

ORIGINAL

Implementation of a Project-Based Inquiry Learning Model for Electrical Motor Installation: Evaluating Its Effectiveness in Vocational Education

Implementación de un modelo de aprendizaje por investigación basado en proyectos para la instalación de motores eléctricos: Evaluación de su eficacia en la formación profesional

Chrismondari^{1,2} , Wakhinuddin Simatupang³ , Waskito⁴ , Rahmat Fadillah⁵ , Bayu Rianto⁶ 

¹Universitas Negeri Padang, Doctoral Program of Technical Vocational and Education. Padang, Indonesia.

²Sekolah Tinggi Teknologi Pekanbaru, Department of Electrical Engineering. Pekanbaru, Indonesia.

³Universitas Negeri Padang, Department of Automotive Engineering. Padang, Indonesia.

⁴Universitas Negeri Padang, Department of Mechanical Engineering. Padang, Indonesia.

⁵Universitas Negeri Padang, Department of Electronic Engineering. Padang, Indonesia.

⁶Universitas Islam Indragiri, Department of Information System. Indragiri Hilir, Indonesia.

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Corresponding author: Bayu Rianto 

ABSTRACT

Vocational education plays a key role in equipping students with the practical skills needed for workforce participation, particularly in technical fields like electrical motor installation. This study investigates the effectiveness of the Project-Based Inquiry Learning (PBIL) model in enhancing students' learning outcomes in electrical motor installation within vocational education. The primary objective is to evaluate whether PBIL can improve students' technical competencies, critical thinking, problem-solving abilities, and collaborative skills, which are crucial for success in the electrical and industrial sectors. The research was conducted using a quasi-experimental design with a Nonequivalent Control Group. The experimental group (37 students) received PBIL instruction, while the control group (35 students) followed traditional teacher-centered methods. Data were collected through pre- and post-tests, practical performance assessments, surveys, and semi-structured interviews, analyzed using both quantitative and qualitative methods. The results indicate that the experimental group showed significant improvements in technical skills, problem-solving, and teamwork compared to the control group. PBIL also enhanced students' motivation, engagement, and adaptability to technological demands. The study concludes that PBIL is an effective instructional approach for bridging the gap between theoretical knowledge and real-world application in vocational education. It is recommended that further research explore PBIL's long-term impact and its scalability across different vocational fields. Overall, PBIL supports the development of a skilled workforce, better aligning education with industry needs.

Keywords: Project-Based Inquiry Learning; Electrical Motor Installation; Vocational Education; Effectiveness.

RESUMEN

La formación profesional desempeña un papel clave a la hora de dotar a los estudiantes de las habilidades prácticas necesarias para participar en el mercado laboral, especialmente en campos técnicos como la instalación de motores eléctricos. Este estudio investiga la eficacia del modelo de aprendizaje por investigación basado en proyectos (PBIL) para mejorar los resultados de aprendizaje de los estudiantes en

la instalación de motores eléctricos dentro de la formación profesional. El objetivo principal es evaluar si el PBIL puede mejorar las competencias técnicas, el pensamiento crítico, la capacidad de resolución de problemas y las habilidades de colaboración de los estudiantes, que son cruciales para el éxito en los sectores eléctrico e industrial. La investigación se llevó a cabo mediante un diseño cuasiexperimental con un grupo de control no equivalente. El grupo experimental (37 estudiantes) recibió instrucción PBIL, mientras que el grupo de control (35 estudiantes) siguió métodos tradicionales centrados en el profesor. Los datos se recogieron mediante pruebas previas y posteriores, evaluaciones prácticas de rendimiento, encuestas y entrevistas semiestructuradas, analizadas con métodos cuantitativos y cualitativos. Los resultados indican que el grupo experimental mostró mejoras significativas en habilidades técnicas, resolución de problemas y trabajo en equipo en comparación con el grupo de control. El PBIL también mejoró la motivación, el compromiso y la adaptabilidad de los estudiantes a las exigencias tecnológicas. El estudio concluye que el PBIL es un enfoque didáctico eficaz para salvar la brecha entre el conocimiento teórico y la aplicación al mundo real en la formación profesional. Se recomienda seguir investigando el impacto a largo plazo de los PBIL y su escalabilidad en diferentes campos profesionales. En general, los PBIL contribuyen al desarrollo de una mano de obra cualificada, adaptando mejor la educación a las necesidades de la industria.

Palabras clave: Aprendizaje por Investigación Basado en Proyectos; Instalación de Motores Eléctricos; Formación Profesional; Eficacia.

INTRODUCTION

Vocational education plays a pivotal role in equipping students with the practical skills required to effectively participate in the workforce, especially in technical fields. One such field is electrical motor installation, which is crucial across various industries, including manufacturing, automotive, and construction. ^(1,2) According to the International Labour Organization (ILO), the demand for skilled tradespeople has surged globally, particularly as industries modernize with new technologies. In fact, the World Economic Forum has reported that nearly 50 % of all industries are undergoing significant changes due to technological advancements, emphasizing the need for a workforce capable of adapting to new systems, especially in technical sectors like electrical motor installation. ⁽³⁾ However, traditional vocational education has struggled to keep pace with these rapid changes.

Historically, vocational education programs have been predominantly teacher-centered, focusing on theoretical knowledge delivery and passive learning methods. These traditional instructional approaches, while useful for providing foundational knowledge, have not been effective in fostering critical skills such as problem-solving, critical thinking, and hands-on experience, which are essential for success in today's workforce. ^(4,5) Studies by Setiyawami ⁽³⁾ indicate that the gap between theoretical knowledge and its practical application in vocational fields has resulted in disengaged students who struggle to transition to real-world applications. Furthermore, research by Brkovic ⁽⁶⁾ confirms that passive learning methods often leave students underprepared for the complex, technology-driven challenges they face in the workforce.

As industries like manufacturing and automotive increasingly rely on automation and advanced robotics, the gap between classroom instruction and real-world application becomes more pronounced. Vocational programs need to evolve to meet the growing demands of the workforce. ^(7,8) Traditional methods that focus on rote learning fail to address the pressing need for students to develop not only technical expertise but also the ability to solve complex, real-world problems. ⁽⁹⁾ A shift toward more active, hands-on, and technology-integrated learning models is necessary to prepare students for the rapidly evolving industrial landscape. The increasing demand for skilled professionals who can adapt to technological advancements has highlighted the critical need for more effective vocational training programs. ^(10,11)

In response to these challenges, Project-Based Learning (PBL) has emerged as an innovative pedagogical method that aims to bridge the gap between theory and practice. ⁽¹²⁾ PBL focuses on engaging students in real-world projects that require them to apply theoretical knowledge to practical tasks. ^(13,14) This student-centered approach encourages active learning and collaborative problem-solving, which are vital in fields such as electrical motor installation. ^(15,16) According to Krauss, ⁽¹⁷⁾ PBL helps students gain a deeper understanding of subject matter by involving them in tasks that mimic real-world scenarios, thereby preparing them for the complexities of the workforce.

Research on PBL shows that it significantly enhances students' ability to apply knowledge practically, which is especially crucial in technical fields. A study by Hastuti ⁽¹⁸⁾ highlights that students involved in PBL develop a more profound understanding of their subject matter, as they actively engage with real-life problems. Additionally, PBL helps develop essential soft skills, such as communication, teamwork, and adaptability, which are increasingly important in today's job market. ^(19,20) In vocational education, PBL allows students to

connect their learning to actual industry practices, making them more job-ready upon graduation.^(6,21)

However, while PBL offers many benefits, its successful implementation in vocational education, particularly in technical fields like electrical motor installation, requires careful integration with existing curricula and instructional strategies.⁽¹⁵⁾ PBL necessitates a shift from traditional teacher-led instruction to a more interactive, student-driven approach.^(22,23,24,25) This transition requires instructors to provide structured guidance and ensure that students have the necessary resources and support to succeed. As highlighted by Ridlo⁽²⁶⁾ the teacher's role is not just to impart knowledge, but to facilitate the learning process by creating an environment where students can actively engage in inquiry and problem-solving.

Project-Based Inquiry Learning (PBIL), a hybrid model combining project-based and inquiry-based learning, takes this a step further by emphasizing student exploration and reflection.^(17,27) PBIL encourages students to take ownership of their learning by asking questions, seeking answers, and solving problems collaboratively.^(28,29,30,31,32,33) In the context of electrical motor installation, PBIL can involve students in projects such as motor system installation, troubleshooting, and optimization, where they must apply their knowledge to practical challenges.^(34,35,36,37) This approach not only enhances technical skills but also fosters critical thinking, problem-solving, and teamwork—skills that are highly valued by employers in the electrical and industrial sectors.^(38,39,40,41)

The relevance of PBIL to vocational education is particularly significant in fields such as electrical motor installation, where hands-on experience is essential. As industries continue to evolve, the demand for skilled workers who can apply theoretical knowledge to practical tasks becomes more critical.^(42,43,44,45) By engaging in PBIL, students gain valuable real-world experience that prepares them to meet the technical and cognitive challenges they will face in their careers.^(46,47) Studies by Wahyudi⁽⁴⁸⁾ confirm that PBIL increases student engagement, motivation, and achievement, particularly in technical education, where practical skills are paramount.

The primary hypothesis of this study is that the implementation of the Project-Based Inquiry Learning (PBIL) model in Electrical Motor Installation practical courses significantly improves students' learning outcomes compared to the traditional teacher-centered learning method used in the control group. The research problem centers on the gap between traditional instructional methods and the increasing need for hands-on, practical learning approaches in vocational education. Specifically, this study investigates whether PBIL enhances students' technical skills, problem-solving abilities, and critical thinking in Electrical Motor Installation courses.

The primary objective of this study is to investigate the implementation and effectiveness of Project-Based Inquiry Learning (PBIL) in electrical motor installation education within vocational training programs. Specifically, the study aims to evaluate whether PBIL can enhance students' technical competencies, critical thinking, problem-solving abilities, and collaborative skills, all of which are highly valued by employers in the electrical and industrial sectors. Additionally, this research seeks to assess whether PBIL can bridge the gap between traditional teaching methods and the evolving practical demands of the industry, particularly in fields like electrical motor installation, where hands-on experience is crucial for success. By integrating inquiry-based and project-based learning approaches, the study will explore how PBIL can better prepare students for the workforce, aligning with the growing need for adaptable and skilled workers in a rapidly changing technological landscape.

METHOD

Research Design

This study employs a quasi-experimental research design, specifically a Nonequivalent Control Group Design, to assess the effectiveness of the Project-Based Inquiry Learning (PBIL) model in Electrical Motor Installation practical courses. A quasi-experimental design was chosen due to the inability to randomly assign students to experimental and control groups. This approach allows for the comparison of two different instructional methods (PBIL and traditional teacher-centered learning) while acknowledging the natural classroom setting.⁽³³⁾ In this study, the experimental group (37 students) received instruction through the PBIL model, while the control group (35 students) followed a traditional, teacher-centered approach. The study was conducted with eleventh-grade students from the Electrical Power Installation Engineering (TITL) program at SMK Muhammadiyah 2 Pekanbaru, Riau.

The research spanned over seven sessions, with both groups covering the same core material but delivered through different instructional strategies. The PBIL approach emphasized student-centered learning through inquiry, collaboration, and hands-on project execution, while the control group relied on lecture-based teaching. The study aims to assess the impact of the PBIL model in enhancing students' practical skills in motor installation, as well as their problem-solving abilities and teamwork. By implementing this design, the research provides insights into the potential of inquiry-based project learning to improve the quality and relevance of vocational education in technical subjects.

Table 1. Research Design			
Group	Pre-Test	Treatment (X)	Post-Test
Experiment	O ₁	X	O ₂
Control	O ₃	-	O ₄

Explanation:

O₁ & O₃: Pretest observation for the experimental and control group.

X: The treatment or intervention given to the experimental group

O₂ & O₄: Posttest observation for the experimental and control group.

The target population for this study consisted of eleventh-grade students enrolled in the Electrical Power Installation Engineering (TITL) program at SMK Muhammadiyah 2, Pekanbaru Riau. The students were not randomly assigned to the experimental and control groups due to the nature of the study design. The selection was based on class divisions, with one class receiving the PBIL intervention and the other class continuing with the traditional teacher-centered approach. Both groups had similar prior academic backgrounds and were taught by the same instructor to minimize potential biases.

Methodological Definitions:

- Project-Based Inquiry Learning (PBIL): An instructional model that combines project-based learning with inquiry-based methods, encouraging students to actively engage in real-world projects that require them to apply theoretical knowledge and solve practical problems collaboratively.
- Control Group: The group of students who were taught using traditional teacher-centered methods, focusing on lecture-based instruction and passive learning.
- Experimental Group: The group of students who received instruction through the PBIL model, emphasizing active learning, collaboration, and inquiry.

The study was structured with clear stages to ensure that it could be replicated in other contexts. Initially, both groups completed a pre-test to assess their baseline knowledge and skills. The experimental group was then exposed to the PBIL model, while the control group continued with traditional lecture-based teaching. After the intervention, both groups completed a post-test to evaluate improvements in theoretical knowledge and practical skills. Additionally, practical assessments were conducted to evaluate students' performance in real-world motor installation tasks. Both groups were also surveyed to capture their engagement, motivation, and perceptions of the learning methods.

Data Collection Instrument

The study utilized a mixed-methods approach for data collection, combining both quantitative and qualitative methods. For quantitative data, pre-tests and post-tests were administered to assess students' understanding of electrical motor installation theory and their ability to apply this knowledge in practical tasks, measuring both conceptual understanding and practical application. Practical performance assessments were also conducted to evaluate students' skills in tasks such as installation procedures, troubleshooting, and system optimization. For qualitative data, surveys were distributed to both groups to gauge student engagement, motivation, and perceptions of the PBIL approach. The surveys included Likert-scale items and open-ended questions to gather both quantitative and qualitative feedback. Additionally, semi-structured interviews were conducted with both students and instructors to explore their experiences with the PBIL model, focusing on aspects such as collaboration, problem-solving, and overall satisfaction.

The surveys were designed to capture students' experiences with the PBIL model, their motivation levels, and their engagement in the learning process. The Likert-scale items measured students' perceived value of inquiry-based learning, their ability to collaborate with peers, and their overall satisfaction with the instructional methods. The surveys were administered at the beginning and end of the study, with follow-up surveys conducted midway to gauge changes in student attitudes.

All collected data were stored in a secure digital database, with identifiers to protect the privacy of participants. The quantitative data from pre-tests, post-tests, and practical performance assessments were entered into a statistical software program for analysis. The qualitative data from surveys and interviews were transcribed and analyzed using thematic analysis to identify common themes and patterns.

This study adhered to ethical guidelines for research involving human participants. Informed consent was obtained from all students and their parents or guardians before participation. Students were assured that their participation was voluntary and that their responses would remain confidential. The study adhered to ethical standards set forth by the institution's review board, ensuring that no personal or sensitive information was disclosed without permission. Additionally, students were free to withdraw from the study at any time without penalty.

Data Analysis Techniques

This study employs both quantitative and qualitative methods to evaluate the effectiveness of the Project-Based Inquiry Learning (PBIL) model in Electrical Motor Installation practical courses. The research involves two groups of eleventh-grade students from the Electrical Power Installation Engineering (TITL) program at SMK Muhammadiyah 2: the experimental group consisting of 37 students receiving the PBIL intervention, and the control group of 35 students following traditional teacher-centered instruction.

For quantitative analysis, descriptive and inferential statistics will be applied. Pre-test and post-test scores from both groups will be compared using statistical tests such as t-tests or analysis of variance (ANOVA) to determine whether significant differences exist in learning outcomes. It is expected that the experimental group, which participates in the PBIL model, will show greater improvements in both theoretical understanding and practical skills related to electrical motor installation compared to the control group.

Qualitative data, collected through surveys and semi-structured interviews, will be analyzed using thematic analysis to identify key themes and patterns regarding student engagement, motivation, and perceptions of the PBIL learning process. By integrating both quantitative and qualitative data, this study aims to provide a comprehensive evaluation of the PBIL model's impact on students' learning experiences, particularly in terms of problem-solving, teamwork, and hands-on skill development in vocational education.

Project-Based Inquiry Learning (PBIL) Model Approach

The Project-Based Inquiry Learning (PBIL) model, implemented in the context of Electrical Motor Installation practical courses, emphasizes active student participation through inquiry-driven, collaborative, and hands-on projects. This approach enables students to work in teams to investigate and solve authentic problems related to electrical motor installation, thereby strengthening not only their technical competencies but also essential soft skills such as communication, critical thinking, and teamwork. PBIL combines the principles of inquiry learning with project-based activities, requiring students to actively explore concepts, formulate questions, and collaborate effectively to complete practical tasks. This pedagogical strategy promotes a deeper understanding of theoretical material while enhancing students' problem-solving skills, which are critical in the vocational field of electrical motor installation.



Figure 1. Project-Based Inquiry Learning Handbook

The effectiveness of the PBIL model was assessed by comparing the performance of students in the experimental group, who engaged in the PBIL approach, with a control group that followed traditional teacher-centered methods. Students in the experimental group were assigned projects that involved designing, assembling, and troubleshooting electrical motor systems, demanding the practical application of theoretical knowledge in realistic scenarios. These projects were carefully designed to simulate challenges typically encountered in the industry, thereby enriching students' hands-on learning experiences. The results showed that the experimental group outperformed the control group in both technical skills and collaborative abilities, highlighting the PBIL

model's positive impact on preparing students for real-world professional demands.

Moreover, the PBIL approach fostered a dynamic and student-centered learning environment where learners took responsibility for their own learning processes. This method aligns with the goals of 21st-century education, which emphasize not only the mastery of technical knowledge but also the development of skills necessary for teamwork, critical inquiry, and adaptability in evolving technological contexts. The study found that integrating PBIL into Electrical Motor Installation practical courses significantly increased student engagement, improved academic performance, and enhanced overall learning outcomes, reinforcing the value of project-based inquiry learning as an effective teaching strategy in vocational education.

RESULTS

Data Analysis and Findings

The data analysis conducted in this study reveals significant improvements in student learning outcomes following the implementation of the Project-Based Inquiry Learning (PBIL) model in Electrical Motor Installation practical courses. Both quantitative and qualitative data were collected, with pre- and post-assessment tests serving as the primary instruments for measuring academic performance. Descriptive and inferential statistical analyses were applied to the scores from both the experimental and control groups. The experimental group, which engaged in PBIL, demonstrated substantial improvements in practical skills, problem-solving abilities, and the application of electrical motor installation concepts. In contrast, the control group, which experienced traditional teacher-centered instruction, showed comparatively smaller gains across these domains.

The comparison between the experimental and control groups highlights the effectiveness of the PBIL model. Analysis of the pre-test and post-test results indicates a statistically significant enhancement in the academic performance of students in the experimental group, particularly in their ability to apply theoretical knowledge to practical, real-world electrical motor installation tasks. These findings are summarized in the accompanying table, illustrating the superior performance of the PBIL group compared to the conventional learning group. The results confirm that Project-Based Inquiry Learning offers a more effective and engaging educational experience, fostering deeper understanding and skill mastery in vocational education settings.

Overall, the integration of PBIL into the Electrical Motor Installation curriculum not only improved technical competencies but also enhanced students' critical thinking, collaboration, and motivation to learn. These outcomes suggest that inquiry-based, project-centered pedagogies are well-suited to meet the evolving demands of technical vocational education, preparing students more effectively for professional challenges in the electrical engineering field.

Table 2. Results of the Descriptive Analysis Results for Pre-Test and Post-Test

Group	Mean Pre-Test Score	Mean Post-Test Score
Experiment	53,31	79,26
Control	49,00	70,00

The table presents the descriptive analysis results comparing the mean pre-test and post-test scores of two groups: the experimental group and the control group. The experimental group, which experienced the project-based inquiry learning model, demonstrated a significant increase in mean scores from 53,31 in the pre-test to 79,26 in the post-test. In contrast, the control group, which presumably followed a conventional teaching approach, showed a smaller improvement, with mean scores rising from 49,00 to 70,00. These findings suggest that the project-based inquiry learning model positively impacted students' understanding and skills in electrical motor installation, highlighting its effectiveness as a teaching strategy in vocational education. Additionally, a normality test was performed to assess the appropriateness of the data for inferential tests, specifically evaluating how closely the data followed a normal distribution. The Shapiro-Wilk test results were used to analyze the data distribution.

Table 3. Results of the Shapiro-wilk Test

Group	Pre-Test (p-value)	Post-Test (p-value)
Experiment	0,078	0,019
Control	0,224	0,043

The results show that the data in both groups, for both pre-test and post-test, were normally distributed ($p > 0,05$). Levene's Test was used to examine the homogeneity of variances between the experiment and control groups.

Table 4. Results of Levene's Test		
Variable	F	Sig. (p-value)
Post-Test	6,156	0,015

The analysis indicates that the variances of the experiment group to the control group were similar ($p > 0,05$) suggesting that the groups could be compared parametrically. To establish the researching hypothesis the two condition Independent Sample T-Test was used to compare the post test results between the experimental and control groups.

Table 5. Results of T-Test				
Test Type	Variable	t	Sig. (p-value)	Interpretation
Independent Sample T-Test	Pre-Test vs Post-Test	-3,492	0,001	The experimental group achieved a higher mean post-test score than the control group

The results of the independent sample t-test indicate a significant difference between the pre-test and post-test scores, with a t-value of -3,492 and a p-value of 0,001. This statistical evidence suggests that the implementation of the Project-Based Inquiry Learning Model in the context of electrical motor installation effectively enhanced students' learning outcomes in vocational education. Specifically, the experimental group demonstrated a significantly higher mean score on the post-test compared to the pre-test, highlighting the model's positive impact on students' knowledge and skills development in this technical subject area. These findings support the effectiveness of the applied instructional approach in improving vocational education performance.

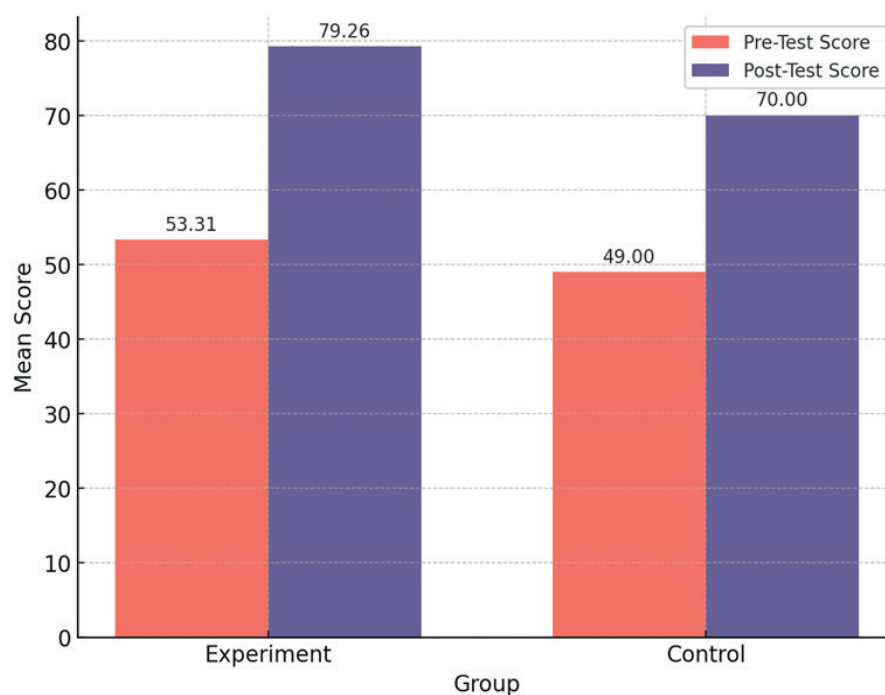


Figure 2. Pre-Test and Post-Test Scores Bar Chart

Based on the simulated boxplot results, it is evident that the Post-Test scores for both the Experimental and Control groups significantly improved compared to their respective Pre-Test scores. Notably, the Experimental group exhibited higher median scores and a broader score range than the Control group in the Post-Test phase. These findings suggest that the implementation of the Project-Based Inquiry Learning model in electrical motor installation effectively enhances students' understanding and skills within vocational education more than traditional teaching methods. Additionally, the narrower score range observed in the Experimental group's Post-Test indicates greater consistency in learning outcomes, further supporting the efficacy of this instructional approach in improving technical competencies comprehensively.

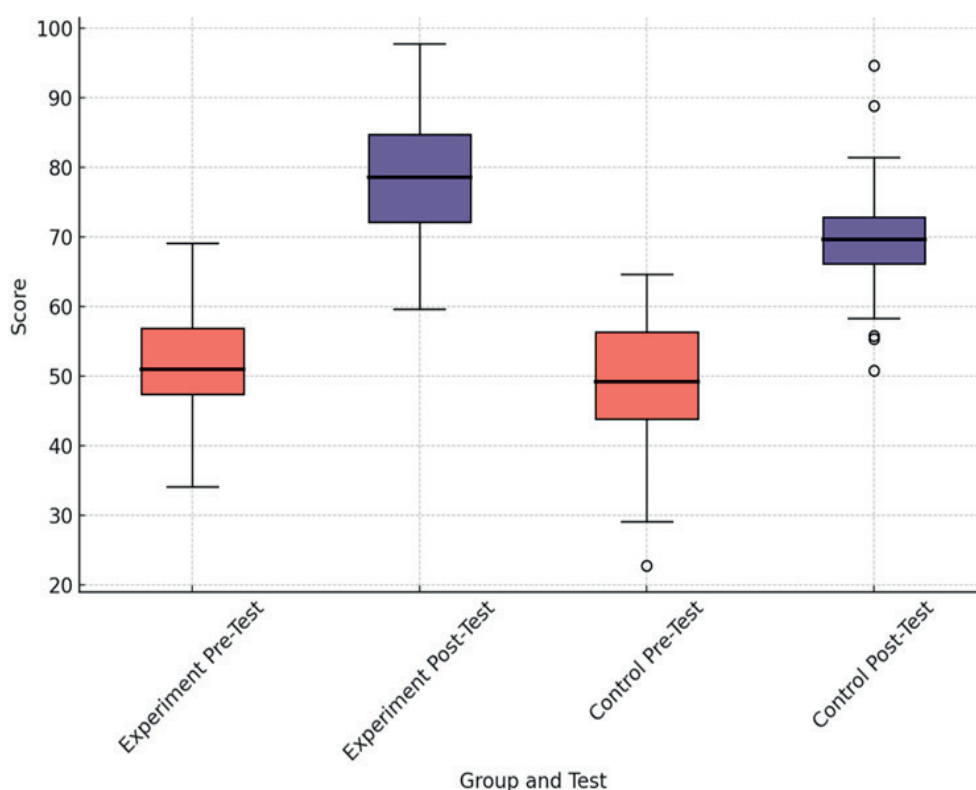


Figure 3. Box Plot Pre-Test and Post-Test Scores

DISCUSSION

The findings of this study underscore the significant impact of the Project-Based Inquiry Learning (PBIL) model on vocational education, particularly in the context of electrical motor installation. Aligning with prior research highlighted in the introduction, the study confirms that traditional teacher-centered approaches often fall short in equipping students with the practical skills and critical thinking abilities essential for the dynamic industrial environment. This study's results demonstrate that PBIL fosters deeper engagement and facilitates the integration of theoretical knowledge with hands-on practice, thereby addressing the prevalent gap between classroom learning and real-world applications.

The quasi-experimental design employed allowed for a rigorous comparison between the experimental group exposed to PBIL and the control group receiving conventional instruction. The statistically significant improvement in post-test scores of the experimental group supports previous assertions that inquiry-driven, project-based methodologies enhance both cognitive and technical competencies in vocational learners. This finding aligns with Chen and Huang's⁽⁴⁾ emphasis on active learning's role in promoting deeper understanding and student motivation, as well as with Nayab⁽¹³⁾ work on collaborative projects enhancing practical skill development.

Moreover, the incorporation of inquiry within the project-based framework encourages learners to actively question and explore concepts rather than passively receive information. This approach resonates with Krauss and Boss's⁽¹⁷⁾ characterization of inquiry learning as a catalyst for deeper conceptual grasp and lifelong learning skills. In this study, students' involvement in troubleshooting and optimizing motor installation projects demonstrated enhanced problem-solving skills, corroborating previous studies that emphasize inquiry's role in vocational education to promote critical thinking and adaptability.

The hands-on nature of the PBIL model is particularly well-suited to vocational education fields such as electrical motor installation, where practical skills are paramount. This study's results validate findings by Supriyono⁽³⁰⁾ and Yudiono⁽³²⁾ which advocate for project-based assignments as vehicles for improving technical competence and teamwork skills essential for industry readiness. The experimental group's superior performance not only in knowledge assessments but also in collaborative tasks indicates that PBIL effectively nurtures both hard and soft skills demanded by modern employers.

Furthermore, the qualitative insights gathered through interviews and surveys reinforce the quantitative data, illustrating increased student motivation, satisfaction, and ownership of learning within the PBIL framework. This reflects the active learning benefits described by Song⁽⁴²⁾ and Zhao⁽⁴⁹⁾ who link student agency in inquiry-based environments with improved retention and application of knowledge. By empowering students to take charge of their learning, PBIL facilitates a more engaging and responsive educational environment

compared to traditional lecture-based methods.

In terms of assessment, the statistically significant results from the independent sample t-tests and normality tests affirm the robustness of the PBIL model's impact on learning outcomes. The careful research design, including control of variances and pre-test equivalency, strengthens the validity of these findings. This methodological rigor aligns with Creswell⁽⁴¹⁾ recommendations for quasi-experimental designs in educational research, which emphasize the importance of naturalistic classroom settings when randomization is impractical. (50,51,52)

The study also contributes to the growing body of literature advocating for pedagogical innovation in vocational education to meet industry demands. As the introduction and results suggest, technological advancements and evolving labor market requirements necessitate curricula that integrate inquiry, collaboration, and project-based learning to prepare students effectively. The demonstrated success of PBIL in this study echoes calls by Brkovic⁽⁶⁾ and Zhang⁽⁴⁴⁾ for workforce training that bridges theoretical and practical knowledge in technical fields.

Limitations of the study include the relatively small sample size and the focus on a single vocational program within one institution. Future research should explore longitudinal impacts of PBIL, its scalability across diverse vocational disciplines, and its effects on employability and career progression. Additionally, incorporating objective measures of soft skills development alongside technical competencies could provide a more holistic evaluation of PBIL's efficacy.

This study confirms that implementing a Project-Based Inquiry Learning model in electrical motor installation courses significantly enhances students' technical skills, critical thinking, and engagement compared to traditional methods. The findings underscore the relevance of active, inquiry-based pedagogies in vocational education, supporting educational reforms aimed at aligning training programs with contemporary industry needs. Such approaches are essential to equip students with the comprehensive competencies required for success in rapidly evolving technical professions.

CONCLUSION

This study confirms that the implementation of the Project-Based Inquiry Learning (PBIL) model in electrical motor installation education effectively enhances students' technical competencies, critical thinking, problem-solving abilities, and collaborative skills, which are essential in vocational training. PBIL bridges the gap between theoretical knowledge and real-world applications, meeting the evolving demands of industries that require skilled workers. The model aligns educational practices with industry needs by fostering student engagement, motivation, and adaptability. It also supports the development of critical skills necessary for the modern workforce, ensuring that students are better prepared for the challenges they will face in their careers. Although the study's sample size was limited, the results underscore the potential of PBIL to improve vocational education. Future research should focus on the long-term impact of PBIL and explore its broader applications across other vocational fields.

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AUTHORSHIP CONTRIBUTION

Conceptualization: Chrismondari, Wakhinuddin Simatupang, Waskito.

Data curation: Chrismondari, Bayu Rianto, Rahmat Fadillah.

Research: Chrismondari, Wakhinuddin Simatupang, Waskito, Bayu Rianto, Rahmat Fadillah.

Methodology: Chrismondari, Wakhinuddin Simatupang, Waskito.

Software: Bayu Rianto, Rahmat Fadillah.

Validation: Wakhinuddin Simatupang, Waskito.

Drafting - original draft: Chrismondari, Wakhinuddin Simatupang, Waskito.

Writing - proofreading and editing: Bayu Rianto, Rahmat Fadillah.