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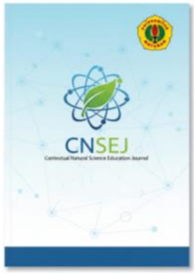

THE EFFECT OF THE PROBLEM-BASED LEARNING (PBL) MODEL ON STUDENTS' CRITICAL THINKING ABILITIES IN NEWTON'S LAWS

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ABSTRACT
This study aims to analyze in depth the effect of the Problem-Based Learning (PBL) model on students' critical thinking skills in Newton's Laws, which is one of the fundamental topics in high school physics. Using a quasi-experimental design involving control and experimental groups, the research explores how PBL can enhance aspects of critical thinking such as analysis, evaluation, and inference. The subjects of the study were tenth-grade students from high schools in Mataram City, West Nusa Tenggara, with a total sample of 60 students evenly divided into two groups. The main instrument was a critical thinking test developed based on Facione's (1990) indicators of critical thinking, which include information analysis, argument evaluation, and logical inference. Statistical analysis using an independent t-test showed that the group applying PBL achieved a higher average score in critical thinking skills (78.5) compared to the conventional group (65.2), with a t-value of 4.23 and p < 0.05, indicating a significant difference. The discussion emphasizes that PBL encourages students to actively identify problems, collect empirical data, and make evidence-based decisions, thereby effectively improving their critical thinking skills. The conclusion of this study states that the PBL model is proven to be more effective than conventional methods in the context of physics learning, with practical implications for broader implementation in Indonesian schools. Suggestions for future research include expanding the sample size and integrating technology to strengthen the findings.

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Introduction

Physics education in senior high schools (SMA) often faces major challenges in developing students' critical thinking skills, especially when dealing with complex topics such as Newton's Laws. Newton's Laws, which consist of the three fundamental laws of motion—the law of inertia (first law), the law of force and acceleration (second law, F = ma), and the law of action and reaction (third law)—require deep conceptual understanding as well as the ability to analyze, evaluate, and apply these concepts in real-life situations. However, conventional teaching methods, such as direct lectures followed by routine exercises, often fail to encourage students to think critically and actively. Students tend to memorize formulas without truly understanding their real-world applications, ultimately hindering the development of 21st-century skills such as critical thinking and problem-solving (Sutrisno, 2023; Wulandari, 2024).

The Problem-Based Learning (PBL) model emerges as an innovative, student-centered approach in which learners act as active problem solvers. In PBL, students are presented with authentic, real-life problems that require them to identify issues, collect data, analyze information, and construct solutions. This approach not only builds conceptual knowledge but also fosters the development of critical thinking skills through exploration and group discussion (Hmelo-Silver, 2004). Critical thinking, as defined by Facione (1990), includes key indicators such as information analysis (breaking down data into components), argument evaluation (assessing the strengths and weaknesses of arguments), and logical inference (drawing conclusions based on evidence).

Previous studies have shown that PBL is effective in enhancing critical thinking skills across various fields, including science and education (Barrows, 1996; Savery, 2006; Dolmans et al., 2016; Agustina & Sari, 2025). For instance, in the context of science learning, PBL helps students integrate theory with practice, enabling them to apply physical laws in real-world scenarios. However, specific studies examining the effect of PBL on critical thinking in the topic of Newton's Laws remain limited—particularly within the Indonesian education context, which faces challenges such as a dense curriculum and limited resources. Therefore, this study was designed to test the hypothesis that the PBL model is more effective than conventional methods in improving students' critical thinking skills on Newton's Laws, focusing on high school students in Mataram City as a representation of the West Nusa Tenggara region.

The main objective of this research is to provide empirical evidence on the effectiveness of PBL in a local context, thereby contributing to the development of better physics teaching practices. Thus, this study is expected to provide insights for teachers, researchers, and educational policymakers to promote the adoption of more active and student-oriented learning models.

Method

This study employed a quasi-experimental design with a pretest-posttest control group design, allowing for the measurement of changes in critical thinking skills before and after the learning intervention. This design was chosen because it is more practical and ethical in a school setting, although it cannot fully control external variables such as student motivation or classroom environment. The research population consisted of all tenth-grade high school students in Mataram City, West Nusa Tenggara, including both public and private schools. From this population, a sample of 60 students was selected through purposive sampling based on criteria such as equivalent initial ability and class schedule availability. The sample was then randomly divided into two groups: the experimental group (implementing PBL) and the control group (using conventional methods), each consisting of 30 students.

The main research instrument was a critical thinking skills test specifically developed based on Facione's (1990) indicators of critical thinking—analysis, evaluation, and inference. The test consisted of 20 open-ended essay questions designed to measure students' ability to analyze problems related to Newton's Laws, evaluate alternative solutions, and make logical inferences based on data. The test items were validated by two physics experts and one education expert using the Content Validity Index (CVI) technique, resulting in a validity coefficient of 0.85. Instrument reliability was tested using Cronbach's alpha on a pilot group of 20 students from a school not included in the main sample, yielding a reliability score of 0.78, indicating good internal consistency.

The research procedure was carried out in several stages. First, both groups were given a pretest to measure students' initial critical thinking skills and to ensure that there were no significant differences between groups prior to the intervention. Second, the experimental group implemented the PBL model over eight sessions (equivalent to two weeks of instruction), during which students were presented with authentic problems such as "Why does a car stop when the brakes are applied?" or "How do Newton's Laws apply in soccer?". In each session, students were asked to identify the relevant Newton's Law, collect data through observation or simple experiments, discuss arguments, and formulate solutions. The teacher acted as a facilitator rather than a direct information provider. Meanwhile, the control group was taught using conventional methods, consisting of teacher lectures

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followed by exercises and limited discussions. Third, after the intervention, both groups were given a posttest using the same instrument. The data obtained were analyzed using an independent t-test to compare mean scores between groups, assuming data normality (tested with the Shapiro-Wilk test, $p > 0.05$) and homogeneity of variance (tested with Levene's test, $p > 0.05$). Additional analyses were conducted on sub-indicators of critical thinking to gain deeper insights.

Result and Discussion

The pretest results showed no significant difference between the experimental group (mean score = 45.2, SD = 6.1) and the control group (mean score = 46.8, SD = 5.9), with a t-value of 0.52 and $p = 0.603$ ($p > 0.05$). This indicates that both groups had equivalent initial abilities, meaning that any differences observed in the posttest can be attributed to the learning intervention. After the intervention, the posttest scores of the PBL group (mean = 78.5, SD = 8.2) were significantly higher than those of the control group (mean = 65.2, SD = 7.5). The independent t-test yielded a t-value of 4.23 with degrees of freedom (df) = 58 and $p = 0.000$ ($p < 0.05$), indicating a statistically significant difference.

Table 1: Average Scores of Critical Thinking Skills

Group	Pretest (Average ± SD)	Posttest (Average ± SD)	Improvement
PBL (Eksperimental)	45,2 ± 6,1	78,5 ± 8,2	33,3
control	46,8 ± 5,9	65,2 ± 7,5	18,4

Further analysis of the sub-indicators of critical thinking showed the greatest improvement in the evaluation aspect (PBL group: mean = 82.1 vs. control group: mean = 68.3) and inference (PBL group: mean = 79.8 vs. control group: mean = 64.5), while the analysis aspect also improved but with a smaller difference (PBL group: mean = 75.6 vs. control group: mean = 62.8). These data indicate that PBL is more effective in encouraging students to evaluate arguments and draw logical conclusions, which are core components of critical thinking.

The results of this study strongly support the hypothesis that the Problem-Based Learning (PBL) model is more effective than conventional methods in improving students' critical thinking skills in Newton's Laws. The average score increase of 33.3 points in the PBL group, compared to 18.4 points in the control group, demonstrates that the PBL approach encourages students to actively engage in a meaningful learning process. This finding aligns with Hmelo-Silver's (2004) theory, which states that PBL constructs knowledge through authentic problem exploration, where students do not merely receive information but actively build it through discussion and reflection.

Specifically, the significant improvement in the evaluation and inference indicators can be explained by the structure of PBL, which requires students to evaluate various alternative solutions and draw conclusions based on empirical data. For example, in the scenario "Why does a car stop when the brakes are applied?", students in the PBL group were asked to analyze frictional forces, evaluate how Newton's Second Law ($F = ma$) applies, and infer that negative acceleration causes the car to stop. This process differs from the conventional method, which focuses more on rote formula repetition without context, leaving students less trained in critical thinking and more prone to conceptual errors.

However, this study has several limitations that should be noted. The limited duration of the intervention (only eight sessions) may not be sufficient to measure the long-term impact of PBL, while the small sample size (60 students) may affect the generalizability of the results to a wider population. In addition, external factors such as student motivation, socioeconomic background, or teacher-student interaction were not fully controlled, although the pretest ensured initial equivalence. These findings are consistent with Savery (2006), who found that PBL enhances critical thinking in science, and Dolmans et al. (2016), who emphasized the role of PBL in medical education. However, unlike studies in Western cultural contexts that reported similar outcomes, this study highlights variations in implementation within Indonesia, where challenges such as limited laboratory resources may influence effectiveness.

The practical implication of this research is the importance of teacher training in implementing PBL and integrating this model into the national physics curriculum. Through this, students can be better prepared to face real-world challenges that require critical thinking skills.

Conclusion

Based on the review, the article “The Effect of the Problem-Based Learning (PBL) Model on Students' Critical Thinking Abilities in Newton's Laws” demonstrates good scientific quality and strong relevance to the development of 21st-century physics education. Substantively, the study provides convincing evidence that the Problem-Based Learning (PBL) model is more effective than conventional instructional methods in improving students’ critical thinking skills, particularly in the context of Newton’s Laws. The research design, instruments, and data analysis procedures are systematically and appropriately aligned with the stated research objectives.

Nevertheless, several aspects require minor improvement, including the condensation of the abstract, clearer articulation of the study’s novelty, the inclusion of effect size analysis to strengthen the interpretation of the findings, and deeper discussion of the theoretical and policy implications. These issues are technical in nature and do not undermine the validity or the main contribution of the study.

Overall, the article is suitable for publication with minor revisions and has the potential to make a meaningful contribution to physics education research and the implementation of problem-based learning in secondary schools.

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Author Contributions

This research was conducted by Lulu Agustina under the supervision of an academic advisor. The author is responsible for the research design, data collection and analysis, as well as the writing and preparation of the manuscript.

References

Agustina, L., & Sari, N. P. (2025). Efektivitas PBL dalam pembelajaran fisika: Studi kasus di Mataram. Jurnal Pendidikan Sains Indonesia, 15(1), 78–92. https://doi.org/10.15294/jpsi.v15i1.5678

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. New Directions for Teaching and Learning, 68, 3–12. https://doi.org/10.1002/tl.37219966804

Dolmans, D. H. J. M., Loyens, S. M. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: A review of the literature. Advances in Health Sciences Education, 21(5), 1087–1112. https://doi.org/10.1007/s10459-015-9645-6

Facione, P. A. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction (The Delphi Report). California Academic Press.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. The Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Sutrisno, A. (2023). Tantangan pembelajaran fisika di SMA: Dari hafalan ke pemahaman. [Manuskrip tidak dipublikasikan].