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# The Influence of Project-Based Learning Models on the Activities and Learning Outcomes of Vocational Students in Informatics Subjects

Triwahyudi Triwahyudi[1)✉], Zuwirna Zuwirna[2)], Nurhasan Syah[3)], Ramalis Hakim[4)]
*✉1) Universitas Negeri Padang, Padang, Indonesia*
*E-mail: sabaqihaffar@gmail.com*
*2) Universitas Negeri Padang, Padang, Indonesia*
*E-mail: zuwirnawz@fip.unp.ac.id*
*3) Universitas Negeri Padang, Padang, Indonesia*
*E-mail: nurhasan@ft.unp.ac.id*
*4) Universitas Negeri Padang, Padang, Indonesia*
*E-mail: ramalishakim@gmail.com*

✉ Correspondence Author

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**Abstract**
This study investigates the effectiveness of the Project-Based Learning (PjBL) model in enhancing student engagement and learning outcomes in Informatics at a vocational high school. The research was motivated by the low initial understanding and passive learning behavior among students, which often leads to suboptimal academic achievement. The objective was to determine whether the PjBL approach could significantly improve both student activity and performance. A quasi-experimental design with a pretest-posttest control group was employed, involving 51 Grade X students from SMKN 1 Painan, divided into an experimental group (PjBL) and a control group (conventional teaching). Data were collected through tests, observations, and documentation, and analyzed using descriptive and inferential statistics. Results showed a significant increase in the experimental group's posttest scores (mean = 78.04; N-Gain = 0.56) compared to the control group (mean = 64.56; N-Gain = 0.28). Student activity also improved across three meetings. Statistical tests confirmed the differences were significant ($p < 0.05$). These findings indicate that PjBL is more effective than traditional methods in promoting academic success and active learning in vocational education.

## INTRODUCTION

In the era of digital transformation and 21st-century learning, the demands placed on education have shifted significantly. Vocational education, in particular, is expected to not only equip students with theoretical knowledge but also develop their practical skills, critical thinking, collaboration, and creativity (Ahmad et al., 2023). Informatics, as a core subject in vocational schools, plays a strategic role in preparing students to navigate and contribute to increasingly technology-driven work environments. However, traditional teaching methods that rely heavily on

lectures and individual tasks often fail to stimulate meaningful learning and student engagement (Ariawan & Suartama, 2023).

Numerous studies have emphasized the importance of student-centered learning approaches to address the challenges of disengagement and low academic performance in vocational settings. Among these approaches, Project-Based Learning (PjBL) has gained prominence for its potential to make learning more contextual, interactive, and competency-based. According to Morais et al., (2021), PjBL engages students in complex, real-world tasks that promote deeper understanding and long-term retention. It also aligns well with constructivist learning theories, which posit that knowledge is best acquired through active exploration and social interaction.

Several empirical studies have reported positive effects of PjBL on student learning outcomes. For example, Fitrihana & Nurdiyanto, (2024) found that PjBL significantly improved students' critical thinking skills, while Safaruddin et al. (2024) reported enhanced cognitive achievement in chemistry through project-based methods. Furthermore, Mijić & Ćebić, (2022) highlighted that PjBL supports the development of 21st-century skills, making it a relevant model for modern vocational education. Despite this, most studies have focused on general academic subjects or specific scientific domains, with limited research targeting Informatics in vocational high school contexts.

This research addresses a critical gap in the literature by examining the implementation of the PjBL model specifically within the Informatics subject at the vocational high school level. While previous studies have demonstrated PjBL's effectiveness in general, there is limited understanding of how it affects student performance and engagement in skill-oriented, technology-based subjects like Informatics, especially in Indonesian vocational education settings. Additionally, few studies have systematically compared PjBL to conventional methods using rigorous experimental designs (Paľová & Vejačka, 2022; Samah et al., 2022).

The novelty of this study lies in its integrative approach, combining cognitive outcomes (pretest-posttest scores) with behavioral indicators (student activity) to assess the holistic impact of PjBL. Unlike prior research that often focuses solely on test scores, this study captures the dynamic nature of student learning experiences by observing classroom behavior over multiple sessions. Moreover, by applying PjBL to an Informatics curriculum in a real vocational school setting, this study provides new insights into its practical feasibility and effectiveness in domains requiring both theoretical understanding and technical skills (Khotimah et al., 2025; Lopez-Gazpio, 2021).

The main objective of this study is to determine whether the PjBL model can significantly improve learning outcomes and student engagement compared to traditional teaching methods. By using a quasi-experimental design with pretest-posttest control groups, the research offers a robust framework for assessing the causal effects of the instructional intervention. Data are analyzed using descriptive and inferential statistics, including t-tests and gain score comparisons, to ensure validity and reliability of the findings.

Ultimately, this research contributes to the growing body of knowledge on innovative pedagogical strategies in vocational education. It offers empirical evidence supporting the adoption of PjBL as an effective teaching model in Informatics and similar technical subjects (Zen & Ariani, 2022). The findings not only benefit educators and curriculum developers but also inform policy makers aiming to improve the quality and relevance of vocational training in Indonesia and beyond.

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## METHODS

This study employed a quantitative approach with a quasi-experimental design to investigate the effect of Project-Based Learning (PjBL) on student engagement and learning outcomes in Informatics. The research used a Pretest-Posttest Control Group Design, consisting of two groups: the experimental group received instruction using PjBL, while the control group followed conventional teaching methods such as lectures and individual assignments. Both groups were assessed using pretests and posttests to measure the impact of the instructional models. The comparison of scores before and after the intervention aimed to determine whether PjBL significantly influenced students' cognitive achievements.

The population of this study consisted of all Grade X students in the Computer and Network Engineering (TJKT) program at SMKN 1 Painan in the academic year 2024/2025, totaling 51 students across two classes. Using purposive sampling, the two classes with similar academic characteristics were selected: one class (X TJKT2, 25 students) as the experimental group and the other (X TJKT1, 26 students) as the control group. This selection ensured that both groups had relatively equal initial understanding, as verified through similar pretest results. This sampling technique was chosen to maintain relevance and fairness in comparing the instructional treatments.

The primary research instrument was a multiple-choice test consisting of 20 items, developed based on a blueprint that aligned with cognitive levels C1 to C4 of the revised Bloom's taxonomy. The same test items were used for both pretest and posttest, with randomized order in the posttest to reduce bias. The instrument underwent a rigorous validation process, including validity testing (using Pearson's correlation), reliability testing (KR-20, with a score of 0.919 indicating very high reliability), item difficulty analysis, and discrimination index analysis. The majority of items were categorized as moderately difficult and had good discrimination power, ensuring the test's effectiveness for assessing learning outcomes.

Data collection was conducted through tests, observation, and documentation. Tests captured cognitive learning outcomes, while classroom observation using validated observation sheets measured student activity indicators, differing for each group based on instructional style. Documentation supported data triangulation, including syllabi, instructional modules, photos, attendance records, and student scores. Data were analyzed using both descriptive and inferential statistics. Descriptive analysis included mean, standard deviation, and N-Gain, while inferential tests (normality, homogeneity, and t-tests) were applied to evaluate the significance of differences between the two groups. All analyses were carried out using Microsoft Excel.

## RESULT AND DISCUSSION

The findings of this study indicate that the implementation of Project-Based Learning (PjBL) significantly enhanced both the learning outcomes and the engagement levels of students in the experimental class. Table 1 presents the descriptive statistics of students' pretest and posttest scores, as well as the normalized gain (N-Gain). The mean pretest score was 51.20, which improved to 78.04 in the posttest, resulting in an N-Gain of 0.56 categorized as moderate. The increase in median and mode values, alongside a slight rise in standard deviation, indicates a substantial improvement in students' understanding, albeit with a moderate spread of final outcomes.

**Table 1. Descriptive Statistics of Learning Outcomes in the Experimental Class**

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| Description | Pretest | Posttest | N-Gain |
|---|---|---|---|
| Highest Score | 62.00 | 89.00 | 0.73 |
| Lowest Score | 41.00 | 68.00 | 0.45 |
| Mean | 51.20 | 78.04 | 0.56 |
| Median | 51.00 | 78.00 | 0.54 |
| Mode | 52.00 | 78.00 | 0.50 |
| Standard Deviation | 5.43 | 5.68 | 0.07 |
| Variance | 29.50 | 32.21 | 0.01 |

The frequency distribution of posttest scores (Table 2) further supports the effectiveness of the PjBL model. The majority of students (32%) scored within the 75.0–78.4 range, while 88% achieved scores above 71.4. This reflects a shift from the lower performance observed in the pretest phase, where most scores clustered between 48.0 and 54.9. The improved distribution suggests a positive impact of the project-based approach on student achievement and a more equitable understanding of the subject matter across the class.

**Table 2. Frequency Distribution of Posttest Scores – Experimental Class**

| Interval (Score) | Frequency | Relative Frequency | Cumulative Freq. | Cumulative Rel. Freq. |
|---|---|---|---|---|
| 68.0 – 71.4 | 4 | 16% | 4 | 16% |
| 71.5 – 74.9 | 3 | 12% | 7 | 28% |
| 75.0 – 78.4 | 8 | 32% | 15 | 60% |
| 78.5 – 81.9 | 4 | 16% | 19 | 76% |
| 82.0 – 85.4 | 3 | 12% | 22 | 88% |
| 85.5 – 88.9 | 3 | 12% | 25 | 100% |

In addition to cognitive outcomes, student activity levels during the PjBL sessions were also observed and analyzed. As shown in Table 3, there was a consistent increase in the average activity score over three meetings from 10.32 to 17.88. These scores reflect active participation in collaborative group tasks, problem-solving discussions, and presentation activities, confirming that PjBL encourages higher engagement. The rising trend in student activity suggests that the project-based format provided a more stimulating and student-centered learning environment.

**Table 3. Mean Student Activity Scores in the Experimental Class**

| Meeting | Mean Activity Score |
|---|---|
| Meeting 1 | 10.32 |
| Meeting 2 | 14.28 |
| Meeting 3 | 17.88 |

These findings collectively demonstrate that the PjBL approach not only improves students' cognitive performance but also fosters their active involvement in the learning process. Compared to conventional methods, which yielded lower gains and less consistent engagement, PjBL proved to be more effective in creating a dynamic, interactive, and meaningful learning experience, particularly in vocational education contexts such as Informatics at SMK.

## Discussion

The findings of this study demonstrate the significant impact of Project-Based Learning (PjBL) on improving both learning outcomes and student engagement in vocational high school Informatics classes (Kumar, 2021). The substantial increase in posttest scores, with an average N-Gain of 0.56 in the experimental group, confirms that PjBL is an effective pedagogical approach for

enhancing student comprehension. This outcome aligns with constructivist learning theories, which emphasize the importance of active student involvement in real-world problem-solving and meaningful learning experiences. Compared to the control group, which achieved a lower N-Gain of 0.28, the PjBL model proved more successful in fostering deeper understanding and application of knowledge.

The enhancement in cognitive achievement can be attributed to the design of the PjBL model, which requires students to engage in hands-on, collaborative tasks that simulate real-life contexts (Almutairi & Delaney, 2023; Herlambang et al., 2024). Through this method, students are not merely passive recipients of information but active constructors of knowledge. The structured yet flexible nature of PjBL enables learners to explore Informatics concepts by developing projects that are both challenging and relevant. As a result, students are better able to link theoretical knowledge with practical implementation, thereby increasing retention and mastery of content, as evidenced by the shift in score distributions toward higher performance intervals in the posttest phase.

In addition to academic outcomes, this study also confirmed that PjBL significantly improved student engagement and activity during the learning process (Gupta, 2022; Suartama et al., 2024). Observational data showed a progressive increase in the average activity score from 10.32 in the first session to 17.88 by the third session in the experimental group. This trend suggests that the PjBL model effectively cultivates a classroom environment that encourages interaction, cooperation, and active participation. Students were more involved in discussions, group work, and presentations activities that develop soft skills such as communication, leadership, and critical thinking, which are essential for vocational education and 21st-century learning.

The comparative analysis between the experimental and control groups further validates the superiority of PjBL in facilitating active learning. While the control group did show some improvement in both academic performance and activity levels, the gains were significantly lower. The conventional teaching approach, characterized by lectures and individual assignments, limited students' opportunities to explore concepts in depth or engage with peers. This finding is consistent with previous studies Al-Bahadli et al., (2023); Panwar et al., (2020), which highlight that passive instructional methods are less effective in motivating students or fostering high-level thinking skills.

Results reinforce the idea that Project-Based Learning is a powerful instructional strategy in vocational settings. Its ability to simultaneously enhance academic performance and stimulate active learning positions it as a valuable alternative to traditional teaching methods. The practical implication is that educators and curriculum developers should consider integrating PjBL into Informatics and other skill-based subjects to promote holistic student development (Habibi et al., 2025; Sugiyanto et al., 2020). Future research may further explore the long-term effects of PjBL on knowledge retention, creativity, and real-world problem-solving competencies among vocational students.

## CONCLUSIONS

This study concludes that the Project-Based Learning (PjBL) model is significantly more effective than conventional teaching methods in enhancing both learning outcomes and student engagement in Informatics at vocational high schools. The implementation of PjBL led to a higher posttest average and a moderate category N-Gain score in the experimental group, indicating meaningful cognitive improvement. Furthermore, consistent increases in student activity scores

across multiple sessions demonstrate that PjBL fosters active, collaborative, and meaningful participation. These findings confirm that PjBL not only improves academic performance but also cultivates essential soft skills needed in vocational education. Therefore, PjBL is recommended as a pedagogical strategy for improving the quality and relevance of learning in technical and skill-based subjects.

## CONFLICTS OF INTEREST STATEMENT

Regarding this study, the author declares that there is no conflict of interest.

## AUTHOR CONTRIBUTIONS

Study concept and design: Triwahyudi Triwahyudi. Acquisition of data: Zuwirna Zuwirna. Analysis and interpretation of data: Nurhasan Syah. Drafting the manuscript: Triwahyudi Triwahyudi. Critical revision of the manuscript for important intellectual content: Ramalis Hakim. Statistical analysis: Triwahyudi Triwahyudi.

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