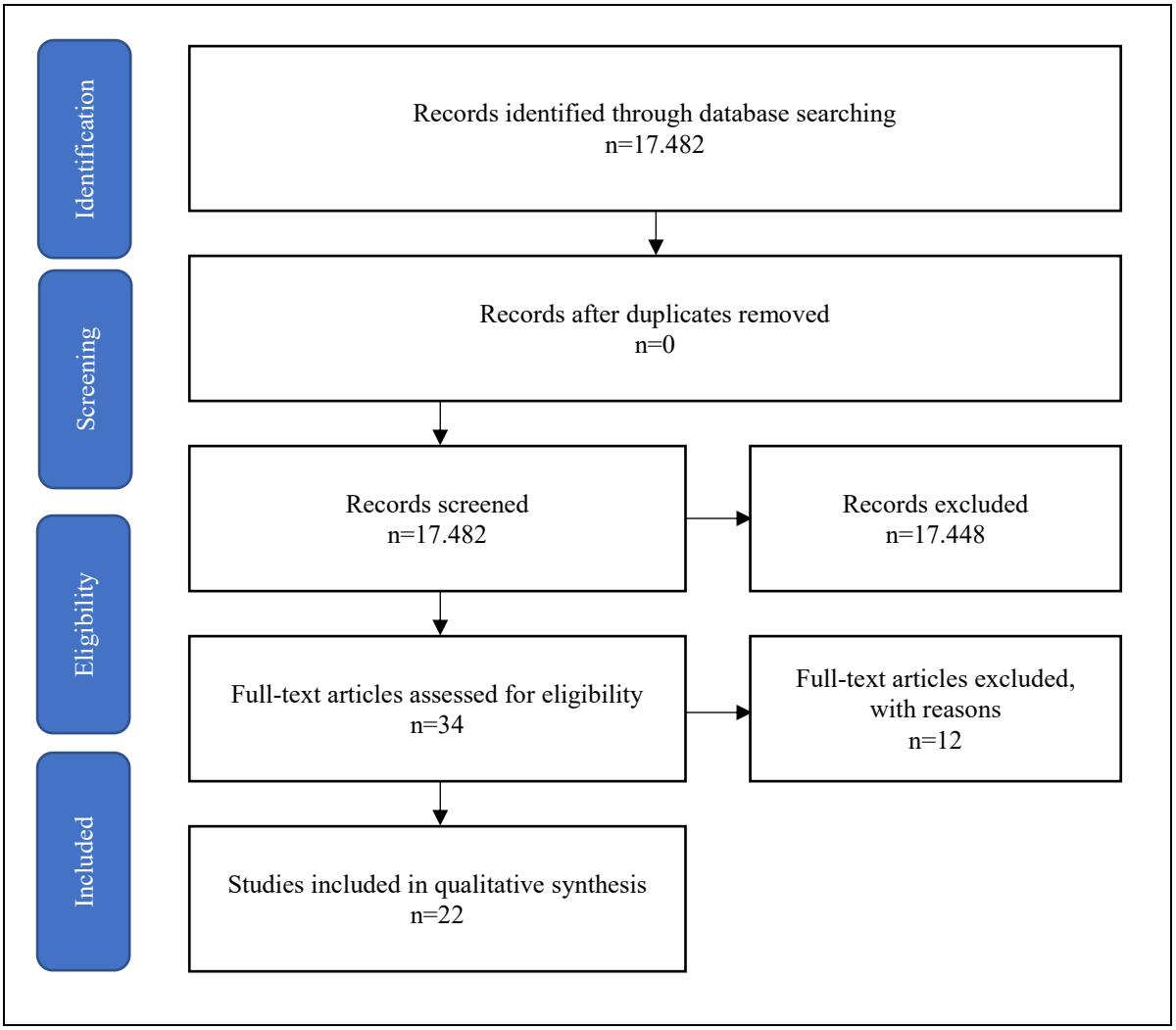


Figure 1. PRISMA flow diagram (Liberati et al., 2009)

Data Analysis and Coding

22 articles that were reached as a result of the literature review and that met the research criteria were examined (Appendix 1). An online article analysis table was created to avoid subjectivity during the analysis stage. Categories included in the table, excluding the article information: (1) Year of publication, (2) Method, (3) Experimental method, (4) Sample group, (5) Sample size, (6) Data collection tools, (7) Data analysis method, (8) Research topic, (9) Activity duration and number, and (10) Country. Findings are presented in tables and graphs with frequency and percentage values.

Validity and Reliability

For the validity of the research, a data search and filtering protocol was created during the data collection stage, where the search term can reach the studies suitable for the purpose of the research. Expert opinion was often used at this stage. Inclusion and exclusion criteria are clearly defined (54). Besides, the researcher explains each step of the process in detail.

The articles within the scope of the research were coded into the online article analysis table by another researcher who completed her Ph.D. Then, the percentage of agreement between the two codings was examined. The percentage of intercoder agreement was calculated as 98% (Miles & Huberman, 1994). This ratio shows an acceptable level of reliability.

Findings

Distribution of Studies by Year and Country

Figure 2 shows the distribution of the articles analyzed in line with the research problem by country.

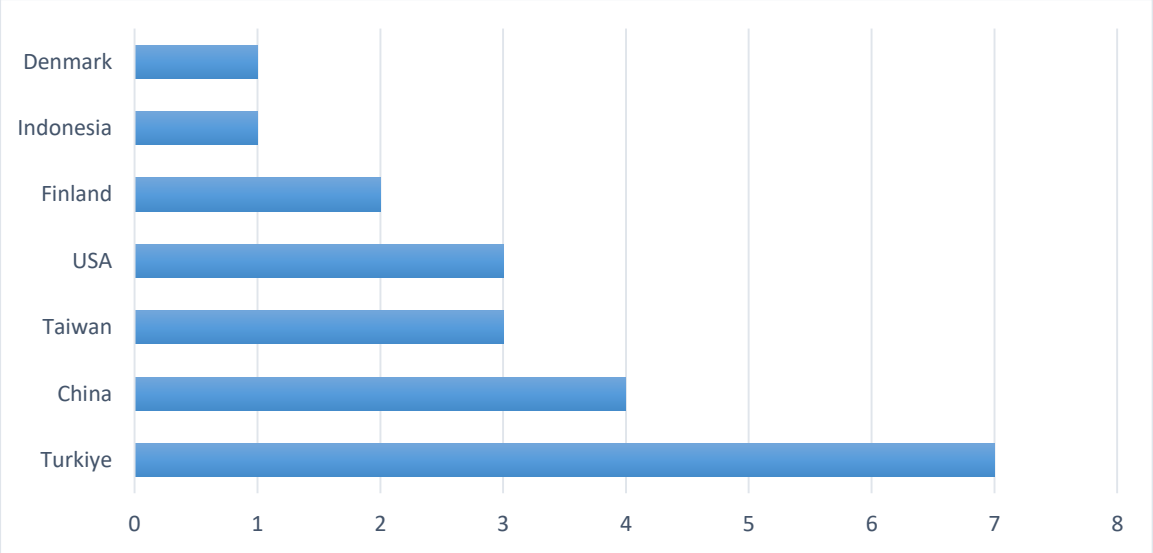


Figure 2. Distribution of articles by country

Figure 2 suggests that the articles were published in 7 different countries. Among these countries, most articles were conducted in Turkey (f=7) and China (f=4), followed by Taiwan, the USA, Finland, Indonesia, and Denmark.

The analysis results of the experimental articles covered in the research by year are shown in Figure 3.

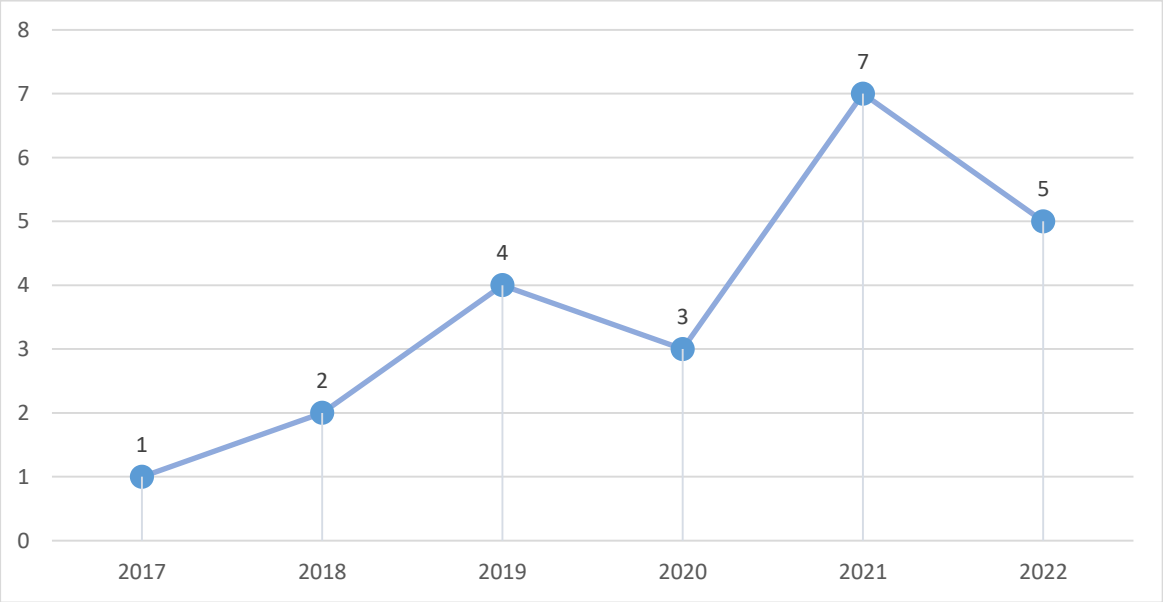


Figure 3. Distribution of articles by year

SSCI-indexed articles in this study were conducted between 2017 and 2022. Most articles were published in 2021 (f=7). Notably, four articles were published in 2019 and 2022. The articles generally tend to increase. However, there is a decrease only in 2020 and 2022 compared to the previous year.

Methods and Designs Used in Research

In line with the research's second sub-problem, the experimental articles' methods and designs were discussed (Figure 4).

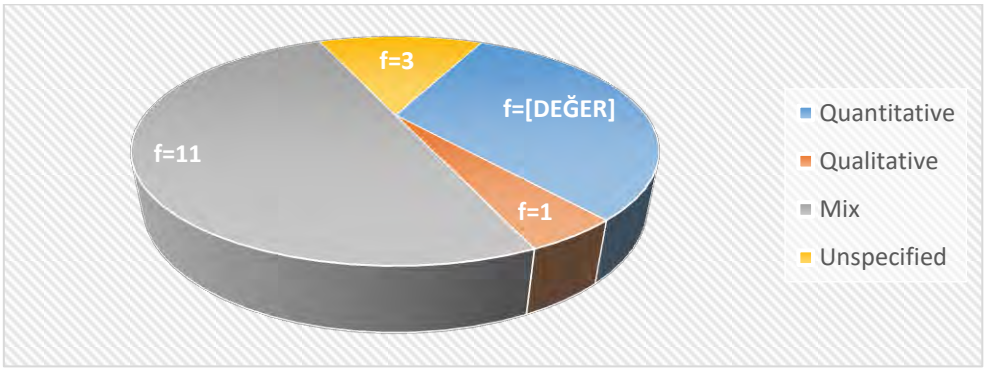


Figure 4. Distribution of articles by the methods used

As a result of the analysis, the experimental articles are generally conducted with a mixed method in which quantitative and qualitative methods are used together (f=11). While the number of articles using the quantitative method was 7, 1 article was designed with qualitative methods. In the remaining three articles, no clear information was given about the method used. When the articles are evaluated in terms of the experimental design they use, a total of 11 articles clearly indicate that they use the experimental design. No information was given about the experimental design used in the remaining articles. While the quasi-experimental design is used in 9 of the articles, the weak-experimental design is used in 2 articles.

Sample Group and Sample Size of Articles

Sample groups of experimental articles examined in the context of STEM education were examined. Descriptive data for these groups are shown in Figure 5.

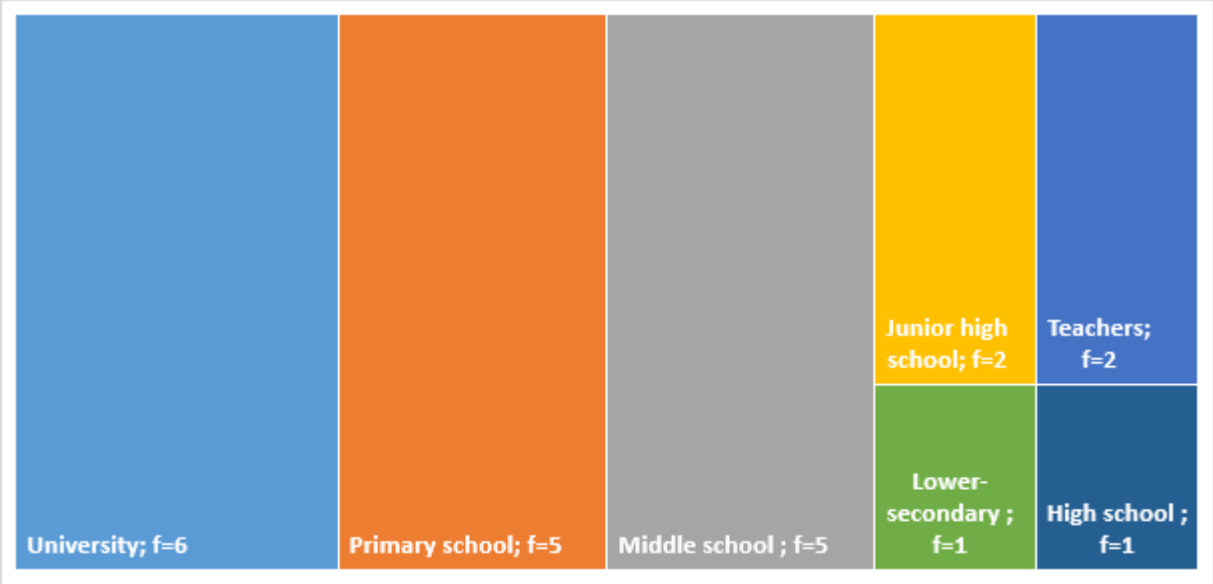
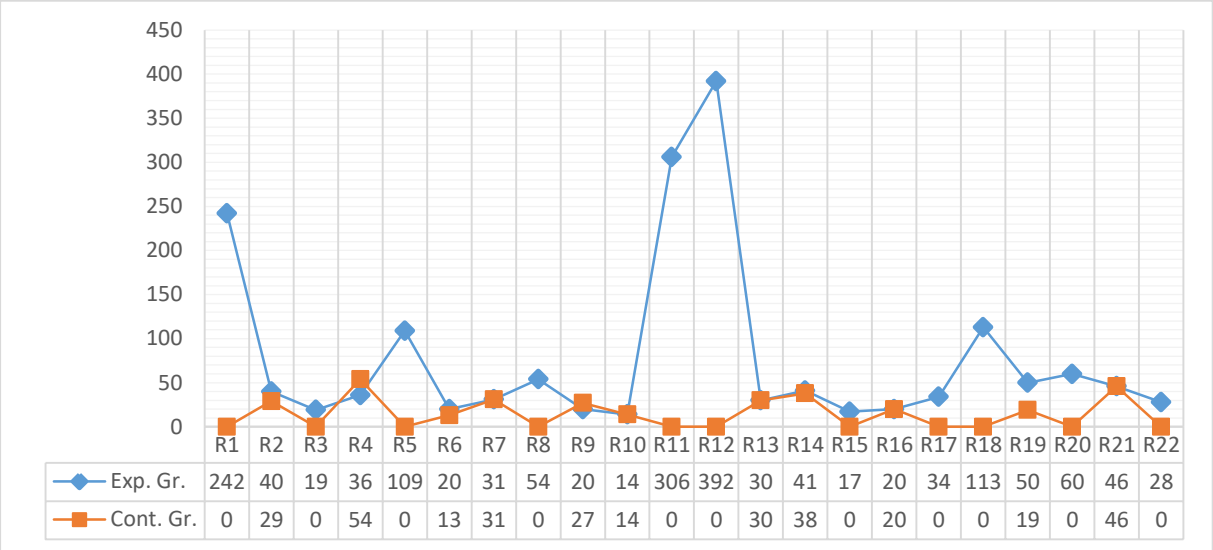


Figure 5. Distribution of articles by the sample group

Figure 5 reflects that university students are the sample group most in the experimental articles on STEM education (f=6). 2 of these 6 articles were conducted with prospective teachers, followed by primary school students (f=5) and middle school students (f=5) sample groups, respectively.

The number of participants in the experimental and control groups of the experimental articles was also analyzed. Figure 6 shows the number of participants in the experimental and control groups.



	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
Exp. Gr.	242	40	19	36	109	20	31	54	20	14	306	392	30	41	17	20	34	113	50	60	46	28
Cont. Gr.	0	29	0	54	0	13	31	0	27	14	0	0	30	38	0	20	0	0	19	0	46	0

Figure 6. Distribution of the number of participants in the experimental and control groups

Figure 6 points out that half of the articles (f=11) were carried out by including control groups. This means that at least two different groups represent the sample of these articles. The experimental groups consisted of at least 14 and at most 382 people. This is a remarkable finding, given that experimental articles are usually carried out in small groups. In the control groups, the number consists of at least 14 and at most 54 people.

Data Collection Tool and Data Analysis Techniques of Articles

The findings regarding the data collection tools used in the SSCI-indexed experimental articles on STEM education are shown in Figure 7. A total of 57 data collection tools, 36 of which were quantitative and 17 were qualitative, were used in the articles.

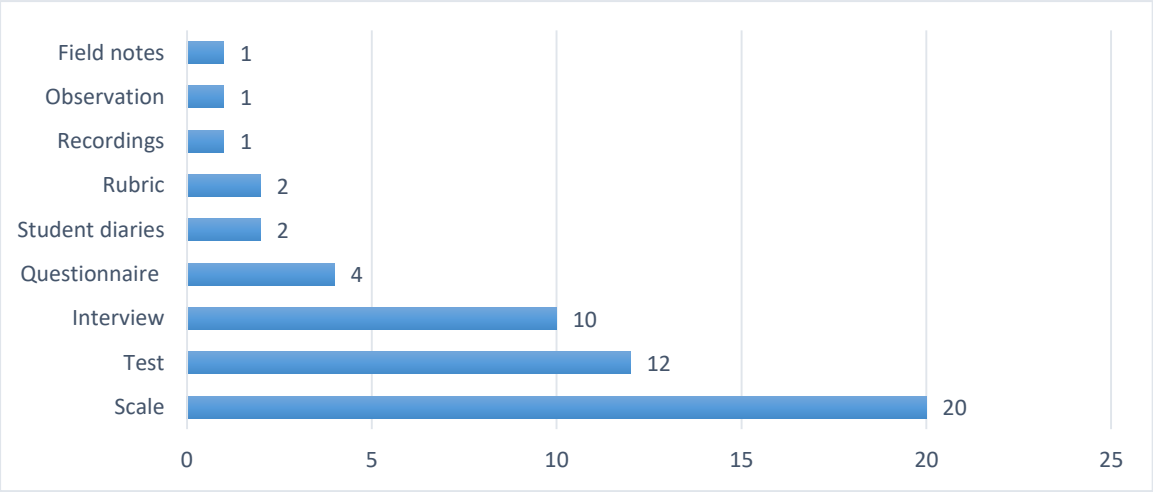


Figure 7. Distribution of data collection tools used in articles

Figure 7 reveals that scale, test, and interview are generally used as data collection tools. Creativity and skills (f=4), attitude (f=3), motivation (f=3), and career interest (f=3) scales are frequently used. In addition to these, self-efficacy (f=2), literacy (f=1), and computational thinking (f=1) are other scales used in research. However, not as much as scales, tests (f=12) and interviews (f=10) are frequently used in experimental articles. Considering the tests, it is among the findings obtained from the research that the achievement (f=6) and knowledge (f=3) tests were used the most. Besides, creativity (f=1) and problem-solving (f=1) tests are also used, albeit not very often. Another measurement tool that is frequently used in experimental articles within the scope of the research is interviews (f=10). Almost all the interviewed articles were conducted with semi-

structured interviews (f=8). In some articles, structured interviews and focus group interviews were used. Other data collection tools used in the articles are questionnaires (f=4), diaries (f=2), and rubrics (f=2).

The analysis methods used by the experimental articles were examined under two headings as qualitative and quantitative (Figure 8).

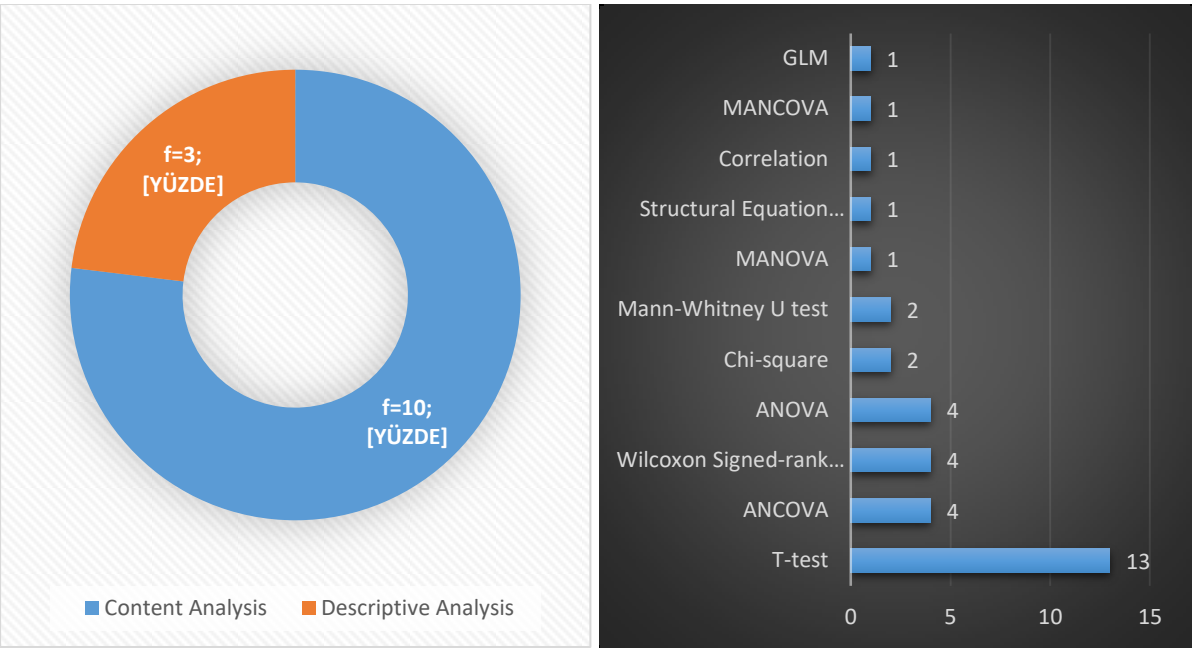


Figure 8. Distribution of qualitative and quantitative analysis methods used in articles

Content analysis (f=10) is used more than descriptive analysis (f=3) in the qualitative dimensions of experimental articles. In one of the articles, both content analysis and descriptive analysis were used together. In the quantitative analysis methods used in the articles, the number of t-tests (f=13) is more than the others, followed by ANCOVA (f=4), Wilcoxon Signed-rank Test (f=4), ANOVA (f=4), Chi-Square (f=2), and Mann-Whitney U Test (f=2).

Topic and Application Process of Articles

The topics on which the effect of STEM education was investigated in the experimental articles analyzed within the scope of the research are shown in Table 5. In some articles, more than one topic is examined.

Table 5. Topics examining the effect of STEM education in the articles

Subject	f	%	Subject	f	%
Skills	5	11.26	Professional development	1	2.32
Achievement	4	9.30	Gender	1	2.32
Attitude	3	6.97	Autonomy	1	2.32
Learning	3	6.97	Visual reasoning	1	2.32
Creativity	3	6.97	Abstract thinking	1	2.32
Career interest	3	6.97	Self-explanation	1	2.32
Self-efficacy	2	4.65	Cognitive load	1	2.32
Project-based learning	2	4.65	Conceptual understanding	1	2.32
Motivation	2	4.65	Computational thinking	1	2.32
Cognitive learning	2	4.65	Task value	1	2.32
Flow experience	1	2.32	Socio-scientific issue-based instruction	1	2.32
Opinion	1	2.32			
Total				43	100

Table 5 indicates that the experimental articles deal with quite wide and different topics. To this end, 24 different topics were examined by researchers in 22 experimental articles. Experimental articles are mostly

focused on skills (f=5), achievement (f=4), attitude (f=3;), learning (f=3), creativity (f=3), and professional interest (f=3).

The word cloud consisting of the titles of all the articles within the scope of the research is shown in Figure 9. Conjunctions and meaningless expressions were excluded while creating the word cloud. In this sense, the concepts of STEM, effect, and learning are prioritized in the word cloud.

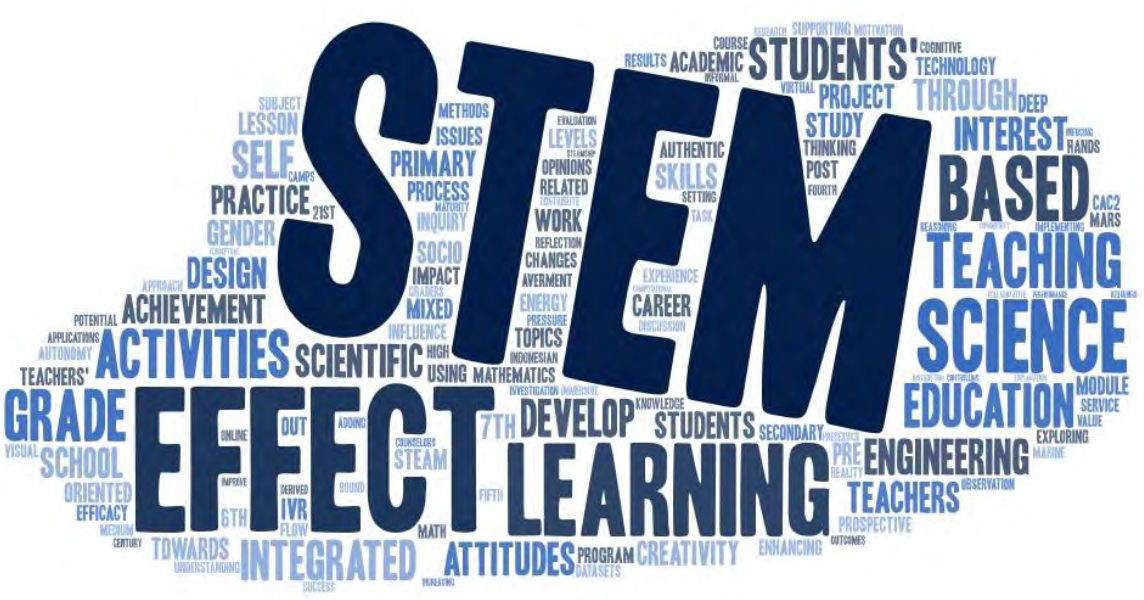
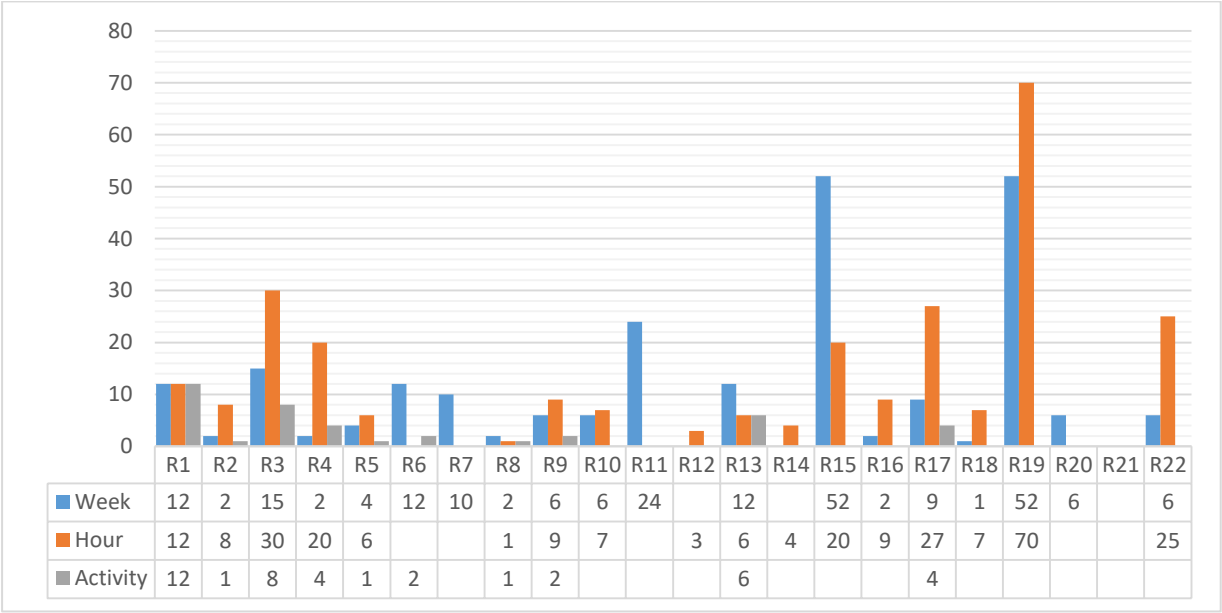


Figure 9. Word cloud of titles of experimental articles

The articles conducted on STEM education and the distribution of the experimental application processes of these articles are shown in Figure 10. The figure gives information about how many weeks the application covers, how many hours it is completed, and the number of activities implemented. If there is no information about the application in the article, the relevant fields are left blank.



	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
Week	12	2	15	2	4	12	10	2	6	6	24		12		52	2	9	1	52	6		6
Hour	12	8	30	20	6			1	9	7		3	6	4	20	9	27	7	70			25
Activity	12	1	8	4	1	2		1	2				6				4					

Figure 10. Distribution of the experimental application process in the context of week, hour, and activity

Figure 10 shows that STEM activities within the scope of experimental articles are carried out between 1 and 52 weeks. There are three articles that do not provide information on how many weeks STEM activities last. Time information is provided for activities in two of these articles. Additionally, the activities are carried out between 1 and 70 hours. In total, five articles did not provide information about the time allocated for the activities.

Besides, there are 1 to 12 STEM activities in the experimental articles within the scope of the research. The number of studies without information about the number of STEM activities applied is 12.

Discussion

As a result of the use of systematic review studies in education fields, the number of systematic review studies on various perspectives of STEM education has rapidly increased. Systematic reviews are important in giving a general idea about the researched area. As a matter of fact, through systematic reviews, topics that need to be researched in the future, gaps, and insufficient areas in the literature can be identified (Çınar, 2021). In this research, a systematic review of experimental articles on STEM education on WoS was made. Thus, a profile of experimental articles for STEM education is thought to be created.

When evaluated in terms of countries, the experimental articles in Turkey and China are notable, which can be explained by the high interest in STEM education in these two. Thus, there are many initiatives for STEM education in Turkey (Integrated Teaching Project, Scientix Project, etc.). This also signifies that qualified researchers are producing quality publications on STEM education in these countries. There are studies in the literature that infer different results (Sawangmek, 2019; Talan, 2021). It is significant that in some of these studies, the USA is in the leadership position (Le Thi Thu et al., 2021; Marín-Marín et al., 2021; Yu et al., 2016). Indeed, the USA is far ahead in the Wilson et al. (2022) study. In another study, South Korea, the USA, and Indonesia were the most productive countries (Santi et al., 2020). The contrast encountered here is thought to be related to the keyword, search strategies, and database used.

Experimental articles on STEM education generally tend to increase. It was concluded that there was a decrease only in 2020 and 2022 compared to the previous year. Since this research was carried out in 2022, the studies in 2022 are expected to be lower than in the previous year. A similar finding was obtained by Talan (2021). Many studies in the literature also show a similar trend (Ha et al., 2020; Li et al., 2019; Marín-Marín et al., 2021; Wilson et al., 2022; Yu et al., 2016). Irwanto et al. (2022) reported that the number of articles between 2011 and 2020 is in regular increase. Chomphuphra et al. (2019) also have similar results.

The studies examined within the scope of the research mainly use mixed research methods. The main reason for combining quantitative and qualitative methods in mixed methods is to reveal their strengths by compensating for the weaknesses of both approaches (Merriam, 2013). According to Kurniati et al. (2022) concluded that the qualitative method is preferred in studies on STEM education. Irwanto et al. (2022), on the other hand, found that the quantitative method was used more frequently. The emergence of different results is thought to be a result of search strategies. Besides, Kalemkus (2019) concluded that the experimental research on STEM education that he examined used the mixed method more often.

This research proposes that university students are frequently involved as participants in experimental articles. Additionally, experimental articles are conducted with an average of 20 to 40 people. In contrast to this research, Kalemkus (2019) found that studies on STEM education are generally conducted with secondary school students. There are studies in the literature showing that studies on STEM education are frequently carried out at the level of K-12 (Mizell & Brown, 2016), graduates (Jayarah et al., 2014), preschool (Sawangmek, 2019), high school (Farwati et al., 2021), and middle school (Gao et al., 2020). This difference can be explained by conducting the relevant study on a national scale. According to Çavaş et al. (2020), university students are preferred more than other groups. University students often take part in scientific research as a study group, which can be explained by the desire of researchers to access data quickly and easily.
Scales and tests are prominent as data collection tools in experimental articles. They are frequently used in experimental studies. This case can be explained as a result of the design of the studies with a mixed method. Having conducted a study on STEM education trends in Turkey, Çavaş et al. (2020) have reached a similar conclusion. A similar conclusion was also obtained in another study examining studies on augmented reality in STEM education (Sırakaya & Alsancak Sırakaya (2022). Some studies show that the interview is more prominent (Wilson et al., 2022). When experimental articles are analyzed in terms of data analysis, qualitative data are analyzed using content analysis, and quantitative data are generally analyzed using a t-test. There are studies with similar results in the literature (Çavaş et al., 2020; Gül et al., 2022).

As a result of the research, the experimental articles mostly focus on subjects such as skills, success, attitude, learning, creativity, and professional interest. When the titles of the examined articles are transformed into a word cloud, the concepts of “STEM,” “effect,” and “learning” are the most repeated ones. The reason for this can be explained by the nature of experimental studies, covering the effect of something on something and the

topic area. This finding is supported by similar results in the literature (Aseffa & Rorissa, 2013; Novia et al., 2021; Tas & Bolat, 2022; Wilson et al., 2022; Yu et al., 2016). Gülhan (2022), on the other hand, stated that the most examined variables are attitudes and skills.

It is seen that the implementation processes of the experimental articles examined within the scope of the research last up to 52 weeks, and some activities total 70 hours. The number of activities was found to be at most 12. Günbatar and Tabar (2019) report that STEM activities last 1-2 months in their studies. Kalemkuş (2019), on the other hand, noted that STEM activities were carried out intensively between 6 and 10 weeks. Sufficient time and the number of activities for STEM education may vary in line with the content of the subject and the knowledge and skills targeted to be gained. For example, an experimental process that aims to determine the effect of STEM activities on attitudes needs to be designed comprehensively.

Conclusion

Although there are systematic review studies on STEM education in the literature, studies examining experimental studies are limited. The current studies cover certain education periods. In this research, experimental articles with SSCI on STEM education were examined. As a result of the research, which examines the experimental articles on STEM education, the countries with the highest number of articles are Turkey and China. One of the research results is that the number of experimental articles regularly increase yearly, and most articles were published in 2021. In experimental articles, mixed method design was most preferred. It was noted that some articles did not provide any information about the method. Another result of the research is that the study group usually consists of university students. One of the research results is that half of the experimental studies were designed with a control group. It is indicated that scale, test, and interview are frequently used as data collection tools. Due to the intensive use of mixed methods in the research, data analyzes were collected in two groups. Content analysis in qualitative data analysis and t-test in quantitative data analysis are the most preferred analysis methods. Another result is that the researchers covered subjects such as skills, achievement, and attitudes towards STEM education more. It is seen that experimental applications are carried out with an average of 1 to 10 weeks and 1 to 10 activities. Besides, it was observed that many articles did not explain the implementation process in detail.

Recommendations

The number of systematic review studies on STEM education can be further increased. Investigations can be made on the sample of countries. Studies with experimental and control groups, which have an important place in experimental studies, can be carried out more. Studies can be conducted with more than one experimental and control group. Studies can be conducted on how long and with how many activities the skills of STEM applications, such as problem-solving and scientific creativity, can be learned.

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Appendix

Articles reviewed by including systematic review

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