JPR
Journal of Pedagogical Research

Research Article

Research trends in mathematics education: A quantitative content analysis of major journals 2017-2021

Katibe Gizem Yığ

Burdur Mehmet Akif Ersoy University, Turkey (ORCID: 0000-0001-5783-3861)

This research aims to uncover current trends and key issues by examining the research in mathematics education during the period 2017-2021. For this purpose, five major peer reviewed academic journals indexed by the Social Sciences Citation Index (SSCI) in Web of Science (WoS) have been examined in detail: "Educational Studies in Mathematics", "Journal for Research in Mathematics Education", "International Journal of Science and Mathematics Education", "Journal of Mathematics Teacher Education" and "Mathematical Thinking and Learning". A total of 881 articles were examined within the scope of the research. Bibliometric analysis and social network analysis (SNA) were used in the analysis procedure. Occurrence/co-occurrence combinations of author keywords and concepts in abstract sections have been created in order to perform the relevant analyses. These undirected network combinations were then analysed through NodeXL and VOSviewer software. The results were visualized and interpreted according to link strength, relevance scores, betweenness and degree centrality metrics. According to the common findings from both analysis approaches, in the 2017-2021 period, the most focused and prominent research issues in the field of mathematics education have revealed different main sets: studies related to mathematics teachers and teacher education (and especially teacher noticing topic), equity-culture-gender studies, and studies on mathematical problem posing, problem solving, modelling, STEM and STEAM education. The findings of this study may be useful in identifying current potential research areas in the field of mathematics education.

Keywords: Mathematics education; Trends in mathematics education; Bibliometric analysis; Social network analysis

Article History: Submitted 21 April 2022; Revised 5 June 2022; Published online 30 June 2022

1. Introduction

The importance of mathematics education comes from the fact that mathematics is a basic human activity such as music, painting, literature or "making of good shoes" (Hilton, 1984, p. 2). Pure mathematics also shapes the environment in which human daily activities occur. According to Schoenfeld (2000), mathematics education serves two purposes, one pure and the other applied. In pure mathematics, the goal is to understand the nature of mathematical thinking and learning-teaching, while in applied mathematics, it is aimed to improve mathematics teaching with the understandings obtained from pure mathematics. In other words, mathematics is a fundamental

element of science and technology, and in order to understand the environment, pure and applied mathematics fields must be presented with a balanced and successful mathematics education (Hilton, 1984). Because there is a mutual relationship between these two areas and, without a deep understanding of mathematical thinking, learning and teaching, sustainable practice cannot be developed (Schoenfeld, 2000).

Mathematics education is a discipline where various concepts and topics are used intensively (Türkdoğan et al., 2015). In this direction, the use of concepts in the field and the relationships between them are important components for the rotation of the field. With a proper understanding of these components, mathematics education provides researchers "new glasses" in which they can see the details of different topics, ask new questions, and even see alternative ways/possibilities (Ernest et al., 2016). Schoenfeld (2000) lists the questions that mathematics education explores as follows:

- theoretical perspectives to understand thinking, learning and teaching;
- different aspects of cognition (e.g., mathematical thinking; students' understandings and misconceptions)
- evidence of existence (situations in which students can learn problem-solving, induction, and group theory; applicability of various types of teaching)
- the consequences of various forms of teaching (positive and negative).

For innovative mathematics education research in today's technologically driven educational world, the concepts and answers must be thoroughly analyzed. With the understanding of this requirement, as Sierpinska and Kilpatrick (1998) noted, mathematics education studies has increased significantly in the last half century. Research in the field of mathematics education first began to appear in the WoS database in the 1980s and gradually increased in number (Gokce & Guner, 2021). Today, it is seen that the number of researches in mathematics education field have increased a lot in number and variety, but also deepened in special areas. Kilpatrick (2020) stated that the mathematics education field is now too broad and comprehensive to be addressed as a whole. The gradual expansion of mathematics education research leads to an increase in research diversity and the replacement of old approaches by new ones. It encourages researchers to examine the similarities and differences of their research frameworks with others (Hanula, 2009). In this context, it can be said that the detailed examination of mathematics education studies serves a critical purpose.

There are different studies examining regional or international research in the field of mathematics education (Baki et al., 2011; Hanna & Sidoli, 2002; Hannula, 2009; Inglis & Foster, 2018; Lubienski & Bowen, 2000; Schoenfeld, 2016; Shin, 2020). As previously emphasized, mathematical education research has changed radically since the 1980s (Schoenfeld, 2016), in this context, systematic examination of studies in the field are critical research activities that can provide guidance to researchers and other educational stakeholders.

Analysis and synthesis aimed at determining trends in math education are also the source of the development of innovative mathematics teaching-learning processes, egalitarian in-class practices and educational policies (Young & Young, 2022). Although mathematics is the basic element of science and technology, as mentioned earlier, it should not be forgotten that mathematics education, unlike other fundamental sciences, is significantly influenced by social and cultural developments (Sriraman & English, 2005). We can talk about a reciprocal interaction here because mathematics education has also the power to shape society (Gokce & Guner, 2021).

1.1. Rationale of the Study

As in other disciplines, paradigm changes in education, emerging technologies and current diversified student characteristics are expected to create contextual and methodological differences in mathematics education. Based on this, the main objective of this research is to determine the global research trends in mathematics education.
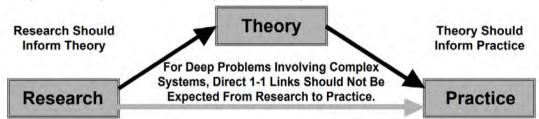
Identifying research issues and trends in a specific field of research is critical in many aspects for the relevant academic field. These quantitative or qualitative researches are primarily important in order to reveal the changes in the field (Çiftçi et al., 2016). This approach also provides researchers with the opportunity to guide the field, to evaluate past experiences and contributions, to establish a connection between the past, present and the future, and to guide future studies in this context (Bozkurt et al., 2019). Presenting a research agenda in a given area is crucial for regional-global educational institutions or learning networks to understand ongoing changes or interrelated disciplines (Anderson & Zawacki-Richter, 2014). It also allows researchers to share existing practice, experience, perspective, new policies or perspectives (Bozkurt et al., 2016). Thus, it enables the development of new queries related to the field and the ability to make more specific analyzes. This can lead to a better understanding of the field of mathematics education.

Identifying research trends in mathematics education, as mentioned earlier, can guide different researchers or educational stakeholders (such as teachers, experts, students) who want to carry out study in this field (Cohen et al., 2007; Gokce & Guner, 2021). In order to see the big picture in mathematics education, it will be a very important move to determine the clustered themes in the field and their relationships (Bakker et al., 2021).

Another important justification for the trend and issue determination research related to mathematics education is that, the field of mathematics education strives to "produce models" instead of a one-to-one matching (Q&A relationship) between academic research and field problems (Sriraman & English, 2005).

Figure 1
Theory, research, practice relationship (Lesh, 2002, p.34)

In this context, one of the main reasons for this study is to observe the relationships between theory, research and practice in the field of mathematics education and to reveal the orientations related to new models. In this respect, detailed examination of different researches is a prerequisite for developing mathematical theories and applications.

In line with all these justifications above, the peer reviewed academic articles in the field of mathematics education in the 2017-2021 period were analysed, the trends and issues in mathematics education researches were tried to be identified. For this purpose, the following research questions have been addressed:

(1) What is the distribution of publication numbers by year in mathematics education research in 2017-2021 period?

(2) What is the distribution of publication numbers by country in mathematics education research in the period 2017-2021?

(3) What are the most-cited journals and articles in mathematics education researches in 2017-2021 period?

(4) Which research subjects featured in mathematics education research in the 2017-2021 period according to occurrences/co-occurrences of author keywords?

(5) Which author keywords have the high betweenness centrality (BC) and degree centrality (DC) values (in the most cited articles by years)?

(6) Is there a change in mathematics education research subjects in the 2017-2021 period by year?

2. Methodology

This research aims to uncover current trends and important/key issues by examining research in the mathematics education field during the 2017-2021 period. For this purpose, 5 major peer reviewed academic journals indexed by the Social Sciences Citation Index (SSCI) in Web of Science (WoS) have been examined in detail: "Educational Studies in Mathematics (ESM)", "Journal for Research in Mathematics Education (JRME)", "International Journal of Science and Mathematics Education (IJSME)", "Journal of Mathematics Teacher Education (JMTE)" and "Mathematical Thinking and Learning (MTL)". Although there are 6 math education peer reviewed journals in the SSCI, it was decided to remove "ZDM – Mathematics Education" from the scope of analysis in this study (in which research trends were determined) on the grounds that it published only thematic issues in the relevant years.

2.1. Inclusion and Exclusion Criteria

Peer reviewed articles written only in English language were included to the research scope after the identification of the journals. While editorial articles were excluded from the scope of analysis, early access articles were included within the scope. Since IJSME also publishes publications in the field of science, mathematics education articles in this journal have been identified and then included in the scope. Articles written in languages other than English, evaluation papers, white papers and similar types of studies were excluded. According to the specified criteria, 881 studies were included in the research.

2.2. Data Analysis Methods and Processes

Bibliometric analysis (BA) and social network analysis (SAA) were used along with some descriptive statistics to answer the research questions sought in this research.

2.2.1. Bibliometric analysis

Bibliometrics is a statistical analysis approach based on the analysis of academic publications, which increasingly reach very large numbers quantitatively through academic journals, books, printed papers, in the context of various variables. In the bibliometric analysis approach, mass descriptive or relational research analyses can be performed in various parameters such as journal, author, country, citation, keywords, text mining stored and organized in WoS, Scopus and similar databases. In this context, bibliometrics, especially supported through computer software, has been recognized as a "research evaluation" methodology for ever-increasing scientific research (Ellegaard & Wallin, 2015). Bibliometric analysis allows researchers to study various changes in depth in a specific area (Huang et al., 2020).

In this research, multiple analysis approaches were used and bibliometric analysis of research articles in WoS database was implemented to determine the outstanding topics in mathematics education researches in the 2017-2021 period. With this analysis method, important topics and concepts can be revealed according to the coexistence of the concepts in the keyword sections in the articles. VOSviewer text mining software was used for bibliometric analysis. VOSviewer is a software capable of making visualizes and constructing data on various bibliometric parameters (Van Eck & Waltman, 2010).

In this context, the research articles of ESM, JRME, IJSME, JMTE and MTL journals in the relevant years were scanned on WoS and the results were listed. The results of the 881 research articles were downloaded in full record and tab-delimited (Win format) format and transferred to VOSviewer software. Co-occurrence and occurrence analyses were performed on the author keywords and abstract sections of the sampled papers and total link strength and relevance scores were reported in the findings section.

By the help of occurrence and co-occurrence analysis, the distribution of author keywords, the clusters and networks they create can be defined. These analyses calculate the correlations between different keywords or terms in a document. According to the calculated correlations, clusters are

formed according to the co-occurrence/occurrence of the concepts examined and the resulting concept network is visualized.

2.2.2. SNA based keyword network analysis

In this research, in addition to bibliometric analysis, SNA approach was used to determine the prominent subjects in mathematics education in 2017-2021 and diversification of analysis was provided. SNA examines the interactions between network nodes or the co-occurrences of nodes, but also allows for the determination of strategic actors and interaction channels within a network, slightly different from bibliometric analysis. With social network analysis, relational data on a network are analysed according to different metrics and important nodes in that network are determined (Crossley et al., 2015). In this research, betweenness centrality and degree centrality metrics were used and, in this way, it was aimed to determine the core or strategic issues in mathematics education.

From the centralized measures used in SNA, degree centrality deals with how many connections (using direct links) a node in the network establishes with others. Betweenness centrality, on the other hand, attempts to define how positionally important/strategic a node on the network is when communicating with other nodes (Leydesdorff, 2007). Also, this metric defines the mediation role of a node in the network (Zhang & Luo, 2017). When considered in the context of this research, "the betweenness centrality defines strategically important topics/concepts that serve as a bridge between different concepts/topics and control the relationship of other nodes with each other" (Yığ & Sezgin, 2021). A basic criterion has been set for listing keywords to be included in the SNA process. Accordingly, the keywords of the top 10 most cited studies for each year in 2017-2021 are included in the SNA. However, since there are articles with equal citation numbers in 2017 and 2018, it was decided to include 12 articles in 2017 and 13 in 2018 instead of the top 10 articles in these years. In the last case, the keywords of a total of 55 articles were analysed.
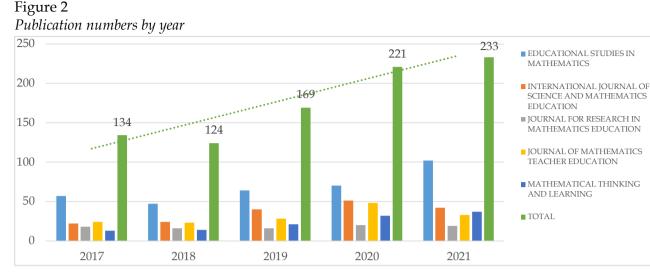
To perform the analysis, binary combinations of keywords in an article were created and entered into the NodeXL software. This process was repeated for each article. After this process, 222 different keywords (nodes) and 481 keyword pairs (ties) were created from the combination of author keywords of 881 studies included in the analysis procedure. The co-occurrence network created was transferred to NodeXL (Smith et al., 2009) software, and the calculation of centrality measures, creation of the concept network and network visualization were carried out through NodeXL. Detailed information about the relevant centrality measures and the network formed is presented in the findings section.

3. Findings

3.1. Distribution of Publication Numbers by year in Mathematics Education Research in 2017-2021 Period

Figure 2 presents the distribution of publication numbers by year in mathematics education research in 2017-2021 period.

According to the distribution of the studies included in the study by year, the total number of mathematics education studies rose significantly from 2017 to 2021, except for 2018.

Figure 2
Publication numbers by year

3.2. Distribution of Publication Numbers by Country in Mathematics Education Research in 2017-2021 Period

Figure 3 shows the distribution of the studies examined within the scope of the research by country. In the table, the top 12 countries with the most studies in the relevant major journals are listed.
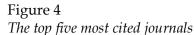
Figure 3
Publication numbers by countries

It is noticable that the numver of studies is more intense in developed countries. Among them, it is noteworthy that Turkey ranks as a developing country.

3.3. The Most-cited Journals and Articles in Mathematics Education Researches in 2017-2021 Period

Among the five SSCI journals examined, the ranking of the most cited journals in the 2017-2021 period and the top three most cited studies by year were presented in Figure 4 and Table 1, respectively.

Figure 4
The top five most cited journals

Accordingly, the most cited SSCI indexed journal was ESM, followed by IJSME. This situation can be interpreted depending on the total number of articles published in the journals or it can be interpreted with the general quality of the journal.

Table 1
The top three most cited studies by year

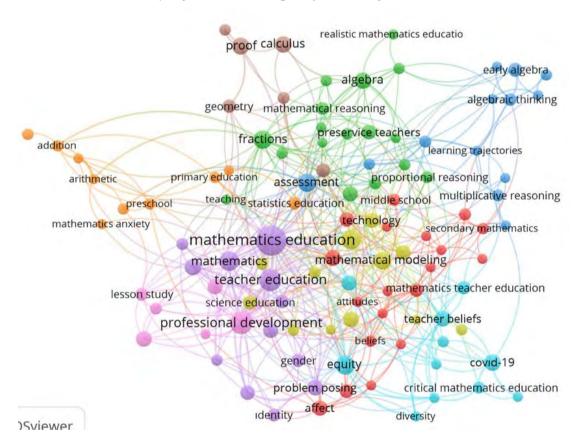| Paper	Year	Times Cited
"Advancing Elementary and Middle School STEM Education"	2017	76
"What Mathematics Education May Prepare Students for the Society of the Future?"	2017	49
"Professional competencies of (prospective) mathematics teachers-cognitive versus situated approaches"	2017	47
"An Integrated Analysis of School Students' Aspirations for STEM Careers: Which Student and School Factors Are Most Predictive?"	2018	48
"Culture and ideology in mathematics teacher noticing"	2018	42
"Equity Analytics: A Methodological Approach for Quantifying Participation Patterns in Mathematics Classroom Discourse"	2018	38
"Routines we live by: from ritual to exploration"	2019	31
"Mathematical competencies revisited"	2019	26
"Language and Mathematics-Key Factors influencing the Comprehension Process in reality-based Tasks"	2019	21
"Pandemic: lessons for today and tomorrow?"	2020	23
"Considering mathematical creative self-efficacy with problem posing as a measure of mathematical creativity"	2020	10
"Mathematical modeling in Germany and France: a comparison of students' modeling processes"	2020	10
"Relationship Between Chinese Mathematics Teachers' Knowledge and Their Professional Noticing"	2021	12
"Gender Differences in Mathematics Self-concept Across the World: an Exploration of Student and Parent Data of TIMSS 2015"	2021	10
"Future themes of mathematics education research: an international survey before and during the pandemic"	2021	8

In support of other research questions, the most cited topics were teacher noticing, STEM, teachers' professional development, and studies about the pandemic. These findings coincide with the bibliometric analysis and social network analysis findings performed.

3.4. Research Subjects Featured in Mathematics Education Research in the 2017-2021 Period According to occurrences/co-occurrences of Author Keywords

To determine the prevalent topics and commonly used concepts, a co-occurrence analysis was used of author keywords of sampled research. This analysis is based on the assumption that keywords list important topics and concepts that are discussed in a research article. In the co-occurrence analyses, the frequency of keywords and total strength of the co-occurrence links of keywords are calculated. In this context, the full counting option of VOSviewer was used in the co-occurrence analysis and the minimum number of a keyword occurrence was determined to be at least 5. 106 keywords that meet these requirements are mapped (Figure 5). Within the scope of the analysis, 106 key concepts were collected under 9 different clusters. The resulting clusters are visualized on the map in different colours and locations. These clusters are formed according to the coexistence of keywords in a study.

Figure 5

Occurrence network map (by total link strength) of author keywords

Examining the most prominent concepts, it is evident that concepts such as teacher education, teacher knowledge, and professional development come to the fore in number and relation to other concepts. Furthermore, teacher beliefs, prospective teachers, pedagogical knowledge, and teacher noticing concepts have also been identified as strong concepts. COVID-19, problem posing, proof, fractions, mathematical modelling and STEM are concepts also with high total connectivity and high occurrence value.
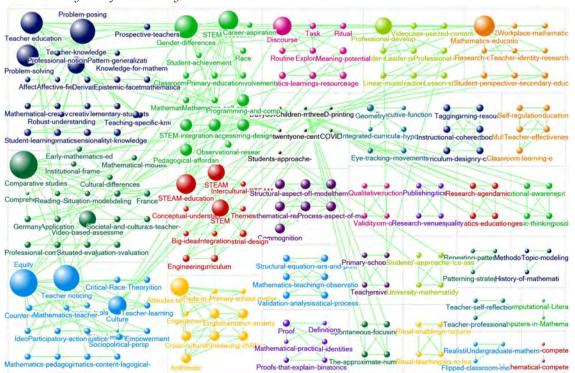
Table 2
Total link strength and occurrence values of top 20 author keywords

Keyword	Total link Strength	Occurrences
Mathematics education	79	68
Teacher education	43	31
Professional development	40	31
Teacher knowledge	32	23
Equity	31	22
Fractions	31	20
Assesment	30	20
Mathematics	23	24
Prospective teachers	23	16
Problem posing	22	14
Mathematical modeling	18	19
Pedagocical content knowledge	18	14
Teacher beliefs	18	14
Problem solving	17	11
Curriculum	17	10
Algebra	16	16
Affect	16	13
Teacher noticing	15	12
Content knowledge	15	7
COVID-19	14	15

3.5. The betweenness Centrality (BC) and Degree Centrality (DC) Values of the Author Keywords (in the most cited articles by years)

The undirected network graph generated represents 222 nodes with 481 edges between them. The keywords in Figure 6 are created according to the BC values described earlier in the method section according to their relationship with each other.

Figure 6
The SNA layout of author keywords

Keywords were mapped out using the Grid layout algorithm. Also, keywords were grouped by cluster using the Wakita Tsurimi cluster algorithm. The analysis was based on the DC and BC of the keywords analysed. The calculated centrality values for keywords in the resulting network are presented in Table 3 and Table 4.

Table 3
Degree centrality values of author keywords

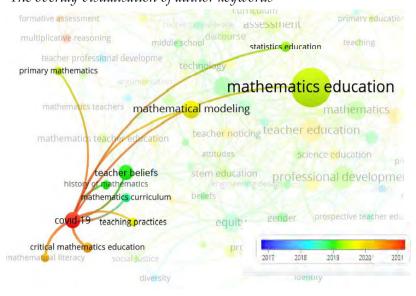| No	Keyword	Degree centrality	No	Keyword	Degree centrality
1	Comparative studies	17.000	11	Attitudes to mathematics	9.000
2	Equity	16.000	12	Discourse	9.000
3	Teacher noticing	15.000	13	Culture	9.000
4	Teacher education	14.000	14	Problem solving	9.000
5	Mathematics education	14.000	15	STEAM	8.000
6	Modeling	11.000	16	Professional development of teachers	8.000
7	Gender differences	11.000	17	Teacher knowledge	8.000
8	STEAM education	10.000	18	Video based assesment	8.000
9	Problem posing	10.000	19	STEM	8.000
10	STEM education	10.000	20	Engineering design	7.000

Table 4
Betweenness centrality values of author keywords

No	Keyword	Betweenness centrality	No	Keyword	Betweenness centrality
1	Teacher noticing	1.637	11	STEAM	232
2	Equity	1.602	12	Problem posing	191
3	Gender differences	1.345	13	Culture	152
4	Modeling	1.282	14	Teacher knowledge	119
5	Teacher education	1.226	15	Video based assesment	100
6	STEM education	1.151	16	Professional development of teachers	20
7	Comparative studies	1.141	17	Attitudes to mathematics	15
8	Mathematics education	620	18	Proof	6
9	STEAM education	363	19	Lesson-Study	6
10	Problem solving	245	20	Linear-model	6

Table 3 and Table 4 present the top 20 concepts with the highest DC and the BC. Accordingly, in the 2017-2021 period, the most focused researches in the field of mathematics education have revealed 3 main sets: studies related to mathematics teachers (teacher noticing, teacher education, teacher knowledge etc.), equal opportunity in education-culture-gender studies, and studies on comparison of different countries. In addition, according to the analysis results, there are also clues that problem posing, problem solving, modelling, STEM and STEAM education studies are trending topics in the field during this period.

3.6. Mathematics Education Research Subjects in the 2017-2021 Period by Year

An occurrence analysis was carried out on the abstract sections and author keywords of the sampled papers, based on relevance scores and total link strength parameters, to determine if there was a change/trend in mathematics education subject distribution. As a result of both analyses, there was no significant variability in the distribution of subjects by year.

Figure 7
The overlay visualisation of author keywords

This analysis and the map created as a result have been created to determine which issues come to the fore according to the years. The only significant change in the relevant period occurred in 2021, and it was observed that the studies on COVID-19 increased rapidly. In connection with COVID-19; critical mathematics education, mathematics curriculum, teaching practices, teacher beliefs, elementary school mathematics, thematic literacy studies have been observed.

4. Discussion and Conclusion

This study aimed to identify trends and highlights in mathematics education research in the five-year period from 2017 to 2021. In the first research question, the quantitative distribution of peer reviewed articles in major mathematics education journals was questioned whether there was a variability in the 2017-2021 period, and a significant upward trend in the number of mathematics education studies was identified during this period. The remarkable point of this rise is that there has been a significant increase in 2020 and 2021 compared to previous years. Although there is no similar study to compare this increase, it is thought that the disruptive effect (Daniel, 2020) of the COVID-19 pandemic in educational research may cause this.

The second research question of the study examines the distribution of the number of publications of mathematics education research by country in the 2017-2021 period. Based on the findings, it was determined that the top 12 countries that published the most in major mathematics education journals, were predominantly developed countries. This situation can be examined from different angles. First of all, it is noticeable that in different systematic reviews in mathematics education, developed countries provide an important domination in terms of publication numbers (Gokce & Guner, 2021; Yığ & Sezgin, 2021). It is a generally accepted argument that the main reason for the success of developed countries is their level of academic development. In order to sustain their success, these countries may strive to diversify their educational research in various fields (mathematics education, science education, etc.) and to increase their innovative academic work (Yığ & Sezgin, 2021). This may be the reason for the aforementioned finding.

In the third research question of the study, most cited major journals and publications in mathematics education during the 2017-2021 period were examined. According to the findings, ESM was identified as the most cited journal during this period. The number of citations is a very important metric regarding the quality of an academic journal, and this result is actually a confirmation of a fact accepted in mathematics education field. In their research, Williams and Leatham (2017) evaluated academic mathematics education journals and stated that ESM is by far one of the most cited and respected high-quality journals in the field of mathematics education.

However, IJSME, which ranked 11th in the study of Williams and Leatham (2017), was identified as the 2nd most cited journal according to the findings of this study. It can be said that this journal is highly accepted by researchers in the field of mathematics education and has made significant progress in terms of visibility/dignity.

In the 4th and 5th research questions of this research, key/trending research subjects in mathematics education researches were tried to be identified and two different analysis approaches were used for this purpose. The findings of the first approach, bibliometric analysis, were clustered as 3 separate mathematical education components. Accordingly, in the period 2017-2021, various concepts related to teacher education (professional development, teacher knowledge, pedagogical content knowledge, prospective teachers, teacher noticing), some mathematical skills subjects/issues (problem posing, problem solving, fractions, modelling, algebra) and equity concepts were found to be at the top of both occurrence and link strength scores. The second approach, SNA, was also discussed in 3 different groups with the 2017-2021 period. Accordingly, studies related to mathematics teachers, equal opportunity in education, studies on culture, gender and comparison of different countries, and problem posing, problem solving, modelling, STEM and STEAM education studies were determined as critical subject areas according to BC scores.

As mentioned earlier, in this study, the subject of mathematics teacher education and the variables related to this subject are among the prominent findings. The importance of teacher education in mathematics education has been systematically emphasized in different trends/issues studies in mathematics education since the 1980s (Schoenfeld, 2016). In parallel, the effect of teacher knowledge on mathematics teaching within the classroom and therefore its role in student learning has been studied for many years (Ball et al., 2008; Schoenfeld, 2020; Shulman, 1986). Second Handbook of Research on Mathematics Teaching and Learning (Lester, 2007) detailed the importance of studies on teacher knowledge, effect and beliefs. The focus among these subjects is the beliefs of mathematics teachers. Lubienski and Bowen's (2000) analysis covering 1982 and 1998 found that teacher actions were popular topics of that period, but the keyword "teacher education" was one of the least popular topics. In a more recent study, Hannula (2009) determined that teacher education and teacher professional development were the most popular topics in the period 1997-2007. Inglis and Foster (2018) examined articles published over the past 5 decades at ESM and JRME, and the most notable finding was the conclusion that since the 1980s, both journals have increasingly focused on teacher knowledge and beliefs. In one of the most recent studies, Shin's work (2020) stated that pre-service teachers were the most commonly used subject of study in the period 2000-2019, followed by the professional development of teachers. Bakker et al. (2021) investigated which themes mathematics education studies should focus on in the next decade in their studies, in which they collected repetitive data before and during the pandemic period. In their research, mathematics education experts from different countries emphasized the importance of teacher professional development and also pointed out that teachers are incredibly important with the pandemic period of 2020.

In the social network analysis carried out, it was determined that the concept of "teacher noticing" for the period 2017-2021 was the most important and key subject among the subjects of mathematics education. This finding is quite remarkable compared to trend analysis research covering previous years. Teacher noticing, in short, aims to recognize what is important and remarkable in classroom interaction, while understanding what they mean about learning and teaching based on a situation/context that arises in classroom interaction (van Es & Sherin, 2021). In support of the findings of this research, it is noted that in recent years educational researches have investigated topics such as teacher noticing, teacher noticing detection and development (Callejo & Zapatera, 2017; Lesseig et al., 2017; Louie, 2018; Simpson & Haltiwanger, 2017; Taylan, 2017; Tekin-Sitrava et al., 2021). This study shows that the emphasis is still mostly on the role of teachers in math education. Teacher noticing, teacher's professional development, content knowledge, pedagogical content knowledge, issues continue to be dominant topics in 2017-2021.

Apart from the subjects related to math teacher training and skills, there are some common issues that stand out in the two analysis approaches used in this study: Concept of equity, gender differences, problem posing, problem solving and modelling. The results of the analysis reveal that these issues are both frequently studied and of great strategic importance in the development of the field in the 2017-2021 period. Students' differences in culture, language, race and socioeconomic status required a focus on equity in math classes (Gutierrez, 2013). Besides, equity and gender studies are frequently emphasized topics in mathematics education since the 80s, and it is thought that the equity and access issues in particular have not been resolved to this day (Schoenfeld, 2016). For the years that followed, Shin's (2020) study also revealed that equity and social justice were the most highlighted mathematics education issues in the period 2000-2019. For the period 2020-2021, in the study of Bakker et al. (2021), math field experts strongly emphasized the importance of equity in mathematics education. In support of this argument, the results of this study provide clues that equity in mathematics education remains of strategic importance and is still an unresolved phenomenon. Especially in 2020-2021, due to the COVID-19 pandemic, the teaching processes were suspended or remote online teaching practices were carried out in some regions. It is thought that, this development may have resulted in some disadvantaged groups being excluded from the educational process, resulting in a re-and stronger focus on equity in math education by researchers.

The results of the research also determined the intensity and importance of gender related studies in maths education. Gender studies in maths education peaked in the 80s (Inglis & Foster, 2018). Lubienski and Bowen's (2000) research, covering the years 1982-1998, specifically examined gender, ethnicity, class and disability issues, and concluded that gender-related research was more common among these subjects. Although there was no significant trend in gender studies in the 2000s, this research shows that gender studies have become a trend again in mathematics education. This finding may indicate that changing learning needs in math education may have a decisive role in gender context.

Problem posing, problem solving and modelling topics have been identified as popular and strategic mathematical skills topics that stand out in two different analysis approaches carried out in this research. Hanna and Sidoli (2002) found that interest in problem solving peaked in the 1980s in the field of mathematics education. Lubienski & Bowen (2000) examined the period from 1982 to 1998, and problem solving and geometry were the most popular mathematical subjects. Hannula's (2009) research stated that this interest continued in part during the period 1997-2007, but in the studies of Inglis and Foster (2018) for the last 5 decades, it was stated that this high trend in problem solving studies did not continue to this day.

The findings of this research have shown that interest in problem solving in the field of mathematics education has increased again and has come to the fore. One of the important findings of this research is that the problem posing issue has emerged as an important mathematical skill subject. Problem posing was a topic that had not been prominent in previous trend researches examining the field of mathematics education. In fact, problem posing is an important mathematical skill that is highly related to creativity and is also associated with complex problem solving (Cai et al., 2017). Although problem-posing activities in mathematics education can provide important opportunities for the development of "both cognitive and affective competencies", it can be said that problem-posing research is still new (Cai & Leikin, 2020).

Another common mathematical skill topic that stands out in the research is modelling. In the research of Bakker et al. (2021), mathematical education experts, who were study participants, stated that more attention should be paid to modelling research with the pandemic period. According to Schoenfeld (2016), a mathematical measurement focused solely on exam results fails to produce a valid result on students' ways of thinking and achievements, however a measurement system supported by problem solving and modelling approaches can provide the teacher with comprehensive and valid information about the ways students think. From this point of view, it can be considered that the mathematical skill subjects that stand out in this study, such as problem

posing, problem solving and modelling, are the issues that researchers focus on as an alternative way to traditional measurement approaches. In addition to this argument, teacher noticing and skills in teacher education, which are also very prominent in this study, can provide important clues to researchers in the field for the ongoing transformation in mathematics education.

Another mathematics teaching topic featured in the study is STEM and STEAM concepts. In the study of Bakker et al. (2021), many of the field experts recommended linking math teaching subjects with disciplines other than mathematics education such as technology, science, engineering and art. In this context, it may be common for mathematics education researchers to take such interdisciplinary approaches in the field.

Another research question sought in the study examined whether there was a differentiation in mathematical education research subjects by year in the 2017-2021 period. When the distribution of keywords by year was examined, no significant trend was observed between 2017 and 2021. However, during 2020-2021, the keyword "COVID-19" appears to have become quite apparent. Although this is a predictable result, it has also been observed that studies have been carried out on critical mathematics education, mathematics curriculum, teaching practices, teacher beliefs, elementary school mathematics and thematic literacy in connection with this keyword. COVID-19, as expected, has implications for many studies from different educational disciplines published during the pandemic period (Daniels, 2020; Rassudov & Korunets, 2020; Rose, 2020). The relevant finding provides clues that there may be outstanding topics in the field of mathematics education during the pandemic period, especially in the transition from face-to-face education to online learning related to curriculum and teaching design. In addition, it is thought that teacher characteristics and competencies were questioned again during the pandemic period. It can be also commented that the focus on mathematics teaching studies, especially at the elementary school level, is a remarkable finding for mathematics educators.

5. Implications and Future Research

In this research, mathematics education articles published between 2017 and 2021 were analyzed and current trends and issues in the field were tried to be identified. The transformation in many educational fields is also expected to occur in the field of mathematics education with the development of technology and greater integration into human daily life. This change has started to manifest itself in different components in mathematical competencies and mathematics teaching. Especially with the COVID pandemic of 2019, new transformations are likely.

According to the common findings from both analysis approaches, in the 2017-2021 period, the most focused and prominent research issues in the field of mathematics education have revealed different main sets: studies related to mathematics teachers and teacher education (and especially teacher noticing topic), equity-culture-gender studies, and studies on mathematical problem posing, problem solving, modelling, STEM and STEAM education. As mentioned in the discussion section, if we examine the topics researched in mathematics education from past to present, we can notice that the rise of teacher noticing, problem posing and STEM subjects in recent years. This is a remarkable point. In this context, it can be assumed that these issues may become increasingly important in the field in future research. It may also become easier to see connections to other topics in the field after reflecting on why these issues come to the fore.

Funding: No funding source is reported for this study.

Declaration of interest: No conflict of interest is declared by author.

References

Anderson, T., & Zawacki-Richter, O. (2014). Conclusion: Towards a Research Agenda. In O. Zawacki-Richter & T. Anderson (eds.), *Online distance education: Towards a research agenda* (p. 485– 492). AU Press.

Baki, A., Karataş, I., Akkan, Y., & Çakıroğlu, U. (2011). Trends in Turkish mathematics education research: from 1998-2007. *Hacettepe University Journal of Education, 40,* 57-68.

Bakker, A., Cai, J., & Zenger, L. (2021). Future themes of mathematics education research: an international survey before and during the pandemic. *Educational Studies in Mathematics*, *107*(1), 1-24. https://doi.org/10.1007/s10649-021-10049-w

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Bozkurt, A., Keskin, N. O., & De Waard, I. (2016). Research trends in massive open online course (MOOC) theses and dissertations: Surfing the tsunami wave. *Open Praxis*, *8*(3), 203-221. http://dx.doi.org/10.5944/openpraxis.8.3.287

Bozkurt, A., Zawacki-Richter, O., & Aydin, C. H. (2019). Using social network analysis to review the research in open and distance learning. In *Proceedings of The Association for Educational Communications and Technology (AECT) 2019 International Convention* (pp. 38-44). Retrieved from https://eric.ed.gov/?id=ED616450

Cai, J., & Leikin, R. (2020). Affect in mathematical problem posing: Conceptualization, advances, and future directions for research. *Educational Studies in Mathematics*, *105*(3), 287-301. https://doi.org/10.1007/s10649-020-10008-x

Cai, J., Morris, A., Hohensee, C., Hwang, S., Robison, V., & Hiebert, J. (2017). Clarifying the impact of educational research on students' learning. *Journal for Research in Mathematics Education*, *48*(2), 118–123. https://doi.org/10.5951/jresematheduc.48.2.0118

Callejo, M. L., & Zapatera, A. (2017). Prospective primary teachers' noticing of students' understanding of pattern generalization. *Journal of Mathematics Teacher Education, 20*(4), 309-333. https://doi.org/10.1007/s10857-016-9343-1

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education.* Routledge.

Crossley, N., Bellotti, E., Edwards, G., Everett, M. G., Koskinen, J., & Tranmer, M. (2015). *Social network analysis for ego-nets: Social network analysis for actor-centred networks*. Sage.

Çiftçi, Ş. K., Danişman, Ş., Yalçın, M., Tosuntaş, Ş. B., Ay, Y., Sölpük, N., & Karadağ, E. (2016). Map of scientific publication in the field of educational sciences and teacher education in Turkey: A bibliometric study. *Educational Sciences: Theory & Practice, 16*, 1097-1123. https://doi.org/10.12738/estp.2016.4.0009

Daniel, S. J. (2020). Education and the COVID-19 pandemic. *Prospects*, *49*(1), 91-96. https://doi.org/10.1007/s11125-020-09464-3

Ellegaard, O., Wallin, J.A. (2015). The bibliometric analysis of scholarly production: How great is the impact?. *Scientometrics, 105,* 1809–1831. https://doi.org/10.1007/s11192-015-1645-z

Ernest, P., Skovsmose, O., Van Bendegem, J. P., Bicudo, M., Miarka, R., Kvasz, L., & Moeller, R. (2016). *The philosophy of mathematics education*. Springer Nature. https://doi.org/10.1007/978-3-319-40569-8

Gokce, S., & Guner, P. (2021). Forty years of mathematics education: 1980-2019. *International Journal of Education in Mathematics, Science and Technology*, *9*(3), 514-539. https://doi.org/10.46328/ijemst.1361

Gutiérrez, R. (2013). The sociopolitical turn in mathematics education. *Journal for Research in Mathematics Education*, *44*(1), 37-68. https://doi.org/10.5951/jresematheduc.44.1.0037

Hanna, G., & Sidoli, N. (2002). The story of ESM. *Educational Studies in Mathematics*, *50*(2), 123-156. https://doi.org/10.1023/A:1021162617070

Hannula, M.S, (2009). International trends in mathematics education research. In M. Lepik (Ed.), *Teaching mathematics: retrospectives and perspectives:Proceedings of the 10th international conference* (pp.11-16). Tallinn University.

Hilton, P. (1984). Current trends in mathematics and future trends in mathematics education. *For the Learning of Mathematics*, *4*(1), 2-8.

Huang, C., Yang, C., Wang, S., Wu, W., Su, J., & Liang, C. (2020). Evolution of topics in education research: A systematic review using bibliometric analysis. *Educational Review*, *72*(3), 281-297. https://doi.org/10.1080/00131911.2019.1566212

Inglis, M., & Foster, C. (2018). Five decades of mathematics education research. *Journal for Research in Mathematics Education*, *49*(4), 462-500. https://doi.org/10.5951/jresematheduc.49.4.0462

Kilpatrick, J. (2020). History of research in mathematics education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 349-354). Springer. https://doi.org/10.1007/978-3-030-15789-0_71

Lesh, R. (2002). Research design in mathematics education: Focusing on design experiments. In *Handbook of international research in mathematics education* (pp. 39-62). Routledge.

Lesseig, K., Elliott, R., Kazemi, E., Kelley-Petersen, M., Campbell, M., Mumme, J., & Carroll, C. (2017). Leader noticing of facilitation in videocases of mathematics professional development. *Journal of Mathematics Teacher Education, 20*(6), 591-619. https://doi.org/10.1007/s10857-016-9346-y

Lester, F. K. (Ed.). (2007). *Second handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics*. IAP.

Leydesdorff, L. (2007). Betweenness centrality as an indicator of the interdisciplinarity of scientific journals. *Journal of the American Society for Information Science and Technology, 58*(9), 1303-1319. https://doi.org/10.1002/asi.20614

Louie, N. L. (2018). Culture and ideology in mathematics teacher noticing. *Educational Studies in Mathematics*, *97*(1), 55-69. https://doi.org/10.1007/s10649-017-9775-2

Lubienski, S. T., & Bowen, A. (2000). Who's counting? A survey of mathematics education research 1982–1998. *Journal for research in mathematics education*, *31*(5), 626-633. https://doi.org/10.2307/749890

Rassudov, L., & Korunets, A. (2020). *COVID-19 Pandemic challenges for engineering education* [Paper presentation]. XI International Conference on Electrical Power Drive Systems (ICEPDS), IEEE, Russia. https://doi.org/10.1109/ICEPDS47235.2020.9249285

Rose, S. (2020). Medical student education in the time of COVID-19. *Jama*, *323*(21), 2131-2132. https://doi.org/10.1001/jama.2020.5227

Schoenfeld, A. H. (2000). Purposes and methods of research in mathematics education. *Notices of the AMS, 47*(6), 641-649.

Schoenfeld, A. H. (2020). Reframing teacher knowledge: a research and development agenda. *ZDM Mathematics Education, 52*, 359–376. https://doi.org/10.1007/s11858-019-01057-5

Schoenfeld, A. H. (2016). Research in mathematics education. *Review of Research in Education*, *40*(1), 497-528. https://doi.org/10.3102/0091732X16658650

Shin, D. (2020). A comparative study of domestic and international research trends of mathematics education through topic modeling. *The Mathematical Education*, *59*(1), 63-80. https://doi.org/10.7468/mathedu.2020.59.1.63

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.2307/1175860

Sierpinska, A., & Kilpatrick, J. (1998). Continuing the search. In *Mathematics education as a research domain: A search for identity* (pp. 527-548). Springer.

Simpson, A., & Haltiwanger, L. (2017). "This is the first time I've done this": Exploring secondary prospective mathematics teachers' noticing of students' mathematical thinking. *Journal of Mathematics Teacher Education*, *20*(4), 335-355. https://doi.org/10.1007/s10857-016-9352-0

Smith, M. A., Shneiderman, B., Milic-Frayling, N., Mendes Rodrigues, E., Barash, V., Dunne, C., ... & Gleave, E. (2009). Analyzing (social media) networks with NodeXL. In J. M. Carroll (Ed.), *Proceedings of the fourth international conference on Communities and technologies* (pp. 255-264). Association for Computing Machinery. https://doi.org/10.1145/1556460.1556497

Sriraman, B., & English, L. D. (2005). Theories of mathematics education: A global survey of theoretical frameworks/trends in mathematics education research. *ZDM, 37*(6), 450-456. https://doi.org/10.1007/BF02655853

Taylan, R. D. (2017). Characterizing a highly accomplished teacher's noticing of third-grade students' mathematical thinking. *Journal of Mathematics Teacher Education, 20*(3), 259-280. https://doi.org/10.1007/s10857-015-9326-7

Tekin-Sitrava, R., Kaiser, G., & Işıksal-Bostan, M. (2021). Development of prospective teachers' noticing skills within initial teacher education. *International Journal of Science and Mathematics Education*, 1-24. https://doi.org/10.1007/s10763-021-10211-z

Türkdoğan, A., Güler, M., Bülbül, B. Ö., & Danişman, Ş. (2015). Studies about misconceptions in mathematics education in Turkey: A thematic review. *Mersin University Journal of the Faculty of Education*, *11*(2), 215-236. https://doi.org/10.17860/efd.26545

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

van Es, E. A., & Sherin, M. G. (2021). Expanding on prior conceptualizations of teacher noticing. *ZDM–Mathematics Education*, *53*(1), 17-27. https://doi.org/10.1007/s11858-020-01211-4

Williams, S. R., & Leatham, K. R. (2017). Journal quality in mathematics education. *Journal for Research in Mathematics Education*, *48*(4), 369-396. https://doi.org/10.5951/jresematheduc.48.4.0369

Yığ, K.G., & Sezgin, S. (2021). An exploratory holistic analysis of digital gamification in mathematics education. *Journal of Educational Technology and Online Learning, 4*(2), 115-136. https://doi.org/10.31681/jetol.888096

Young, J., & Young, J. (2022). Equity trends in mathematics education: A content analysis of meta-analytic research. *International Journal on Studies in Education (IJonSE)*, *4*(1), 24-42. https://doi.org/10.46328/ijonse.57

Zhang, J., & Luo, Y. (2017). Degree centrality, betweenness centrality, and closeness centrality in social network. In X. Luo (Ed.), *Proceedings of the 2017 2nd International Conference on Modelling, Simulation and Applied Mathematics (MSAM2017)* (pp. 300-303). Atlantis Press. https://doi.org/10.2991/msam-17.2017.68