

THE EFFECT OF IMPLEMENTING PROJECT-BASED LEARNING ON CONCEPTUAL UNDERSTANDING OF ELECTRICAL ENGINEERING SUBJECTS IN VOCATIONAL HIGH SCHOOLS**Riswan Wahyudi, Rusijono, Bachtiar Syaiful Bachr and *Fajar Arianto**

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Abstract

This study aims to investigate the effect of implementing Project-Based Learning on the conceptual understanding of electrical engineering subjects at Bhakti Samudera Vocational High School. This study used a quasi-experimental design involving 56 students who were randomly selected from the same school. Before the intervention, a pre-test was carried out to measure students' initial understanding of the concepts of electrical engineering subjects. Furthermore, students were divided into two classes: the experimental class and the control class. The allocation process ensures that relevant characteristics, such as age and grade, are similar between the two classes. Statistical analysis using a paired sample t-test confirmed the significance of this finding. The t value is -2.151 and the Sig value (2-tailed) is 0.041, indicating a significant difference between the experimental class and the control class in understanding the concept of electrical engineering subjects. This shows that the application of project-based learning affects students' understanding of concepts in electrical engineering subjects. However, it is important to be aware of some limitations in this study. The research was conducted in one school with a limited sample, so the generalization of the findings needs further investigation. Further research is needed to explore the factors that influence the effectiveness of project-based learning in different educational contexts. Further research and application of project-based learning in various educational contexts are recommended to continue exploring its potential for improving learning outcomes and preparing students to face future challenges in the era of globalization.

Keywords: Project-based learning, Conceptual understanding, Electrical engineering, Vocational high school.

INTRODUCTION

Vocational education in Indonesia has an important role in preparing students to face the challenges of the globalization era (Puslitjakdikbud, 2017). In global competition, students' ability to understand basic concepts and apply them in real-world contexts is very important. Understanding concepts can be interpreted as the ability to understand a concept by connecting the facts contained therein (Mustika & Ain, 2020). The main problem faced in education in Indonesia is the low learning outcomes of students at school. There are still many students who face difficulties understanding concepts in depth. Conventional learning that focuses on lectures and individual assignments is often less effective in increasing students' conceptual understanding and developing the practical skills needed in the world of work. This description is proven by the results of the observations of researchers at the Bhakti Samudera Vocational High School, which show that in learning electrical engineering subjects that are part of the grouping of productive subjects with limitations for the minimum completeness criterion of 75, Electrical engineering subjects are one of the compulsory subjects mastered by students in the competency environment of the Engineering and Nauticals Department of Bhakti Samudera Vocational High School, Surabaya. However, in reality, there are still many students who do not get results according to predetermined standards. Electrical engineering can be a difficult subject to teach. It requires, on the part of students, a much higher level of abstraction than other disciplines (Belagra & Draoui, 2018). Therefore, many students do not understand or do not understand material related to electrical engineering, so the understanding of the concepts of electrical

engineering subjects is not evenly distributed. The project-based learning model has been used in research to improve conceptual understanding (Sastrika *et al.*, 2013). Understanding the concept is one component of the cognitive domain. Understanding the concept as a process of exploring and defining meaning through communication. Students' understanding of concepts can be formed through interactions between teachers, students, and peers. Through a good concept learning design, someone (directly or indirectly) will understand a concept that was previously unknown (Meyer & Land, 2005). With the rapid advancement of electrical engineering, students need a set of skills and innovative approaches that cannot be learned from textbook problems and traditional teaching methods (Lei *et al.*, 2012). Therefore, it is important to investigate the effect of implementing Project-Based Learning on Conceptual Understanding of Electrical Engineering Subjects at Bhakti Samudera Vocational High School. Factors that can influence the understanding of the concept are learning media and learning models or methods. Applying the right learning models and media can improve students' understanding of concepts (Mustika & Ain, 2020). The project-based learning model is a constructivism-based method that supports student involvement in problem-solving situations. Students in project-based learning are directly involved in the real-life environment in solving problems, so the knowledge gained is more permanent (Haryudo *et al.*, 2020). In project-based learning, students are given complex, moderately difficult, complete, but realistic projects and then given sufficient assistance so that they can complete the task. The project-based learning model is project-based learning for solving contextual problems innovatively and uniquely as well as producing the output presented (Berhitsu *et al.*, 2020). By implementing project-based learning in electrical engineering at Bhakti Samudera Vocational High School, it is hoped that students will be able to improve their understanding of

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electrical engineering concepts and hone their practical skills. This will help students prepare themselves to enter the world of work, which is increasingly competitive and faces the demands of globalization. Based on the results of previous research, using the project-based learning model can help students in class XI at a senior high school understand the ideas of elasticity and Hooke's law better. In addition, student responses to learning are very good, and for further learning with the project-based learning model, it can be recommended that it be implemented in schools (Safriana *et al.*, 2022). Furthermore, other findings show that the application of the guided project-based learning model can significantly increase students' activeness and understanding of concepts in Momentum, Impulse, and Collision material at Nurul Islami High School (Puspitasari *et al.*, 2020). Thus, research on the effect of implementing Project-Based Learning on the Conceptual Understanding of Electrical Engineering Subjects at Bhakti Samudera Vocational High School will provide important insights for the development of quality vocational education that is relevant to the demands of globalization.

METHODS

The research method used in this study is a quasi-experimental design, which is widely utilized in educational research to assess the effectiveness of interventions or educational programs (Gopalan *et al.*, 2020). This study focuses on implementing project-based learning as an intervention to enhance students' understanding of electrical engineering concepts. Project-based learning is an instructional approach that revolves around projects or tasks, engaging students in real-world problem-solving and fostering active learning, critical thinking skills, collaboration, and the application of concepts in practical contexts. The research participants consist of 56 students randomly selected from the same school. Before the intervention, a pretest is administered to assess their initial comprehension of electrical engineering concepts, particularly Kirchhoff's laws 1 and 2, which involve voltage and current in series, parallel, and mixed circuits. Subsequently, the students are divided into two classes: the experimental class and the control class. The allocation process ensures that relevant characteristics, such as age and grade, are similar between the two classes.

The experimental class receives project-based learning as the intervention, while the control class continues with conventional instruction. Upon completion of the intervention, both classes undergo a posttest to measure their improvement in concept comprehension following the respective instructional approaches. The research hypothesis analyzed using the paired sample t-test, a statistical analysis method. It enables a comparison of the differences in concept comprehension outcomes between the experimental and control classes after the intervention. This method allows for determining whether there is a significant disparity between conventional instruction and project-based learning in enhancing students' understanding of electrical engineering concepts.

RESULTS

In this study, it can be seen that the results based on the pretest and posttest data by providing interventions with a project-based learning model for electrical engineering subjects, it is indicated that it will be able to increase students' understanding of the concept of electrical engineering subjects.

In the control class, the test for understanding the concept of electrical engineering subjects obtained a mean pre-test of 14.53 (see Table 2) and a mean post-test result of 15.75 (check Table 4).

The data shows a change with an increase of 1.22 points. In the experimental class testing the understanding of the electrical engineering subject's concept, the mean pre-test was 15.61 (check table 2) and the mean post-test results were 19.85 (check table 4).

The data shows a change with an increase of 4.24 points. Finally, the results of the post-test analysis using the paired sample t-test showed a value of $t = -2.151$ and a Sig (2-tailed) of 0.041. The basis for decision-making if 0.041 is smaller than 0.05, it can be concluded that there is an effect of the Project Based Learning model on the conceptual understanding of the Electrical Engineering Subject at Bhakti Samudera Vocational High School.

Table 1. Test outline of conceptual understanding of electrical engineering subjects

Basic competencies of conceptual understanding	Indicators	Thinking Level	Number Of Questions
1 Using Ohm's law and electrical energy	Using the concept of the amount of electrical voltage to resistance	Application	1,2,3,12
2 Kirchoff's laws 1 and 2	Using the amount of electric current to resistance	Application	4,5,6
	Using the concept of electric current and voltage	Application	7,10,29
	Using the summation of electrical voltage and electrical current summation	Application	9,14,19
3 Applying electrical power to the circuit	Determine the amount of power on the loaded circuit	Application	18,25
4 Determining the Series circuit and parallel circuit	Presents a series circuit with a load	Understanding	20,24
	Presents a parallel circuit with a load	Understanding	28
5 Using the principle of installation on the circuit	Conceptualize and adjust to a single line chart on electric lighting installation	Application	22,23,27
	Conceptualize and adjust to double line charts in electric lighting installation	Application	15,16,30
6 Applying diagram application on electric lighting installation	Operate instrument equipment	Application	8,11,21
	Operate electric lighting installation equipment and loads	application	13,17,26

Table 2. Pre-test data output from paired samples statistics

	Group	Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Control	14.5357	28	8.05758	1.52274
	Experiment	15.6071	28	6.98856	1.32071

Table 3. Pre-test data output from paired sample test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Control-Exsperiment Group	-1.07143	13.06941	2.46989	-6.13922	3.99636	-.434	27	.668

Table 4. Post-test data output from paired samples statistics

	Group	Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Control-Experiment	15.7500	28	7.06910	1.33593
	Kelas Eksperimen Posttest Pemahaman Konsep MPTL	19.8571	28	4.97188	.93960

Table 5. Post-test data output from paired sample test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Control-experiment	-4.10714	10.10442	1.90955	-8.02523	-.18906	-2.151	27	.041

DISCUSSION

The findings from this study provide valuable insights into the effect of the implementation of Project-Based Learning on the conceptual understanding of electrical engineering subjects at Bhakti Samudera Vocational High School. The results showed that there was a significant increase in the conceptual understanding of students who received project-based learning lessons. The experimental class showed a substantial increase in post-test scores compared to pre-test scores, indicating a positive effect of the project-based learning intervention on students' conceptual understanding of electrical engineering subjects. In contrast, the control class that received conventional learning showed an increase in post-test scores. Statistical analysis using a paired sample t-test confirmed the significance of the findings. The t value is -2.151 and the Sig (2-tailed) value is 0.041, indicating a significant difference between the experimental class and the control class in terms of understanding the concept. This shows that the application of project-based learning affects students' understanding of concepts in electrical engineering subjects. The findings from this study are in line with previous research, which also demonstrated the effectiveness of the Project-Based Learning model in increasing students' conceptual understanding and engagement. Based on previous findings in various fields of knowledge, project-based learning has proven to be effective in engineering education. To apply project-based learning in engineering courses, it is important to observe the objectives, content, and learning outcomes that students must achieve in this course. Learning objectives and outcomes will determine the course objectives and enable the identification of the teacher's commitment to the course (Iturregi *et al.*, 2017). Applying project-based learning to engineering learning can be considered a valid method that will contribute to encouraging creative engineers in future product development environments (Chen *et al.*, 2019). Integrating project-based learning into learning in vocational high schools, it aims to equip students with the skills and knowledge necessary to succeed in a competitive world of work. The project-based nature of Project-Based Learning allows students to be actively involved

in solving real-world problems and developing practical solutions, thus preparing them to face the demands of the global world of work. However, it is important to acknowledge some limitations in this study. The research was conducted in a vocational high school with a limited sample, so it could affect the generalizability of the findings. Further research is needed to explore the factors influencing the effectiveness of project-based learning in different educational contexts.

Conclusion

The research findings show that project-based learning has a significant effect on students' understanding of concepts. The experimental class that received project-based learning experienced a significant increase in post-test scores compared to the pre-test scores, while the control class that received conventional learning showed a smaller increase. The application of Project-Based Learning has a positive impact on understanding the concept of electrical engineering subjects at Bhakti Samudera vocational high school. The results of statistical analysis using a paired sample t-test confirmed that the difference in conceptual understanding between the experimental class and the control class was statistically significant. By implementing project-based learning in electrical engineering subjects, it is hoped that students can increase their understanding of electrical engineering concepts and practical skills needed in the world of work. Project-based learning allows students to be directly involved in solving real problems so that the knowledge gained is more permanent. The conclusions of this study make an important contribution to the development of quality vocational education that is relevant to the demands of globalization and developments in the 21st century. Recommendations for integrating project-based learning into vocational learning practices are further supported by these findings. However, this research has limitations. The research was conducted in one school with a limited sample, so the generalization of the findings needs further study. Future research should involve more schools and students to broaden their understanding of the effectiveness of project-based learning in different educational contexts.

Further research and implementation of PBL in various educational contexts is recommended to continue to explore its potential in improving learning outcomes and preparing students to face demands. Globalization and the development of the 21st century.

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