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Research Article

Problem-posing research in mathematics education: A bibliometric analysis

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The aim of this study is to investigate the trends in research related to problem posing in mathematics education. The study focuses on the articles on problem posing in the Web of Science database between 1990 and 2021. The term co-occurrence map, which was created depending on the data in the text with the bibliometric analysis of the articles on problem posing that met the specified criteria, revealed a four-cluster structure according to the degree of relations between the terms. These clusters are called effect (the effect of problem posing on various variables), creativity (the relationship between problem posing and creativity), construct (understandings of how it is thought in the problem posing process and the nature of problem posing) and intervention (opportunities provided by changing existing teaching by including problem posing). This study provides evidence on trends in problem posing related studies. Knowing the research trends on this issue will help researchers obtain information about the areas where more research is needed and plan their future work in that direction.

Keywords: Bibliometric analysis; Problem posing; Mathematics education; Trend

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1. Introduction

One of the most important skills aimed to be developed during mathematics education is problem solving. Problem solving is not only the goal of learning mathematics but also an important way of doing mathematics (National Council of Teachers of Mathematics [NCTM], 2000). Since the 1940s, there has been a long history of interest in problem solving in the mathematics education community with the work of Polya (1945), and since the 1980s (Schoenfeld, 1992), problem solving has been part of classroom instruction (Rosli et al., 2015). Another skill, the importance of which has been emphasized significantly in both teaching documents and mathematics education literature in recent years, is problem posing (Chen et al., 2015).

Problem posing has been described in different ways by different researchers. Silver (1994) defined problem posing as the creation of new problems and the arrangement of given problems, whereas Stoyanova and Ellerton (1996) defined it as students' interpretations of concrete situations as meaningful mathematical problems. Similarly, Tichá and Hošpesová (2009) defined problem posing as the creation of new problems or the modification of the data of a given problem or its generalization on the basis of the 'if not' question, etc. On the other hand, when the literature is

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examined, it is noted that different classifications are made for problem posing. Silver (1994) examined problem posing in three categories: before, during and after the solution. In the category of problem posing *before the solution*, there is problem posing related to the given situation. In the category of posing a problem *during the solution*, a new problem is created that is related to a problem that has been solved. In the category of problem posing *after the solution*, there is re-writing the problem by changing the goals of a previously solved problem. Stoyanova and Ellerton (1996), on the other hand, divided problem posing into three categories: structured, semi-structured and free problem posing. There is posing a problem similar to a given problem or its solution in structured problem posing, while, in semi-structured problem posing, a new problem is posed, or an unfinished problem is completed by using previous knowledge and skills from a given situation. On the other hand, it is expected that an easy or difficult problem will be posed from any given situation in the form of posing a free problem. Christou et al. (2005) proposed a problem posing model including four processes. These are *the editing* where a problem is desired to be posed by giving any situation; *the selecting*, in which a new problem is desired to be posed based on a given answer; *the comprehending*, where a problem is posed using mathematical operations, and the *translating* processes, in which a problem is posed using visual representations.

Although the last of the problem solving stages stated by Polya (1945) as *understanding the problem, making a plan, carrying out the plan* and *looking back* refers to posing new/related problems, problem posing in mathematics education has attracted the attention of society starting from the beginning of the 1980s (Silver, 2013). The publication of Brown and Walter's groundbreaking 1983 book 'The Art of Problem-Posing' was a watershed moment in drawing the attention of the mathematical education community to problem posing on a large scale and in coordination. In this book, the authors have defined pedagogical techniques and ways of thinking, such as the 'if not' strategy that can encourage and support students to create their own problems by synthesizing a case related to students' problem posing. Kilpatrick's (1987) chapter on problem posing can be taken as the first argument related to research on problem posing (Liljedahl & Cai, 2021). Kilpatrick (1987) argues that problem posing should be seen as not only a goal of teaching but also a teaching approach, and having the experience of posing one's own math problems should be part of every student's education. NCTM (1989) has made a very clear call for students to be given problem posing opportunities in math classes, pointing out the importance of problem posing to make it easier for students to learn. This call has led to the faster spread of the idea of problem posing in the mathematics education community (Liljedahl & Cai, 2021). After the publication of Kilpatrick's chapter (1987), Edward Silver carried out the first funded experimental study on mathematical problem posing in 1989 in a project supported by the US National Science Foundation and published the findings of the project in academic papers (Silver, 1994; Silver & Cai, 1996; Silver et al., 1996). The studies conducted on this subject have expanded over time to include aspects such as the relationship of problem posing with problem solving, students' problem solving strategies, how teachers can facilitate problem posing in their classrooms, and how problem posing can contribute to students' conceptual development (Cai et al., 2013; Ellerton, 1986; English, 1997, 1998; Kilpatrick, 1987; Silver & Cai, 1996; Stoyanova & Ellerton, 1996).

There have been several reviews (Cai et al., 2015; Cai & Hwang, 2020; Lee, 2021; Liljedahl & Cai, 2021; Osana & Pelczer, 2015; Singer et al., 2013; Silver, 2013; Weber & Leikin, 2016) presenting the most recent state of the art in problem posing. Of these, for example, Lee (2021) identified the current state of problem posing by analyzing a total of 62 articles related to problem posing in 13 major (major) mathematics education journals with publication year history ranging from 14-49 years until 2018 or 2019, according to research types, sample groups, research topics and problem posing task types. Cai and Hwang (2020) analyzed articles in a special issue of the International Journal of Educational Research, focusing on the three aspects of mathematical problem posing (MPP) identified as MPP as a variable, MPP as a construct, and MPP as an intervention, and the methodological choices associated with them. Liljedahl and Cai (2021), in their article where they focused on problem solving and problem posing together, first described the seminal moments related to these issues in the history of research and examined 16 other empirical articles in a special issue where their own work was published. The above-mentioned studies deal with the in-depth review of a small working group. However, bibliometric analysis provides the opportunity to examine hundreds or even thousands of studies with a macro-level perspective and thus to evaluate the structure and dynamics of the research area studied from a broader perspective (Zupic & Čater, 2015). However, in the literature review, no bibliometric analysis studies related to studies on problem posing were found. The bibliometric analysis of the studies on problem posing will give us ideas about the current situation in this research area, the pioneering studies of the field, and through the maps to be obtained, more specific and in-depth research topics will be determined. By looking at the studies from a broad perspective, it will also be possible to determine in what way problem posing is handled over the years and in which areas there is a need for research. So it is thought that this study will make important contributions to the literature. Considering all these it is aimed at investigating the trends in problem posing through bibliometric analysis in this study. For this purpose, answers to the following problems were sought. (1)What is the distribution of articles related to problem posing by years? (2) What are the mostly occurring keywords in the articles related to posing? How do these keywords change over the years? (3) What kind of structure emerges with the bibliometric analysis of articles related problem posing?

2. Methodology

In this study, articles related to problem posing in mathematics education in the Web of Science database were examined using the bibliometric analysis method. The bibliometric analysis method, which is one of the tools considered important in the evaluation of academic research (Dede & Özdemir, 2022; Yığ, 2022) is a quantitative data analysis application to explore, evaluate and examine large amounts of scientific data (Donthu et al., 2021; Zupic & Cater, 2015). The bibliometric analysis approach uses techniques, such as co-occurrence analysis, keyword analysis, cluster analysis, and bibliometric maps to examine studies in the literature systematically (Song & Wang, 2020). This way, it is possible to obtain information about the trends in research studies with a retrospective review (Gökçe & Güner, 2022).

2.1. Research Design

In the design of the research, the mentioned stages were used in the important bibliometric studies (Gökçe & Güner, 2021; Gökçe & Güner, 2022; Güner & Gökçe, 2021) conducted in the field of mathematics education and contributed significantly to the literature. As shown in Figure 1, these stages are in the exploration stage where the Web of Science database is investigated; the visualization stage, where visualizations are performed using the VOSviewer software; the identification stage, where networks are named, and the verification stage, where evidence is discovered.

Figure 1
Research phases

2.2. Data Collection

A total of 724 studies conducted on problem posing in the Web of Science database have been reached. After filtering, considered in the determination of the studies to be included in the study and carried out using the criteria given in Table 1, 162 articles were examined and bibliometric analyses were performed.

Table 1
Summary of the investigation criteria

Criteria	
Data source	Web of Science
Fields	Topic (title, abstract, author keywords, and Keyword Plus)
Search terms	"problem posing" or "problem-posing" and "math*"
Citation index	SSCI, SCI Expanded, ESCI
Publication periods	January 1990 to December 2020
Document type	Article
Language	English

2.3. Data Analysis

The analysis of the data was started with descriptive analyses carried out through the Web of Science's system. For bibliometric analysis, the VOSviewer software was used. The VOSviewer software provides statistical information on the items, connections between items, and links between clusters of items that occur most frequently during bibliometric analysis (Van Eck & Waltman, 2020). Through this software, bibliometric maps can be created, such as network maps, which show the relationship between items and group them into clusters according to the strength of the connections; overlay map, which displays a color bar depending on changes over the years, and a density map that shows the occurrence frequency of items with keywords highly present in publications (Gökçe & Güner, 2022). Following the criteria determined within the scope of this study, the data of 162 articles accessed from the Web of Science database were transferred to the VOSviewer software, the necessary bibliometric analyses were performed and maps were created.

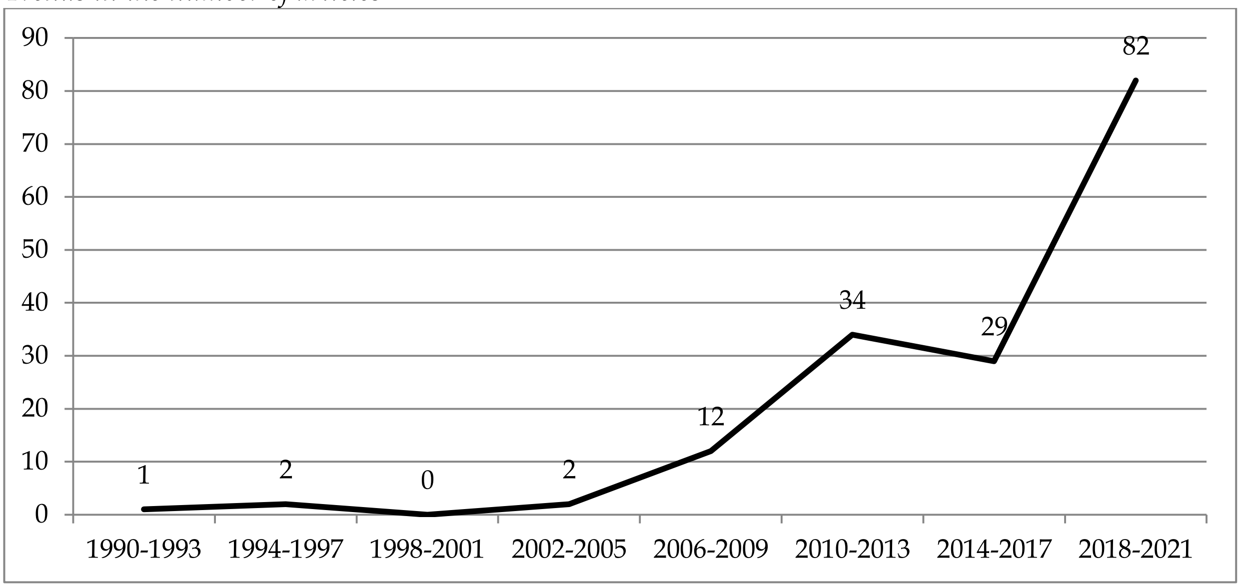
3. Results

In this section, the findings obtained throughout the research are given, depending on the stages given in the design section of the research.

3.1. Exploration

The exploration phase involves identifying the studies in the Web of Science database in accordance with the criteria determined within the scope of the research and examining them from various aspects. First, the trend over the years has been determined in the number of articles reached. The change in the number of articles between 1990 and 2021 is given in Figure 2.

Figure 2
Trends in the number of articles



From Figure 2, it is understood that the articles on problem posing in mathematics education that were scanned in the Web of Science database started to be published 1990. It is worth noting that the number of articles published in the first four-year periods is 1, 2, 0 and 2. It is seen that the rapid increase in the number of published articles started with 12 articles published in 2006–2009. The number of articles published between 2010 and 2013 was 34, approaching almost three times the number of articles published in the previous period. The fact that the number of articles published between 2014 and 2017 was 29 indicates a relative decrease in the value calculated for this period. On the other hand, Figure 2 shows a larger increase in the number of articles published between 2018 and 2021, with 82 articles

The most frequently used keywords in articles about problem posing are presented in Table 2.

Table 2
Highly occurring keywords

Keyword	*f*	*Keyword*	*f*
Problem solving	32	Teacher education	6
Mathematics education	10	Creativity	6
Prospective teacher	7	Preservice teacher	5
Mathematics	6	Fractions	4
Teacher learning	6	Mathematical creativity	4

In Table 2, it is noted that the keyword that repeats the most in articles on problem posing and the frequency of which is quite high when compared with other keywords is 'problem solving'. In addition, it is seen that the frequencies of the other keywords that repeat the most are close to each other. Of these, keywords such as 'prospective teacher', 'teacher learning', 'teacher education', and 'preservice teacher' refer to studies investigating the use of problem-posing in teacher education. The keywords 'creativity' and 'mathematical creativity' indicate that problem posing and creativity in mathematics are considered together in the studies carried out. The keyword 'fractions' gives information about the problem posing tasks on fractions in the published articles.

Although the most commonly used keywords in articles on problem posing are 'problem solving', 'mathematics education', 'prospective teacher', 'mathematics', 'teacher learning', 'teacher education', and 'creativity', the reviews, which will be conducted depending on the time, will give more ideas in terms of reflecting trends in this area. Therefore, the first ten keywords were determined for every five-year period with the help of a timeline. Figure 3 was created using these keywords other than 'problem posing', 'problem-posing' and 'mathematical problem posing'.

As can be seen from Figure 3, highly occurring keyword in every 5-year period was 'problem solving'. In addition, it is noteworthy that the keyword 'creativity' was used in the articles published between 2010 and 2014 and 2015 and 2019, and 'teaching mathematics through problem-posing', 'teaching through problem-posing' and 'affect' keywords were used in the articles published after 2020.

3.2 Visualization

In the studies in the data set, the overlay map in which the most used items are hierarchically categorized on the basis of the publication year criterion is given in Figure 4. This map shows how the most commonly used items in the studies obtained by filtering 'problem posing and math*' or 'problem-posing and math*' according to the topics of the studies in the Web of Science database by year. In the color bar in the lower right corner of the map, the transition from blue to yellow provides information about how the most used items in the studies have changed from the first to the last years.

From Figure 4, it is understood that from 2014 to 2016, articles on problem posing with topics such as fraction and division were published. It is noteworthy that the most frequently used terms in the topics of current studies on problem posing are 'creativity', 'mathematical creativity', 'mathematical thinking', 'significant difference', 'control group', etc., which are shown in yellow.

Figure 3
Timeline analysis of highly occurring keywords

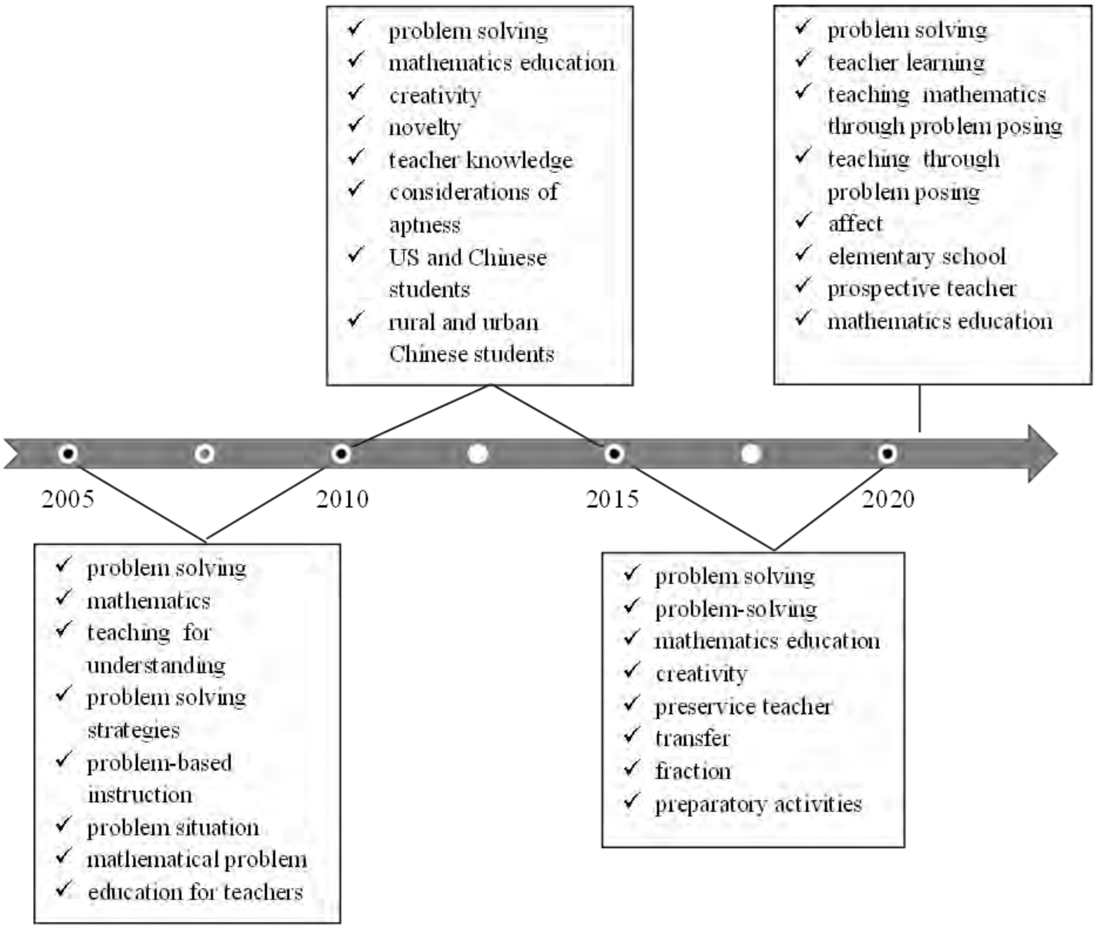


Figure 4
Overlay map of research on problem posing between 1990 and 2021

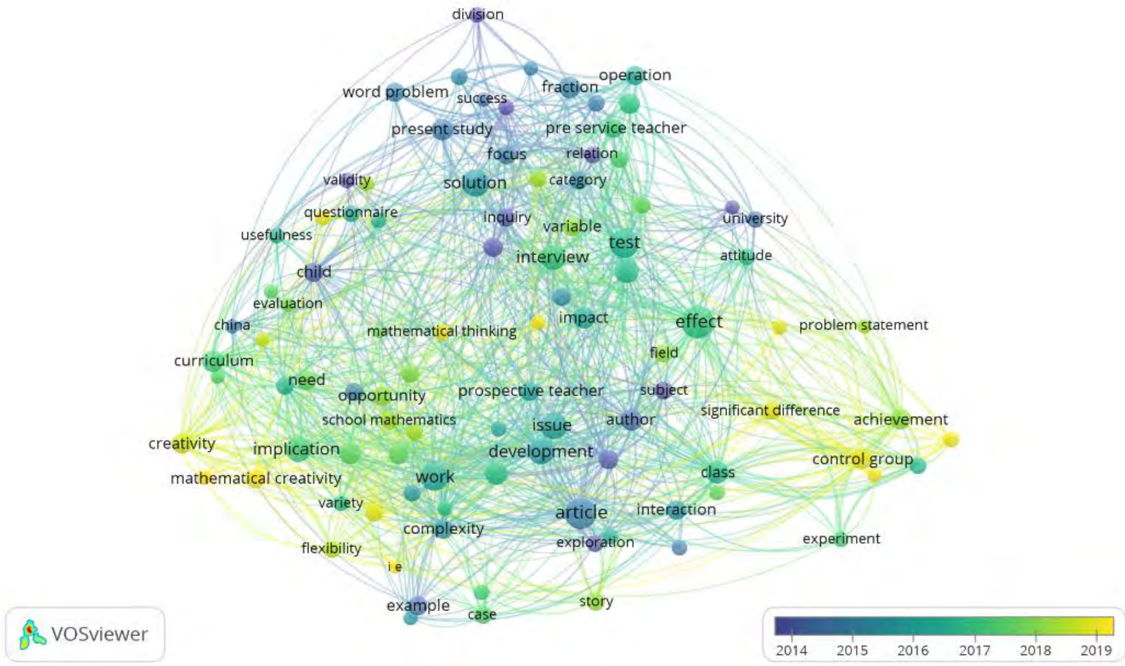
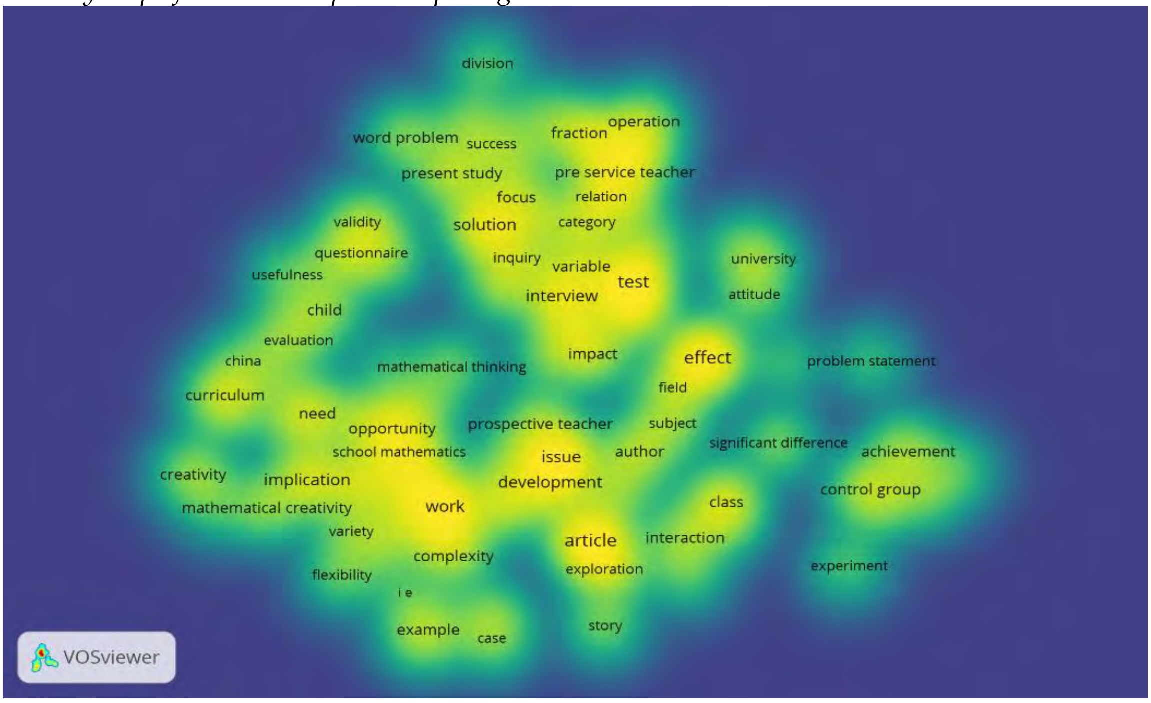


Figure 5 shows the density map where the terms included in the articles based on the number of usages are colored according to their density. In this map, frequently used items are shown in dark yellow, less used items are shown in light yellow, and even less used items are shown in green and blue, in that order.

Figure 5
Density map of research on problem posing between 1990 and 2021



From Figure 5, it is seen that the most frequently used terms in the articles on problem posing are 'test', effect', 'development', 'work', etc., while the more current topics, such as 'flexibility', 'creativity', 'mathematical creativity', are used less.

3.3 Identification

Figure 6 is created according to the items that occur most often, and the naming of clusters is also done in this direction.

Figure 6
Network map of research on problem posing between 1990 and 2021

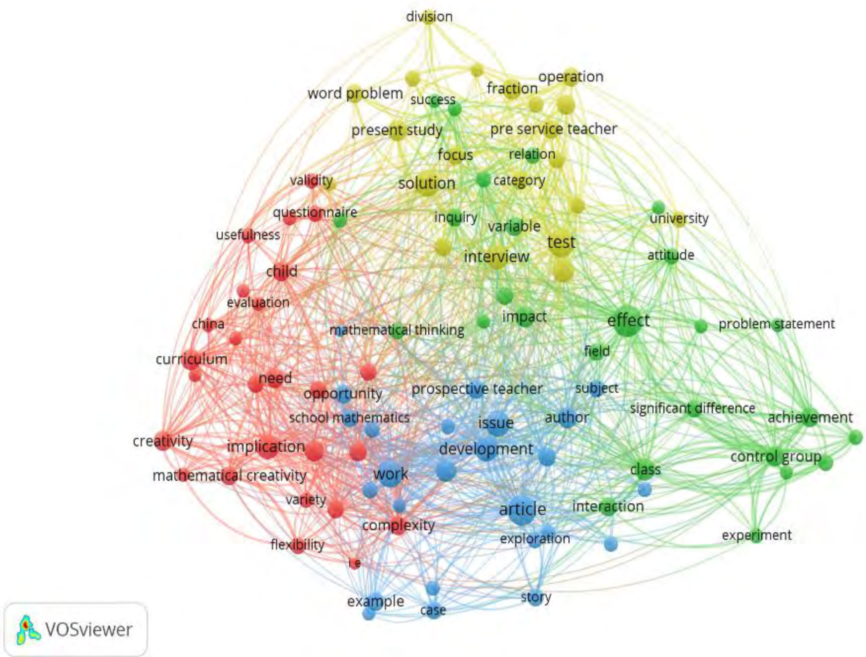


Table 3 lists the frequencies related to the most emerging items from the four clusters that appeared in Figure 6.

Table 3
Identification of clusters

Color	*Cluster name*	*Highly occurring items*
green	effect	effect (27), class (14), achievement (11), control group (11), impact (11), instrument (10), variable (9), word problem (9), response (9), pre service teacher (9), operation (9), inquiry (9), interaction (9), significant difference (8), experimental group (8), relation (8),
red	creativity	implication (15), curriculum (11), framework (13), complexity (10), child (10), creativity (10), mathematical creativity (9), need (9), component (9), connection (9), kind (8), evidence (8), criterium (8), flexibility (7), questionnaire (7)
blue	intervention	article (23), work (20), development (18), issue (18), nature (14), author (11), opportunity (10), prospective teacher (10), description (9), example (9), subject (8), story (8), case (8), feature (8), school mathematics (8), lesson (7), exploration (7)
yellow	construct	test (22), solution (18), interview (18), structure (14), present study (12), fraction (12), instrument (10), focus (10), word problem (9), operation (9), pre service teacher (9), response (9), category (8), semi (8), conceptual understanding (7)

In the process of naming clusters, highly occurring items, such as 'article', 'author', 'present study', were not taken into account. The highly occurring items in the green cluster were 'effect', 'class', and 'achievement', 'control group', 'impact', 'instrument', 'variable', 'word problem', 'response', 'pre service teacher', 'operation', 'inquiry', 'interaction', 'significant difference', 'experimental group', and 'relation'. Based on these items, the green cluster was called *effect*. The red cluster was named as *creativity* depending on the highly occurring items such as 'implication', 'curriculum', 'framework', 'complexity', 'child', 'creativity', 'mathematical creativity', 'need', 'component', 'connection', 'kind', 'evidence', 'criterium', 'flexibility', 'questionnaire', and 'fluency'. On the other hand, the blue and yellow clusters on the network map were named using the same labels, as they show similar characteristics as the last two of the four aspects of mathematical problem posing as stated by Cai and Hwang (2020). The blue cluster was called *intervention* because the items that occur most often in this cluster were 'work', 'development', 'opportunity', 'prospective teacher', 'school mathematics', 'lesson', and 'exploration'. This cluster is related to professional development studies and the opportunities provided to teachers for them to change their current teaching by including problem posing in their courses or to teach based on problem posing. Based on the highly occurring items such as 'test', 'solution', 'interview', 'structure', 'fraction', 'instrument', 'focus', 'response', and 'conceptual understanding' the yellow cluster was called *construct*. This cluster refers to the nature of problem posing and the understanding of students' or teachers' thinking and understanding in the problem posing process.

3.4. Verification

To verify the clusters shown on the network map and named during the identification stage, the articles in which the items that appear in each cluster come from have been examined in detail.

3.4.1 Cluster 1: Effect

When the green cluster is examined, items such as 'effect', 'effectiveness', 'experiment', 'experimental group', 'impact', 'significant difference', 'control group', which suggest intervention studies, and independent variables such as 'achievement', 'attitude', 'belief' where the effect of the intervention is investigated attract attention. The quasi-experimental study conducted by Kopparla et al. (2019) in which the effect of problem posing and problem solving interventions on the problem solving and problem posing skills of school-age children is of this nature. In addition, the quasi-experimental study conducted by Suarsana et al. (2019), in which the problem-posing learning model in the experimental group and the conventional learning in the control group were examined to see whether the problem solving skills of the students differed significantly according to the teaching, have similar characteristics. On the other hand, in some studies, the effect of teaching using various approaches or models based on problem posing on variables such as success, attitude, etc. is also noteworthy. For example, Özdemir and Şahal (2018) examined the effect of problem posing approach on students' academic achievements and attitudes in the teaching of integers. Cankoy (2014) indicates that the students in the experimental group pose more logical and solvable problems in cases of free problem-posing after the intervention carried out in his study by providing an interlocked problem-posing instruction model in the experimental group and traditional problem-posing training in the control group. Toluk-Uçar (2009), in her study, in which problem posing is used as a teaching strategy, examined the effect of problem posing on the understanding of the concept of fractions by pre-service teachers and showed that problem posing has a positive effect on the knowledge of pre-service teachers.

3.4.2 Cluster 2: Creativity

When the red cluster is examined, items such as 'mathematical creativity', 'creativity' and 'flexibility' attract attention. When the studies (Ayvaz & Durmuş, 2021; Biçer et al., 2020; Elgrably & Leikin, 2021; Leikin & Elgrably, 2020; Nuha et al., 2018; Singer et al., 2017; Van Harpen & Sriraman, 2013; Voica & Singer, 2013) in which these items are used are analyzed, it is understood that the creativity of individuals is examined with problem posing tasks. For example, Voica and Singer (2013) highlighted that in their study where they asked fourth- and sixth-graders to change a given problem, cognitive framing changes were effectively detected in problem posing situations, and this is an indicator of students' creative potential. Van Harpen and Sriraman (2013) aimed to explore the mathematical creativity of high school students by analyzing the problem posing skills of geometric scenarios based on the argument that the problem posing skill mentioned in the literature is an important indicator of creativity in mathematics. In the action study conducted by Ayvaz and Durmuş (2021) to improve the problem posing skills and mathematical creativity of seventh-grade students with problem posing-based activities, the practice was effective in the development of students' problem posing skills and mathematical creativity. On the other hand, Biçer et.al (2020) conducted a study to reveal how problem posing interventions are related to the mathematical creative abilities of primary school students. In this study the mathematical creativity of the students in the problem posing group was seen to have increased more than that of the students in the control group, and the authors highlighted that integrating problem posing activities into primary school mathematics teaching can nurture mathematical creativity.

3.4.3 Cluster 3: Intervention

The items 'work', 'development', 'issue', 'nature', 'opportunity', 'prospective teacher', 'description', 'case', 'feature', 'school mathematics', 'lesson', and "exploration" which appeared when examining the blue cluster, attract attention. When the studies that include these frequently occurring items in their abstracts are examined in detail, it is seen that these studies are mostly related to the professional development of teachers/preservice teachers. In the related studies (Crespo, 2003; Leavy & Hourigon, 2020; Li et al., 2020; Cai et al., 2020; Cai & Hwang, 2021), it is emphasized that teachers/preservice teachers change their existing teachings by including problem-setting in their courses; teaching based on problem posing, professional development studies and including trainings sometimes within the scope of a course and apprised them of the opportunities on offer upon taking these measures. For example, Crespo (2003) discovered changes in the practices of preservice teachers by integrating problem posing into a mathematics teacher-training course. Leavy and Hourigon (2020) examined the effect of attending a mathematics education course containing a series of lectures and tutorials related to problem solving and problem posing on the problem posing skills of prospective teachers. This research also provides information about how the understanding of what constitutes a good problem develops throughout the educational program. Similarly, Li et al. (2020) examined the performance of teachers who teach mathematics through problem solving during a series of workshops and their beliefs about teaching through problem posing. Cai et al. (2020) examined the problem posing conceptions and skills of the teachers who participated in a problem posing workshop about the mathematics lesson where the problem posing approach was used and pointed out that at the end of the process, the teachers were more familiar with teaching mathematics using problem posing as well as problem solving.

3.4.4 Cluster 4: Construct

On the other hand, items such as 'conceptual understanding', 'structure', 'interview', 'solution', and 'instrument' bring to mind the idea that problem posing tasks are seen as a cognitive activity used to evaluate the mathematical thinking of students or teachers. Indeed, in relevant studies (Doğan-Coşkun, 2019; Işık & Kar, 2012; Kılıç, 2013a, 2013b, 2015, 2017; Koichu & Kontorovich, 2013; Kontorovich & Koichu, 2016; Kotsopoulos & Cordy, 2009; Land, 2017; Olson & Knott, 2013; Parhizgar et al., 2021; Ponte & Henriques, 2013; Tichá & Hošpesová, 2013; Xie & Masingila, 2017; Xu et al., 2020; Yao et al., 2021), it has been understood that students' or pre-service teachers' mathematical thinking, conceptual understanding or misconceptions/errors/difficulties are determined through problem posing tasks. For example, Tichá and Hošpesová (2013) used problem posing tasks to reveal prospective elementary students' conceptual understanding of fractions, and Yao et al. (2021) to reveal pre-service mathematics teachers' conceptual understanding of division in fractions. In addition, Parhizgar et al. (2021) examined students' misconceptions about the concept of function through problem posing tasks. Xie and Masingila (2017), on the other hand, examined how the interaction between problem solving and problem posing activities supported pre-service teachers' conceptual understanding and the difficulties encountered.

4. Discussion and Conclusion

This study aimed at investigating the trends in the articles on problem posing through bibliometric analysis. Bibliometric analysis of studies on problem posing in mathematics education reveals a significant increase in studies in this area. The findings show that the first studies on problem posing were published in the early 1990s. When the publications made in every four-year period since 1990 are examined, it is seen that the number of publications in the first three periods is very limited. It is worth noting that the number of studies conducted on this issue has increased rapidly in the fifth period, which includes the years 2006–2009. The number of articles completed during this period has reached more than twice the number of all articles conducted in previous years. The number of articles completed in the sixth period, which includes the years 2010–2013, is almost three times as many as the number of articles published in the previous period. No significant changes were understood to have taken place in the number of articles published between 2014 and 2017 and that the number of articles published in the previous period was decreased when compared with the number of articles published in the previous period. On the other hand, it is worth noting that the number of papers published during the latest four-year period of 2018–2021 has increased significantly, approaching three times that of the previous four-year period. These data confirm that problem posing articles have a history of about 30 years in the mathematics education literature. Furthermore, the significant rise in the number of publications published, particularly in recent years, demonstrates that problem posing has retained its popularity in the mathematics education literature. It is believed that the study of problem posing in relation to different issues in recent years has had an impact on this situation. Indeed, as of 2010, papers (Ayvaz & Durmuş, 2021; Biçer et al., 2020; Elgrably & Leikin, 2021; Leikin & Elgrably, 2020;

Mallart et al., 2018; Nuha et al., 2018; Van Harpen & Sriraman, 2013; Voica & Singer, 2013) related to and investigating creativity and problem posing are examples of this argument. In addition, the fact that the studies using the keywords 'teaching mathematics through problem-posing' or 'teaching through problem-posing' (Cai & Hwang, 2020; Cai & Hwang, 2021; Cai et al., 2020; Li et al., 2020; Zhang & Cai, 2021) and affect (Cai & Leikin, 2020; Guo et al., 2020; Parhizgar et al., 2021; Schindler & Bakker, 2020) were published after 2020, in the last period, indicates that these issues are the most current trends in this research area. On the other hand, keyword analysis shows that in many studies (Abramovich, 2014; Abramovich & Cho, 2008; Aytekin-Uskun et al., 2021; Cai et al., 2013; Chang, 2007; Chen et al, 2013; Ellerton, 2013; English, 2020; Ertane-Baş & Özturan-Sağırlı, 2021; Hartmann et al, 2021; Koichu, 2010; Kopparla et al., 2019; Leavy & Hourigan, 2020; Leavy & Hourigan, 2021; Mallart et al, 2018; Mamona-Downs & Downs, 2005; Martinez & Blanco, 2021; Özdemir & Şahal, 2018; Palmer & van Bommel, 2020; Samkova & Ticha, 2016; Samkova & Ticha, 2017; Schindler & Bakker, 2020; Singer & Voica, 2013; Singer et al., 2013; Van Harpen & Sriraman, 2013; Xia et al., 2007; Xie & Masingila, 2017) problem solving and problem posing are considered together with various aspects. For example, Xie and Masingila (2017) focused on discovering what actually happens in the process of preservice teachers alternately participating in problem solving and problem posing activities. In this study, they concluded that problem posing contributes to the problem solving of prospective primary teachers in different ways, and problem solving also supports problem posing. Indeed, the literature states that problem posing and problem solving are intertwined skills that support each other -(Cai & Brook, 2006; Kilpatrick, 1987; Silver, 1994, 2013) but that there are still many unanswered questions about the nature of the relationship between problem posing and problem solving (Xie & Masingila, 2017. Thus, it is believed that more research is needed to address and explain this association.

The overlay map shows that terms, such as 'fraction', 'division', 'inquiry', 'response', and 'belief', among others, discussed in 2014–2016, and the 'response', 'effect', 'test', 'class', 'implication', 'curriculum', 'interview' and 'solution', discussed in 2016–2018, in the articles on problem posing were handled at a high rate. On the other hand, it is understood that the most frequently included items in current studies in this field are 'creativity', 'mathematical creativity', 'mathematical thinking', 'significant difference', 'control group', among others. Moreover, in the articles using the density map problem posing subject, the most commonly used items are test, effect, development, work, etc., while the most current elements, such as flexibility, creativity, and mathematical creativity, among others, are used less frequently. Indeed, in recent years, some changes have occurred in the focus of problem posing studies, from studies carried out to determine problem posing skills, errors, or beliefs in certain subjects, such as fractions or operations with fractions (Chen et al., 2013; Işık & Kar, 2012; Koichu et al., 2013; Kılıç, 2015), to studies in which problem posing is considered together with different fields of study such as modelling (Hartmann et al., 2021) and mathematical creativity (Ayvaz & Durmuş, 2021; Biçer et al., 2020; Elgrably & Leikin, 2021; Leikin & Elgrably, 2020), among others. Cai and Hwang (2020) state that one of the potential benefits of including problem posing in math classes is that it provides useful insights about students' mathematical thinking. In this direction, it is noteworthy that in recent years, there has been a greater orientation toward studies wherein problem-setting is used as a cognitive activity to evaluate the mathematical thinking of teachers or students (Guo et al., 2021; Hartmann et al., 2021; Silber & Cai, 2021; Xu et al., 2020; Yao et al., 2021). To increase our understanding of this field, it is proposed to increase the number of studies to be conducted.

The network map, created because of an analysis based on the items most commonly used in the abstracts of articles on problem posing, visualizes that the items are grouped into four clusters, depending on the degree of relationships between them. The first cluster is called *effect* because it has been determined that the most common items that occur are 'effect', 'class', 'achievement', 'control group', 'impact', 'instrument', 'variable', 'word' 'problem', 'response', 'pre service teacher', 'operation', 'inquiry', 'interaction', 'significant difference', 'experimental group' and, 'relation'. This cluster is related to the investigation of the effect of problem posing studies on variables, such as achievement, attitude, and belief. The second cluster is called *creativity* because it has been understood that the items that occur most often are 'implication', 'curriculum', 'framework', 'complexity', 'child', 'creativity', 'mathematical creativity', 'need', 'component', 'connection', 'kind', 'evidence', 'criterium', 'flexibility', 'questionnaire' and, 'fluency'. This cluster is intended for studies in which the relationship between problem posing and creativity in mathematics is considered from various aspects. The third cluster is called *intervention* because items, such as 'work', 'development', 'opportunity', 'prospective teacher', 'school mathematics', 'lesson', 'exploration' which occur most often in this cluster, are related to the opportunities provided by teachers to include problem posing tasks in their lessons and thus change their current teaching. The fourth cluster is called *construct* because of the highly occurring items, such as 'test', 'solution', 'interview', 'structure', 'fraction', 'instrument', 'focus', 'response' and, 'conceptual understanding'. This cluster is related to the understanding of how students or teachers think during the problem posing process and the nature of problem posing.

In this study, only articles on problem posing in English published in the Web of Science database are examined. The studies that will be conducted in the future might disclose trends in studies in various databases, languages, and research areas. New studies to be carried out in line with the determined trends in the articles published on problem posing in this study will contribute toward having more detailed information in these fields of study.

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