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Literature Review

Systematic Literature Review: Research Trend Analysis on Problem-Based Learning and Computational Thinking in Mathematics Learning

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Abstract: The purpose of this study is to analyze trends and characteristics of related research. Problem-Based Learning (PBL) and computational thinking (CT) in mathematics learning. The background of this research is grounded in the importance of 21st century of higher-order thinking skills, contrasting with the currently limited research integrating PBL and CT. The method used in this research is a Systematic Literature Review (SLR) with reference to the PRISMA guidelines. Data were collected from Google Scholar, Publish or Perish, Garuda, and Sinta databases, appliying inclusion criteria for the 2022-2026 period, a total of 20 relevant articles were selected. The results of this study show that the trend of PBL and CT research is increasing, although the trend is not stable each year. Most of these studies employ a qualitative approach, focusing primarily on elementary and secondary education. In addition, the results show that PBL improves students' critical thinking and problem-solving skills, while CT helps build students' systematic thinking patterns. However, research that combines PBL and CT is not much. In addition to providing an overview of research trends, this study provides a basis for developing learning models that combine PBL and CT in mathematics learning. Therefore, this reseach is expected to yield a significant impact by mapping current research trends and identifying existing gaps. It serves as a practical framework for mathematics educators to design lessons that integrate PBL with CT and as a guideline for future researchers to explore uncharted research gaps.

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INTRODUCTION

Educational developments in the 21st century require students to possess higher-order thinking skills, such as problem-solving, critical thinking, and computational thinking. These skills are crucial in mathematics learning, as they trains students to think logically, systematically, and analytically in solving problems. One skill that is receiving increasing attention is computational *thinking* (CT) or computational thinking. According to Wing (2011), computational thinking encompasses the skills of decomposition, pattern recognition, abstraction, generalization, and algorithms. However, in reality, many students still struggle when faced with complex math problems. This occurs because the learning process often focuses only on final the result, rather than the underlying thinking process. Therefore, fostering computational thinking skills in learning mathematics is eesensial to improve the quality of students' cognitive abilities.

Fostering CT capacities in math education necessitates an instructional framework that drives learners to engage actively in problem-solving tasks. A highly suitable approach for this objective is *Problem-Based Learning* (PBL). Prior literature indicates that PBL centers pedagogical activities around core problems, thereby boosting student involvement and cognitive growth during mathematics lessons (Ningrum et al., 2025; Portuna et al., 2025). The PBL learning model emphasizes that students conduct investigations and solve problems to facilitate and optimize their full potential(Yelvalinda et al., 2019). To further enhance students' understanding, this instructional model is highly effective for use in the classroom (Hermansyah et al., 2024). The relationship between PBL and CT lies in the mental processes that students go through. In the initial phase of PBL, students are required to be able to identify problems, which in this case can train decomposition skills. Furthermore, in the investigation stage, students are required to find patterns from data and create systematic steps to find solutions. Thus, the PBL model can create an ideal learning environment for students to practice the components of computational thinking naturally. Furthermore, the PBL model assists students in applying their understanding of a concept by presenting a problem at the beginning of the lesson to be discussed and solved collaboratively (Rifa'i et al., 2019).

As an educational framework, PBL stimulates self-directed problem solving and critical analysis embedded in authentic situations (Portuna et al., 2025). Through this approach, students can directly perceive the benefits of learning because the topics analyzed stem from real-world problems (Nisak & Istiana, 2017). Meanwhile, CT is a more systematic and procedural thinking ability (Nayyiroh et al., 2024). The integration of PBL and CT allows students to systematically structure complex problems and develop data-driven, logical mathematical solutions. Based on various studies that have been conducted, most studies still focus on the influence of PBL on certain abilities, such as problem-solving or mathematics learning outcomes, while in this study, regarding CT, more emphasis is placed on the development of computational thinking skills in general. Research that specifically examines the relationship between PBL and CT in mathematics learning is still limited and has not been systematically analyzed. Based on that, the objectives of this study are: (1) to describe research trends on PBL and CT in mathematics learning, and (2) to describe the characteristics of previous studies that examine PBL and CT in mathematics learning. Beyond identifying overarching publication patterns, this investigation seeks to offer tangible, action-oriented benefits for classroom practitioners. The results of the analysiscan serve as a reference for teachers to design innovative learning strategies. In addition, for future researchers, this research provides a clear direction to fill unexplored research gaps regarding the intersection of PBL and CT.

METHOD

This research employs the *Systematic Literature Review* (SLR) method, which aims to identify, review, and systematically analyze research related to *Problem-Based Learning* (PBL) and *computational thinking* (CT) in mathematics learning. The SLR method is used to obtain an overview of research trends and the characteristics of previously conducted research. To guide the systematic gathering and filtering of articles, this investigation strictly follows the PRISMA *(Preferred Reporting Items for Systematic Reviews and Meta-Analyses)* framework.

Data collection was conducted through a documentation study by searching for relevant research articles from various scientific journals available online. Article searches were conducted using keywords. *Problem-based learning*, *computational thinking*, and mathematics learning. Following the primary compilation, specific boundary parameters were exclusion criteria aligned with the study's core targets. The finalized selection and rejection of this review are detailed in the Table 1.

Table 1. Inclusion and Exclusion Criteria for Literature Review

No	Inclusion Criteria	Criteria Exclusion
1.	Articles published in the last five years (2022-2026)	Articles that do not have empirical data or are only in the form of a literature review without research results
2.	Research Using PBL and CT in the Field of Mathematics Education	Research that is not relevant to the context of Mathematics Education, PBL, or CT.
3.	Articles that focus on PBL and CT research trends	Articles written in a language other than English or Indonesian
4.	Articles published in national journals, accredited, reputable international journals, or scientific proceedings that have gone through a peer-review process	Articles published in journals, non-academic *blogs*, unpublished reports, or sources without a peer-review process.

Following article selection, the next step is data extraction. At this stage, researchers categorize important information from articles, such as publication year, educational level, research methods, and focus of the study. This process involves several steps. First, all articles found in the initial search are imported into reference management software, such as Mendeley, to facilitate management and removal of duplicates. Second, the title and abstract of each article are reviewed to determine whether they meet the inclusion criteria. Third, articles that pass this stage are thoroughly reviewed to ensure relevance and methodological quality.

The final step involved data synthesis and analysis. This process entails examining the research finding to identify trends and characteristis learning related to PBL and CT in mathematics learning. Data collected from selected articles include information on research methods, samples used, learning contexts, and outcomes related to the use of PBL and CT in mathematics learning. This study notes the positive and negative results of each study to provide an overview of PBL and CT research. Data analysis was conducted using qualitative descriptive analysis, grouping and describing the findings of selected studies to examine the development of research trends, methods used, and the focus of research studies in the field. Findings from the article search across various databases are presented in the diagram below.

The following are the 4 stages of PRISMA (Figure 1.), namely identification, screening, suitability, and final (Liberati et al., 2009). The following is an explanation of the four steps:

1. Stage 1 (Identification)
   This stage is the initial process of searching for articles from various databases using certain keywords to obtain as much literature as possible (Vessonen et al., 2025). At this stage, 60 research articles on PBL and CT models in mathematics learning were found in Google Scholar, Publish or Perish, Sinta, and Garuda searches.
2. Level 2 (Screening)

This stage involved removing duplications and assessing the relevance of articles based on their titles and abstracts (Sitorus et al., 2025). At this stage, 53 articles were available for use after duplication removal.

3. Level 3 (Suitability)
   This stage aims to assess the suitability of articles through full-text review according to the research inclusion criteria (Vessonen et al., 2024). Based on the selection results based on the inclusion criteria, 20 articles were considered for further study.
4. Stage 4 (Final Article)
   This final stage is the scope of the study, which is truly relevant and ready. It is further analyzed in the literature synthesis (Page et al., 2021). At this stage, there are 20 articles that are relevant to the criteria regarding PBL and CT research trends in mathematics learning.

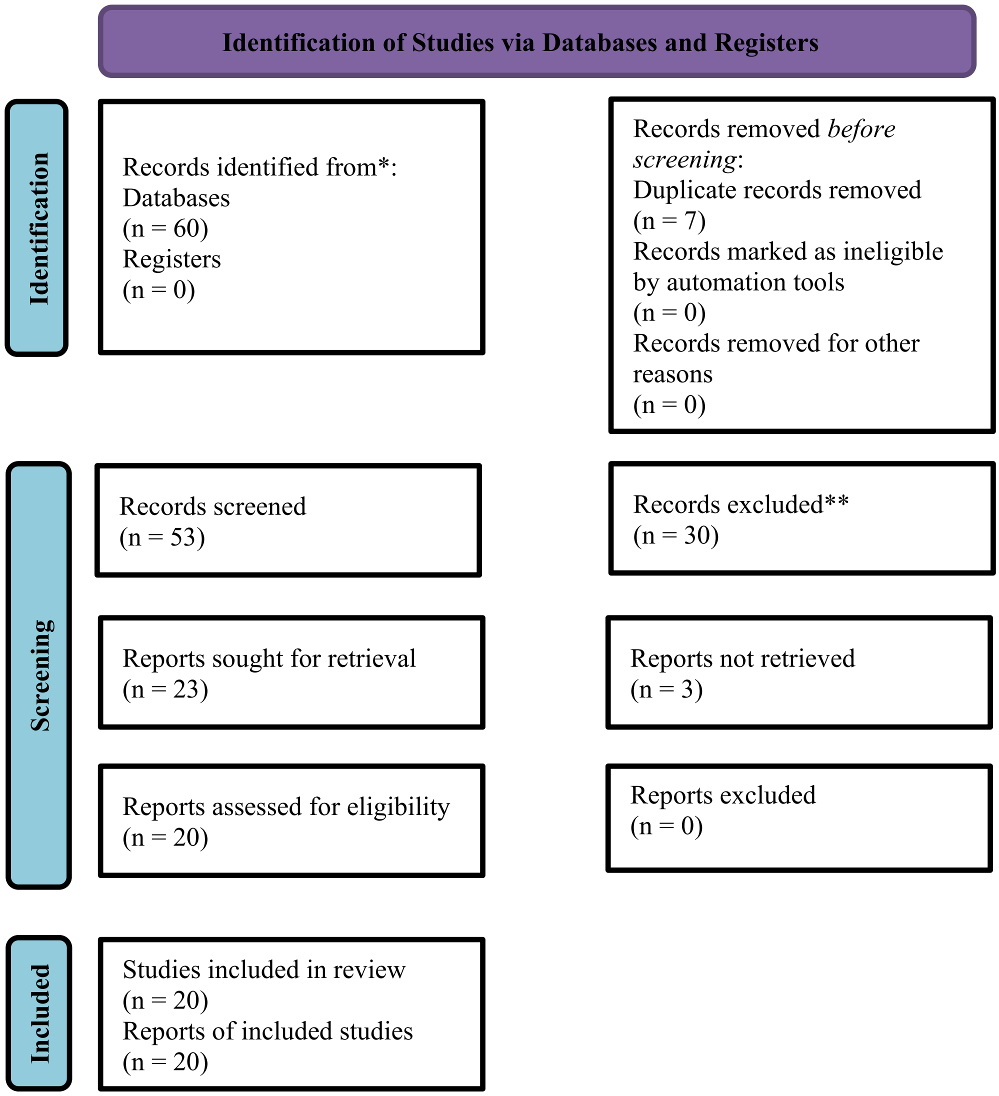

Figure 1. PRISMA Flow Diagram

RESULTS

The findings of this study were obtained through a systematic analysis of articles published between 2022 and 2026 across various databases, including Google Scholar, Publish or Perish, Garuda, and Sinta. By examining selected manuscripts according to their authorship, publication timelines, journal venues, and empirical outcomes, this review establishes a clear mapping of current academic trajectories specifically concerning the application of *Problem-Based Learning* (PBL) alongside *computational thinking* (CT) frameworks in math instruction. Through this process, 20 articles met the inclusion and exclusion criteria: these are presented in the table below to illustrate the research trends of PBL and CT in mathematics education.

Table 2. Article Findings Based on Inclusion and Exclusion Criteria for 2022-2026

No.	Researcher (Year)	Journal	Results
1.	Rahmawati, Purnomo and Mawarsari (2025)	Journal of Mathematics Research and Mathematics Education	The study shows that the application of the PBL model for teaching mathematical problem-solving remains predominantly focused on numbers and calculations in elementary and junior high school. Additionally, research publications on this topic exhibited inconsistency between 2021 and 2025.
2.	Nayyiroh, Susanto, Suwito, and Firmansyah (2024)	Journal of Educational Integration and Development	This investigation demonstrates that deploying the PBL framework effectively enhances student's academic performance and cognitive skills, thereby serving as a viable alternative pedagogical strategy.
3.	Asmal and Yahfizham (2024)	Journal of Character Education	This research indicates that implementing the PBL framework actively fosters deeper student engagement, strengthens critical reasoning capacities, and enhances the comprehension of core concepts, proving that the PBL model is an effective approach to improving mathematics learning.
4.	Hikmah, Zaenuri, and Walid (2025)	Suska Journal of Mathematics Education	The research findings show that the integration of computational thinking improve students' abilities, specifically their problem-solving, logical thinking, and higher order thinking skills. Furthermore, CT is considered essential in preparing students to face the challenges of the digital era.
5.	Laila Rahmawati, Eko Andy Purnomo, and Venissa Dian Mawarsari (2025)	Proximal Journal	The results show that the PBL model consistently exerts a positive impact on problem-solving skills by encouraging students to think critically, actively, and engage in contextual problem-solving. Furthermore, research trends indicate that the application of PBL serves as an effective learning strategy to improve student's mathematical abilities across various levels of education.
6.	Inuhan, Lekitoo, Romsery, Wariaka and Tetiwar (2025)	Journal of Mathematics and Mathematics Education	The results of the study indicate that publication trends in computational thinking have increased significantly each year, with dominant contributions from institutions in the United States as well. Source publication major, such as ACM.

No.	Researcher (Year)	Journal	Results
7.	Aisyah and Gumala (2025)	Papanda Journal of Mathematics and Science Research	This investigation demonstrates that the PBL Framework successfully enhances advanced cognitive capabilities, particularly analytical, evaluative, and consistently reflective reasoning, while serving as a strategic tool to upgrade instructional quality.
8.	Mitrayana and Nurlaelah (2023)	Indonesian Journal of Teaching in Science	Empirical data indicate steady annual growth in the volume of literature focused on CT development. This trend appears most prominent at the lower secondary education tier, where researchers frequently employ descriptive designs alongside assessment tests or interviews to underscore the necessity of instructional frameworks that embed CT attributes into math lessons.
9.	Pramana and Wijayanti (2026)	Journal of Mathematics Education Research	The results of this study indicate that it is necessary to strengthen empirical construct validity and reliability testing so that CT research can establish a more robust and replicable methodological foundation.
10.	Saad and Zainudin (2022)	Learning and Motivation	The results of this study indicate that PBL and CT complement each other in learning strategies and problem solving. However, several studies have failed to explicity describe the PBL-CT framework and have highlighted limitations in implementing the model integratively, particularly regarding the dominant use of scaffolding and visual tools.
11.	Widiyatmoko and Wulandari (2024)	Proceedings of the National Science Seminar	Research results show that only 20 countries have implemented CT-based learning, particularly at elementary and junior high school levels. Furthermore, the adoption of different integration strategies tailored to each country's policies and curriculum remains limited. .
12.	Nurasiah, Paristiowati, Erdawati, and Afrizal (2023)	International Journal of Social and Management Studies	This investigation demonstrates that deploying technology-enhanced PBL frameworks substantially elevates student CT performance, highlighting the beneficial role of digital tools within PBL to drive *computational thinking* skills.
13.	Sholihah, Herlambang, and Wijoyo (2025)	Journal of Information Technology and Computer Science Development	Empirical findings indicate that incorporating digital tools into PBL environments exerts a profound impact on cognitive and psychomotor growth, while delivering a noticeable, moderate improvement in student's CT advancement. Concequently, this pedagogical design is recommended for various subjects using simpler teaching materials.

No.	Researcher (Year)	Journal	Results
14.	Prilyani Hermansyah, Heni Pujiastuti, and Maman Fathurrohman (2024)	Scientific Journal of Educational Sciences	This research reveals that the PBL framework functions as an effective pedagogical tool for enhancing students' general mathematical capacities.
15.	Awaliyah Septiani, Heni Pujiastuti, and Maman Fathurrohman (2022)	Journal of Educational Sciences	The data indicate that integrating the PBL model into classroom instruction successfully boosts students' mathematical *problem-solving* competencies.
16.	Trian Fajrianto, Larasati Rizki, Meiliasari, and Wardani Rahayu (2025)	Gammath Journal	The results of this study show that the ability students' logical and analytical thinking skills increases due to the contributions of CT integration.
17.	Risma Hayati, Rahayu Kariadinata, and Ida Nuraida (2025)	Mathematics Education on Research Publication (MERP)	The results of this study indicate that appropriate integration of learning models and media is required to accurately measure students' computational abilities in solving mathematical problems.
18.	Muhammad Rifa Udin, Zaenuri Mastur, and Walid (2025)	Pasundan Journal of Research in Mathematics	The results of this study show that the application of the PBL model with a STEM approach can improve the problem-solving abilities of junior high and high school students.
19.	Khusna and Saltifa (2026)	Jakarta Journal of Mathematics Education Research	The result of this research is the implementation of CT, which acts as a mathematical thinking framework.
20.	Nurkamilah and Juandi (2024)	Journal of Research and Education and Learning Studies	The results of this study indicate that CT and mathematical content can be affectively utilized as the context and orientation for learning outcomes in Geometry learning.

From Table 2. above, several important findings have been identified to address the proposed research questions.

Research trends on PBL and CT in mathematics learning

Based on Figure 2. and the analysis results above, the number of published articles shows an unstable trend throughout the period from 2022 to 2026. In 2022, there were only 2 articles; then, there was no increase in 2023, with 2 articles. In 2024, there was a steady increase to four articles, followed by a sharp rise in 2025, reaching the highest number of publications with ten articles. However, in 2026, the number dropped drastically to two articles. Despite these annual variations, the data indicate that the research trend on PBL and CT in mathematics learning continues to evolve.

Scholarly work concerning PBL remains heavily centered on enhancing capacities such as computational thinking and problem-solving, particularly within primary and lower secondary schooling environments. Meanwhile, research on CT shows a fluctuating trend but indicates growing interest in mathematics learning as a 21st-century skill. Furthermore, this trend indicates that technology used in PBL-based learning is increasingly being used to support CT development.

Publications related to CT are not only increasing in quantity but are also beginning to develop in various learning approaches and contexts. However, research specifically examining the direct integration of PBL and CT within a single learning framework is still limited, creating an opportunity for further research.

Figure 2. PBL and Computational Thinking Research Trends

Characteristics of previous research that examined PBL and CT in mathematics learning

Previous research has shown that the impact of PBL on students' mathematical and computational abilities has been largely measured through quantitative approaches, involving experimental or quasi-experimental designs. The research subjects were mostly from elementary and middle schools, with a smaller number from high schools.

In terms of methodology, most studies still rely heavily on instruments such as ability test, questionnaires, and interviews. Additionally, statistical data analysis was used, such as significance tests and N-gain. Literature Reviews and systematic approaches have been utilized in several studies to explore trends and progress on this topic in greater depth. Ultimately, improving problem-solving skills, computational thinking skills, and higher-order thinking skills (HOTS) remains the primary focus on this research area.

However, previous research exhibits several limitations. For instance, some instruments were not comprehensively tested for validity and reliability. Furthermore, the integration of technology-based PBL and CT still yields mixed results, highlighting the need for further research to optimize their outcomes in mathematics learning.

DISCUSSION

Analysis of development trends in PBL and CT publications

The results of the analysis of 20 articles show that the research trends related to Problem-Based *Learning* (PBL) and computational *thinking* (CT) in mathematics learning experienced an unstable increase in the 2022-2026 period. This indicates that while both approaches have been recognized as priorities in the transformation of modern education, the consistency and implementation of research in the field still experience unstable dynamics (Rahmawati et al., 2025). This inconsistency reflects that the development of learning strategies that combine systematic thinking processes with problem-based learning models is still in the stage of searching for an ideal form (Pramana & Wijayanti, 2026). This shows that the main problem is no longer about the "what" of PBL and CT, but about "how" to combine the two inside a coherent instructional system.

Despite the unstable research trend, the literature consistently supports evidence that PBL models are highly effective in increasing active student engagement through the presentation of contextual problems. However, a major challenge is the limited research that explicitly combines PBL and CT into a single, coherent learning model. Most current literature examines these two aspects separately, resulting in the lack of a truly systematic integration framework.

Regarding quantitative outcomes, numerous prior investigations confirm that PBL serves as a powerful approach to boost student CT capacities. For instance, research conducted by Hayati & Kariadinata (2025)revealed that embedding digital tools such as Edmodo within PBL environments enabled learners to reach a 75% mastery level in CT. These data are consistent with the outcomes reported by Sholihah et al. (2025), whose post-test evaluation generated an effect size value of 0.796, which represents a medium-tier classification. Based on this value, it can be interpreted that the implementation of a PBL method assisted by ChatGPT and GitHub exerts a moderate influence on improving students' CT skills. Additionally, Rimalita et al. (2023) found a substantial effect size of 2,73, concluding that the PBL model has a significantly large influence on the mathematical problem-solving skills of tenth-grade students at SMAN 1 Singkawang. Furthermore, recent studies continue to support the positive impact of this model on various mathematical outcomes. For instance, Murzal et al. (2025)demonstrated that the implementation of the PBL model significantly affects the mathematical understanding skills of ninth-grade students at MTsN 13 Pesisir Selatan, as indicated by a t-value (1,96) higher than the t-table (1,67). Similarly, Aisyanah & Kurniasari (2017) found that combining the PBL model with a dice puzzle prop strategy significantly influences the mathematics learning outcomes of eighth-grade students at SMPN 1 Sumbergempol, proven by a Moses test with a significance value (1-tailed) of 0,008, which is well below the 0,05 threshold. Therefore, these research findings robustly validate PBL as a highly effective instructional vehicle to elevate students' mathematical CT mastery.

Characteristics of methodology and implications for educational levels

Looking through a methodological lens, a substantial body of research continues to rely on quantitative frameworks, employing assessment tests and surveys alongside analytical methods like statistical significance testing and N-gain scores. Currently, scholarly attention remains heavily concentrated on primary and lower secondary education tiers, leaving the upper secondary school level largely underexplored. This gap in senior high school literature is critical, as students at at this cognitive internalization of CT. This suggests an opportunity for future research to develop a more consistent and comprehensive PBL and CT integration framework to fill the existing research gap, particularly in the development of computational thinking skills in senior high school education. To address this gap, further research needs to compare and integrate PBL and CT frameworks within the senior high school mathematics curriculum. Existing literature still largely revolves around elementary and junior high school levels, making comparative studies at the senior high school level highly crucial. Based on the results of this systematic literature review (SLR), such an approach will generate relevant and implementable models, helping future researchers design effective advanced learning to improve the CT skills of senior high school students.

CONCLUSION

By synthesizing 20 articles published between 2022 and 2026, this Systematic Literature Review (SLR) assesses how PBL and CT intersect within mathematics education. The analysis reveals a fluctuating publication trend, which peaked in 2025 with 10 articles before declining to 2 articles in 2026. The primary finding of this study indicates that while the PBL model is serves as an effective vehicle for students' CT activities, significant gaps remain regarding the systematic integration of the two approaches, particularly at the senior high school level, alongside a need for more diverse research methodologies.The practical contribution of this research is the urgent need for a guide or teaching module that explicitly combines PBL syntax with CT components (decomposition, abstraction, pattern recognition, and algorithms). Consequently, given the scarce exploration in upper secondary education identified by this SLR, subsequent investigations should focus on evaluating the integrated PBL-CT framework across diverse mathematical subtopics at the high school tier. The continuation of such research is crucial to address the identified literature gaps and to ensure that this integrated model can consistently develop students' systematic thinking skills required to face 21st-century challenges.

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