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The Effect of Using the Problem-Based Learning (PBL) Model on Students' Critical Thinking Skills in Science Learning : A Literature Review

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Abstract : The level of critical thinking skills among students in science education is still relatively low because the learning models used have not been able to optimize their thinking processes, which are still teacher-centered and lack meaningful problem-solving experiences. This study aims to analyze the impact of the PBL model in improving students' critical thinking skills by applying the Systematic Literature Review method in accordance with the PRISMA guidelines. This research method identified 781 articles through Google Scholar, of which 22 articles met the inclusion criteria. The results show that PBL effectively optimizes students' higher-order thinking skills by involving them in contextual learning. PBL also provides more structured opportunities for scientific reasoning compared to other models. Further research is recommended to analyze the integration of PBL with various other digital media that can explore long-term impacts and involve broader levels of education for more comprehensive results.

Keywords : Critical Thinking, Science Learning, Problem Based Learning.

INTRODUCTION

According to Arifin *et al*, (2024) science education is important in shaping students' scientific thinking and is abstract in nature. In learning science, students are not only guided to understand basic scientific concepts, but also trained in the skills of observing, analyzing, and drawing conclusions based on facts obtained from real experiences (Prayunisa & Marzuki 2023). This learning process trains students to develop logical, critical, and systematic thinking habits when analyzing various natural phenomena that occur in their surroundings. However, in practice, there are still obstacles, namely the use of teaching methods that tend to be traditional or conventional. Teachers rely more on lectures or conventional approaches, resulting in one-way learning that does not provide enough space for students to participate actively. According to Muliana *et al*., (2024) this condition proves the need for transformation in learning plans, particularly by applying methods that are more relevant to the demands of

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21st-century competencies, which require advanced thinking skills, creativity, and collaboration skills.

PBL is a model that positions learners as the main focus of the learning process, where authentic problems from everyday life are used as a starting point to stimulate them to independently seek and find solutions. PBL facilitates learners to actively contribute to investigative activities, construct conceptual understanding, and conclude results through stages that require advanced thinking skills (Cahyani & Ahmad, 2024). According to Muliana *et al*., (2024) explains that this model is designed to develop important competencies such as critical thinking skills, accuracy in analyzing information, and independent learning, by presenting challenges as a core learning platform. This model is in line with 21st century education standards, where learners are expected not only to master the concepts, but also to work togetherargue logically, and solve problems creatively. Through this process, students are encouraged to actively think, discuss, and evaluate various alternative solutions, making PBL a learning model that is relevant and appropriate for today's educational needs.

The PBL model has the advantage of improving critical thinking, problem solving, collaboration, and communication skills through authentic problems that encourage analysis and creativity. This model also fosters independent learning and links theory with practice, making learning more meaningful. However, PBL has limitations such as the need for more time, high teacher competency requirements, and the ability of students to learn independently (Indarti & Jannah 2022). Assessment is also complex because it must cover the cognitive, affective, and psychomotor domains. Nevertheless, with careful planning, PBL remains effective in developing 21st-century skills. The stages include problem identification, group formation, investigation, presentation of results, and analysis and evaluation (Adiningsih *et al*., 2024). Overall, PBL not only strengthens understanding of science concepts but also trains critical thinking skills relevant to 21st-century challenges.

According to Williams, (2017) critical thinking is essential for students' cognitive development and their ability to adapt to rapid technological and informational changes. In an era filled with information overload and continual innovation, students must possess strong critical thinking skills to evaluate information, solve problems, and make accurate decisions. PISA 2012 data show that Indonesia ranked 64th out of 65 countries with a literacy score of 382 (Hamidah *et al.,* 2021). Indicating that most students were only at levels 1 and 2 of the six assessed levels, reflecting low critical thinking abilities. This condition did not improve significantly in PISA 2018, as Indonesia's scores 371 in reading, 379 in mathematics, and 389

in science remained below the OECD average (OECD, 2012). However, Indonesia is classified as a low-performance yet high-equity country, suggesting substantial potential for improving learning quality and fostering students' critical thinking skills.

Previous studies have shown that the Problem-Based Learning (PBL) model is effective in improving students' critical thinking skills in science learning (Islawati *et al*., 2024). However, most of these studies are empirical in nature and examine the effectiveness of PBL as a whole without systematically analyzing how each stage of the PBL process contributes to the development of students' critical thinking skills. In addition, existing research remains fragmented, and no systematic literature review has comprehensively examined the consistency of findings regarding the relationship between specific PBL stages such as problem identification, information gathering, data analysis, and solution development and students' critical thinking skills in science education. Therefore, this study differs from previous research by employing a systematic literature review approach to synthesize empirical evidence and to identify which stages of the PBL model contribute most significantly to enhancing students' critical thinking skills, thereby providing a more in-depth and structured understanding of PBL implementation in science learning.

RESEARCH METHOD

This study employed a descriptive qualitative approach using the Systematic Literature Review (SLR) method guided by PRISMA. The review aimed to systematically identify and analyze studies referencing Tamrin *et al*., (2015) related to the implementation of the PBL model in the Merdeka Curriculum and its impact on students' critical thinking skills. Article searches were conducted through Google Scholar and selected based on predetermined inclusion criteria. The selected studies were then examined thoroughly to extract essential information, including publication details, learning models, PBL focus, and key findings. The literature search used the keywords "Problem-Based Learning Model," "Critical Thinking of Students," and "Science Subject Matter."

The inclusion criteria for this study are articles published within the last 5 years (2021-2025), in the form of scientific journal articles that are accessible in full text, written in Indonesian or English, accredited by SINTA 1-6, and focusing on PBL models relevant to students' critical thinking skills. Meanwhile, the exclusion criteria are publications older than 5 years, non-journal articles (proceedings or literature studies), articles that are only accessible in abstract form and not in full text, and articles that are not accredited by SINTA 1-6 and are not

relevant to the research focus. The specifics of the inclusion and exclusion criteria are explained in detail in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication year	2021-2025	Before 2021
Publication type	SINTA 1-6 indexed scientific journal articles	Articles not indexed by SINTA 1-6, non-peer reviewed proceedings, undergraduate/master's/doctoral theses
Accessibility	Full text	Abstract only
Language	Indonesian and English	Other foreign languages
Main focus	Focus on the PBL model in students' critical thinking skills.	Outside the research context/irrelevant to the research.

A literature search using Google Scholar yielded 781 articles. Initial screening based on publication year (2021–2025) eliminated 98 articles, with no duplicates found. Completeness checks based on SINTA 1–6 accreditation then eliminated 583 unindexed articles, leaving 100 articles. Of these, 4 articles were irrelevant to the study, leaving 96 articles for further screening. Final screening based on PBL topics and critical thinking eliminated 74 articles, 8 non-scientific articles, 18 without scientific material, and 48 that did not fit the PBL model for measuring critical thinking. Thus, 22 articles met all inclusion criteria. The identification, screening, and selection stages based on the PRISMA framework are illustrated in Figure 1.

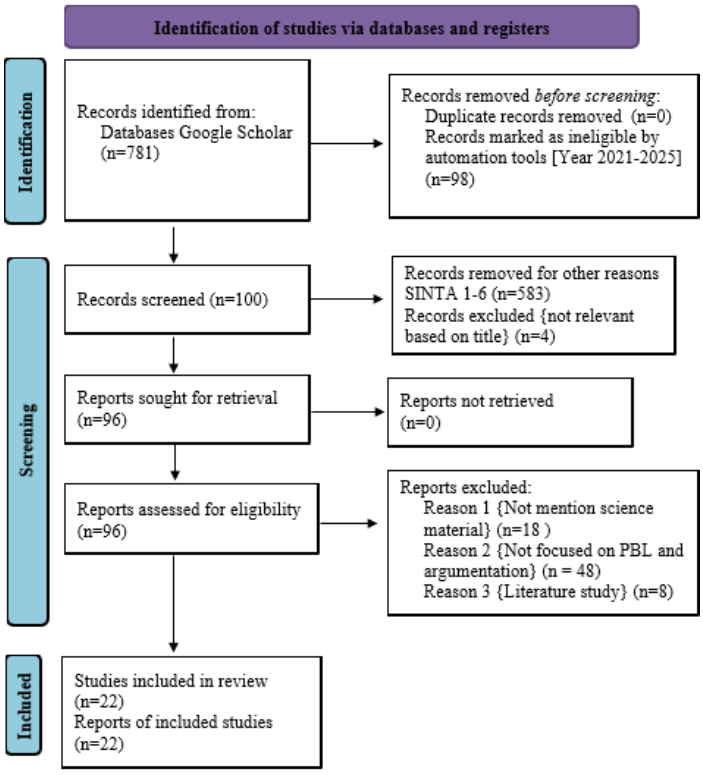

Figure 1. PRISMA Frame Screening Process

RESULT AND DISCUSSION

This literature review aims to assess how the use of the PBL model helps strengthen students' critical thinking skills. Based on the SLR that has been conducted, 22 articles that meet the criteria were selected for further review. The articles were selected by screening them against the inclusion criteria that had been formulated previously and were in line with the research objectives of this article, namely to examine the PBL model in science learning and critical thinking skills. The selection results are presented in Table 2.

Table 2. Results of Article Analysis Effectiveness of PBL on Critical Thinking Skills

No.	Main Theme	Description of General Findings	Number of Articles	Supporting Sources
1.	PBL model on students' critical thinking skills in science subjects	The results of the analysis of the article show that the PBL model has a significant effect on improving students' critical thinking skills in science learning.	16	(Rauf *et al*., 2022); (Hesy *et al*, 2023); (Rosyidah & Marzuki, 2025); (Anggraini *et al al.*, 2022); (Purwaningtias *et al*., 2025); (Sonia et al., 2024); (Andriyaman *et al*., 2023); (Supriatin *et al.*, 2025); (Laksita *et al*., 2025); (Karvandi *et al*., 2024); (Wilhelmina & Mawardi, 2024); (Berlian *et al*., 2025); (Darma, 2024); (Rosadah *et al*., 2024); (Amsal *et al*., 2025) dan (Fahyuddin *et al*., 2023).
2.	Comparison of the improvement in critical thinking and learning outcomes of students using the PBL model	The results of the analysis and discussion in the article show that the PBL model has an effect on critical thinking skills and science learning outcomes between students who follow this learning model and students who follow conventional learning models.	2	(Rambe *et al*., 2024) dan (Supriana *et al*., 2023).
3.	Comparison of PBL and PjBL models in improving students' critical thinking	The results of the article analysis show that the PBL-based learning model is proven to be superior to PjBL in developing the critical thinking	1	(Suryaningsih & Koeswanti, 2021).

No.	Main Theme	Description of General Findings	Number of Articles	Supporting Sources
		skills of elementary school students.		
4.	The effect of using PBL models assisted by LKPD and E-LKPD in improving students' critical thinking	The results of the article analysis show that learning that is still centered on lecture methods has not been able to improve students' critical thinking with the help of media (LKPD & E-LKPD) which are a means for more effective learning solutions.	3	(Robiah *et al*., 2024); (Yeni *et al*., 2025) dan (Nurhalimah *et al*., 2023).

The synthesis of sixteen articles examining the implementation of the Problem-Based Learning (PBL) model in science education indicates that PBL is consistently effective in improving students' critical thinking skills across various educational levels, from elementary to high school. These findings align with previous studies which emphasize that PBL facilitates higher-order thinking by actively engaging students in problem identification, information exploration, data analysis, and solution development (Khadijah *et al*., 2025). Through these stages, students are not only trained to analyze and evaluate information but also to construct logical conclusions based on scientific reasoning, resulting in deeper conceptual understanding and more meaningful learning experiences. Thus, the PBL model is a model that has a significant contribution to developing students' higher-order thinking skills by giving them the opportunity to be actively involved in the process of discovering, analyzing, and solving contextual problems, thereby training their logical, systematic, and in-depth thinking skills in understanding science concepts. These results are consistent with the findings Limat *et al.,* (2024) who found that the integration of real-life problems within PBL encourages students to connect scientific concepts with everyday contexts, thereby strengthening critical thinking, conceptual mastery, and scientific attitudes such as responsibility and independent learning.

The synthesis results show that the application of the PBL model not only enhances students' critical thinking skills but also positively influences their learning outcomes in science. This is because the model positions students as the center of learning so that they actively seek, understand, and solve real problems relevant to the material. Through this process, students gain a deeper, more meaningful, and longer-lasting understanding of concepts compared to students who are taught through conventional learning models. According to Khadijah *et al*., (2025) states that through the stages of problem identification, information gathering, data analysis, and solution development, students build knowledge independently.

This learning process enables students to construct scientific concepts more deeply, relate them to concrete experiences, and strengthen analytical thinking skills, which leads to improved overall learning outcomes.

Findings from multiple studies indicate that both Problem-Based Learning (PBL) and Project-Based Learning (PjBL) contribute positively to the development of students' critical thinking skills in science learning, but the effectiveness of PBL at the elementary school level tends to be more prominent. The characteristics of PBL, which guide students to understand problems, explore information, and build understanding through concrete experiences, make it more suitable for honing critical thinking from an early age. Through the stages of defining the problem, processing the data, and designing solution alternatives students are directly involved in the scientific reasoning process that strengthens critical thinking skills. Meanwhile, PjBL focuses more on the final product so that concept analysis and reasoning are not the center of learning. The results of the study found that Suryaningsih & Koeswanti (2021), shows an increase in pretest–posttest scores in both models, but the increase in PBL is higher (52.83% to 77.34%) than in PjBL (49.47% to 66.77%). These findings confirm that PBL is more effective in honing critical thinking skills because it requires active student involvement in reasoning and data-based problem solving, while PjBL places more emphasis on product completion so that the reasoning aspect is not dominant.

The application of the PBL model integrated with LKPD and E-LKPD has proven to be effective in improving students' critical thinking skills because it helps them follow the PBL stages in a more structured manner, from formulating problems, gathering information, analyzing data, to determining solutions. At each step, students are encouraged to think actively, engage in dialogue, express their reasons, and draw conclusions so that they are not only able to grasp the concepts at a theoretical level, but also capable of applying them in real-world contexts. The analysis of the three articles shows that the use of PBL-based LKPD and E-LKPD can improve analytical thinking skills and make learning more interactive because students are directly involved in discovering concepts. These findings are in line with the results of the study Ernawati *et al*., (2025) the use of PBL-based LKPD and E-LKPD has been proven effective, demonstrating significant improvements in students' critical thinking skills, as supported by studies confirming that these materials successfully enhance critical thinking. The feasibility test by subject matter and media experts also showed percentages of 87.27% and 94.66%, both of which are in the very feasible category, indicating that the learning tools have met the

feasibility criteria in terms of content and design so that they can optimally support the implementation of PBL syntax.

CONCLUSION

The synthesis of various studies indicates that consistent implementation of the PBL model significantly enhances students' critical thinking skills in science learning. Its effectiveness lies in positioning students at the center of problem-solving activities that train analytical, logical, and reflective thinking. Through problem identification and solution development, students gain deeper and more contextual concept understanding. The use of PBL-based LKPD and E-LKPD has also been proven feasible, practical, and effective, as shown by expert validation, practicality testing, and increased pretest–posttest scores. These tools guide students through PBL stages more systematically, encouraging active thinking, discussion, and independent conclusion-drawing. Thus, applying PBL either alone or supported by LKPD and E-LKPD effectively develops critical thinking and improves science learning quality. Future research is suggested to explore the integration of PBL with other digital media, examine long-term impacts, and involve broader educational levels for more comprehensive findings. Further research is recommended to examine in greater depth the contribution of each stage of Problem Based Learning (PBL) to the improvement of critical thinking skills in science learning through experimental and longitudinal research designs. In addition, the study needs to be expanded to various levels of education and take into account the characteristics of students. The integration of PBL with learning technologies, such as digital worksheets or E-worksheets, also needs to be further researched to strengthen the effectiveness of PBL in supporting the development of critical thinking in the era of digital learning.

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