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Developing creative thinking abilities in mathematics education: A systematic literature review

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Abstract

Mathematical creative thinking ability is the ability to think logically and divergently to produce ideas or various kinds of solutions to given mathematical problems. This systematic review of literature aims to look at research trends related to creative thinking abilities in mathematics education, indicators, research methodology, and learning models used in developing mathematical creative thinking abilities. A Systematic Literature Review (SLR) was carried out using the PRISMA method. This paper reviews 30 research articles from 2019 to 2023 from which such data were obtained from Scopus. The findings show that research themes such as tests, abilities, and creative thinking have been widely carried out. Indicators of creative thinking abilities that are often used are fluency, flexibility, and originality. The learning models or approaches that are widely used in developing creative thinking skills in mathematics education are contextual learning models such as problem-based learning and STEM/STEAM. These findings are useful for researchers and teachers.

Keywords: Creative thinking; learning model; mathematics education; PRISMA; systematic literature.

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1. Introduction

The 21st century has brought extraordinary changes in the world of education, work, and everyday life. Technological developments, globalization, and the complexity of the challenges facing humans in this century require major changes in education and the development of everyone's abilities. 21st-century education is an educational concept that focuses on preparing students to face the demands of a world that continues to change rapidly. 21st-century education emphasizes the development of skills that are relevant to today's world. According to Dilecki and Kataray (2023), the skills that an individual must have in the 21st century are critical thinking, problem-solving, creative thinking, and cooperative work skills. Van Laar et al. (2020) and Nahar (2022) stated that 21st-century skills are known as 4C skills, namely creative thinking skills, critical thinking skills, communication skills, and collaborative thinking skills.

The 4Cs are basic skills for students in the 21st century that show ways to cultivate the talents needed for future social development (Ye & Xu, 2023). According to Zhao et al. (2023), 4C skills refer to 21st-century skills that need to be applied in a variety of situations. These 4C skills are not only important in the workplace, but also in everyday life, in personal development, and in solving complex problems in an increasingly complex world. This is in line with Sukarjo et al. (2023) which states that 4C skills are very important to prepare students to successfully face every challenge in complex life processes so that they have strong personalities. The 4Cs skills play an important role in preparing students to deal with rapid change, collaborate with other students, tackle difficult problems, and find innovative solutions. So, the 4C skills are needed by students as one of the keys to success in facing the 21st century.

One of the thinking skills needed in the 21st century is creative thinking. Creative thinking is one of the key factors needed in life in the 21st century. Creative thinking abilities enable students to face complex challenges, collaborate well in a variety of contexts, and become lifelong learners who are motivated to acquire new skills and knowledge. Creative thinking skills not only help students master facts and knowledge but also help them apply, analyze, and synthesize information in innovative ways (Lin 2023; Chamberlin et al., 2022).

The ability to think creatively plays an important role in students' personal development. Creative thinking plays an important role for students in solving the problems they encounter. Creative thinking skills also help students become more curious, creative, and interested in different types of jobs, which can allow them to explore diverse careers in the future. In line with this, according to Promkham (2020), Creativity is very important for work and everyday life because it allows someone to create work or innovation that has never existed before which is beneficial for themselves and society. Additionally, creativity enables learning to occur, especially creative activities that are designed in a way that allows students to utilize their imagination. Thus, new things are created through problem-solving efforts and applied in society and life.

1.1. Purpose of study

Research on creative thinking in mathematics learning has been carried out in various research aspects. Therefore, to increase the relevance of mathematics learning, a literature review related to this topic is needed. This literature review can be carried out systematically. The results of this research can be a reference and starting point for other researchers who are interested in creative thinking in

mathematics learning. They can also provide the knowledge and experience to spot research trend opportunities to discover novelty and prevent future repetition. So, the questions in this systematic literature review are:

1. What are the research trends on creative thinking abilities in mathematics education from 2019-2023?
2. What indicators of creative thinking abilities are used in research?
3. What methods are often used in researching creative thinking abilities?
4. What models or approaches are popular in developing creative thinking abilities?

2. Method and materials

This review was conducted to analyze, evaluate, and synthesize research related to the answers to the review questions. We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Johnson & Hennessy, 2019). A review protocol was created to explain the eligibility criteria, literature search process, data extraction, and data analysis procedures (Su & Yang, 2023).

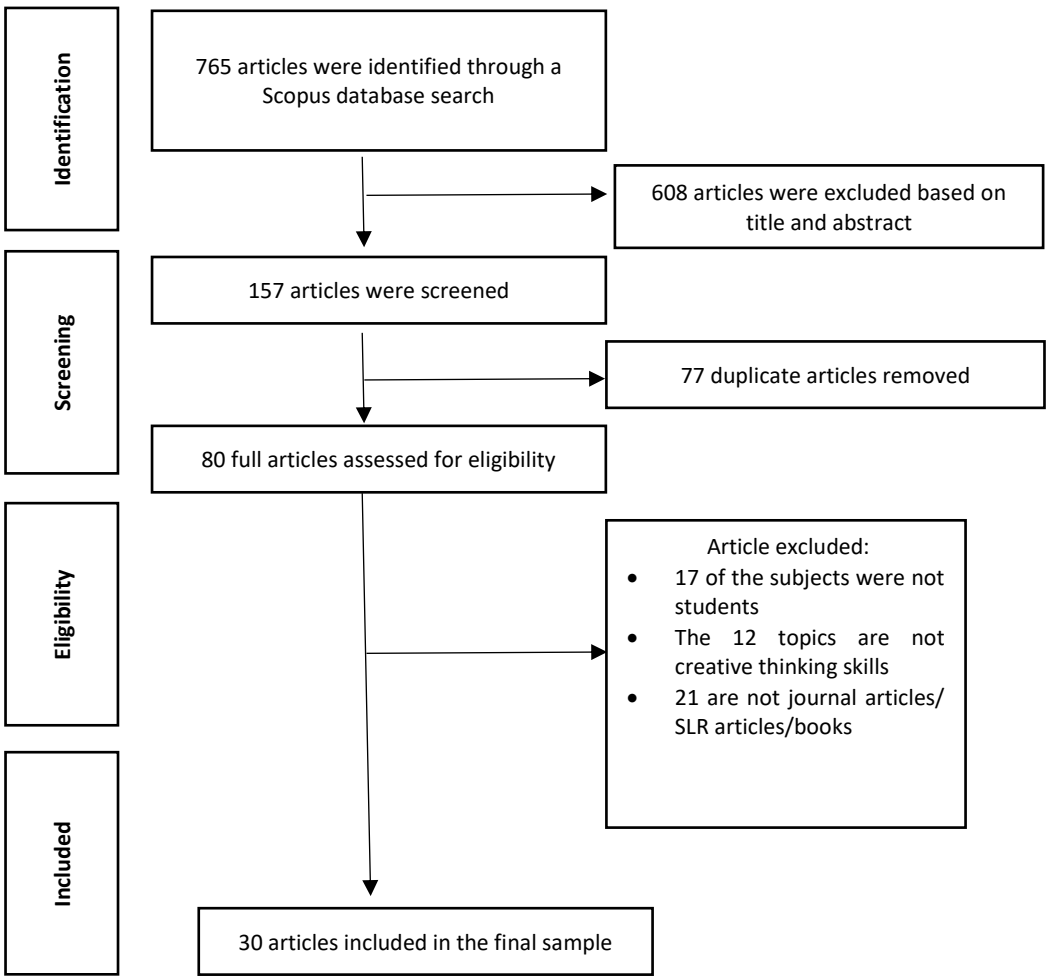
The first process is identification which begins by searching for the title of the article from Scopus. Scopus is the main source for searching for databases related to this systematic literature. Keyword searches about "mathematical creative thinking" or "creative thinking in mathematics". To facilitate database searches, this research examined peer-reviewed articles published from 2019 – 2023. All articles were accessed on Scopus in October 2023. Search results obtained 765 articles based on keywords. Data used for analysis includes title, keywords, and abstract. So, 608 articles were deleted because they were inappropriate. After obtaining 157 articles, the next step was the filtering process.

In the screening process, articles are included and removed according to specified criteria. Deleted articles are articles whose titles and abstracts do not match. The title of the article in this step is more specific, namely the ability to think creatively in mathematics or the ability to think creatively in mathematics. This step also deletes duplicate articles found during the search.

Next, articles are included and removed according to specified criteria. As shown in Figure 1, using several keywords, 765 articles were identified from Scopus. Articles whose titles and abstracts do not match are deleted according to the following criteria: 1). Research not relevant to the research topic (n = 608). For example, the title of this research is not related to creative thinking abilities in mathematics; 2). Multiple research articles (n = 77); 3). The research subjects were not students (n = 17); 4). The research topic is not creative thinking abilities (12), and 5) the articles are not journal articles but conference papers/SLR articles/books (n = 21). All articles must be written in English by the inclusion criteria in this literature systematic. Thus, this systematic literature review consists of 30 articles.

The selected articles are then saved in Microsoft Excel and RIS. Microsoft Excel is used to process tables and graphic data by including some important information from the selected articles. This important information includes author, research title, year of publication, research design, participants, tools, location, assessment process, and findings. Meanwhile, RIS is used for libbiometric analysis using the VOSviewer application. VOSviewer can perform mapping by creating co-authorship and different occurrences of keywords. The VOSviewer application enables data representation through network visualization, overlay visualization, and density visualization. Network visualization shows the interrelationships and clusters of research themes related to keywords. An overlay visualization was used to determine the year in which the relevant research theme was implemented. Frequently and rarely researched research themes are evaluated with density visualization.

Figure 1
PRISMA Diagram



Source: Page et al. (2021)

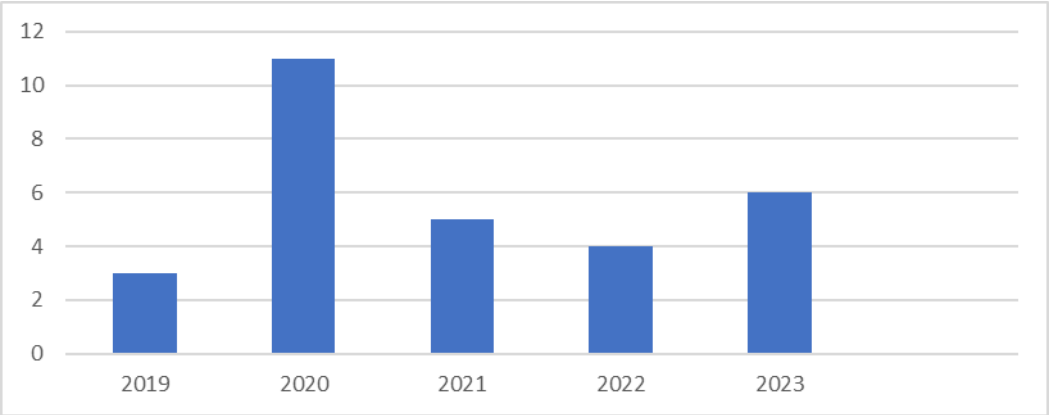
3. Results

3.1. Trend creative thinking abilities in mathematics education research was published from 2019–2023

Publishing trends are an important indication for knowing the development of a field (Subramaniam et al., 2022). Many articles about creative thinking skills in mathematics were published from 2019 – 2023. There were 30 articles selected based on research questions. Below is Figure 2 which depicts the distribution of the number of articles from 2019 – 2023.

Figure 2

Total of Creative Thinking Abilities in Mathematics Articles in 2019-2023

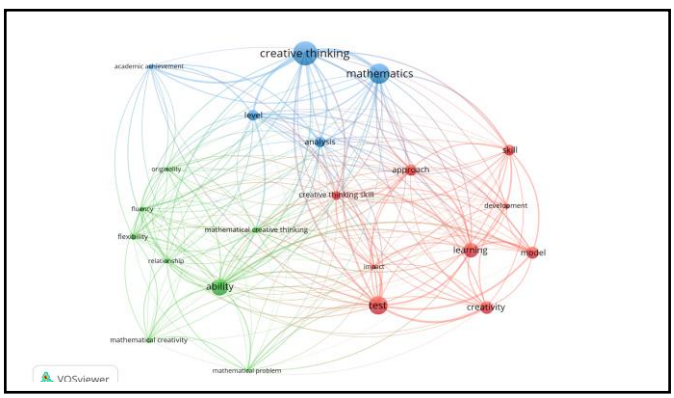


The number of articles per year is presented in Figure 2 which shows the number of articles increasing and decreasing. In 2019 there were 3 articles; in 2020 it increased to 11 articles, in 2021 there are 5 articles; in 2022 there will be 4 articles and in 2023 there will be 6 articles. According to publication data, research on creative thinking skills in mathematics education is regularly published every year, and the 11 articles in 2020 are the most so far.

Research trends over the last five years were obtained from bibliometric data processing with VOSviewer, as shown in Figure 3. Clusters with the same color and the same circle size indicate the popularity of keywords. The larger the circle size shows that the topics discussed in the 30 articles are increasingly popular. Direct relationships between keywords are shown by lines connecting the circles. Cluster analysis using the binary calculation method found 818 terms, and only 22 items were connected with 3 clusters and 209 links. Below is a network visualization image.

Figure 3

Network Visualization of Co-occurrence



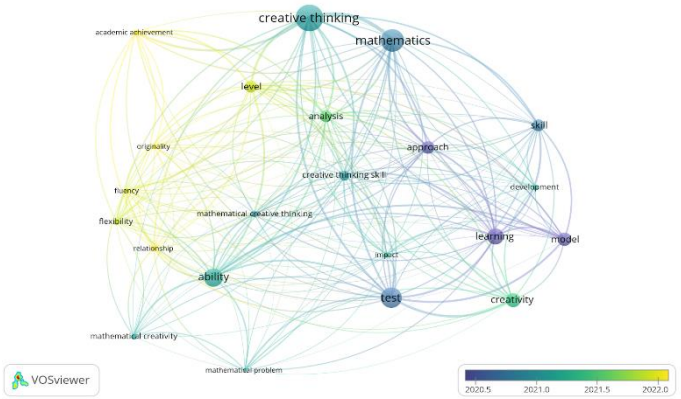
Source: VOSviewer

The Network Visualization results show that there are items with larger circles that are most clearly visible among the others. The circle is test (cluster 1, shown in red), ability (cluster 2, shown in green), and

creative thinking (cluster 3, shown in blue. The large circle illustrates that tests, ability, and creative thinking are studied widely. The central theme used in this research may be the creative thinking ability. Below is the data depicted with keywords from the author using a visualization overlay in Figure 4.

Figure 4

Overlay Visualization of Co-occurrence



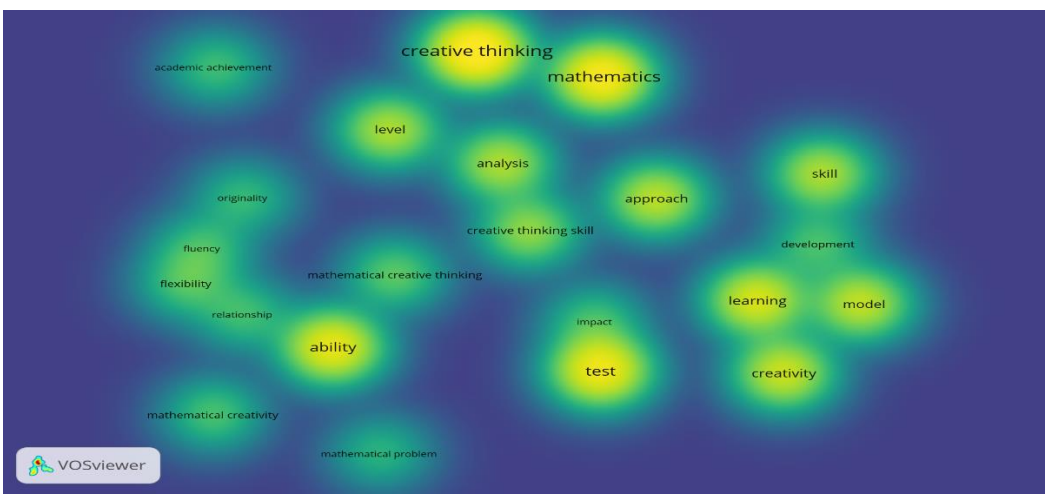
Source: VOSviewer

Figure 4 shows that in the overlay network, creative thinking items have the most connections. Test, ability, and creative thinking were published widely between 2020-2022. The darkest color indicates that this publication has been published a long time ago. Yellow is an item with the latest publications such as academic achievement, relationship, originality, fluency, originality, and level.

Density Visualization of the Co-occurrence of creative thinking abilities in mathematics education distribution is presented in Figure 5.

Figure 5

Density Visualization of Co-occurrence



Source: VOSviewer

Figure 5 shows that creative thinking, mathematics, tests, creativity, ability, learning, and models have the brightest colors. This shows that these themes are widely used in research on creative thinking abilities in mathematics education. Meanwhile, other themes such as achievement, development, relationships, mathematical academic creativity, mathematical problems, mathematical creative thinking, impact, originality, fluency, and flexibility are still little researched. These themes can be developed into further research to improve students' mathematical creative thinking abilities.

Important themes in any research or body of knowledge are discovered through analysis of overlay visualization and density visualization. This result was obtained by calculating the frequency of keyword pairs (Nagy, 2018). To perform the analysis, Vosviewer was used. Each cluster is associated with another term, as can be seen. This shows the relationship between the progress of research on the topic. Author Authority can also be identified through network analysis (Bilik et al., 2020).

3.2. Indicators of creative thinking in mathematics education

In several selected articles there are indicators of creative thinking abilities which are used to measure creative thinking abilities. These indicators are presented in Table 1 below.

Table 1
Indicators of Creative Thinking Ability

No	Author (Year)	Indicators
1.	Ibrahim et al., (2020)	Fluency, flexibility, authenticity, elaboration
2.	Toheri et al., (2020)	Fluency, flexibility, originality, elaboration
3.	Wahyudi et al., (2020)	Fluency, flexibility, originality, elaboration, novelty
4.	Yaniawati et al. (2020)	Fluency, flexibility, originality, elaboration
5.	Jebur (2020)	Fluency, flexibility, originality
6.	Elsayed et al., (2020)	Fluency, flexibility, originality
7.	Syaiful et al., (2020)	Fluency, flexibility, originality
8.	Ozkan et al., (2021)	Fluency, flexibility, originality
9.	Jawad et al., (2021)	Fluency, flexibility, originality, relationship
10.	Rahayuningih et al., (2021)	cognitive flexibility, cognitive fluency
11.	Sadak et al., (2022)	Fluency, flexibility, originality
12.	Tabieh et al., (2022)	Fluency, flexibility, originality
13.	Shatter et al., (2023)	Sensitivity, fluency, flexibility, originality, elaboration
14.	Sbaih A. D. (2023)	Fluency, flexibility, originality, elaboration
15.	Vlasenko et al., (2020)	Flexibility, novelty, the ability to identify and state problems, the ability to generate numerous ideas, the ability to improve the object, to add details

Table 1 shows that the indicators most often used to measure students' creative thinking abilities are fluency, flexibility, and originality. Meanwhile, other indicators are elaboration, authenticity, novelty, relationship, sensitivity, the ability to identify and state problems, the ability to generate numerous ideas, and the ability to improve the object to add details.

Fluency is the ability to produce as many relevant ideas as possible and can be described in the form of words, expressions, or images (Jawad et al., 2021). Flexibility refers to the ability to generate various ideas or concepts (Vlasenko et al., 2020). Originality is an ability that refers to the number of different solutions compared to the solutions available for a certain group of people (Sadak et al., 2022). Elaboration is the ability to develop ideas and provide an in-depth explanation of the problem being solved so that it is interesting (Toheri, 2020). Novelty is a student's ability to solve problems and realize them differently from other students (Wahyudi et al., 2020).

Rahayuningsih (2021) uses other terms, namely cognitive fluency and cognitive flexibility. Cognitive fluency and cognitive flexibility are used in solving open-ended problems (Rahayuningsih, 2021; Güner & Gökçe 2021; Eshet & Margaliot 2022). Cognitive fluency includes the ability to interpret answers fluently and precisely and correct answers even when errors occur in operational processes. Cognitive fluency shows the capacity to effectively and efficiently process mentally challenging tasks in a relatively easy and fluid manner (Song & Li, 2023).

Meanwhile, cognitive flexibility refers to a person's ability to adapt to a changing environment, consider different perspectives, and be able to solve new or difficult problems (Uhlig et al., 2023). In line with this, Lung & Bertone (2023) stated that cognitive flexibility is the ability to change known concepts or rules.

Indicators that are rarely used in research on creative thinking abilities are authenticity, relationship, and sensitivity. Authentic or original thinking is a student who can provide their ideas in a way that is unique and unusual for most people. Relationship means the student's ability to create relationships between what he learns, for example defining similarities, symmetry, and differences (Ambrose 2017). Sensitivity involves the ability to find problems and distinguish irrelevant facts and concepts (Sari, 2019). Sensitivity can encourage someone to try harder to carry out activities such as observation, exploration, and so on that can express their opinions so that they can develop creative thinking abilities.

3.3. Research methodologies used on creative thinking abilities in mathematics education

In research on creative thinking abilities, various research methodologies are used. The methods used in this article include quantitative, qualitative, mixed methods, and R&D.

Table 2

List Research Methodologies

No	Authors (Years)	Title	Methods
1.	Hendriana et al., (2019)	The students' mathematical creative thinking ability in junior high school through a problem-solving approach	Quantitative
2.	Catarino P et al. (2019)	Cooperative learning on promoting creative thinking and mathematical creativity in higher education	Quantitative
3.	Ibrahim & Widodo (2020)	Advocacy approach with open-ended problems to mathematical creative thinking ability	Quantitative
4.	Kirisci et al., (2020)	The effectiveness of the selective problem-solving model on students' mathematical creativity: A Solomon four-group research	Quantitative
5.	Toheri et al., (2020)	Where exactly to enhance critical and creative thinking: The use of problem posing or contextual learning	Quantitative
6.	Wahyudi et al., (2020)	The impact of the 3CM model within blended learning to enhance students' creative thinking ability	Quantitative
7.	Maskur (2020)	The effectiveness of problem-based learning and aptitude Treatment Interaction in improving Mathematical creative thinking Skills on Curriculum 2013	Quantitative
8.	Jebur (2020)	Identification of instructional learning design by Alan Hoffer's model and its effect on students' creative thinking in mathematics	Quantitative
9.	Elsayed et al., (2020)	The effectiveness of a mathematics learning program based on the mind habits in developing academic achievement motivation and creative thinking among Prince Sattam bin Abdulaziz University students	Quantitative
10.	Ozkan et al., (2021)	Exploring the effectiveness of STEAM design processes on middle school students' creativity	Quantitative
11.	Jawad et al., (2021)	The Impact of Teaching by Using STEM Approach in The Development of Creative Thinking and Mathematical Achievement Among the Students of The Fourth Scientific Class	Quantitative
12.	Tabieh et al., (2022)	The impact of blended-flipped learning on mathematical creative thinking skills	Quantitative
13.	Schoevers et al., (2022)	The relation between creativity and students' performance on different types of geometrical problems in elementary education	Quantitative

No	Authors (Years)	Title	Methods
14.	Sbaih (2023)	Creative thinking in students of mathematics in universities and its relationship with some variables	Quantitative
15.	Han et al. (2023)	The effects of shadow education on high school students' creative thinking and academic achievement in mathematics: the case of the Republic of Korea	Quantitative
16.	Borg Preca C et., al. (2023)	Are STEM Students Creative Thinkers?	Quantitative
17.	Syaiful et al., (2020)	Emotional quotient and creative thinking skills in mathematics	Qualitative
18.	Vlasenko et al., (2020)	A problem-based approach to develop creative thinking in students majoring in mathematics at teacher training universities	Qualitative
19.	Sister et al. (2020)	Analysis of students' difficulties in mathematical creative thinking on a problem-based learning model	Qualitative
20.	Wijaya et al., (2021)	Improving the Creative Thinking Skills of the Next Generation of Mathematics Teachers Using Dynamic Mathematics Software	Qualitative
21.	Lewis & Colonnese (2021)	Fostering Mathematical Creativity Through Problem Posing and Three-Act Tasks	Qualitative
22.	Rahayuningsih et al., (2021)	Using open-ended problem-solving tests to identify students' mathematical creative thinking ability	Qualitative
23.	Othman et al., (2022)	Creative Teaching STEM Module: High School Students' Perception	Qualitative
24.	Shater & Shana (2023)	The Effectiveness of Star Strategy Learning on Gifted Students' Mathematical Creative Thinking Ability	Qualitative
25.	De Carvalho et al., (2023)	Critical and creative thinking in probability teaching in the early years of elementary school	Qualitative
26.	Hidajat (2021)	Students creative thinking profile as a high order thinking in the improvement of mathematics learning	Qualitative
27.	Yaniawati et al., (2020)	Integration of e-learning for mathematics on resource-based learning: Increasing mathematical creative thinking and self-confidence	Mix method
28.	Sadak et al., (2022)	Investigating mathematical creativity through the connection between creative abilities in problem-posing and problem-solving	Mix method
29.	Suhendri et al., (2019)	Develop mathematics modules based on guided discovery learning to improve the creativity skills of blind students	R&D

Table 2 shows that of the 30 articles the research methods were classified as follows: Quantitative with 16 articles, qualitative with 11 articles, mixed method with 2 articles, and R&D with 1 article. Quantitative research comes from various countries including Indonesia, Portugal, Turkey, Iraq, Saudi Arabia, Jordan, The Netherlands, Korea, Malta, Ukraine, United States, Malaysia, United Arab Emirates, and Brazil.

Quantitative research is the approach most widely used by researchers in studying students' creative thinking abilities. Quasi-experiments are the most frequently used type of quantitative research. The greater number of quantitative studies compared to other types of research is in line with several previous studies which show that the dominant method in language test and assessment research is quantitative, due to the level of quantitative use by researchers throughout the world (Rahman, 2020). Mohajan (2020) also stated that quantitative methods are used to obtain accurate and reliable measurements. In line with this, according to Queiros et al. (2017), quantitative methodology seeks to obtain accurate and reliable measurements that enable statistical analysis.

The quantitative research used in this literature is related to the effectiveness of mathematics learning models on creative thinking abilities. This mathematics learning model emphasizes student involvement in activities such as open-ended problem-solving, projects, and collaborative discussions. These learning models are interesting because they emphasize creative thinking skills, such as fluency in developing ideas, flexibility in adapting, and novelty in finding new perspectives. With the right learning model, students not only learn formulas and algorithms, but also learn to think critically, be innovative, and be able to face challenges from various points of view.

Furthermore, in creative thinking skills, qualitative methods are also widely used. Qualitative research is an iterative process that increases the understanding of the scientific community by making significant new differences as a result of getting closer to the phenomenon under study (Aspers & Corte, 2021). The results of the research in the articles show that emotional intelligence, problem-based learning, and technology can help students develop creative mathematical thinking skills. However, there are still challenges that students must face, namely the fear of failure and limited divergent skills can also hinder the ability to think creatively and mathematically. So, to foster mathematical creative thinking abilities, educators need to create a supportive environment and provide a variety of learning experiences that can stimulate students' mathematical creative thinking abilities (Gómez & Suárez 2020).

Between research that uses quantitative and qualitative, each has its strengths and weaknesses. According to Gerring (2017), While quantitative work is expressed in numbers and statistical models, qualitative work is expressed in natural language. Apart from that, Qualitative data is neither as "scientifically sound" nor as the "gold standard" of impartiality as quantitative data (Maula & Stam, 2020). However, quantitative and qualitative research methods can also be combined, which is called a mixed method.

3.4. Model or approach to developing creative abilities in mathematics education

The collected articles discuss many learning models used to develop creative mathematical thinking abilities. The models used are presented in the following table.

Table 3

List of qualitative research on creative thinking in mathematics education

No	Authors (Years)	Model /Approach
1.	Vlasenko et al., (2020)	Problem-based approach
2.	Sister et al., (2020)	problem-based learning model
3.	Wijaya et al., (2021)	Project-based learning
4.	Lewis et al., (2021)	Three-Act Tasks
5.	Rahayuningsih et al., (2021)	Open-ended problem-solving assessment tool
6.	Othman et al., (2022)	Creative Teaching Modules STEM
7.	Shater et al., (2023)	Star Strategy Learning
8.	Yaniawati et al., (2020)	Resource-Based Learning (RBL) with a scientific approach
9.	Suhendri et al., (2019)	Discovery-based mathematical modules
10.	Hendriana et al., (2019)	problem-solving approach
11.	Catarino P et al., (2019)	cooperative learning
12.	Ibrahim & Widodo. (2020)	advocacy learning
13.	Kirisci et al. (2020)	Selective Problem Solving Model (SPS)
14.	Toheri et al., (2020)	the problem-posing lesson, contextual learning
15.	Wahyudi et al., (2020)	3CM learning model
16.	Maskur (2020)	Problem-Based Learning (PBL) and Aptitude Treatment Interaction (ATI) models.
17.	Jebur (2020)	instructional learning designs by Alan Hoffer's model
18.	Elsayed et al., (2020)	learning program based on the Mind Habits
19.	Ozkan et al., (2021)	STEAM design activities
20.	Jawad et al., (2021)	STEM approach

No	Authors (Years)	Model /Approach
21.	Tabieh et al., (2022)	the blended learning strategy, the flipped learning strategy
22.	Borg et al., (2023)	STEM

Table 3 shows that the learning models/approaches used to develop creative thinking abilities vary. The number of models or approaches used include problem-based learning (3), project-based learning (1), problem posing (1), three-act task (1), star strategy learning (1), Resource-Based Learning (RBL) with a scientific approach (1), problem-solving approach (2), Discovery-based mathematical modules (1), cooperative learning (1), advocacy learning (1), Selective Problem-Solving Model (SPS) (1), contextual learning (1), 3CM learning model (1), Aptitude Treatment Interaction (ATI) models (1), instructional learning designs by Alan Hoffer's model (1), learning program based on the Mind habits (1), STEAM/STEM approach (3), the blended learning strategy (1) and the flipped learning strategy (1). It can be seen that the models or approaches that are widely used are problem-based learning and STEAM/STEM.

Problem-based learning is a problem-centered learning model that can make it difficult for students to solve problems given by the teacher (Adhelacahya et al., 2023). The problem-based learning model can help students think more easily and be more creative and can also help students work in small groups to solve problems (Wulandari et al., 2023). Vlasenko et al. (2020) stated that open-ended and integrative problems used in problem-based learning contribute to the development of key components of creative thinking. In line with this, Maskur et al., (2020) stated that by using an open approach, the problem-based learning model can have an impact on mathematical creative thinking abilities. However, the research results of Maskur et al., (2020), it was found that the Aptitude Treatment Interaction (ATI) model had a better influence on students' creative thinking abilities compared to the Problem-Based Learning (PBL) model.

Another learning approach that is most widely used is the STEAM or STEM Approach. The science, technology, engineering, and mathematics (STEM) approach is the most innovative learning approach and is very important for assessing students' learning motivation and thinking abilities (Ilyas et al., 2022). According to Jawad et al., (2021), STEM is a pedagogical approach that aims to integrate these four fields in teaching and learning. To achieve this goal, students need an environment that allows practical activities, research projects, workshops, and so on (Shin et al., 2021.)

Meanwhile (Kong & Matore, 2022) STEM is an educational approach that is student-centered and uses inquiry to solve problems. The integration between STEM and arts has increased in recent years, resulting in the emergence of the term STEAM (Science, Technology, Engineering, Art, and Mathematics). STEAM is an educational approach that can help and further integrate broad knowledge so that the knowledge studied is not just data. (De la Garza, 2021).

The research results of Borg et al. (2023) stated that STEM can help young people become creative. Jawad et al. (2021) also stated that learning using a STEM approach can create an interesting and enjoyable mathematics learning atmosphere and can increase learning motivation, creativity, and innovation. This is also by the research results of Ozkan and Umdu (2021) which show that educators can help students become creative through STEAM activities because in STEAM learning students are given the freedom to be creative during class activities, and student creativity increases. This is in line with the research results of Eitah and Abueita (2023) where the STEAM-based learning approach shows a significant increase in students' creative abilities.

Another learning model is problem posing. According to Cai and Laikin (2020) In recent years, attention to problem posing in mathematics education has increased because mathematics is its process and approach to the development of other skills. In mathematics education, problem posing refers to two

processes, namely creating new problems and reformulating existing problems (Hartmann et al., 2023). The research results of Toheri et al. (2020) stated that compared to contextual learning, problem-posing learning improves creative thinking abilities. According to Sadak et al. (2022), problem posing is a learning model that can develop students' mathematical creative thinking abilities.

4. Conclusion

There are many more approaches or learning models used to develop creative thinking abilities. Each learning model must be adapted to the characteristics of students, the subjects studied, and the learning objectives. By using the right approach, teachers can help students develop creativity which is very important for facing difficulties and changes in the future. So, it can be concluded that the ideal learning model or approach is a learning model or approach that can stimulate student creativity, make students active, achieve effective learning goals, and take place in a comfortable environment for students.

This review shows that creative thinking skills in mathematics education are still a trending research topic today. Indicators of creative thinking ability are also used as benchmarks for success. Mathematical creative thinking abilities can also be developed from various aspects. One way is to use a learning model that is relevant and linked to mathematical problems. The learning models used in this research have a significant impact on increasing students' mathematical creative thinking abilities. Future research is recommended to conduct quantitative and qualitative studies on a broader scale that require in-depth analysis of mathematical creative thinking abilities.

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