Exploration of the implementation of project-based learning in technical drawing courses toward

Rizki Fitra*, Febri Prasetya and Junil Adri

Departemen of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, **INDONESIA**

Abstract: The instruction of Manufacturing Technical Drawings remains predominantly teacher-centered, lacking diversity in methodologies, thereby causing students to perceive the subject as challenging. This challenge primarily stems from their struggles in comprehending CAD drawing concepts, interpreting existing drawings, and understanding the functionalities of tools in the AutoCAD application, as outlined in the job sheet. Consequently, students' learning achievements fall short of the minimum passing standards SMK Negeri 1 Tanjung Raya set. This research aims to evaluate the impact of project-based learning on learning outcomes in manufacturing technical drawings and assess the quality of instructional tools employed. The study involves two groups, experimental and control groups, selected through cluster random sampling. Data collection includes pretests administered before the instructional intervention and post-tests conducted after both groups receive different treatments. Results reveal that students in the experimental group attain significantly higher average scores than the control group, indicating a substantial influence of project-based learning on learning outcomes. This approach enhances students' understanding, engagement, and critical thinking abilities within the subject area.

Keywords: Vocational School; Detail drawing; Drafter learning; Mechanical Engineering Education

*Corresponding Author: rizkifitra046@gmail.com
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1. Introduction

Education plays a crucial role in human life (Waskito et al., 2024). It serves not only as a fundamental foundation for social interaction but also exerts significant impacts on enhancing future life quality (Syahril et al., 2022, 2021). In this context, education is construed as efforts to improve various aspects of life, which are essential for achieving positive progress, moral development, and national self-esteem (Dewi & Alam, 2020). To attain these goals, education must align with national directives while remaining responsive to the needs and dynamics of the global era.

The significance of education for the advancement of a nation cannot be underestimated (Muskhir et al., 2023). However, regrettably, the current educational situation in Indonesia faces various challenges. The shortage of fully professional educators and the inadequacy of educational facilities and infrastructure all contribute to the quality of education falling short of expected standards (Budiharso & Tarman, 2020; Prasetya, Fajri, et al., 2023). The primary goal of education is to shape individuals who are faithful, morally upright, healthy, intelligent, and capable of contributing constructively (Abad-Segura et al., 2020; Almulla, 2020). As the primary educational institutions, schools are responsible for achieving national educational objectives. Hence, school management must be conducted effectively to ensure the education meets the anticipated standards.

The role of Vocational High Schools (SMK) in preparing individuals for the workforce is increasingly emphasized (Soputan & Sumual, 2019; Suharno et al., 2020). Vocational education is formulated to cultivate various skills, knowledge, attitudes, work habits, and appreciation necessary for workers to succeed in a productive and meaningful work environment (Indrawati & Kuncoro, 2021; Ismara et al., 2023; Ridwan et al., 2022). As one of the formal educational institutions, SMK Negeri 1 Tanjung Raya plays a crucial role in equipping learners with relevant skills for various fields of work. Among the competencies offered, mechanical engineering stands out. The Manufacturing Technical Drawings subject is an integral aspect of its curriculum (Alhayani & Abdallah, 2020).

In this context, manufacturing technical drawings serve as a means of communication between planners and implementers in manufacturing tools and machines. In this instructional setting, students are trained to master the skill of drawing components, tools, or machine designs according to standards using Computer-Aided Design (CAD) software (Tumulu & Sarkar, 2018). Teachers assign tasks as job sheets that students will later implement during practical sessions using machine tools (Prasetya et al., 2021; Prasetya, Fortuna, et al., 2023). This learning activity aims to prepare students to enter the workforce equipped with relevant and up-to-date skills.

One increasingly prominent approach is project-based learning (Aziz et al., 2023). This methodology places students in situations resembling real-world scenarios, where they are assigned project tasks demanding problem-solving and the application of learned concepts in practical contexts (Jalinus et al., 2022; Wulansari et al., 2023). Project-based learning has garnered significant attention in higher education, particularly in courses requiring the application of technical concepts such as Technical Drawing (Syahril et al., 2021). Within project-based learning, students are afforded opportunities to engage in practical projects necessitating the application of learned concepts in real-world contexts. This approach is anticipated to enhance conceptual understanding, practical skills, and student engagement (Wayan Santyasa et al., 2021).

Research pertaining to the influence of project-based learning on learning outcomes has emerged as a primary focus in contemporary educational literature. Previous studies have underscored the benefits of this approach, indicating that project-based learning can significantly enhance conceptual understanding, problem-solving skills, and student engagement (Chang et al., 2022; Karan & Brown, 2022). However, despite these promising findings, more in-depth research is still required to comprehensively understand the mechanisms and factors influencing the effectiveness of project-based learning in specific contexts, such as the Technical Drawing course.

In this context, research on the impact of project-based learning on learning outcomes in the Technical Drawing course is both relevant and crucial (Mursid et al., 2022). This course exhibits specific characteristics regarding applying technical concepts, problem-solving, and design skills. By leveraging the project-based learning approach, it is anticipated that students can cultivate a deeper understanding of the principles of technical drawing and effectively apply them in real project contexts. Consequently, this study aims to investigate the tangible effects of employing project-based learning in enhancing student learning outcomes in the Manufacturing Technical Drawings

course and explore the factors influencing its effectiveness. Despite the widespread recognition of project-based learning approaches, there remains a need for a more comprehensive understanding of their impact on student learning outcomes, particularly in courses such as Manufacturing Technical Drawings. Relevant research questions in this context include:

RQ1. How does the project-based learning approach affect students' understanding of basic engineering drawing concepts?
RQ2. Can the project-based learning approach improve students' practical skills in designing and interpreting engineering drawings?

2. Material and methods

2.1 Research design

This study employs quantitative methods to test hypothesis conclusions through statistical analysis (Mohajan, 2020). The research design utilized is quasi-experimental, employing one experimental group and one control group to observe differences in student learning outcomes between the experimental and control groups. After the instructional period, a test will be administered to both groups (Miller et al., 2020).

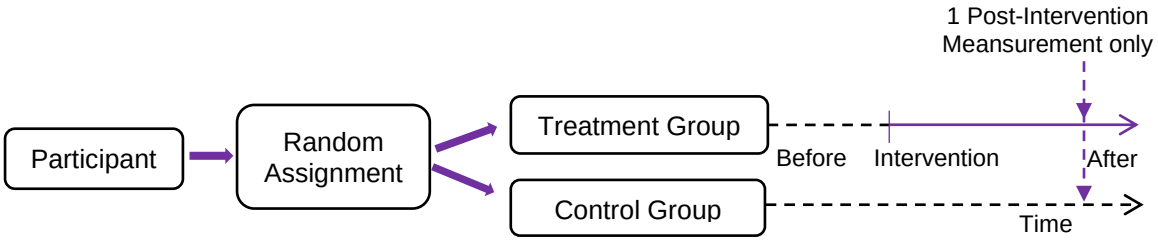

Figure 1. Quasi Experimental design

2.2 Research subject

The research subjects are confined to entities or individuals serving as sources of information for the variables under investigation (Albus et al., 2021). The research subjects were students of the Mechanical Engineering Study Programme at SMK Negeri 1 Tanjung Raya, West Sumatra, Indonesia. The research subjects for this study consisted of 20 students from Class XI TPM 1 and 20 students from Class XI TPM 2, who served as the control group.

2.3 Data collection technique

Student performance assessment in the psychomotor aspect is conducted during practical activities. Performance assessment is a technique used to evaluate behaviors demonstrated by students directly through process-based assessment and direct observation by teachers, evaluating both process and results using rubrics containing criteria and scores (Caena & Redecker, 2019). Documentation is a data collection technique derived from written materials (Asrial et al., 2019). Researchers

can directly obtain existing document materials and acquire the required data, such as a list of student names.

2.4 Data analysis technique

This study utilized the One-sample Kolmogorov-Smirnov test for data processing. Statistical analysis was conducted using SPSS version 24.0, with a significance level set at 0.05. If the significance level yields a value greater than 0.05, the sample is considered to have a normal distribution. Conversely, the Barlett test was employed via SPSS 24.0 to assess homogeneity, with a significance level (α) of 0.05. A significance value exceeding 0.05 indicates homogeneous group data variance. The t-test was utilized for hypothesis testing; specifically the two-tailed T-Test, conducted using SPSS version 24.0. If the two-tailed significance value is less than 0.05, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted.

3. Results

3.1 Data description

The data description in this study is derived from research conducted at SMKN 1 Tanjung Raya in the Manufacturing Technical Drawing course for Grade XI Mechanical Engineering students. Research data were obtained from assessing psychomotor performance aspects using rubrics to assess students' practical performance. Initial data were obtained from the pretest scores of 20 students' knowledge assessments. Pretest scores were obtained before instruction and were used to determine the experimental and control groups. The highest average pretest score determined the control group, while lower pretest scores were allocated to the experimental group. The final data were post-test scores, which were a basis for comparing the effects of project-based learning and conventional teaching methods using practical performance assessments.

The pretest was administered to students during the first session. Subsequently, the researcher collected, examined, and analyzed the outcomes. The student's learning outcomes in classes XI PTM 1 and XI PTM 2 before receiving any treatment are presented in Table 1.

Table 1. Recap of Pretest Score Results

Class Group	Total Value	Average
XI TPM 1	1.180	59.00
XI TPM 2	1.278	63.90

The pretest results show that the average in XI TPM 2 is higher than XI TPM 1, so the XI TPM 1 class is used as the experimental class, and the XI TPM 2 class becomes the control class. The post-test serves as the final assessment conducted after the treatment is administered to students, aiming to ascertain the learning progress of both classes following instruction using the implemented model. The outcomes of the post-test for both classes are presented in Table 2.

Table 2. Summary of Post-Test Values of Experimental and Control Classes

Statistics	Experiment class	Control class
Number of Students (N)	20	20
Total Value	1587	1438
Average	79,38	71,94
Standard Deviation	8,46	10,12
Variance	71,63	102,37
Maximum Value	91,25	87,5
Minimum Value	60	56,25

Based on the summary table of post-test scores above, it is observed that N represents the number of students in the experimental class, which is 20 students, while the number of students in the control class is also 20. The total scores from the experimental class amount to 1587, whereas the total scores from the control class amount to 1438. Furthermore, the average score obtained from the experimental class is 79.38, and from the control class is 71.94. The standard deviation for the experimental class is 8.46, and the control class's is 10.12. Additionally, the variance for the experimental class is 71.63, and for the control class is 102.37. Moreover, the maximum score attained by the experimental class is 91.25, with a minimum score of 60, while the maximum score achieved by the control class is 87.5, with a minimum score of 56.25.

3.2 Normality test

The learning outcomes data applied using project-based learning (A1) 0.130 > 0.05 indicates normal data distribution. The learning outcomes data obtained from conventional methods (A2) 0.054 > 0.05 also suggests normal data distribution. Overall, the significance value or probability value > 0.05 allowing for a conclusion that the learning outcomes in both the experimental and control classes follow a normal distribution.

3.3 Homogeneity test

The homogeneity of variance test results for student learning outcomes data indicates that the significance value or probability value of 0.085 > 0.05. Therefore, a decision can be made that the variance of student learning motivation data is equal.

3.4 Hypothesis Test

The t-test results with a significance value of 0.00 indicate that the significance value is < 0.05. Therefore, the decision drawn from this test result is to reject the null hypothesis (Ho) and accept the alternative hypothesis (Ha).

4. Discussion

This study results from research conducted at SMKN 1 Tanjung Raya in the Manufacturing Technical Drawing course for Grade XI Mechanical Engineering students. The research data were obtained from assessing psychomotor performance

using a performance rubric. The research outcomes are expected to yield positive learning outcomes for students, thereby fostering effective learning interest in the educational realm or providing solutions to existing problems. The research instrument underwent evaluation, including validation. Two validators, namely two subject matter experts in manufacturing technical drawing, validated the instrument to ensure its suitability.

Implementing the project-based learning model in manufacturing technical drawing can make students more active, thus increasing their learning interest. Based on the validation analysis by subject matter experts, it is evident that, according to the data analysis obtained, there is a difference between the experimental and control groups in both sample classes. This can be observed from the average learning outcomes obtained from the Post-test scores, with the experimental class scoring 79.38 and the control class scoring 71.94. These data indicate that the average learning outcomes for the experimental class, which implements project-based learning, are higher than those for the control class, which employs conventional methods.

Furthermore, comparing the average scores of both sample classes, a t-test was conducted to test the research hypothesis. Based on data analysis, the significance value (2-tailed) is 0.00 for both class groups, which is smaller than 0.05. Thus, the hypothesis proposed can be accepted, indicating the influence of the project-based learning model on learning outcomes in manufacturing technical drawing at SMKN 1 Tanjung Raya with significant and acceptable levels. After undergoing the research phases and testing, the project-based learning model used by the researcher proved effective as a learning medium in the manufacturing technical drawing course.

5. Conclusion

Education plays a crucial role in enhancing human quality of life and the development of a nation. In Indonesia, the educational landscape faces various challenges, ranging from a shortage of professional educators to inadequate educational facilities and infrastructure. Vocational High Schools (SMK) are pivotal in preparing individuals for the workforce. One significant subject in this context is Manufacturing Technical Drawing. In the teaching of Manufacturing Technical Drawing, project-based learning approaches are increasingly emphasized as they can enhance conceptual understanding, practical skills, and student engagement. This study employs a quasi-experimental method with one experimental class and one control class to examine the influence of project-based learning on learning outcomes in the Manufacturing Technical Drawing course at SMK Negeri 1 Tanjung Raya. The research findings indicate that the project-based learning model effectively improves student learning outcomes. Statistical analysis reveals a significant difference between the learning outcomes of students using the project-based learning approach and those using conventional methods.

The scope of this study encompasses focusing on the influence of the project-based learning model on student learning outcomes in the Manufacturing Technical Drawing course at SMK Negeri 1 Tanjung Raya. The research uses a quasi-experimental method to involve one experimental class and one control class. The research subjects consist of 20 students from Grade XI TPM 1 as the experimental class and 20 from Grade XI TPM 2 as the control class. Data collection involves assessing

psychomotor aspects of student performance using a performance rubric. Data analysis entails conducting tests for normality, homogeneity, and hypothesis using SPSS software version 24.0.

Future research endeavors include expanding the research scope to various types of schools and educational levels to generalize findings more broadly, considering additional factors that may influence learning outcomes, such as student motivation, learning environment, and family support. Additionally, further studies should be conducted to compare the effectiveness of various project-based learning methods in different subject contexts and investigate the impact of project-based learning models on cognitive, affective, and psychomotor aspects of student learning outcomes in more depth. Employing more complex research designs, such as longitudinal research design, to observe the development of learning outcomes over time is also warranted. Ultimately, further research to identify the most effective project-based learning strategies for achieving specific learning objectives will provide a better understanding of enhancing student learning outcomes in an evolving educational context.

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Declarations

Author contribution

Rizki Fitra contributed to the development of the research design, the development of instruments to assess mechanical drawing skills, data collection, processing of research data and writing the first draft of the article. Febri Prasetya contributed to the processing and interpretation of research data. Junil Adri contributed to the revision of the research instrument, research methodology, results and discussion.

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Conflict of interest

There is no conflict of interest in this study.

Ethical Clearance

This research was approved by the local education authority and the school where the research was carried out. Prior to conducting the study, the authors obtained the consent of the students involved as subjects in this study.

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