



The Effect of Problem-Based Learning Model on Students' Learning Outcomes Viewed from Learning Styles

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Article History

Received: 25-04-2024

Revised: 10-05-2024

Published: 31-05-2024

Keywords: Problem-based learning, learning styles, educational outcomes, quasi-experimental design

Abstract

This study explores the effectiveness of the Problem-Based Learning (PBL) model on students' learning outcomes, focusing on how different learning styles—visual, auditory, and kinesthetic—affect its efficacy. Conducted at SMA Negeri 1 Narmada, the research employed a quasi-experimental design with a pretest-posttest nonequivalent control group setup to measure the impacts of PBL versus traditional teaching methods. Findings from the study revealed significant improvements in the physics learning outcomes for the experimental group, which engaged with the PBL model, compared to the control group that used conventional direct instruction methods. Statistical analysis using a two-way ANOVA showed a significant enhancement in learning outcomes associated with the PBL model ($p = 0.030$), but no significant interaction between learning styles and the learning model was found, indicating that the PBL model benefits all learning styles equally without preference. These results suggest that while PBL universally improves learning outcomes, individual learning styles do not significantly alter its effectiveness. The study highlights the potential of PBL to not only increase academic performance in physics but also to foster a more engaging and participatory learning environment. It underscores the importance of adopting educational models that accommodate diverse learning preferences and provide dynamic, student-centered learning experiences. This research contributes to the understanding of instructional effectiveness and supports the broader implementation of PBL in physics education to cater to varied educational needs and learning styles.

How to Cite: Arni, K., Kosim, K., & Verawati, N. (2024). The Effect of Problem-Based Learning Model on Students' Learning Outcomes Viewed from Learning Styles. *Hydrogen: Jurnal Kependidikan Kimia*, 12(2). doi:<https://doi.org/10.33394/hjkk.v12i2.11788>



<https://doi.org/10.33394/hjkk.v12i2.11788>

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INTRODUCTION

In an ideal science education, a student-centered approach is crucial for enhancing students' abilities to comprehend, construct, and apply learned concepts (Hariawan et al, 2014). This approach aligns with constructivist learning theory, which emphasizes that knowledge is actively built by learners rather than passively received from teachers. Implementing constructivist teaching methods in physics education can lead to improved learning outcomes

by engaging students in constructing their understanding of physics concepts (Jamila et al., 2023).

Student-centered learning is regarded as an effective approach because it provides students with the space, opportunity, and freedom to independently explore knowledge through a variety of accessible resources. This autonomy in learning allows students to acquire a deeper understanding and significantly enhances their educational outcomes (Ramadhani, 2017). Learning outcomes play a crucial role in the educational process, as they serve as a benchmark for assessing the extent of change in students following their learning experiences. These changes can be observed and measured in terms of knowledge, attitudes, and skills (Samsudin, 2019). Additionally, learning outcomes are influenced by individual learning styles. Effective learning outcomes often reflect effective learning styles, as understanding and adapting to the optimal learning style for each student can significantly enhance their learning efficiency, ultimately leading to maximal academic achievements (Marpaung, 2015). This holistic approach not only fosters academic excellence but also cultivates a conducive learning environment that is responsive to the diverse educational needs and preferences of students.

Learning style refers to the ways in which individuals receive, process, remember, and apply information effectively. By identifying the learning styles of students, educators can tailor their teaching methods to align with these styles, thereby enhancing the learning outcomes of their students. This personalized approach ensures that learning experiences are optimized for each student's unique preferences and capabilities, thereby fostering better engagement and understanding (Widayanti, 2013). Learning styles are a blend of how individuals absorb information, and subsequently organize and process this information into meaningful knowledge. This processing can occur through various modalities such as visual (seeing), auditory (hearing), and kinesthetic (engaging in physical activity) approaches. The alignment between a student's learning style and the instructional methods employed can significantly influence their academic performance (Saputri, 2016). Specifically, visual learners excel when information is presented through images and spatial understanding, auditory learners benefit from listening and verbal interactions, while kinesthetic learners thrive in environments that allow them to move and engage physically in the learning process (Cicilia & Nursalim, 2019).

Based on observations and interviews, physics education at SMA Negeri 1 Narmada has not yet implemented a student-centered learning model and has not previously examined student learning outcomes from the perspective of their learning styles. Furthermore, there is a prevailing belief among students that physics is a difficult subject. This perception contributes to the average scores of the mid-semester assessments for the 11th grade science stream being relatively low, falling below the average. In response to these issues, it is essential to find a solution to improve the low learning outcomes of the students. One instructional model that encourages active participation and is suitable for teaching physics is Problem-Based Learning (PBL). According to Parasamya et al. (2017), this model engages students more deeply, boosting their enthusiasm and interest in learning, which can subsequently enhance their physics learning outcomes.

The PBL model has been shown to improve students' learning outcomes by promoting active involvement and fostering students' awareness of their own learning process, as highlighted by Munandar et al. (2018). The PBL instructional model includes stages that train cognitive abilities at various levels—understanding, applying, analyzing, and evaluating—which support the enhancement of students' cognitive learning outcomes (Pratiwi et al., 2019). Additionally, aligning the instructional model with student characteristics, such as learning styles, can further improve learning outcomes, as noted by Nurmayani et al. (2016). This approach not only

enhances students' academic performance but also tailors the learning experience to better meet their individual needs and preferences.

Given the issues outlined, the researcher is motivated to conduct a study to explore the effects of the Problem Based Learning (PBL) model on students' physics learning outcomes from the perspective of learning styles. Learning styles, as defined in this study, refer to the methods an individual uses to absorb, process, and respond to information or lessons to solve problems and apply these solutions in daily life (Zagoto, 2019). It is well-documented that each student has a preferred learning style, which can be broadly categorized into visual, auditory, and kinesthetic modes (Wahyuni, 2017). According to Jeanete and Neleke (2016), the visual learning style involves learning through seeing, observing, and looking, while the auditory style pertains to learning through listening, and the kinesthetic style involves learning through movement, hands-on work, and touching.

Specifically, the aim of this research is to examine the impact of the problem-based learning model on the learning outcomes of students, as well as the interaction between the learning model and the students' learning styles. This approach seeks to identify how these styles influence the effectiveness of the PBL model in teaching physics. By integrating learning styles into the instructional design, the study intends to provide insights on how to enhance educational strategies to better cater to the diverse needs of students, potentially leading to improved academic performance and deeper engagement in the learning process.

Novelty of the Study

The novel aspect of this research lies in its in-depth investigation into the effectiveness of the Problem-Based Learning (PBL) model tailored to different learning styles—visual, auditory, and kinesthetic—specifically within the domain of physics education. Unlike general studies on PBL, this study meticulously examines the intersection of PBL and individual learning styles in enhancing physics learning outcomes. Physics, with its complex concepts and quantitative nature, often poses significant challenges to students. By applying the PBL approach, this study seeks to ascertain whether the active engagement and problem-solving required by PBL are equally effective across the different modalities through which students best learn and process information. This differentiation is crucial, as it addresses the educational challenge of making physics accessible and comprehensible to all students, regardless of their predominant learning style. The findings from this study could thus have significant implications for instructional strategies in physics, potentially leading to more effective teaching methodologies that are cognizant of individual learning preferences.

Moreover, this study contributes to the literature by specifically focusing on how the PBL model can be integrated into physics education to address the educational needs of students with varied sensory preferences. The research extends beyond the typical application of PBL by not only assessing its effectiveness in fostering critical thinking and problem-solving skills but also examining how these skills are developed differently according to each learning style. This approach could lead to a better understanding of how educational practices can be adapted to maximize learning outcomes for all students in physics classrooms. By exploring these dynamics, the study offers valuable insights into the practical application of PBL, suggesting ways to refine and tailor educational interventions in physics to enhance student engagement and understanding. This could ultimately lead to broader educational reforms where teaching methods are customized to meet the diverse cognitive and perceptual needs of students, making physics education more effective and inclusive.

METHOD

This study employs a quantitative approach with a quasi-experimental design, as not all variables (emerging phenomena) and experimental conditions can be strictly controlled and manipulated by the researcher. Quasi-experimental research examines the causal relationships between an experimental group and a control group concerning a specific treatment. The treatment is administered to determine whether it exerts an influence on specific variables (Setyosari, 2012). This type of design is selected because it allows for the evaluation of the effects of interventions in settings where random assignment is not feasible, thereby providing a practical approach to investigate the efficacy of educational interventions in real-world classroom settings.

The specific research design utilized in this study is the Pretest-Posttest Nonequivalent Control Group Design combined with a 2x3 factorial arrangement. This design involves administering a pretest before any intervention is applied and a posttest after the intervention, for each group involved in the study. This structure is particularly effective in educational research as it helps to measure the changes in outcomes attributed to the intervention while accounting for initial differences between the control and experimental groups. The detailed structure and methodology of this research design are outlined in Table 1. This table provides a clear visualization of the experimental setup, illustrating how participants are allocated and how data collection is synchronized across different stages of the research process.

Table 1. The factorial desain 2x3

Variable		Learning Model	
		PBL (X ₁)	Conventional (X ₂)
Learning Style	Visual (Y ₁)	X ₁ Y ₁	X ₂ Y ₁
	Auditory (Y ₂)	X ₁ Y ₂	X ₂ Y ₂
	Kinesthetic (Y ₃)	X ₁ Y ₃	X ₂ Y ₃

This research commenced in May 2023 with data collection occurring during the second semester of the 2023/2024 academic year at SMA Negeri 1 Narmada. The study population comprises all the students in the 11th grade Science stream, totaling six classes. For the purpose of sampling, a purposive sampling technique was employed, which involves selecting samples based on the researcher's judgment. Specifically, class XI IPA 1, consisting of 33 students, was chosen as the experimental group, and class XI IPA 6, with 34 students, served as the control group. This method ensures that the selected classes provide relevant and insightful data for addressing the research questions regarding the impact of the Problem-Based Learning (PBL) model on physics learning outcomes.

The study received ethical approval from the University of Mataram and SMA Negeri 1 Narmada, ensuring compliance with all ethical standards for research involving human subjects. Ethical considerations included obtaining informed consent from all participants, maintaining confidentiality and anonymity of participant data, and ensuring no harm to the students. These measures were upheld throughout the research to protect the participants' rights and well-being, while also ensuring that the benefits of the Problem-Based Learning model were communicated and understood. The research aimed not only to enhance students' educational outcomes but also to contribute positively to educational practices and policies.

The research process was structured into three main phases: planning, implementation, and reporting. In the initial planning phase, the research team set clear objectives and developed precise methods, while also preparing all the necessary materials and tools essential for

conducting the study effectively. Following this, the implementation phase commenced, where the Problem-Based Learning (PBL) model was actively applied to the experimental class, contrasting with traditional teaching methods used in the control class. This crucial phase also incorporated the administration of pre-tests and post-tests designed to assess the initial learning outcomes and the subsequent changes after the PBL model was applied, thereby providing empirical data on the model's effectiveness. The final phase of the study, reporting, was dedicated to a thorough analysis of the collected data, followed by the compilation of the findings into a comprehensive report that not only detailed the outcomes but also explored the implications of the results, offering valuable insights into the effectiveness of the PBL model across different learning styles and suggesting potential improvements for future educational practices.

The instruments used in this study included both questionnaire and test-based tools. The questionnaire utilized a Likert scale with four response options to assess students' learning styles, while the test instrument consisted of a descriptive test with five items that focused on higher cognitive levels (C4-C6) in learning outcomes. Additionally, the research utilized various educational tools such as syllabi, lesson plans, teaching materials, student worksheets, learning media, and evaluation instruments for learning outcomes, alongside the learning style questionnaire.

The assessment of learning outcomes was conducted by administering a 20-item descriptive test at the end of the teaching period, followed by a non-test instrument, namely the learning style questionnaire. The data analysis technique employed was quantitative data analysis. The study's data consisted of students' learning outcomes and their learning styles. For hypothesis testing, a two-way ANOVA was used, which allows for the assessment of average differences with two influencing factors and considers the interaction between these factors (Hasan, 2006). The prerequisites for conducting a two-way ANOVA include having samples from independent groups, homogeneity of variances across groups, and normally distributed data for each group.

RESULTS AND DISCUSSION

The research findings include data on learning styles, as well as initial and final test scores of the participants. For both the experimental and control groups, the initial test scores exhibited a similar range with the highest score being 58 and the lowest being 13. This initial assessment served as a baseline to measure the effectiveness of the instructional interventions applied throughout the study. In contrast, the final test scores showed a significant improvement, demonstrating the impact of the teaching methods utilized. In the experimental group, the highest score achieved was 93, and the lowest was 66, while in the control group, the scores ranged from 86 at the highest to 53 at the lowest. These results indicate a notable advancement in understanding and application of physics concepts among students, especially in the experimental group where the Problem-Based Learning (PBL) model was implemented.

The data on learning styles were gathered through a questionnaire filled out by the students. This information is crucial as it helped in analyzing how different learning styles responded to the teaching methods used in the study. The questionnaire results provided insights into the predominant learning styles within the classroom, which include visual, auditory, and kinesthetic, as previously identified. The analysis of these learning styles in conjunction with the final test scores offers a deeper understanding of the interaction between teaching methods and learning preferences. This detailed assessment is presented in Table 2, which includes the average final test scores for each learning style. Such data is instrumental in illustrating how

tailored instructional strategies can significantly enhance learning outcomes based on the individual learning preferences of the students.

Table 2. Student learning style questionnaire results

Variables	Ekperimental group	Control group
Number of Students	30	30
Number of Students with Visual Learning Style	14	8
Number of Students with an Auditory Learning Style	6	6
Number of Students with Kinesthetic Learning Style	10	16
Average score for visual learning style	77	60
Average score for auditory learning style	66	73
Average score for kinesthetic learning style	81	70

Table 2 presents a detailed breakdown of the distribution of learning styles and associated test scores within both the experimental and control groups, offering a nuanced insight into how different teaching methodologies have impacted students with various learning preferences. In the experimental group, which employed the Problem-Based Learning (PBL) model, there were 14 students identified with a visual learning style, 6 with an auditory learning style, and 10 with a kinesthetic learning style. The average final test scores for these groups were 77, 66, and 81, respectively. This indicates a particularly strong improvement among kinesthetic learners, suggesting that the PBL approach, with its hands-on and engaging nature, may be particularly effective for students who benefit from active participation in their learning process.

Conversely, the control group, which likely followed more traditional teaching methods, consisted of 8 visual learners, 6 auditory learners, and 16 kinesthetic learners. The average scores for these students were 60, 73, and 70, respectively. Interestingly, the auditory learners in the control group outperformed those in the experimental group, with an average score of 73 compared to 66. This might suggest that traditional teaching methods, which often heavily rely on verbal instruction and lectures, are more conducive to auditory learners. The kinesthetic learners, despite being more numerous in the control group, scored lower on average compared to their counterparts in the experimental group, reinforcing the notion that PBL's active learning environment better supports their learning style.

The results of the hypothesis testing conducted using a two-way ANOVA, facilitated by SPSS version 24, are comprehensively detailed in Table 3. This statistical analysis was critical in evaluating the interaction effects between the teaching methods and the different learning styles on the students' physics learning outcomes.

Table 3. Hypothesis test results

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1047.402 ^a	5	3.379	3.379	0.010
Intercept	287619.830	1	4639.680	4639.680	0.000
Learning style	304.956	2	152.478	2.460	0.095
Learning model	309.275	1	309.275	4.989	0.030
Learning style * PBL model	312.311	2	156.156	2.519	0.090

The results outlined in Table 3 from the two-way ANOVA provide significant insights into the effects of the teaching methods and learning styles on students' physics learning outcomes. The analysis reveals that the Problem-Based Learning (PBL) model has a statistically significant

impact on learning outcomes with a p-value of 0.030, indicating that changes in teaching strategies notably affect student performance in physics. Specifically, since the p-value is less than the commonly used threshold of 0.05, the null hypothesis (H_0) that states there is no effect of the PBL model on learning outcomes is rejected, and the alternative hypothesis (H_a) is accepted. This finding underscores the effectiveness of the PBL model in enhancing physics learning outcomes among students.

However, the influence of learning styles on these outcomes shows a different trend. The p-value for learning styles is 0.095, which is above the threshold, suggesting that the learning styles alone do not significantly influence the physics learning outcomes of the students. Consequently, the null hypothesis (H_0) is accepted and the alternative hypothesis (H_a) is rejected for this variable, indicating that learning styles, when considered independently, do not play a significant role in affecting academic performance in physics. Additionally, the interaction between the PBL model and learning styles yielded a p-value of 0.090, also exceeding the significance level. This result suggests that the synergistic effect of the PBL model combined with learning styles does not significantly enhance the physics learning outcomes, leading to the acceptance of the null hypothesis (H_0) and the rejection of the alternative hypothesis (H_a) for this interaction. These findings collectively highlight the critical role of innovative teaching methods like PBL in improving educational outcomes, while also noting that the integration of different learning styles into such models does not additionally enhance learning outcomes.

The absence of an interaction between the Problem-Based Learning (PBL) model and learning styles in affecting physics learning outcomes of students is illustrated in Figure 1. This figure displays an interaction graph between the PBL model and various learning styles, where overall, there is no evident intersection among the three learning styles—visual, auditory, and kinesthetic—indicating no significant interaction effect. This lack of intersection points is particularly notable between the visual and kinesthetic styles compared to the auditory style. In the experimental group, the average scores of students with an auditory learning style are relatively lower than those of the visual and kinesthetic learners. Conversely, in the control group, students with a visual learning style scored lower on average than their counterparts with auditory and kinesthetic styles. This disparity in score distributions across different learning styles and groups highlights the ineffectiveness of integrating learning styles into the PBL model to enhance learning outcomes.

This phenomenon is supported by research from Gunawan et al. (2016), who assert that there is no significant interaction between the learning model and the learning styles employed in education, often due to a negative skew in learning outcomes associated with certain styles. Their findings suggest that certain learning styles do not necessarily benefit from specific educational models and can in fact experience a decrease in learning outcomes. This underlines the complexity of effectively integrating learning styles into educational models and emphasizes the need for a more nuanced understanding of how different educational approaches can cater to diverse learning preferences without compromising overall educational effectiveness. Such insights are crucial for educators aiming to optimize learning strategies to maximize student engagement and achievement.

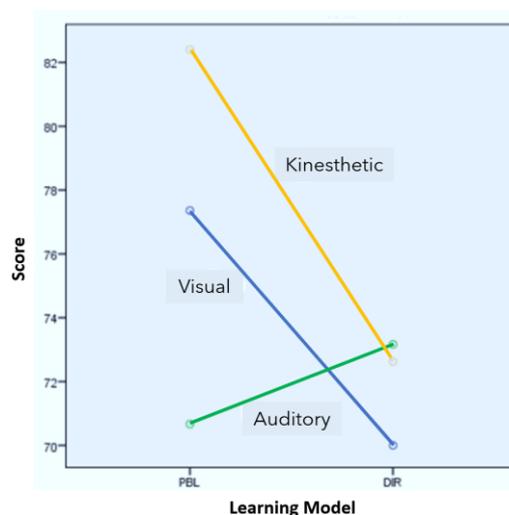


Figure 1. Interaction graph between the model and learning styles in relation to learning outcomes

The research results indicate that while both the experimental and control classes experienced an improvement in average scores, the gains in the experimental class, where the Problem-Based Learning (PBL) model was applied, were significantly higher than those in the control class, which used a direct instruction model with a conventional approach. This significant difference was reflected in the statistical analysis conducted using a two-way ANOVA with SPSS 24, where the p-value was found to be 0.030, suggesting that the impact of the PBL model on physics learning outcomes is statistically significant. Consequently, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_a) was accepted, confirming the effectiveness of the PBL model in enhancing student learning outcomes in physics.

Observations made during the study highlighted the influence of the PBL model phases on student engagement and discipline. Specifically, during the third and fourth phases of the PBL model, which involve guiding individual and group investigations and developing and presenting findings, students were notably more engaged. In the third phase, students conducted experiments under supervision, comparing their observations with real-life problems related to the studied material, such as the characteristics of sound waves. This hands-on approach allowed students to directly connect theoretical knowledge with practical applications, enhancing their understanding and interest in the subject. The fourth phase of the PBL model, which involves students presenting their experimental results, further contributed to enhancing their learning outcomes. During this phase, students are trained to effectively communicate and justify their findings in front of their peers, fostering a sense of responsibility and active participation in their learning process. This aligns with findings from previous studies, such as the research by Paradina et al. (2019), which emphasized that the PBL model facilitates active collaboration and discussion among students, helping them to explore and solve given problems and to relate experimental results to real-world scenarios. However, a second hypothesis testing revealed no significant interaction between the PBL model and learning styles in influencing physics learning outcomes, as indicated by a p-value of 0.09. This was visually supported by Figure 1, which showed no crossing points among the three learning styles in the interaction graph, suggesting that the PBL model's effectiveness in enhancing learning outcomes is not significantly affected by the students' individual learning styles.

This lack of interaction can be attributed to the nature of the PBL model, which promotes an enjoyable and collaborative learning environment that transcends individual learning style preferences. This was supported by Frista et al. (2021), who found no interaction between problem-based learning models and student learning styles, suggesting that while the learning

model could enhance learning outcomes, it did not necessarily benefit any specific learning style over others.

Another factor influencing the absence of interaction is the negative skewness of the auditory learning style results compared to the positive outcomes associated with other styles, indicating that auditory learners did not benefit as much from the PBL model. This observation is in line with findings by Gunawan et al. (2016), who noted that no learning style particularly benefits or is disadvantaged by specific learning models, highlighting a general neutrality in the impact of learning styles on educational outcomes under the PBL model. Further analysis, as seen in Table 2, provided a p-value of 0.095 for the influence of learning styles on physics learning outcomes, which is greater than the significance level of 0.05. This confirmed that learning styles alone do not significantly impact the learning outcomes, a conclusion further supported by the observations of student interactions during group discussions and experimental activities. Students from various learning backgrounds—visual, auditory, and kinesthetic—were able to collaborate and assist each other effectively, suggesting a communal benefit that overrides individual learning style distinctions.

This communal approach to learning, where students with different styles work together, potentially neutralizes the distinct advantages or disadvantages that might typically be associated with any single learning style. This phenomenon was also highlighted in studies by Nurnaifah et al. (2022) and Suci et al. (2018), which both noted the absence of any significant influence of learning styles on physics learning outcomes. They observed that regardless of their individual learning styles, students were capable of achieving high performance through collaborative efforts, emphasizing the universal applicability and benefit of the PBL model across different learning styles.

CONCLUSION

The research conducted on the impact of the Problem-Based Learning (PBL) model on students' learning outcomes, viewed from the perspective of learning styles, conclusively demonstrated that the PBL model significantly enhances student learning outcomes. These findings were substantiated by the observed improvement in test scores from pretest to posttest, particularly in the experimental group where PBL was implemented. Despite initial equivalency in academic performance across both groups, the experimental group exhibited notably higher final scores, suggesting that the active, inquiry-based learning strategies inherent in PBL effectively engage students and promote a deeper understanding and retention of physics concepts. However, the study also highlighted that while PBL significantly impacts learning outcomes, the effect of individual learning styles—visual, auditory, and kinesthetic—was not as pronounced. The absence of a significant interaction between the PBL model and learning styles suggests that while PBL enhances overall learning, it does so irrespective of the individual learning preferences of the students. This indicates a universal applicability of the PBL approach, fostering academic success across diverse learning styles without bias.

Furthermore, the research findings suggest that traditional learning models, such as direct instruction used in the control group, may not equally benefit all types of learners, particularly those who thrive in more dynamic and interactive educational environments like those provided by PBL. The contrast between the PBL and traditional models in catering to different learning styles underscores the necessity for educational strategies that are not only adaptable to the diverse needs of students but also capable of integrating various instructional methods to optimize learning outcomes. The implementation of PBL not only supported the constructivist approach by allowing students to actively construct knowledge but also encouraged a

collaborative learning environment that facilitated peer learning and enhanced problem-solving skills.

RECOMMENDATION

Based on the findings of this study, it is recommended that educational institutions, particularly those teaching complex subjects like science, consider integrating the Problem-Based Learning model into their curriculum. Schools should provide professional development for teachers on the effective implementation of PBL, ensuring they are equipped with the necessary skills and resources to facilitate this dynamic learning environment. Additionally, while the study found that learning styles individually do not significantly influence the effectiveness of PBL, incorporating varied instructional strategies that cater to different learning preferences within the PBL framework could potentially enhance student engagement and satisfaction. It is also suggested that further research be conducted to explore the long-term impacts of PBL on student learning outcomes and to investigate its effectiveness in other subject areas to validate and expand on these findings.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to the staff and students of SMA Negeri 1 Narmada for their participation and cooperation throughout the duration of this study. Special thanks are also extended to the educational experts who provided invaluable insights and support, which greatly contributed to the research's success.

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