Al-Ishlah: Jurnal Pendidikan
Vol.17, 3 (September, 2025), pp. 5683-5695
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v17i3.7008

Evaluating the Effectiveness of Problem-Based Learning (PBL) in Schools: A Comprehensive Meta-Analysis

Deby Cinthia[1], Ganefri [2], Asmar Yulastri[3], M.Giatman[4], Dedy Irfan[5], Hansi Effendi [6]

[1,2,3,4,5,6] Universitas Negeri Padang, Padang, Indonesia; debycinthia@gmail.com

ARTICLE INFO

Keywords:

Problem-Based Learning (PBL);
critical thinking;
meta-analysis;
educational effectiveness

Article history:

Received 2025-01-22
Revised 2025-09-23
Accepted 2025-09-30

ABSTRACT

Problem-Based Learning (PBL) has been widely promoted as a student-centered approach that fosters critical thinking. However, evidence from individual studies often varies across educational levels and contexts. This study aimed to synthesize empirical findings through a meta-analysis to evaluate the overall effectiveness of PBL in enhancing learners' critical thinking skills. A systematic search was conducted across academic databases, yielding 2,250 articles. After applying inclusion and exclusion criteria, 25 studies were selected for analysis. Data were coded based on research design, educational level, and implementation characteristics. Statistical analyses were performed using both fixed-effect and random-effect models to estimate the pooled effect size. Publication bias was examined using Egger's Test, Funnel Plot, and Rank Correlation Test. The meta-analysis indicated that PBL has a significant positive effect on critical thinking skills, with a pooled effect size of 1.134 ($p < 0.001$) and a 95% confidence interval ranging from 0.730 to 1.537. A high heterogeneity level was observed ($I^2 = 95.047\%$), suggesting variations in study characteristics such as instructional methods, learner populations, and cultural contexts. Although Egger's Test suggested possible publication bias, Funnel Plot and Rank Correlation Test results supported the overall robustness of the findings. This study provides strong evidence that PBL is an effective strategy for improving critical thinking across different educational levels. Successful implementation requires adequate institutional support, teacher training, and contextual adaptation. The findings highlight the importance of adopting PBL more broadly as a framework for 21st-century education.

Corresponding Author:
Deby Cinthia
Universitas Negeri Padang, Padang, Indonesia; debycinthia@gmail.com

1. INTRODUCTION

To enhance the quality of education, the adoption of innovative and effective learning models is essential to foster the development of 21st-century skills. One pedagogical approach that has gained

significant attention is Problem-Based Learning (PBL). PBL centers the learning process around real-world problems, enabling students to cultivate critical, analytical, and collaborative thinking abilities. By bridging theoretical knowledge with practical, everyday applications, PBL offers a meaningful and engaging learning experience. Within this framework, educators assume the role of facilitators, guiding students through the process of problem-solving (Ariyatun & Octavianelis, 2020). This method not only deepens students' conceptual understanding but also enhances their capacity for teamwork, effective communication, and structured decision-making.

Moreover, PBL fosters a dynamic and interactive learning environment, in which students are more motivated due to the authenticity and relevance of the challenges presented. The effective implementation of PBL often requires the integration of educational technologies, such as digital tools and online platforms, to support access to information and facilitate collaboration beyond geographical boundaries. This makes PBL particularly pertinent in addressing the demands of globalization and the digital transformation of education (Putri et al., 2020).

A key advantage of PBL lies in its student-centered approach, which positions learners as active participants in the learning process. The PBL cycle typically involves identifying problems, gathering information, engaging in group discussions, and developing evidence-based solutions. Educators support this process by ensuring that learning remains goal-oriented and purposeful. Through this approach, students not only acquire academic knowledge but also develop essential skills in reflective and collaborative problem-solving. Furthermore, PBL promotes self-confidence and learner autonomy, as students take initiative and assume responsibility for their learning outcomes (Temuningsih et al., 2017). By engaging directly in the exploration and resolution of real-world issues, students enhance their adaptability to complex and dynamic situations—a hallmark of contemporary challenges.

In the long term, PBL contributes not only to academic achievement but also to the development of proactive mindsets, communication skills, and critical thinking abilities necessary for success in both professional and societal contexts. As such, PBL is not only pedagogically sound but also strategically significant in preparing future-ready generations (I. C. Wulandari et al., 2020).

Various studies have shown that PBL has a positive impact on learning outcomes, especially in improving higher order thinking skills. PBL has been shown to be effective in various levels of education and subject areas, including science, technology, engineering and math (STEM). In addition, this approach can improve learners' skills in analyzing, evaluating and creating innovative solutions that are relevant to real-world needs. The success of PBL in various subject areas is inseparable from its ability to motivate learners through meaningful contextual learning (Fitriyyah & Wulandari, 2019). By presenting challenging authentic problems, PBL helps learners connect theory with practical applications, so they more easily understand the relevance of the material being studied. This approach also encourages cross-disciplinary interactions, which are essential in solving complex problems in the real world. Furthermore, PBL provides space for learners to develop leadership and teamwork abilities, skills that are indispensable in the era of globalization and digital transformation. With this combination of benefits, PBL not only improves learning outcomes, but also prepares learners to become adaptive, creative and highly competitive individuals (Wilsa et al., 2017).

However, the successful implementation of PBL is strongly influenced by several factors, such as the competence of educators, the readiness of learners, and the availability of supporting facilities. These factors need to be considered to ensure that PBL can run optimally and provide significant benefits for students. By understanding the challenges and potential of PBL, problem-based education policy development can be carried out in a more targeted manner (R. Wulandari et al., 2020). In addition, collaboration between educators, educational institutions, and related parties such as government and communities is key in supporting the implementation of PBL. Educators need to receive continuous training to improve their facilitation skills and PBL-based classroom management, while learners should be trained to be more independent and adaptive in the learning process. The availability of facilities such as learning spaces that support group discussions, access to technology and relevant learning resources are also important elements to support the success of this method. With a holistic

and participatory approach, PBL has great potential to create a learning environment that is innovative, inclusive and relevant to the needs of the 21st century (Nasral & Meliandika, 2022).

This research aims to conduct a meta-analysis of the effectiveness of PBL implementation in improving students' critical thinking skills. By analyzing various previous research results, this study will identify patterns of success and provide practical recommendations for the development of PBL-based learning (Aryawati, Pujani, 2020). The results of this meta-analysis are expected to be the basis for decision-making in the development of more innovative and relevant educational practices in the future. Through this meta-analysis, researchers will also explore factors that influence the level of effectiveness of PBL, such as education level, field of study, duration of implementation, and supporting methods used. By understanding these variables, the research can provide a more comprehensive insight into the optimal conditions for PBL success. In addition, the results of the analysis are expected to provide an overview of the common challenges faced in PBL implementation as well as strategies to overcome them. Thus, the resulting recommendations are not only theoretical, but also applicable, helping educators and policy makers in designing learning programs that are able to improve the quality of education in a sustainable manner (Ratnawati et al., 2020).

2. METHODS

2.1 Research Methods

This research uses the meta-analysis method to analyze the effectiveness of the Problem-Based Learning (PBL) learning model on students' critical thinking skills. Meta-analysis is conducted by combining relevant previous research results to obtain quantitative data-based conclusions. The data used was obtained from various previously published scientific articles, which met the inclusion and exclusion criteria of the study. After the data was collected, the analysis was conducted using a statistical approach to calculate the effect size of PBL implementation on critical thinking skills. This effect size will help determine the extent to which PBL has a significant impact compared to other learning methods. In addition, this study also considered moderator variables, such as education level, field of study, and duration of implementation, to identify the conditions under which PBL is most effective. The results of this analysis are expected to provide deep insights into the patterns of PBL success as well as a basis for practical recommendations for educators and policy makers in improving the quality of learning (Utami et al., 2017).

2.2 Research Processes

2.2.1 Data Collection

Data collection was conducted by identifying relevant articles from various academic databases such as Google Scholar, ResearchGate, and other platforms that provide access to scientific research. The search process used main keywords such as “Problem-Based Learning,” “critical thinking skills,” and “effectiveness of learning models,” which were tailored to the context of the study. The articles found were then screened based on inclusion criteria, such as relevance of the topic, clear research methodology, and publication in an accredited journal. In addition, exclusion criteria were applied to eliminate articles that did not meet quality standards or had incomplete data (Winahyu et al., 2024). This stage aims to ensure that the data analyzed in this study have high validity and reliability to support the results of the meta-analysis. Once the screening process was complete, articles that met the inclusion criteria were further analyzed to identify relevant information, such as study design, sample size, measurement instruments, and reported outcomes. These data were then systematically coded to facilitate statistical processing in the meta-analysis. The next step involved calculating the effect size for each selected study, which was then used to evaluate the effectiveness of Problem-Based Learning in improving critical thinking skills. In addition, the analysis also considered moderator variables, such as educational level or duration of PBL implementation, to understand the factors that could influence

the results. With a structured approach, this meta-analysis is expected to provide comprehensive and reliable findings (Garut et al., n.d.).

2.2.2 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were set to ensure that the articles analyzed in this study were relevant and met the necessary methodological standards. The articles selected had to specifically address the use of Problem-Based Learning (PBL) in learners at primary to secondary school levels, according to the focus of the study. In addition, only articles that presented quantitative data that could be analyzed through a meta-analysis approach were included, ensuring the results obtained had a strong statistical basis. Studies that use other variables without a direct link to critical thinking skills or that do not present quantitative data will be excluded from the analysis. With this rigorous selection approach, the study is expected to produce findings that are valid, reliable, and relevant to the main objectives of the study. Inclusion and exclusion criteria are important steps in the meta-analysis process to ensure that the data used are truly in line with the focus and purpose of the study (Djonomiarjo Guru SMK Negeri & Kab Pohuwato, 2018). Articles that addressed Problem-Based Learning (PBL) in learners at the primary to secondary school level were selected due to their relevance to the context of developing critical thinking skills at that age. Quantitative data was a key requirement as it allows the calculation of effect sizes that provide an objective picture of the impact of PBL. By excluding studies that did not involve critical thinking skills or without quantitative data, this study minimized potential bias and maintained the quality of the analysis. This rigorous selection also helps to create consistency in the interpretation of results, so that the resulting findings can be used as a basis for reliable decision making in the development of PBL-based education (Mustaqfiroh et al., 2024).

This research has focused on primary and secondary education, which are crucial stages in students' cognitive development and basic skill formation. However, the exclusion of studies at the higher education level needs to be explicitly explained to clarify the scope and extent to which the findings can be generalized. Here are some reasons that may support the exclusion: In terms of the different learning needs at primary and secondary levels; students are in a phase of cognitive development where basic skills such as critical thinking, problem solving, and collaboration are still in the formation stage. Therefore, the application of Problem-Based Learning (PBL) at this level is designed to help students develop these foundations. In contrast, students at the higher education level already have these basic abilities, so the focus of PBL is more directed at the application of these skills to solve more complex and subject-specific problems.

Then, in terms of different teaching approaches, PBL at primary and secondary education levels usually requires a more structured approach, with the teacher's role as an active facilitator. Meanwhile, in higher education, PBL is often implemented with a more independent approach, where students are given more freedom to manage their learning process. These differences create contexts that are not fully comparable, thus limiting the generalizability of findings from one level of education to another. Furthermore, Different Cognitive Contexts; At primary and secondary levels, students tend to have limited learning experiences and metacognitive abilities, so PBL serves as a strategy to encourage the development of these abilities. At the higher education level, students generally have broader learning experiences, so the context of PBL application focuses more on mastering specific material and solving problems in a professional or academic context. This difference makes the effects of PBL at both levels of education not fully comparable.

Furthermore, in terms of the specific research objectives, the focus on primary and secondary education allowed this study to explore in depth the effectiveness of PBL in a specific age group with specific learning characteristics. As such, the exclusion of higher education can be seen as an attempt to maintain consistency and relevance of the findings within a more homogenous context.

2.2.3 Data Analysis

Data analysis in this study was conducted using fixed-effects and random-effects model approaches to identify heterogeneity among the studies analyzed. The fixed effects model was used to assume that all studies have similar effects, while the random effects model takes into account variations between studies, thus providing a more comprehensive picture. The effect size was calculated using effect size, which is the main indicator to evaluate how much influence Problem-Based Learning (PBL) has on students' critical thinking skills. For parameter estimation, this study used the Restricted Maximum Likelihood (REML) method, which is known to be effective in processing data with high heterogeneity. This approach ensures the analysis results are more accurate and reliable, thus providing a strong basis for concluding the effectiveness of PBL in improving critical thinking skills.

2.2.4 Bias Analysis of Publications

The analysis was conducted using JASP software. The analysis included effect size estimates, confidence intervals, heterogeneity tests, and publication bias analysis. Forest plot and funnel plot were used to visualize the meta-analysis results. By using this method, the research is expected to provide valid and evidence-based conclusions regarding the effectiveness of PBL in improving students' critical thinking skills. The results obtained from the analysis using JASP will be summarized systematically to provide a comprehensive picture of the impact of Problem-Based Learning (PBL) on critical thinking skills. Forest plots are used to visualize the effect sizes of each individual study and the pooled estimates, making it easier to interpret the consistency of results between studies. Meanwhile, the funnel plot helped identify potential publication bias that could affect the validity of the conclusions. With this combination of statistical analysis and visualization, the research not only reveals the overall effectiveness of PBL but also provides deep insights into the conditions that influence its successful implementation. The results of this study are expected to serve as a strong reference for educators and policy makers in adopting PBL as an effective learning strategy.

2.2.5 Criteria for selecting articles

This study used PRISMA guidelines to ensure transparency and quality of the systematic review and meta-analysis process. The resulting flowchart describes the stages of article selection, from initial search to final selection, providing a detailed overview of the decision-making at each stage. With strict selection criteria, including a focus on the application of PBL, the time span of the study, the language of the article, the type of research design, and the completeness of the data, this study ensured that only relevant and high-quality articles were analyzed. From the 2250 articles found in the initial stage, a gradual screening process left 25 articles that fit the criteria. These articles covered a wide range of studies at different educational levels, providing a broad scope in evaluating the effectiveness of PBL in improving critical thinking skills. With this approach, the research is expected to produce reliable evidence-based conclusions to support the development of PBL-based learning.

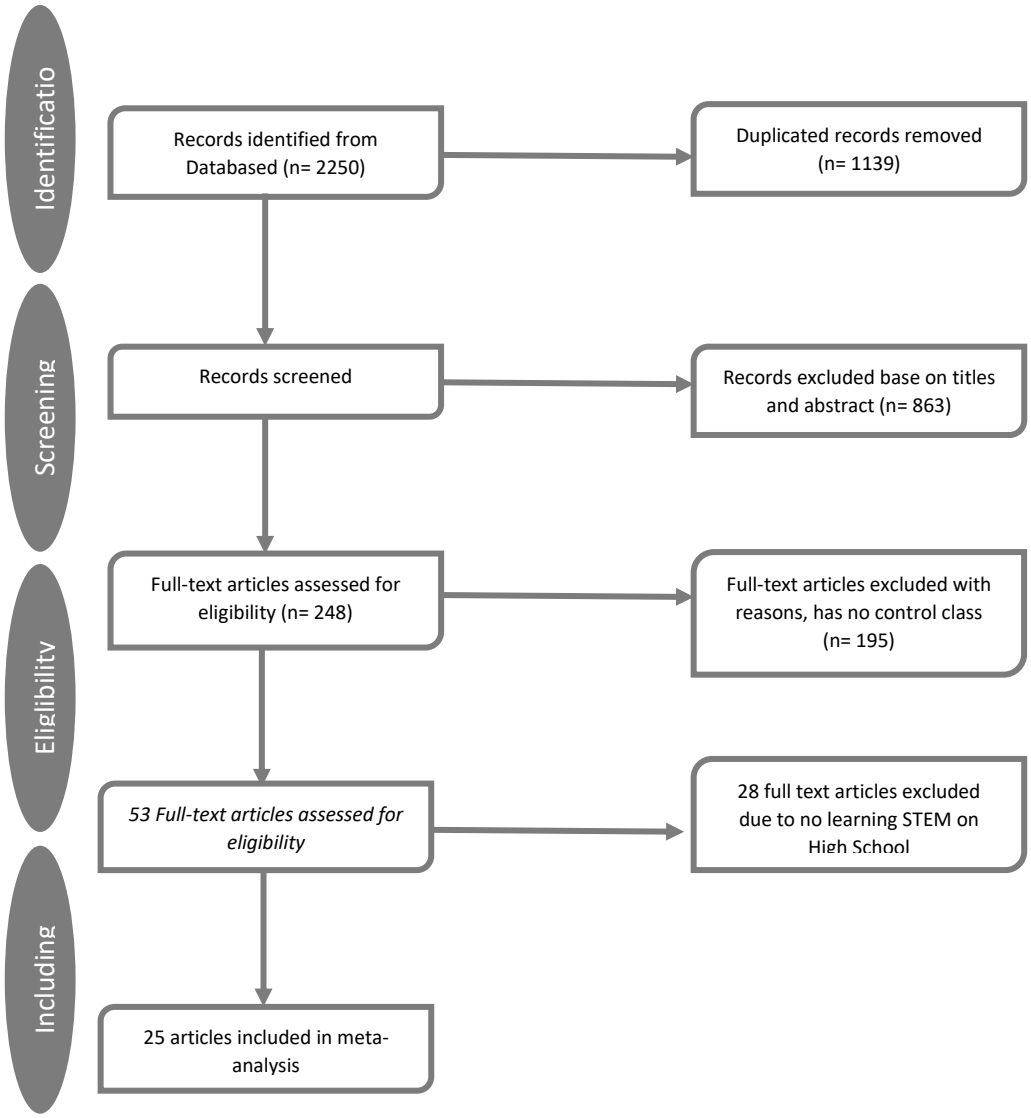

Figure 1. Article Filter Process

3. FINDINGS AND DISCUSSION

3.1 Size Effect Results

Table 1. Coefficients Table

Coefficients

					95% Confidence Interval	
	Estimate	**Standard Error**	**z**	**p**	**Lower**	**Upper**
intercept	1.134	0.206	5.510	< .001	0.730	1.537

Note. Wald test.

The interpretation of the results indicates that the particular approach or intervention analyzed had a significant and meaningful impact on the outcomes measured. The intercept estimate value of 1.134 reflects the average combined effect of all studies, which is large and indicates a substantial effect. With a p-value of <0.001, this result is statistically significant, indicating that the likelihood of this effect

occurring by chance is very small. The 95% confidence interval (0.730 to 1.537) shows the range of the high-confidence combined effect estimate, where the relatively narrow range reflects low uncertainty. These overall results indicate that the analyzed approach or intervention made a real contribution to the measured variables, strengthening confidence in the effectiveness of the approach in the relevant context.

The findings provide a strong basis for recommending the implementation of such approaches or interventions in wider practice. The significant impacts and large pooled effect estimates demonstrate the potential of this approach to produce consistent improvements across multiple contexts. In addition, the narrow confidence intervals reflect the reliability of the results, providing a reference point for policy makers and practitioners in designing more effective strategies. However, it is important to consider the variability of contexts and populations in real-world applications and identify factors that may affect successful implementation. The next step is to conduct follow-up research to strengthen the generalizability of these findings and explore the influence of other relevant variables.

3.3 Publication Bias

The results of the rank correlation test using Kendall's τ ($\tau = 0.267$, $p = 0.065$) indicate no statistically significant evidence of asymmetry in the funnel plot. Although the positive τ value suggests a potential association between effect size and sample size, the *p*-value exceeds the conventional threshold of 0.05, implying that the relationship is not statistically significant. Therefore, based on the rank correlation analysis, there is no strong indication of publication bias within the included studies. This finding enhances the credibility of the meta-analysis results, although further examination may still be warranted to confirm the minimal impact of bias.

The funnel plot itself reveals a largely symmetrical distribution of study points around the overall effect size, suggesting that the included data are representative and not unduly influenced by publication selection. The alignment of data points with sample size distribution further reduces concerns about publication bias.

When considered together—Kendall's τ, Egger's test, and funnel plot visualization—the results offer a nuanced perspective. While Kendall's τ did not reveal significant publication bias, Egger's test suggested a possible bias that merits attention. Nevertheless, the visual symmetry of the funnel plot supports the overall validity of the meta-analytic findings. Despite the minor indication from Egger's test, the consistency between the rank correlation test and the funnel plot supports the reliability of the conclusions drawn regarding the effectiveness of the interventions analyzed.

To further assess potential bias, the trim-and-fill method was employed. This technique estimates the number of potentially missing studies—presumed to be those with extreme effect sizes not published—and adjusts the overall effect size accordingly. It operates under the assumption that studies with extreme values (typically on either side of the distribution) may be underreported. The method "trims" these studies and "fills" the funnel plot with imputed values based on a corrected effect estimate. The results of this analysis reaffirm the symmetrical pattern observed in the funnel plot, with study points distributed proportionally to sample size.

In conclusion, statistical tests and visual inspection collectively suggest minimal risk of publication bias. The findings from the funnel plot, Kendall's τ, and the trim-and-fill method provide confidence in the robustness and validity of the meta-analysis results.

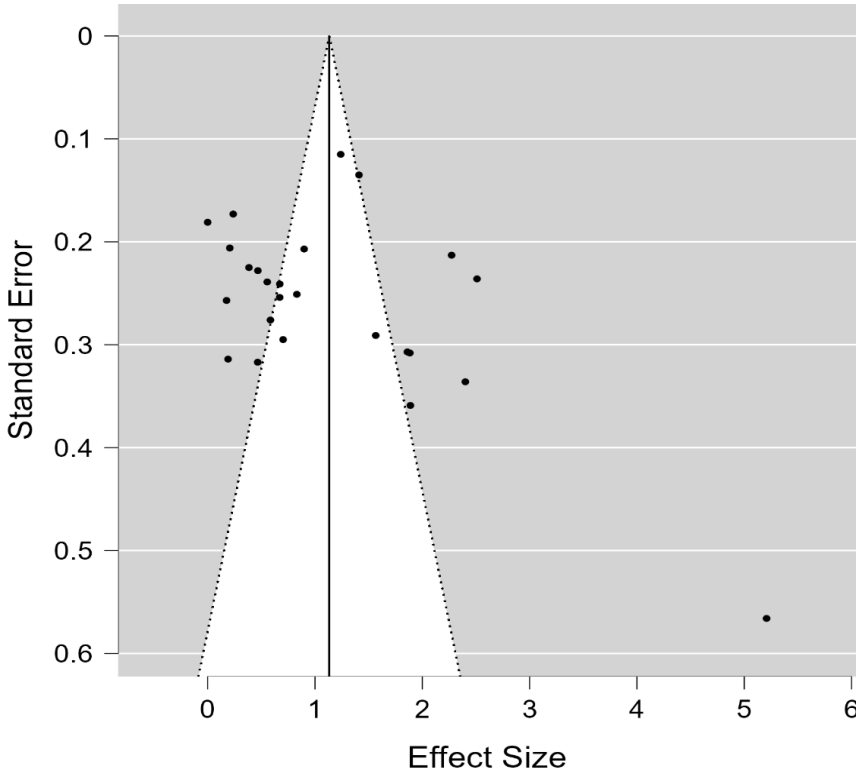

Figure 2. Funnel Plot

3.4 Impact of Problem-Based Learning

The high level of heterogeneity, with an I^2 value of 95.047%, indicates that almost all of the variation among study results in this meta-analysis is due to differences in study characteristics, such as research design, methods used, learner population, or other variables related to the implementation of Problem-Based Learning (PBL). These results indicate significant inhomogeneity among the studies analyzed, which may reflect different contextual conditions in the implementation of PBL. This high level of heterogeneity emphasizes the importance of considering moderator variables in further analysis to understand the factors that influence the effectiveness of PBL. The random effects model approach becomes more relevant in this situation, as it is able to account for variability between studies, resulting in more comprehensive and contextualized conclusions (Lutfiah et al., 2021).

There are several sources of heterogeneity that strengthen the analysis conducted, namely in terms of differences in education level, teaching methods, and cultural context. The application of Problem-Based Learning (PBL) at different levels of education leads to variations in outcomes. In primary and secondary education, PBL is focused on developing basic skills such as critical thinking and problem solving. Students at this level require more guidance and support from teachers. While in higher education, PBL is applied to encourage students to tackle more complex problems with a higher level of independence. This difference in education level affects the depth and manner of PBL implementation.

In terms of teaching methods and the use of technology, the use of technology in the implementation of PBL is a factor causing variation. Some studies involved technology, such as online learning platforms or digital collaboration tools, while others did not. This variation has an effect on the effectiveness of PBL as technology expands access to information and increases student engagement. Next in line is the instructor's approach: The teaching style used by the instructor affects PBL outcomes. Some instructors are more active in guiding students, giving directions, or providing feedback, while others emphasize independent learning. These differences affect how students interact with the problems posed and their level of engagement in the learning process.

In terms of cultural context, in Dominant Educational Approaches, The educational culture in each country or region affects the acceptance and implementation of PBL. In some countries with traditional educational approaches, where teaching focuses on direct instruction and testing, the implementation of PBL faces greater challenges. In contrast, in countries with a more progressive educational approach, PBL is more easily accepted and implemented. Then in Social Norms and Expectations: Social norms that favor teacher authority and hierarchical learning limit the application of PBL, which emphasizes collaboration and self-directed learning. Acceptance of problem-based learning depends largely on how open society is to changes in more traditional ways of learning. Next in Acceptance of New Methods: The level of acceptance of new educational methods, such as PBL, is influenced by the local culture. In some cultures, people are more open to experimentation and innovation in teaching, whereas in others, changes in educational methods face greater resistance. Factors such as education level, teaching methods, and cultural context cause significant variation in the results of studies analyzing the implementation of PBL. Each of these factors plays a role in how PBL is implemented and the extent to which it functions effectively in improving students' skills.

The statistically significant combined effect indicates that the implementation of Problem-Based Learning (PBL) has a real impact on learning outcomes. With an intercept value of 1.134 and a 95% confidence interval in the range of 0.730 to 1.537, this result confirms that the impact of PBL is positive and consistent, as the interval does not include zero. The z value of 5.510 with $p < 0.001$ further strengthens the statistical significance of the combined effect, indicating that the effect of PBL does not occur by chance. These findings provide strong evidence that PBL is an effective approach for improving learning outcomes, both in terms of knowledge and critical thinking skills, and thus deserves wider adoption in a variety of educational contexts.

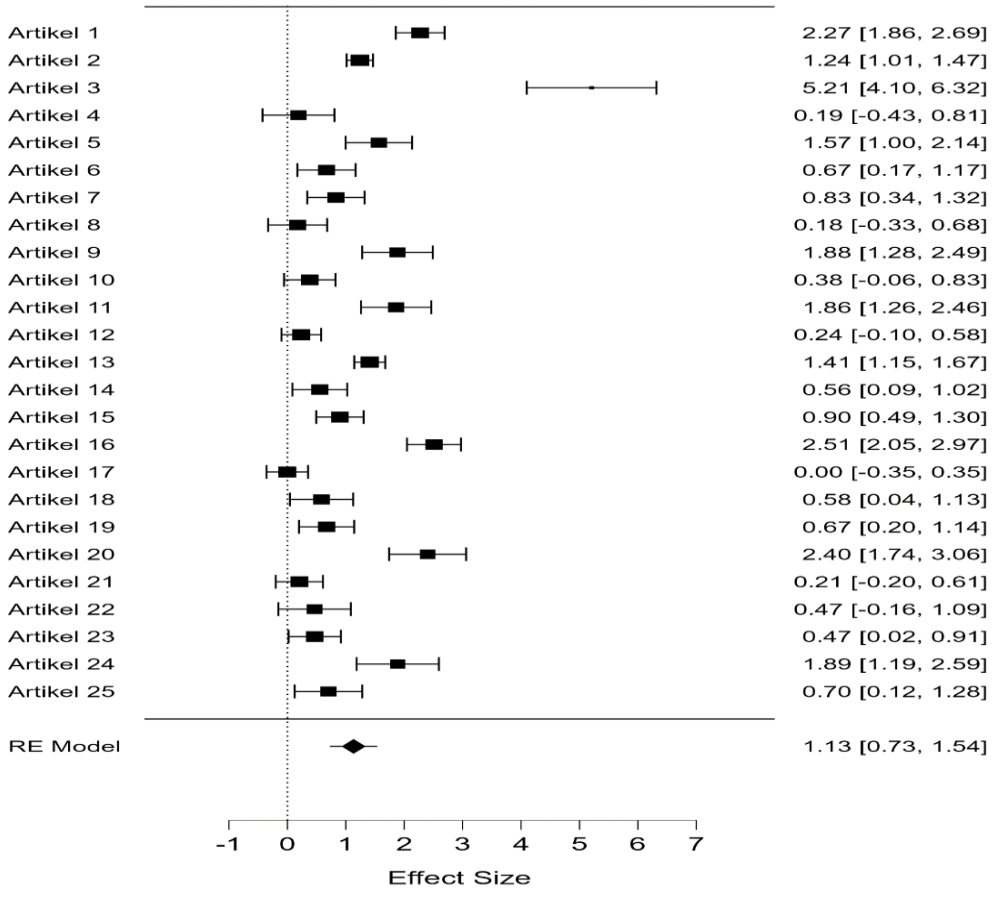

Figure 3. Forest Plot

The confidence interval of the level of heterogeneity (I^2) of 92.151% to 97.813% indicates that the variation among study results remains very high, even under the best conditions. This range reflects that differences in study characteristics, such as design, population and methods, contribute significantly to heterogeneity. In addition, the value of $H^2 = 20.188$ as an additional indicator reinforces this finding, indicating that the results between studies varied by more than 20 times compared to what would be expected if only random error played a role. The high I^2 and H^2 values confirm the need to consider contextual factors and moderator variables in analyzing the effectiveness of PBL to ensure more targeted and relevant results in practical applications.

3.5 Discussion

Problem-Based Learning (PBL) plays a pivotal role in enhancing the quality of education by fostering deeper learning experiences and supporting the development of both students and educators. As an instructional approach grounded in real-world problem solving, PBL creates an active learning environment where students are encouraged to engage in critical, analytical, and collaborative thinking. Fatmawati and Simarmata (2024) emphasize that PBL enables learners to contextualize their understanding, thereby improving their ability to apply knowledge across various domains. Moreover, the implementation of PBL has been shown to significantly enhance not only academic performance but also learners' motivation, attitudes, and behavioral engagement in the learning process. Learners involved in PBL environments often exhibit greater independence, communication skills, creativity, and collaboration—competencies that are essential in navigating the increasing complexity of real-world challenges (Khaeroh et al., 2020).

For educators, the adoption of PBL necessitates a transformation in teaching methodologies. Teachers are required to shift from traditional didactic instruction to more facilitative roles, guiding students through inquiry-driven learning experiences. This transformation involves designing learning contexts that are authentic and interdisciplinary, allowing students to explore content in ways that mirror real-life situations. In doing so, educators not only deepen students' conceptual understanding but also stimulate higher-order thinking skills. However, one of the primary challenges in implementing PBL is the alignment of assessment practices with its learning goals. Conventional evaluation methods often fall short in capturing the depth of learning that PBL fosters. Instead, assessments must be adapted to measure learners' capacities to analyze, evaluate, and develop solutions to complex, authentic problems. This includes the use of project-based assessments, group discussions, reflective journals, and rubrics specifically designed to assess critical thinking and collaborative problem-solving (Sa'diyah et al., 2024).

Institutional and systemic support is crucial for the effective and sustainable implementation of PBL. Ongoing professional development for teachers, adequate learning resources, and collaborative partnerships with external stakeholders such as industry and government are key enablers. Without such support, educators may struggle to fully integrate PBL into their teaching practices. Additionally, the development of localized learning materials tailored to the socio-cultural and economic context of learners can significantly enhance the relevance and effectiveness of PBL (Sitompul, 2021). Cross-sector collaboration also helps ensure that the problems addressed in the classroom reflect real societal needs, making the learning experience more meaningful and impactful.

The findings of this study suggest that PBL should be adopted more widely as a strategic approach to equip students with essential 21st-century skills, including communication, critical thinking, and collaboration. Despite challenges related to assessment and implementation logistics, the benefits of PBL in preparing learners for real-life situations are substantial. Research supports the idea that students exposed to PBL not only perform better academically but also develop stronger problem-solving abilities, emotional resilience, and adaptability—traits increasingly demanded in the modern workforce (Sembiring et al., 2024).

PBL also has important implications for national development. By cultivating learners who are creative, collaborative, and skilled at navigating uncertainty, PBL contributes to building a workforce that is responsive to the evolving demands of society and the global labor market. In this way, the adoption of PBL aligns with broader educational goals aimed at enhancing the quality and competitiveness of human resources on a national scale (Handhika et al., 2021). This positions PBL not merely as an instructional strategy, but as a transformative approach with long-term societal benefits.

A structured implementation framework further strengthens the effectiveness of PBL. When both teachers and students follow a clearly defined process—from problem identification, research, and analysis, to solution design and reflection—learning becomes more systematic and impactful. Each phase of the PBL cycle reinforces critical and reflective thinking while promoting deeper conceptual understanding. Importantly, PBL can be adapted to suit different educational levels. In primary education, the focus lies in fostering curiosity and developing foundational skills. At the secondary level, students are encouraged to think more independently and critically. In higher education, PBL supports professional readiness, mastery of discipline-specific skills, and innovation (Fatmawati & Simarmata, 2024; Khaeroh et al., 2020).

In conclusion, the successful integration of PBL into educational practice requires more than curricular changes; it demands a systemic shift involving teacher development, institutional support, relevant assessment tools, and the creation of authentic, contextualized learning experiences. With adequate support and thoughtful implementation, PBL offers a powerful pathway to prepare learners who are not only academically competent but also socially responsive and future-ready.

4. CONCLUSION

The implementation of Problem-Based Learning (PBL) has been found to significantly enhance student learning outcomes across educational levels by fostering critical, analytical, creative, and collaborative thinking skills that are essential for addressing 21st-century challenges. By engaging students in solving real-world problems, PBL promotes deeper understanding and better prepares them for the complexities of modern life and the workplace. However, despite its proven effectiveness, the successful implementation of PBL faces several limitations, particularly in terms of educator readiness, the need for appropriate assessment tools, and the availability of institutional support. Many teachers require targeted training to adopt PBL methodologies effectively, and schools often lack sufficient resources or cross-sector collaboration—such as partnerships with government and industry—to fully support this approach. Future research should explore strategies for overcoming these implementation barriers, including scalable models for teacher professional development, the integration of digital tools in PBL settings, and the development of context-sensitive assessment frameworks. In addition, longitudinal studies are recommended to evaluate the long-term impact of PBL on students' academic trajectories and life skills development, ensuring that its adoption contributes meaningfully to educational reform and human capital development.

REFERENCES

Ariyatun, A., & Octavianelis, D. F. (2020). Pengaruh Model Problem Based Learning Terintegrasi Stem Terhadap Kemampuan Berpikir Kritis Siswa. *JEC: Journal of Educational Chemistry*, *2*(1), 33. https://doi.org/10.21580/jec.2020.2.1.5434

Aryawati, Pujani, M. (2020). Pengaruh Model Problem Based Learning Terhadap Keterampilan Berpikir Kritis Dalam Pembelajaran Biologi Ditinjau Dari Gaya. *Jurnal Matematika, Sains, Dan Pembelajaran S4*, *14*(1), 105–124. https://ejournal.undiksha.ac.id/index.php/JPM/article/view/24141

Djonomiarjo Guru SMK Negeri, T., & Kab Pohuwato, P. (2018). Pengaruh Model Problem Based Learning Terhadap Hasil Belajar. *Jurnal Ilmu Pendidikan Nonformal Aksar*, *05*, 39–46. http://ejurnal.pps.ung.ac.id/index.php/AKSARA/index

Fatmawati, F., & Simarmata, E. J. (2024). Penerapan Model Problem Based Learning Untuk

Meningkatkan Hasil Belajar Pada Materi Metamorfosis di Kelas IV SD Negeri 1 Tualang Cut. *Jurnal Yudistira: Publikasi Riset Ilmu …*, *2*(2). https://journal.aripi.or.id/index.php/Yudistira/article/view/654

Fitriyyah, S. J., & Wulandari, T. sri H. (2019). Pengaruh Model Pembelajaran Problem Based Learning terhadap Berpikir Kritis Siswa SMP pada Pembelajaran Biologi Materi Pemanasan Global Effect of Problem Based Learning Model on Critical Thinking of Junior High School Students on Biology Learning about Gl. *BIOEDUKASI: Jurnal Pendidikan Biologi*, *12*(1), 1–7. http://dx.doi.org/10.20961/bioedukasi-uns.v12i1.27354

Garut, U., Imam, I., Ayyubi, A., Wildan, M., Dzikri, M., Yasmin, S., & Martini, S. (n.d.). *Fakultas Pendidikan Islam dan Keguruan PENGARUH PEMBELAJARAN PROBLEM BASED LEARNING TERHADAP PEMBENTUKAN KOGNITIF SISWA Sekolah Tinggi Agama Islam Darul Falah , Bandung Barat*. 6–14.

Handhika, D., Santoso, & Ismaya, E. A. (2021). Pengaruh Model Project Based Learning dan Problem Based Learnng Untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Educatio FKIP UNMA*, *7*(4), 1544–1550. https://doi.org/10.31949/educatio.v7i4.1449

Khaeroh, A., Anriani, N., Mutaqin, A., Pertanian, S., & Serang, K. (2020). Tirtamath : Jurnal Penelitian dan Pengajaran Matematika Volume 2 Nomor 1 Tahun 2020 Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Penalaran Matematis. *Tirtamath : Jurnal Penelitian Dan Pengajaran Matematika* , *2*(1), 73–85.

Lutfiah, W., Anisa, A., & Hambali, H. (2021). Pengaruh Model Pembelajaran Problem Based Learning terhadap Hasil Belajar Biologi. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(4), 2092–2098. https://doi.org/10.31004/edukatif.v3i4.1090

Mustaqfiroh, Nizaruddin, N., Muhtarom, M., & Kurniawati, A. (2024). Efektivitas Model Problem Based Learning berbasis Culturally Responsive Teaching untuk meningkatkan Kemampuan Literasi Matematis. *Proximal: Jurnal Penelitian Matematika Dan Pendidikan Matematika*, *7*(2), 937–944. https://doi.org/10.30605/proximal.v7i2.4073

Nasral, & Meliandika, R. (2022). Pengaruh Model PBL (Problem Based Learning) dengan Media Animasi terhadap Kemampuan Berpikir Kritis dan Hasil Belajar Biologi Siswa di SMAN I Kota Bengkulu. *Jurnal Pendidikan Tambusai*, *6*(1), 672–683.

Putri, C. D., Pursitasari*, I. D., & Rubini, B. (2020). Problem Based Learning Terintegrasi STEM Di Era Pandemi Covid-19 Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *Jurnal IPA & Pembelajaran IPA*, *4*(2), 193–204. https://doi.org/10.24815/jipi.v4i2.17859

Pratiwi, V. D., & Wuryandani, W. (2020). Effect of Problem Based Learning (PBL) Models on Motivation and Learning Outcomes in Learning Civic Education. *JPI (Jurnal Pendidikan Indonesia)*, *9*(3), 401. https://doi.org/10.23887/jpi-undiksha.v9i3.21565

Ratnawati, D., Handayani, I., & Hadi, W. (2020). Pengaruh Model Pembelajaran Pbl Berbantu Question Card Terhadap Kemampuan Berpikir Kritis Matematis Siswa Smp. *Edumatica : Jurnal Pendidikan Matematika*, *10*(01), 44–51. https://doi.org/10.22437/edumatica.v10i01.7683

Sa'diyah, M. K., Andara, S., Aisy, Z. I. R., & Prihatini, P. (2024). Hasil Belajar Materi Pengukuran Di Sekolah Dasar Dengan Model Pembelajaran Problem Based Learning. *Bhinneka: Jurnal Bintang Pendidikan Dan Bahasa*, *2*(1), 195–200.

Sembiring., S. S. A. B., Putri., D. F., Ritonga., V. A., & Arwita, W. (2024). Analisis Ketersediaan Fasilitas dan Penerapan Model Pembelajaran Problem Based Learning Kelas XI di SMA Tamansiswa Binjai. *INNOVATIVE: Journal of Social Science Research*, *4*(3), 9767–9776.

Sitompul, N. N. S. (2021). Pengaruh Model Pembelajaran Problem Based Learning terhadap Peningkatan Kemampuan Berpikir Kritis Matematis Siswa SMP Kelas IX. *GAUSS: Jurnal Pendidikan Matematika*, *4*(1), 45–54. https://doi.org/10.30656/gauss.v4i1.3129

Temuningsih, Peniati, E., & Marianti, A. (2017). Pengaruh Penerapan Model Problem Based Learning Berpendekatan Etnosains Pada Materi Sistem Reproduksi Terhadap Kemampuan Berpikir Kritis Siswa. *Journal of Biology Education*, *6*(1), 70–79. https://doi.org/10.15294/jbe.v6i1.14060

Utami, C. A., Haji, S., & Zamzaili. (2017). Pengaruh pembelajaran problem based learning dengan strategi group investigation terhadap kemampuan berpikir kritis siswa SMKN 3 Rejang Lebong. *Jurnal Pendidikan Matematika Raflesia*, *2*(2), 130–138.

Uliyandari, M., Emilia Candrawati, Anna Ayu Herawati, & Nurlia Latipah. (2021). Problem-Based Learning To Improve Concept Understanding and Critical Thinking Ability of Science Education Undergraduate Students. *IJORER : International Journal of Recent Educational Research*, *2*(1), 65–72. https://doi.org/10.46245/ijorer.v2i1.56

Wahdaniyah, N., Agustini, R., & Tukiran, T. (2023). Analysis of Effectiveness PBL-STEM to Improve Student's Critical Thinking Skills. *IJORER : International Journal of Recent Educational Research*, *4*(3), 365–382. https://doi.org/10.46245/ijorer.v4i3.312

Wilsa, A. W., Susilowati, S. M. E., & Rahayu, E. S. (2017). Problem Based Learning Berbasis Socio-Scientific Issue untuk Mengembangkan Kemampuan Berpikir Kritis dan Komunikasi Siswa. *Journal of Innovative Science Education*, *6*(1), 129–137. http://journal.unnes.ac.id/sju/index.php/jise

Winahyu, F. H., Nulhakim, L., & Rumanta, M. (2024). Pengaruh Pembelajaran Problem Based Learning Berdiferensiasi dan Motivasi Belajar terhadap Hasil Belajar Matematika. *Edukatif : Jurnal Ilmu Pendidikan*, *6*(1), 661–669. https://doi.org/10.31004/edukatif.v6i1.6351

Wulandari, I. C., Muldayanti, N. D., & Setiadi, A. E. (2020). Project and problem based learning on students' critical thinking skills at cell material. *JPBIO (Jurnal Pendidikan Biologi)*, *5*(2), 127–139. https://doi.org/10.31932/jpbio.v5i2.580

Wulandari, R., Wardhani, S., & Nawawi, S. (2020). Pengaruh Model Problem Based Learning Pendidikan Biologi Fakultas Keguruan dan Ilmu Pendidikan Universitas Muhammadiyah Palembang Terhadap Keterampilan Berpikir Kritis Siswa Materi Keanekaragaman Hayati. *Journal of Biology, Education, Science, and Technology*, *3*(1), 2614–8064.