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The Effect of The Problem-Based Learning Model Assisted by E-LKPD to Improve Students' Learning Outcomes

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Abstract

Innovative learning approaches are crucial for enhancing student learning. Outcomes, especially for materials that require deep conceptual understanding. This study aims to examine the effect of the Problem-Based Learning (PBL) model, assisted by Electronic Learning Knowledge and Problem-Based Teaching (E-LKPD), on enhancing student learning outcomes. The research employed a one-group pretest-posttest design, where students were given a pretest before and a posttest after the implementation of the PBL model assisted by E-LKPD. Quantitative data analysis, utilizing statistical tests, was conducted to determine whether there were significant improvements in student test scores. The results showed a substantial increase in posttest scores compared to pretest scores, indicating the effectiveness of the PBL model supported by E-LKPD in improving student learning outcomes. In conclusion, the PBL approach, combined with E-LKPD, can be an effective alternative learning strategy for deepening students' conceptual understanding. The scientific implication of this study highlights the importance of integrating digital technology into problem-based learning models to enhance the quality of science education.

Keywords: E-LKPD, Problem-Based Learning, Fluida Dinamis.

INTRODUCTION

21st-century education demands innovation in the learning process to produce graduates who are adaptive, creative, and equipped with critical thinking and problem-solving skills (Trilling & Fadel, 2009). In this context, the development of higher-order thinking skills becomes crucial, especially in complex science subjects such as physics (Hmelo-Silver, 2004). Therefore, learning models that encourage students to be active, critical, and creative are essential in preparing them to face global challenges in the digital era (Savery, 2015).

One learning model proven effective in enhancing critical thinking and problem-solving skills is the Problem-Based Learning (PBL) approach. This model places students at the centre of the learning process by presenting real-world problems relevant to everyday life, thereby promoting active engagement and the construction of knowledge through self-directed learning (Barrows, 1996; Loyens et al., 2015). The integration of PBL with digital media, such as Electronic Student Worksheets (E-LKPD), is believed to strengthen the learning experience by providing more interactive and flexible learning environments (Chai et al., 2015; Lim et al., 2014).

Although PBL has been widely implemented globally and has been shown to improve learning outcomes and student motivation (Hmelo-Silver, 2004; Walker & Leary, 2009; Sungur & Tekkaya, 2006), its classroom implementation still faces several challenges. These include time constraints, limited resources, and students' difficulties in understanding abstract concepts (Hung, 2011). Furthermore, conventional, teacher-centred learning often fails to provide a deep and meaningful learning experience, particularly in complex physics topics such as static fluids (Windari & Yanti, 2021).

Previous studies have demonstrated that integrating PBL with E-LKPD can significantly enhance students' conceptual understanding, critical thinking skills, and academic achievement (Wang, 2016; Lin et al., 2017; Nurhayani et al., 2023; Hidayah, 2022). For instance, Nurhayani et al. (2023) found that the use of PBL-based E-LKPD improved the critical thinking skills of eighth-grade students. Similarly, Hidayah (2022) reported the effectiveness of PBL-based E-LKPD in fostering critical thinking on global warming topics at the senior high school level. However, research on the impact of PBL-based E-LKPD on student learning outcomes, particularly in complex physics materials such as static fluids, remains limited in the Indonesian context.

The novelty of this study lies in evaluating the impact of implementing the PBL model assisted by E-LKPD on students' learning outcomes in static fluid topics using a quasi-experimental design. This study aims to identify significant differences in learning outcomes before and after the application of the method and to contribute meaningfully to the development of digital technology-based learning strategies in the modern era (Ilham et al., 2024).

MATERIALS AND METHODS

Time and Place

This research was conducted in May 2025 at SMAN 1 Narmada, West Lombok Regency, West Nusa Tenggara. The selection of this school as the research site was based on its readiness to implement digital-based

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learning and support the application of innovative learning models (Sugiyono, 2017).

Research Design

The study employed a quasi-experimental design with a pretest-posttest control group design, which enabled researchers to make objective comparisons of student learning outcomes between the experimental and control groups (Creswell, 2012). In this design, the experimental group received treatment using the Problem-Based Learning (PBL) model supported by Electronic Student Worksheets (E-LKPD). In contrast, the control group was taught using conventional learning methods.

Population and Sample

The research population included all Grade XI science students at SMAN 1 Narmada who were studying fluid dynamics during the second semester of the 2024/2025 academic year. The sample consisted of two classes, each comprising 36 students, selected using a purposive sampling technique—a method of selecting classes with similar characteristics and relevance to the research objectives (Sugiyono, 2017). The independent variable in this study was the implementation of the PBL model assisted by E-LKPD, while the dependent variable was students' learning outcomes on fluid dynamics material.

Instrument

The primary research instrument used to collect data was a learning outcomes test, comprising pretest and posttest items that had been validated by content experts (Arikunto, 2019). In addition, observation sheets were used to monitor the implementation of learning activities in both classes. Supporting devices included computers or laptops, projectors, and E-LKPDs specifically designed to align with the PBL syntax and fluid dynamics content.

Research Procedure

The research procedure began with the development and validation of the instruments, followed by the administration of a pretest to both groups to assess students' initial abilities. Next, learning activities were conducted using the respective treatments: the experimental group was taught using the PBL model assisted by E-LKPD, while the control group received conventional instruction. Upon completion of the learning sessions, a posttest was administered to measure students' learning gains. Throughout the learning process, classroom observations were conducted to ensure that the intended instructional models were implemented as designed (Sugiyono, 2017).

Data Analysis Techniques

The learning outcome data were analysed quantitatively. The analysis began with normality and homogeneity tests to verify that the data met the assumptions required for parametric statistical analysis (Priyatno, 2016). The improvement in learning outcomes was measured using the normalised gain (N-gain) formula proposed by Hake (1999). To test the hypothesis, an independent samples t-test was conducted to determine whether there were significant differences in learning outcomes between the experimental and control groups (Creswell, 2012). The results of the analysis were interpreted to conclude that the E-LKPD-assisted PBL model is efficacious in improving students' academic performance.

RESULT AND DISCUSSION

Result

This study aimed to evaluate the effect of implementing the Problem-Based Learning (PBL) model assisted by Electronic Student Worksheets (E-LKPD) on student learning outcomes in fluid dynamics material. Based on the data obtained from the pretest and posttest, there was a significant improvement in the learning outcomes of students in the experimental class compared to those in the control class.

Prior to the treatment, a pretest was administered to both classes to determine students' initial abilities. The average pretest scores were 52.3 for the experimental class and 51.7 for the control class, indicating that both groups started from relatively similar levels. After the learning interventions were implemented according to their respective models, a post-test was conducted. The experimental class, which was taught using the PBL model assisted by E-LKPD, achieved a posttest average score of 82.1. In contrast, the control class, taught through conventional methods, obtained an average score of 70.4.

To measure the effectiveness of the intervention, the normalised gain (N-gain) was calculated using the formula proposed by Hake (1999). The experimental class obtained an N-gain of 0.62, which falls into the moderate to high category, whereas the control class achieved an N-gain of 0.39, categorised as moderate (Table 1).

Before conducting hypothesis testing, the data were subjected to normality and homogeneity tests to ensure the assumptions of parametric analysis were met (Priyatno, 2016). The results of the normality test (Shapiro-Wilk) and homogeneity test (Levene's Test) confirmed that the data were normally distributed and homogeneous. Therefore, further analysis was carried out using the independent samples t-test.

The t-test results showed a statistically significant difference in posttest scores between the experimental and control groups ($p < 0.05$), confirming that the use of the PBL model assisted by E-LKPD had a meaningful impact on improving student learning outcomes (Creswell, 2012).

These findings are consistent with previous studies, such as those by Putri and Nabila (2024), which found that PBL supported by digital media effectively enhanced students' conceptual understanding and cognitive development in physics learning. Similarly, Eduproxima (2024) highlighted the positive influence of E-LKPD in increasing student achievement and active engagement.

In addition to learning outcomes, qualitative observations showed a notable increase in student learning activity and engagement in the experimental class. Students demonstrated active participation in problem-solving, collaboration, and discussion, all of which were facilitated by the interactive features of the E-LKPD. This contrasts with the control class, where student involvement was observed to be more passive.

These results are in line with the findings of Hmelo-Silver (2004), who emphasised that PBL enhances motivation and promotes critical thinking skills. Moreover, Putri (2024) confirmed that digital interactive media, such as E-LKPD, can help overcome the passive nature of traditional learning and foster a more student-centered learning environment.

Overall, the findings of this study support the integration of PBL with E-LKPD as an effective instructional strategy, particularly for complex physics materials such as fluid dynamics. It also aligns with the objectives of the Independent Curriculum, which emphasises active, collaborative, and technology-integrated learning.

Table 1. Average Pretest and Posttest Scores of Student Learning Outcomes

Group	Total	Pretest Average	Posttest Average	N-gain Scores
Eksperimen	36	52,3	82,1	0,62
Kontrol	36	51,7	70,4	0,39

Discussion

The application of the PBL model, which places students at the centre of learning, has proven effective in improving learning outcomes in fluid dynamics material. The integration of E-LKPD offers interactive and easily accessible learning media, facilitating students' understanding of abstract concepts (Barrows, 1996; Chai et al., 2015). These results support Nabila's research (2024), which showed a significant increase in students' learning outcomes and problem-solving abilities through PBL-based electronic modules.

The use of E-LKPD as an interactive learning medium can increase students' learning activities and motivation. This media overcomes the limitations of conventional methods, which tend to be passive, by providing a more engaging and collaborative learning experience (Putri, 2024; Sungur & Tekkaya, 2006). Observations and questionnaires showed positive responses from teachers and students to the use of PBL assisted by E-LKPD as a practical and effective independent teaching material (Eduproxima, 2024).

Overall, the results of this study confirm that the PBL model, assisted by E-LKPD, is efficacious in improving student learning outcomes and activities related to fluid dynamics material. The integration of problem-based learning approaches with digital technology can be an innovative learning strategy that aligns with the demands of independent curriculum development and the advancement of educational technology (Trilling & Fadel, 2009; Ilham et al., 2024). The application of this model is expected to enhance the quality of physics learning at the high school level and motivate students to engage in active and independent learning.

CONCLUSION

Based on the results of the study conducted on grade XI IPA students at SMAN 1 Narmada, it can be concluded that the application of the Problem-Based Learning (PBL) model assisted by E-LKPD significantly improves student learning outcomes in fluid dynamics material compared to conventional learning. The integration of PBL and E-LKPD not only improves students' conceptual understanding but also encourages critical thinking skills and problem-solving abilities more effectively. These findings provide an important contribution to the development of innovative learning strategies based on digital technology that are relevant and applicable in the context of science education in high schools in Indonesia.

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