p-ISSN: 2086-4280
e-ISSN: 2527-8827

Effective Learning Models for Enhancing Mathematical Creative Thinking: A Systematic Literature Review

Siti Nur Amanah[1*], Emi Pujiastuti[2], Sugiman[3], S B Waluya[4]

Mathematics Education Department, Universitas Negeri Semarang
Sekaran, Semarang, Central Java, Indonesia
[1]sitinuramanah_mat@students.unnes.ac.id; [2]emi.mat@mail.unnes.ac.id;*
[3]sugimanwp@mail.unnes.ac.id; [4]s.b.waluya@mail.unnes.ac.id

Article received: 18-02-2025, revision: 22-03-2025, published: 30-04-2025

Abstrak

Berpikir kreatif matematis (Mathematical Creative Thinking/MCT) merupakan kompetensi penting abad ke-21 yang mencakup kelancaran, keluwesan, elaborasi, dan orisinalitas. Namun, berbagai penelitian menunjukkan bahwa siswa masih mengalami kesulitan dalam mengembangkan kemampuan ini. Penelitian ini bertujuan mengidentifikasi tren model pembelajaran yang digunakan untuk meningkatkan MCT melalui metode Systematic Literature Review (SLR). Data diperoleh dari 6 artikel Scopus dan Publish or Perish (PoP) yang diterbitkan pada 2019–2024, dipilih melalui kriteria inklusi dan eksklusi. Hasil kajian menunjukkan bahwa Project-Based Learning (PjBL) merupakan model yang paling banyak digunakan (2 artikel), sedangkan Problem-Based Learning (PBL), Creative Problem Solving (CPS), Resource-Based Learning (RBL), dan representasi dalam pemecahan masalah matematis masing-masing digunakan dalam 1 artikel. Setiap model berkontribusi pada indikator MCT yang berbeda, sehingga tidak ada satu model yang sepenuhnya unggul. Implikasinya, guru perlu mengombinasikan beberapa pendekatan agar pengembangan MCT siswa lebih optimal.
Kata Kunci: Berpikir Kreatif Matematis; Model Pembelajaran; Systematic Literature Review

Abstract

Mathematical Creative Thinking (MCT) is an essential 21st-century competence that encompasses fluency, flexibility, elaboration, and originality. However, various studies have shown that students still face difficulties in develo ping these abilities. This study aims to identify trends in learning models used to enhance MCT through the Systematic Literature Review (SLR) method. Data were obtained from 6 articles Scopus dan Publish or Perish (PoP) published between 2019 and 2024, selected based on inclusion and exclusion criteria. The findings indicate that Project-Based Learning (PjBL) is the most frequently applied model (2 articles), while Problem-Based Learning (PBL), Creative Problem Solving (CPS), Resource-Based Learning (RBL), and representations in solving mathematical problems were each used in 1 article. Each model contributes to different indicators of MCT, meaning that no single model is entirely superior. The implication is that teachers should integrate multiple approaches to more effectively optimize the development of students' MCT.
Keywords: Creative Mathematical Thinking; Learning Models; Systematic Literature Review

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I. INTRODUCTION

Mathematics plays a fundamental role in everyday life and has strong relevance to educational implementation (Putri et al., 2023). Through mathematics learning, students are trained to think logically, critically, systematically, and creatively, as well as to collaborate. These competencies are essential in the 21st century, which is characterized by the rapid development of technology and the demands of the industrial revolution 4.0 (Maskur et al., 2020). In this context, mathematical creative thinking becomes a crucial competency that needs to be developed through appropriate educational practices. Creative thinking refers to the process of generating new ideas based on the integration of prior knowledge and real-world experiences (Duong Huu Tong et al., 2020). It involves the ability to recognize problems from various perspectives and produce new solutions to improve existing knowledge or practices.

In mathematics, students demonstrate creativity when they generate new strategies and approaches to solve well-designed problems (Madihah Khalid et al., 2020). Mathematical creative thinking involves fluency, flexibility, elaboration, and originality (Siswono, 2018; Arnisya & Afriansyah, 2024). Fluency refers to the ability to generate a variety of ideas, while flexibility describes the capacity to shift between different strategies in solving a problem. Elaboration refers to the detail and development of ideas, and originality reflects the ability to generate unique and innovative solutions (Duong Huu Tong et al., 2020; Efwan et al., 2024). These characteristics show that mathematical creative thinking is not only a mental capability but also a skill that can be encouraged and enhanced through appropriate learning processes.

Several studies have shown that the choice of learning model greatly influences students' creative mathematical thinking skills. Madihah Khalid et al. (2020) indicated that Creative Problem Solving (CPS) learning can improve students' creativity and problem-solving abilities, although this improvement remains moderate when learning conditions and motivation are not sufficiently supportive. Yaniawati et al. (2020) found that Resource-Based Learning (RBL) integrated with e-learning and a scientific approach significantly enhances students' creative thinking and self-confidence compared to conventional methods. Likewise, project-based learning has been shown to improve creativity by allowing students to develop manipulative mathematics learning media (Ummah et al., 2019). Moreover, Maskur et al. (2020) reported that the Aptitude Treatment Interaction (ATI) model has a more significant impact on creative thinking skills than Problem Based Learning (PBL). These studies confirm that learning models play a central role in developing students' creative thinking.

In the last few years, several empirical studies have emphasized that innovative and technology-assisted learning models such as Inquiry-Based Learning (Pratiwi et al., 2023), STEAM-oriented Project-Based Learning (Nurhadi et al., 2022), Design Thinking (Firdaus & Turmudi, 2021), Discovery Learning (Dewi & Surya, 2020), and Problem Based Learning integrated with GeoGebra (Suryana & Tanujaya, 2019)

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p-ISSN: 2086-4280
e-ISSN: 2527-8827

are particularly effective in enhancing students' fluency, originality, and flexibility in creative mathematical thinking. These findings further highlight the need for a systematic review to obtain a comprehensive understanding of the most effective learning models in improving students' mathematical creative thinking during 2019–2024.

However, although various studies have investigated the effectiveness of learning models in improving mathematical creative thinking, the findings remain fragmented and context specific. To date, no comprehensive synthesis has been conducted to systematically analyze which learning models are most effective and how they improve students' mathematical creative thinking in recent years. Therefore, there is a need for a systematic literature review that integrates findings from empirical studies to provide broader and evidence-based insights into the effectiveness of learning models in enhancing mathematical creative thinking.

Based on the above background, the research problems in this study are: (1) What learning models can improve students' mathematical creative thinking skills?, and (2) How effective are these learning models in improving students' mathematical creative thinking skills?.

Thus, the objectives of this study are: (1) to identify the learning models that can improve students' mathematical creative thinking skills, and (2) to analyze how effective these learning models are in improving students' mathematical creative thinking skills.

II. METHOD

The research method used was a qualitative approach based on secondary data using a Systematic Literature Review (SLR). This method was conducted to obtain comprehensive and evidence-based information regarding learning models that improve students' mathematical creative thinking (Septiani et al., 2022).

Journal articles were collected from the Scopus dan Publish or Perish (PoP) databases with a publication period from 2019 to 2024. The search process was conducted using Boolean operators and synonyms, specifically: ("learning model" OR "instructional model" OR "teaching model") AND ("mathematical creative thinking" OR "creative mathematical thinking") AND ("effectiveness" OR "improvement"). This strategy was used to capture a wider range of relevant literature related to the topic.

The following inclusion and exclusion criteria were applied to select appropriate articles for analysis.

Table 1.
Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Peer-reviewed international or national articles related to learning models that improve mathematical creative thinking	Articles unrelated to mathematical creative thinking or learning models
Articles published between 2019–2024	Articles published before 2019
Articles obtained from Scopus dan *Publish or Perish* (PoP) databases	Articles obtained from sources other than Scopus dan Publish or Perish (PoP)
Full-text articles	Abstract-only or non-peer-reviewed documents

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The selected articles were evaluated using a quality assessment procedure to ensure methodological rigor. The assessment criteria included: (1) a clear description of the learning model used; (2) a complete description of the research design, including methods, sample, and instruments; and (3) clearly presented results regarding the effectiveness of the learning model in improving mathematical creative thinking. Each criterion was scored using a binary scale (0 = not fulfilled; 1 = fulfilled), and only articles with a minimum total score of three were included in the synthesis.

Data extracted from each article included the author, year of publication, research design, learning model applied, and main findings of the study. The collected data were analyzed using a narrative synthesis technique by grouping the articles according to the types of learning models.

III. RESULT AND DISCUSSION

A. Results of the Search and Selection Process for Inclusion Criteria

The initial search using Publish or Perish through the Scopus dan *Publish or Perish* (PoP) databases with the Boolean keywords ("learning model" OR "instructional model" OR "teaching model") AND ("mathematical creative thinking" OR "creative mathematical thinking") AND ("effectiveness" OR "improvement") yielded 32 articles published between 2019 and 2024.

After screening the articles using the inclusion and exclusion criteria, 6 articles were identified as relevant and met the quality assessment threshold. The characteristics of the selected articles are presented in Table 2.

Table 2.
Classification of Selected Literature and Learning Models Used

Writer	Journal	Types of Methods	Learning Model
Khalid et al. (2020)	Creativity Studies	Quantitative	Creative Problem Solving in Teaching Mathematics
Yaniawati et al. (2020)	I-Jet	Mixed Method	Integration of e-Learning for Mathematics on Resource: Based Learning
Ummah et al. (2019)	Journal on Mathematics Education	Qualitative	Project Based Learning
Maskur et al. (2020)	European Journal of Educational Research	Quantitative	Problem Based Learning
Wawan et al. (2023)	Islamic Guidance and Counseling Journal	Quantitative	Project-Based Learning Model Integrated with Ethnomathematics and Technology
Nugroho et al. (2020)	Journal of Research and Advances in Mathematics Education	Qualitative	Representations in Solving Mathematical Problems Based on Cognitive Style

B. Data Analysis Results

Furthermore, the research data from each article is described in Table 3 related to the findings related to improving mathematical creative thinking skills and the learning models used.

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p-ISSN: 2086-4280
e-ISSN: 2527-8827

Table 3.
Results of Findings of Related Literature related to Improving Mathematical Creative Thinking Skills and the Learning Models Used.

Writer	Result	Indicator
Khalid et al. (2020)	Learning with a collaborative CPS approach can improve students' creativity and problem-solving skills. The improvement is still moderate and can be improved again by creating a conducive learning atmosphere and motivation.	Fluency Originality Elaboration Flexibility
Yaniawati et al. (2020)	The use of e-learning mathematics in Resources-Based Learning (RBL) with a scientific approach, shows that the increase in mathematical creative thinking skills and self-confidence in each class is significantly different. In this case, the best development of mathematical creative thinking skills and self-confidence occurred in the RBL group with a Scientific Approach using e-learning media, followed by the RBL group with a Scientific Approach, and finally the conventional learning group.	Fluency Originality Elaboration Flexibility
Ummah et al. (2019)	The results of this study indicate an increase in creativity through project-based learning. This increase in creativity is based on the project of making manipulative mathematics learning media. The increase in creativity is also based on the fulfillment of bad aspects and novelty in good criteria, while the originality aspect meets the fairly good criteria.	Fluency Originality Elaboration Flexibility
Maskur et al. (2020)	Based on the research results, 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.	Fluency Originality Elaboration Flexibility
Wawan et al. (2023)	The results of multivariate and univariate tests show that the project-based learning model integrated with ethnomathematics and technology is effective in improving problem-solving skills, creative thinking, collaboration, and learning motivation.	Fluency Originality Elaboration Flexibility
Nugroho et al. (2020)	The results of the study showed that both subjects showed different performance in solving problems. In terms of fluency, both subjects used visual representation in interpreting information. In originality, reflective subjects used symbolic representation. while impulsive subjects used symbolic and verbal representation in building mathematical expressions. However, both have not created new ideas in solving problems. In addition, in flexibility, both subjects used visual and symbolic representations that can solve problems by utilizing environmental objects to interpret problems into mathematical expressions. However, reflective subjects made mistakes in explaining formulas and impulsive subjects could do so. These results indicate that both subjects have used representations of each indicator of creative thinking in solving problems.	Fluency Originality Elaboration Flexibility

RQ1: What learning models can improve students' mathematical creative thinking skills?

From the results of Table 2, a bar diagram was obtained regarding the learning model applied in the article related to students' mathematical creative thinking abilities from 2019-2023 as follows.

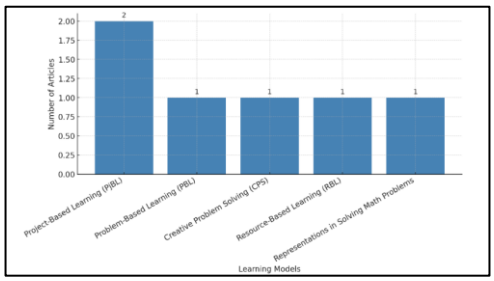

Figure 1. Learning Models Related to Students' Mathematical Creative Thinking Abilities from 2019-2024

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From Figure 1, it can be seen that Project-Based Learning (PjBL) is the most widely used learning model in studies aimed at enhancing students' mathematical creative thinking skills (2 articles). The dominance of PjBL indicates that project-based approaches are considered more relevant in fostering creative thinking skills in mathematics classrooms.

Theoretically, PjBL is grounded in constructivism, which emphasizes students' active involvement in constructing knowledge through authentic experiences (Piaget, 1972; Vygotsky, 1978). Through projects, students are encouraged to explore contextual problems, design solutions, and produce tangible outcomes that reflect their mathematical understanding. This process helps develop fluency (the ability to generate multiple ideas), flexibility (applying different strategies), and originality (creating unique solutions), which are key indicators of Mathematical Creative Thinking (Siswono, 2018).

Empirical studies support the efficacy of PjBL in enhancing mathematical creative thinking. For instance, Putri et al. (2019) conducted a quasi-experimental study with fifth-grade primary school students in West Java, finding that PjBL significantly improved students' creative thinking skills compared to traditional instruction. Similarly, Lubis (2023) reported that tenth-grade students taught via PjBL demonstrated significantly higher mathematical creative thinking abilities than peers experiencing conventional learning.

RQ2: How effective are these learning models in improving students' mathematical creative thinking skills?

The synthesis of six Scopus-indexed articles published between 2019 and 2024 shows that the effectiveness of learning models in improving students' Mathematical Creative Thinking (MCT) varies depending on the approach applied. The Creative Problem Solving (CPS) model, for example, has been proven to foster students' fluency in generating multiple ideas and enhance their problem-solving abilities. However, the effect was categorized as moderate because it strongly depended on external factors such as classroom atmosphere and student motivation (Khalid et al., 2020). This finding indicates that CPS on its own may not be sufficient, but its effectiveness can be optimized when the learning environment is supportive, encouraging, and motivating. In other words, CPS provides the potential to cultivate creativity, but teachers must carefully design conducive conditions to fully realize its benefits.

Another important finding comes from research comparing the Aptitude Treatment Interaction (ATI) model and Problem-Based Learning (PBL). Maskur et al. (2020) concluded that ATI was more effective than PBL in improving creative thinking, particularly in terms of flexibility and originality. Flexibility refers to the ability to change strategies when facing mathematical problems, while originality emphasizes the creation of unique solutions. This result suggests that learning designs that consider students' aptitudes and characteristics may lead to higher gains in creative thinking than conventional

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p-ISSN: 2086-4280
e-ISSN: 2527-8827

problem-based methods. Thus, ATI highlights the importance of differentiated instruction, where the alignment between teaching strategies and students' individual traits becomes a determining factor in achieving creativity-related outcomes.

In addition to ATI and CPS, the Project-Based Learning (PjBL) model stands out as one of the most effective strategies. Studies by Wawan et al. (2023) show that when PjBL is integrated with ethnomathematics and technology, it does not only strengthen students' mathematical creative thinking but also contributes to their motivation, collaboration, and problem-solving skills. Specifically, PjBL promotes fluency by encouraging students to generate diverse ideas throughout the project, and elaboration by requiring them to develop those ideas into concrete and detailed products. This aligns with constructivist theory, which views knowledge as actively constructed by learners through authentic experiences and social interaction (Vygotsky, 1978). PjBL therefore appears to be a holistic approach that benefits not only cognitive but also affective and social domains of learning.

Meanwhile, Resource-Based Learning (RBL) supported by e-learning also demonstrated positive effects on students' creative thinking skills. Yaniawati et al. (2020) reported that RBL significantly improved fluency and flexibility, as students were encouraged to use various learning resources to approach mathematical problems from multiple perspectives. Moreover, the integration of e-learning increased students' self-confidence, as they could access information independently and apply it in problem-solving. This finding indicates that the use of diverse and technology-supported resources can expand students' opportunities to think creatively and strengthen their autonomy in the learning process.

Moreover, several international studies have shown the consistent effectiveness of project- and technology-based learning models in enhancing students' mathematical creative thinking. For example, Himmi et al. (2025) emphasized that Project-Based Learning (PjBL) adapted to the local context can improve students' representation skills and creativity in mathematics. Nasution et al. (2025) demonstrated that a modified PjBL applied in geometry learning effectively develops students' fluency, flexibility, originality, and elaboration. In addition, Rahmawati et al. (2024) reported that integrating technology into Project-Based Learning strengthens students' motivation, collaboration, and problem-solving abilities, thereby enhancing cognitive, affective, and social domains of mathematical creative thinking.

IV. CONCLUSION

Based on the synthesis of six international articles published between 2019 and 2024, this study concludes that several learning models are effective in improving students' Mathematical Creative Thinking (MCT). RQ1 showed that the models most frequently applied include Project-Based Learning (PjBL), Problem-Based Learning (PBL), Creative Problem Solving (CPS), Resource-Based Learning (RBL), and representational approaches in mathematical problem solving. Among

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these, PjBL was the most widely used, indicating its relevance and popularity in fostering creative thinking in mathematics education.

RQ2 revealed that each model contributes to specific dimensions of MCT rather than comprehensively improving all indicators. CPS tends to strengthen fluency and problem-solving skills, while ATI outperforms PBL by enhancing flexibility and originality. PjBL, especially when integrated with ethnomathematics and technology, consistently promotes fluency, elaboration, motivation, and collaboration. RBL supported by e-learning improves fluency, flexibility, and self-confidence, whereas representational approaches help develop flexibility and originality, though their impact on generating entirely new ideas remains limited.

The main contribution of this review is providing a systematic synthesis of recent studies on effective learning models for MCT. The findings highlight that no single model is universally superior; rather, teachers should strategically adapt or combine different learning models to address the diverse aspects of students' creative thinking.

For practice, educators are encouraged to implement project-based and resource-based approaches, as they consistently show positive outcomes across multiple indicators of MCT. For research, further studies should examine how contextual factors such as student motivation, cognitive styles, and the integration of technology moderate the effectiveness of different models. Such investigations will provide deeper insights into how learning models can be optimized to foster mathematical creativity in diverse classroom contexts.

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AUTHOR'S BIOGRAPHY

Siti Nur Amanah, S.Pd., M.Pd.

The author is a lecturer in the Mathematics Education Study Program at Universitas Islam Cirebon. The author was born in Cirebon on April 7, 1986. He earned a Bachelor's degree in Mathematics Education from IKIP PGRI Semarang in 2011 and a Master's degree in Mathematics Education from Universitas Negeri Semarang (UNNES) in 2014.

Dr. Dra. Emi Pujiastuti, M.Pd.

The author is an Associate Professor in the Mathematics Education Study Program, Universitas Negeri Semarang (UNNES), who was born in Indonesia on May 24, 1962. She currently serves as the Head of Laboratory and Chair of the Mathematics Education Program.

Dr. Drs. Sugiman, M.Si.

The author is a Senior Lecturer in the Mathematics Education Master's Program, Universitas Negeri Semarang (UNNES), who was born in Indonesia on January 11, 1964. His research focuses on statistics, mathematics education, and learning for students with special needs, which have been published in various national and international journals.

Prof. Dr. S B Waluya, M.Si.

The author is a Professor in the Mathematics Education Doctoral Program, Universitas Negeri Semarang (UNNES), who was born in Indonesia on September 7, 1968. His research focuses on differential equations, partial differential equations, nonlinear oscillators, and nonlinear dynamics, which have been published in various national and international journals.

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