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A SYSTEMATIC LITERATURE REVIEW ON THE APPLICATION OF PROBLEM-BASED LEARNING IN STUDENTS' CRITICAL THINKING ABILITIES

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ABSTRACT This study aims to explain and evaluate the application of the Problem-Based Learning (PBL) model to students' critical thinking skills based on established indicators, and to examine the distribution of publication years in relation to the educational levels of the research subjects. This systematic literature review employs a meta-analysis approach to obtain article findings that meet the predetermined inclusion criteria. The study follows a protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The final set of primary studies selected for review consists of four research and development (R&D) studies and thirteen quasi-experimental studies. The results show that: (1) 47.06% of the studies applied the PBL model based on theoretical characteristics defined by experts; (2) 52.94% of the studies incorporated critical thinking indicators formulated by experts; (3) 52.94% of the primary studies related to PBL and critical thinking were published in 2020; and (4) the distribution of educational levels in the studies was as follows: elementary school (17.65%), junior high school (35.29%), senior high school (23.53%), and higher education (23.53%). This study offers novelty by integrating systematic literature review and meta-analysis approaches to evaluate the implementation of the PBL model in fostering critical thinking skills, based on expert-formulated indicators. By quantitatively identifying the proportion of articles aligned with PBL theory and critical thinking indicators, and by mapping publication trends by year and educational level, this study provides a comprehensive and current overview of PBL implementation practices in the context of Indonesian education.

Keywords: Problem-Based Learning, critical thinking, systematic literature review, meta-analysis

ABSTRAK Penelitian ini bertujuan untuk menjelaskan dan mengevaluasi penerapan model pembelajaran Problem Based Learning (PBL) terhadap kemampuan berpikir kritis siswa berdasarkan indikator-indikator yang telah ditetapkan, serta melihat distribusi tahun terbit artikel berdasarkan jenjang pendidikan subjek penelitian. Kajian literatur sistematis ini menggunakan pendekatan meta-analisis untuk memperoleh artikel yang sesuai dengan kriteria inklusi yang telah ditentukan. Penelitian ini mengikuti protokol yang mengacu pada Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). Studi primer yang dikaji terdiri atas empat penelitian pengembangan (Research and Development) dan

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tiga belas penelitian kuasi-eksperimen. Hasil kajian menunjukkan bahwa: (1) sebesar 47,06% artikel menerapkan model PBL berdasarkan teori karakteristik dari para ahli; (2) sebanyak 52,94% artikel telah membangun pembelajaran berdasarkan indikator kemampuan berpikir kritis dari para ahli; (3) pada tahun 2020 terdapat 52,94% artikel primer yang membahas PBL dan kemampuan berpikir kritis; dan (4) distribusi jenjang pendidikan dalam artikel terdiri atas: sekolah dasar (17,65%), sekolah menengah pertama (35,29%), sekolah menengah atas (23,53%), dan perguruan tinggi (23,53%). Penelitian ini memiliki kebaruan karena mengintegrasikan pendekatan systematic literature review dan meta-analisis secara khusus untuk mengevaluasi implementasi model PBL terhadap kemampuan berpikir kritis berdasarkan indikator dari para ahli. Dengan mengidentifikasi secara kuantitatif proporsi artikel yang selaras dengan teori PBL dan indikator berpikir kritis, serta memetakan tren publikasi berdasarkan waktu dan jenjang pendidikan, penelitian ini memberikan gambaran yang komprehensif dan mutakhir mengenai praktik implementasi PBL dalam konteks pendidikan di Indonesia.

Kata-kata kunci: Problem Based Learning, berpikir kritis, systematic literature review, meta-analisis

INTRODUCTION

Critical thinking is a skill that must be possessed by students in the 21st century (Muthma'Innah et al., 2019). It is essential for students to have critical thinking skills in the current era. Critical thinking refers to a problem-solving process that requires prior knowledge or strategies (Nggaba, 2020). As a process, critical thinking must be practiced repeatedly so that it becomes a habit. Furthermore, the goal of critical thinking is to make reasonable decisions that lead to accurate and correct results (Anggraini et al., 2022). Therefore, critical thinking skills should be prioritized during the teaching and learning process in the classroom.

At the international level, critical thinking is also a global educational benchmark. This is reflected in the Programme for International Student Assessment (PISA), which evaluates students' abilities to apply their knowledge and skills in key areas, and to assess, reason, and communicate effectively when identifying, interpreting, and solving problems in various contexts (OECD, 2023).

In addition, Indonesian students are now evaluated through the Minimum Competency Assessment (Asesmen Kompetensi Minimum/ AKM), which is conducted by the government to assess the essential competencies required for students to develop their abilities and improve learning outcomes (Anggraini et al., 2022). AKM demands critical thinking skills to solve real-life problems, including both structured and unstructured mathematical problems, requiring reasoning grounded in mathematical concepts (Suwito, 2021). In alignment with this, the current Merdeka Curriculum promotes mathematics education that emphasizes students' cognitive processes, such as computational thinking, critical thinking, generative thinking, and creative thinking (Zafirah et al., 2024).

To foster critical thinking skills, an appropriate learning model is needed. Problem-Based Learning (PBL) is a learning model that presents real-world problems to

students, facilitating the development of critical thinking, problem-solving skills, and conceptual understanding (Darhim et al., 2020). PBL has been shown to improve students' critical thinking abilities (Prihono & Khasanah, 2020), support active student participation in problem-solving, and build habits of critical analysis (Setiyaningrum & Sari, 2023). Furthermore, PBL can develop mathematical critical thinking and improve learning evaluation results (Hartanti & Purnomo, 2023).

Considering the growing number of studies on PBL and critical thinking, there is a need for a review, summary, and synthesis of the existing research to provide a more comprehensive understanding of how PBL is applied to enhance students' critical thinking skills. One appropriate method to achieve this is through a Systematic Literature Review (SLR), which serves to identify, evaluate, and interpret relevant studies (Shomad & Rahayu, 2022).

Critical thinking is one of the essential 21st-century skills that must be developed at all levels of education. The Problem-Based Learning (PBL) model is widely recognized as an effective approach to promoting critical thinking. However, despite the increasing number of studies examining the relationship between PBL and critical thinking, few have systematically evaluated whether these studies are grounded in expert-established PBL characteristics and critical thinking indicators. Moreover, research trends based on publication year and educational level remain scattered and underdocumented.

Thus, it is necessary to conduct a Systematic Literature Review (SLR) and meta-analysis to provide a comprehensive and structured overview of how the PBL model is implemented in the context of critical thinking development, as well as to examine the temporal and educational distribution of such studies. The findings are expected to serve as a foundation for researchers and educators in designing more effective instructional practices.

Therefore, this study aims to explain and evaluate the application of Problem-Based Learning in relation to students' critical thinking skills based on relevant indicators, and to examine the distribution of publication years and educational levels in the reviewed articles. In developing instructional strategies like PBL based on students' critical thinking, it is essential to refer to validated indicators from experts or previous studies to ensure a more structured and measurable implementation. Fundamentally, critical thinking is closely tied to processes indicated by its defining characteristics (Karim & Normaya, 2015). Likewise, any learning model should be grounded in a solid theoretical foundation (Khoerunnisa & Aqwal, 2020).

Based on these objectives, the research questions in this SLR study are as follows:

1. How is the application of the problem-based learning model to students' critical thinking skills constructed based on the characteristics of PBL established by experts?
2. To what extent have research articles on the application of PBL referred to expert-developed indicators of critical thinking skills?

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3. What is the distribution of publication years of articles examining the application of PBL to students' critical thinking skills?
4. What is the distribution of educational levels in articles investigating the relationship between PBL and critical thinking skills?

METHODS

This study employed a Systematic Literature Review (SLR) method using a meta-analysis approach. This method was applied to identify and analyze articles that met the predetermined inclusion criteria. The review procedure adhered to the guidelines of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which include the following stages: identification, screening, eligibility, and inclusion (Page et al., 2021).

A total of 21 primary studies were retrieved from the Scopus database and 23 from the SINTA (Science and Technology Index) database maintained by the Ministry of Education and Culture. These articles were sourced from 23 journals in the field of mathematics education using the keywords *"problem-based learning"* and *"critical thinking"*.

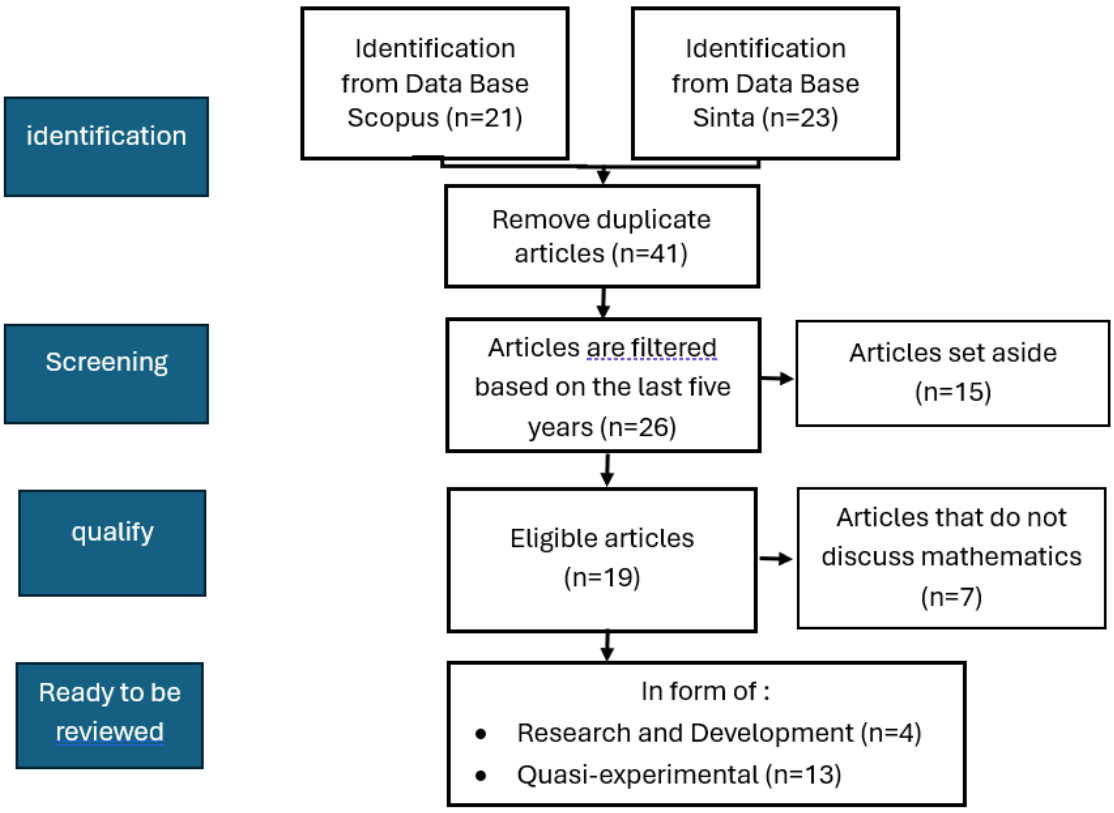

Figure 1. PRISMA flowchart for article selection process.

After removing duplicates from both databases, 41 primary studies remained at the identification stage. During the screening stage, articles were filtered based on their year of publication, with only those published within the last five years being retained. This process resulted in 26 articles.

At the eligibility stage, only articles specifically addressing mathematics education were considered. Seven articles were excluded because they did not focus on mathematics, resulting in 19 eligible studies.

Based on Figure 1 (PRISMA flowchart), the final selection comprised 19 articles eligible for in-depth review. These included 4 articles employing the Research and Development (R&D) method and 13 articles using a quasi-experimental design.

FINDING AND DISCUSSION

Implementation of Problem-Based Learning on Critical Thinking Skills Built Based on PBL Characteristics.

Problem-based learning is a learning model based on everyday problems to learn a concept or unstructured knowledge(Ermida et al., 2024). To see the application of PBL characteristics in the selected primary study, the following PBL characteristics will be used: 1) Learning is student center is learning that emphasizes more on student activities. 2) Authentic problems form the organizing focus for learning is presenting everyday problems so that students can easily understand and apply them in their lives when working in the future. 3) New information is acquired though self-directed learning is a learning that requires students to explore their own learning sources from textbooks, the internet or experts in their fields so that the learning that is carried out becomes more meaningful. 4) Learning occurs in small groups is a teaching and learning process carried out in groups. 5) Teachers act as facilitators is the role of teachers only acting as facilitators and taking a minor role in the classroom(Simatupang & Ritonga, 2023).

After analyzing the selected primary studies, the results obtained were as in Table 1 below:

Table 1. Primary Studies Based on Problem-Based Learning Characteristics

Author	Characteristics of Problem Based Learning				
	Student - centered	Based on problem	Study meaningful	Study in groups	Teacher as facilitator
(Agustina et al., 2020)	☑	☑	☑	☑	☑
(Ahdhianto et al., 2020)	☑	☑	☑	☑	☑
(Darhim et al., 2020)	☑	☑	☑	☑	☑

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Author	Characteristics of Problem Based Learning				
	Student - centered	Based on problem	Study meaningful	Study in groups	Teacher as facilitator
(Hairun et al., 2020)	✓	✓	✓	✓	✓
(Ramadhani et al., 2020)	✓	✓	✓	✓	✓
(Samura et al., 2020)					
(Susilo et al., 2020)					
(Zetriuslita et al., 2020)					
(Rahman et al., 2021)	✓	✓	✓	✓	✓
(Musaad & Suparman, 2023)		✓			
(Hartanti & Purnomo, 2023)		✓			
(Prihono & Khasanah, 2020)	✓	✓	✓	✓	✓
(Putri et al., 2021)		✓			
(Sarwastuti & Purnomo, 2023)	✓	✓	✓	✓	✓
(Setiawi et al., 2021)					
(Setiyaningrum & Sari, 2023)		✓	✓		✓
(Suanto et al., 2022)					

Based on Table 1, it is found that there are eight articles that are in line with the PBL characteristics that are used as a reference. The characteristics of PBL in each article are described in the learning process that is carried out well. One article(Rahman et al., 2021) even provides a flowchart of the characteristics of PBL that are linked to the learning process carried out so as to produce the objectives of each directed critical thinking indicator. For the article written by (Setiyaningrum & Sari, 2023)the characteristics of PBL only describe several characteristics of PBL in the learning

process carried out. While the other three articles only emphasize problem-based learning without describing the characteristics that must be possessed by PBL. Then there are five primary studies that do not include the characteristics of PBL at all and do not explain the steps of PBL in making their primary studies so that the learning steps taken are not visible, making the purpose of using PBL not well defined. This may happen because the research conducted only focuses on the results of increasing statistical figures without explaining its relationship to the characteristics of PBL in question. Basically, a learning model should be built based on the basics of knowledge theory (Khoerunnisa & Aqwal, 2020).

Implementation of Problem-Based Learning on Critical Thinking Skills Built Based on Students' Critical Thinking Skills Indicators.

Critical thinking is a thought that is in accordance with reality, reflective and based on the ability to determine what to do. When obtaining data or facts, a person must be able to think critically to determine the truth of the data obtained. Critical thinking is a skill that a person has in order to determine valid and accurate data on real problems (Ennis, 2011). To see the application of critical thinking skills in the selected primary articles, an analysis will be carried out based on the indicators of critical thinking skills written by Angelo : (1) the ability to analyze is the ability to break down a structure into elements to be able to see a complete picture of the structure, (2) the ability to synthesize is the ability to combine components into other structures, (3) problem-solving skills are skills using rules from several theories, (4) concluding skills are thinking skills based on scientific theory in order to gain new understanding, (5) evaluating or assessing skills are the ability to determine information based on an indicator theory (Haryani, 2017). Furthermore, the results of the review are as follows:

Table 2. Primary Studies Based on Critical Thinking Ability Indicators

Author	Indicator Ability think critical				
	Analyze	Synthesize	Solve problem	Conclude	Evaluate
(Agustina et al., 2020)	☑	☑	☑	☑	☑
(Ahdhianto et al., 2020)	☑	☑	☑	☑	☑
(Darhim et al., 2020)	☑		☑	☑	☑
(Hairun et al., 2020)	☑	☑	☑	☑	☑
(Ramadhani et al., 2020)	☑	☑	☑	☑	☑

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Author	Indicator Ability think critical				
	Analyze	Synthesize	Solve problem	Conclude	Evaluate
(Samura et al., 2020)					
(Susilo et al., 2020)	✓	✓	✓	✓	✓
(Zetriuslita et al., 2020)					
(Rahman et al., 2021)	✓	✓	✓	✓	✓
(Musaad & Suparman, 2023)					
(Hartanti & Purnomo, 2023)	✓	✓	✓	✓	✓
(Prihono & Khasanah, 2020)	✓	✓	✓	✓	✓
(Putri et al., 2021)					
(Sarwastuti & Purnomo, 2023)	✓		✓		✓
(Setiawi et al., 2021)					
(Setiyaningrum & Sari, 2023)	✓	✓	✓	✓	✓
(Suanto et al., 2022)					

Based on Table 2, it is known that nine articles use theories from several different experts, but if the contents of the indicators in question are examined, they are in line with the indicators that have been set. As in the writing of(Prihono & Khasanah, 2020) which includes critical thinking indicators: elementary clarification and basic support in line with analyzing , strategy and tactic in line with solving problems , explanation continue in line with synthesizing , inference in line with concluding and evaluating. In the article written by(Darhim et al., 2020) the indicators of analyzing, solving problems, concluding and evaluating appear in the learning process carried out. Meanwhile, the article written by (Sarwastuti & Purnomo, 2023) only presents indicators of analyzing, solving problems and evaluating in the learning process described. Then there are six articles that do not include indicators of critical thinking skills in writing their articles so that the critical thinking skills in question are not

clearly described in the article. This is because it only focuses on statistical data without explaining again in accordance with the theories about critical thinking skills indicators that have been widely put forward by experts. In principle, critical thinking skills are closely related to the critical thinking process based on its indicators. Critical thinking indicators can be seen from their characteristics so that by having these characteristics a person can be said to have critical thinking skills(Karim & Normaya, 2015).

Criteria based on Year of Publication

Then, for the distribution of articles based on the year of publication, it was found that there was a research trend related to the use of PBL on critical thinking skills in 2020, namely nine articles, then decreased in the following year until in 2024 there was no published research until this research was written related to PBL on critical thinking skills which can be seen in Table 3. Primary Studies based on the Year of Publication as follows:

Table 3. Primary Studies by Year of Publication

Criteria		Amount
Year primary study	2020	9
	2021	3
	2022	1
	2023	4
	2024	0

Criteria based on Education Level

Then for the level of education, it was found that the research was balanced at each level as seen in Table 4. Primary Studies based on Education Level, but at the elementary school level, research related to PBL on critical thinking skills has a smaller number. This is possible because based on the theory piaget elementary school students aged 7-11 years enter the concrete operational stage. At this stage the ability to classify something already exists but cannot solve abstract problems (Marinda, 2020).

Table 4. Primary Studies by Education Level

	Educational level	Amount
Educational level	Elementary	3
	Junior High School	6
	Senior High School/ Vocational	4

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	Educational level	Amount
	High School/Islamic Senior High School	
	College tall	4

Then for the level of education, it was found that the research was balanced at each level, but at the elementary school level, research related to PBL on critical thinking skills had a smaller number. This is possible because it is based on the theory piaget elementary school students aged 7-11 years enter the concrete operational stage. At this stage the ability to classify something already exists but cannot solve abstract problems (Marinda, 2020).

CONCLUSIONS AND RECOMMENDATIONS

Based on the review results, it can be concluded that the implementation of the Problem-Based Learning (PBL) model in developing students' critical thinking skills has not been fully constructed according to the characteristics of PBL established by experts. While some articles clearly demonstrate the integration of PBL principles into the learning process, others only partially mention these features without describing their practical application. Moreover, several studies do not incorporate PBL characteristics at all, indicating inconsistency in understanding and applying the model theoretically and pedagogically.

Similarly, regarding critical thinking indicators, only about half of the articles explicitly refer to indicators developed by experts. The rest either mention them partially or omit them entirely, resulting in unclear connections between the instructional process and the intended development of critical thinking skills. These indicators are essential to ensure that the targeted skills are measurable and grounded in validated theoretical frameworks.

In terms of publication trends, the year 2020 saw the highest number of studies, followed by a noticeable decline in subsequent years, with no related publications identified in 2024 at the time of the data search. This suggests an opportunity to revitalize research on this topic in the coming years.

Regarding educational levels, studies have predominantly focused on secondary and tertiary education, with fewer conducted at the elementary level. This distribution aligns with cognitive development theories suggesting that higher-order thinking skills are more effectively nurtured in students at the formal operational stage. Therefore, future studies are encouraged to apply the PBL model more consistently, grounded in established theories and indicators, and focus on educational levels that provide greater potential for the development of critical thinking skills.

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