ISSN 2963-7511
Journal of Engineering Researcher and Lecturer, Vol. 3, No. 2, pp. 98-108, 2024

Effectiveness of case method learning to optimise students' understanding of industrial mechanical machinery science

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Abstract: Education has a central role in preparing individuals for the complexities of the modern world of work. Particularly in the context of education in Vocational High Schools, developing students' competencies in collaboration, creativity, and problem-solving is essential. This study explores the effectiveness of the case-based learning method in improving students' understanding of industrial mechanics. The study used a quasi-experiment design with control and experimental groups. The statistical analysis results showed that the case method was more effective in improving students' cognitive mastery than the conventional lecture method. Students who participated in case method learning showed significant improvement in the post-intervention test, demonstrating the superiority of this method in supporting a more effective learning process and preparing students for practical challenges in the field. In conclusion, the case method increases students' participation and interactivity in the learning process and deepens their understanding of technical concepts in industrial mechanics. This research provides a solid basis for implementing more effective and relevant learning methods in preparing vocational students for the increasingly complex needs of the world of work.

Keywords: Quality education; Vocational education; Case-based learning; Industrial mechanics, Quasi-experiment design

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Received: March 29th 2024; Revised: June 14th 2024; Accepted: June 21th 2024

https://doi.org/10.58712/jerel.v3i2.144

Reference to this paper should be made as follows: Putra, R. D., Waskito, Arafat, A., García, J. L. C., Ayasrah, F. T. M., & Fortuna, A. Effectiveness of case method learning to optimise students' understanding of industrial mechanical machinery science. *Journal of Engineering Researcher and Lecturer*, 3(2), 98-108. https://doi.org/10.58712/jerel.v3i2.144

1. Introduction

Education is an essential foundation in developing an individual's ability to face the increasingly complex demands of the world of work. Amid technological and industrial developments, a deep understanding of industrial mechanics is the key to success in various sectors. However, effective learning methods to optimize student understanding of this science remain a significant concern in education. In particular, education in vocational high schools is responsible for preparing graduates who are ready to enter the world of work (Wagiran et al., 2019). This includes developing students' competencies in collaboration, creativity, responsibility, problem-solving, and critical thinking (Syahril et al., 2022, 2021). Solving problems is crucial in the learning process, and everyday life (Rahim et al., 2024), and teachers have a significant role in encouraging students to develop these abilities (Gu et al., 2022).

One of the learning methods that attracts attention is the case-based learning method. As one such approach, the case method involves students solving problems based on real cases relevant to the learning material (Almazroui, 2022; Miranda et al., 2021; Wulansari et al., 2023). This approach helps students to hone their case analysis and decision-making skills. In addition, it places students in learning situations similar to the real challenges they will face in the field. In industrial mechanical engineering, applying case-based learning methods has great potential to improve students' understanding of complex concepts and practical applications.

However, despite the many potentials the case-based learning method offers, thorough research on its effectiveness in industrial mechanical engineering is still limited. In order to address this challenge, improvements in the learning process are needed by adopting learning methods that can stimulate students' active engagement (Jalinus et al., 2019, 2022). Case-based learning is one of the effective solutions for improving student engagement and learning outcomes in industrial mechanical engineering (Mahdi et al., 2020). Consequently, a thorough study is needed to evaluate the effectiveness of case-based learning methods, particularly in deepening students' understanding of the science of industrial mechanical machinery.

This research aims to evaluate the positive impact of using case-based learning methods on improving students' cognitive knowledge in industrial mechanical engineering, in the hope of enhancing the interactivity and effectiveness of the learning process and promoting a more profound understanding and development of relevant skills for vocational students. In the context of this need for in-depth research, this study also aims to explore and evaluate the effectiveness of case-based learning methods in enhancing students' understanding of the science of industrial mechanical machinery, intending to create a more effective and relevant learning platform for students to prepare themselves for the challenges of the existing world of work.

2. Methods

This study applied the quasi-experiment method as part of the quantitative approach. The quasi-experiment method utilizes a control group and an experimental group (Miller et al., 2020), with a pre-test and post-test design that uses an unequal control group design (Prasetya et al., 2023, 2024). This study involved two groups: the control group received lecture-based learning, while the experimental group received learning using the case method. Evaluation was conducted through tests to measure students' cognitive knowledge improvement after the learning intervention.

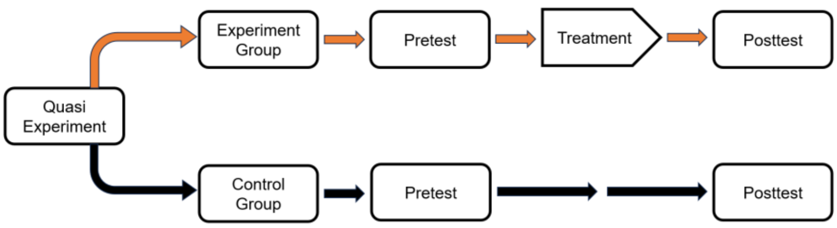
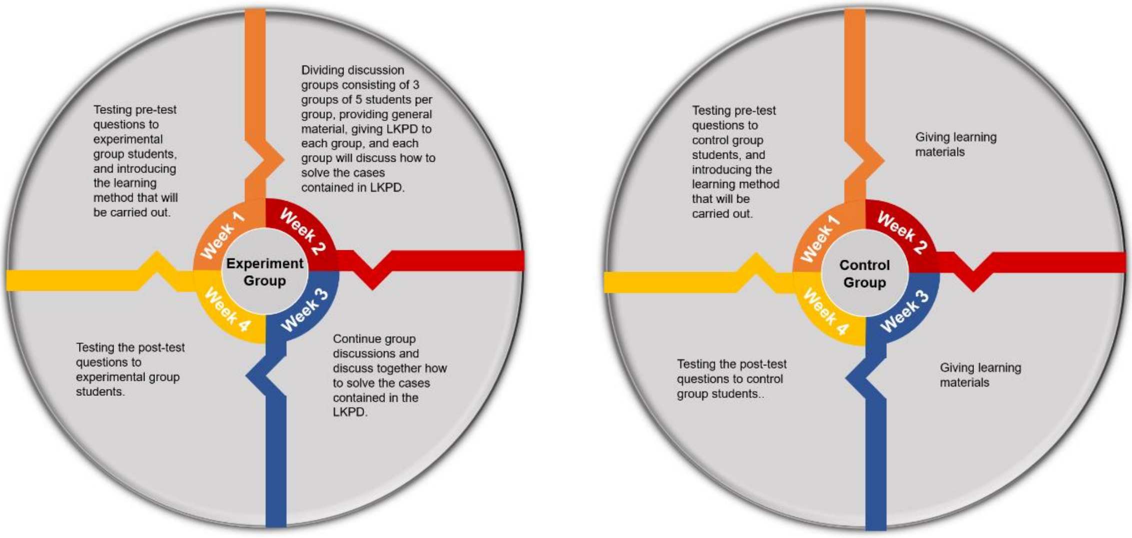


Figure 1. Quasi-experiment method

The sampling method used was total sampling, in which 28 students were selected as samples and divided into two groups. The experimental group consisted of 15 students, while the control group consisted of 13 students. In the experimental group, students were divided into three discussion groups, each comprising five students. Furthermore, the research flow and procedures are presented in Figure 2.



(a) (b)

Figure 2. (a) Experimental group research procedure and (b) Control group research procedure

The data collection method in this study involved the preparation of 20 test items in multiple-choice format. Information regarding the item grids and the results of statistical analyses related to the validity and reliability of the tests can be found in Tables 1, 2, and 3.

Table 1. Question instrument grid

Learning Materials	Problem Indicator	Question Number
Causes of vibration in industrial machinery	Definition and types of vibration.	1-3
	Causes, consequences, and how to deal with vibration in machinery.	4-7, 10,11
	Tools for measuring and analyzing vibrations and their functions.	8,9
	Definition and working principle of shock pulse meter.	12,13,15
Causes of noise in industrial machinery.	Definition and types of noise.	16-18
	Tools for measuring noise and their functions.	14,19
	Permissible noise in the workplace	20

Table 2. Validity test

Question Item	Test Results		Decision
	r_{count}	r_{tabel}	
1	0.456	0.374	Valid
2	0.537	0.374	Valid
3	0.518	0.374	Valid
4	0.438	0.374	Valid
5	0.438	0.374	Valid
6	0.500	0.374	Valid
7	0.523	0.374	Valid
8	0.481	0.374	Valid
9	0.037	0.374	Invalid
10	0.523	0.374	Valid
11	-0.106	0.374	Invalid
12	-0.233	0.374	Invalid
13	0.484	0.374	Valid
14	0.574	0.374	Valid
15	0.538	0.374	Valid
16	0.052	0.374	Invalid
17	0.484	0.374	Valid
18	0.541	0.374	Valid
19	0.523	0.374	Valid
20	0.469	0.374	Valid

In order to determine the validity of the question instrument, it is necessary to compare the calculated r_{value} with the r table value. The value of the r_{table} was obtained by referring to n = 28 and the significance level α = 0.05, namely r table = 0.374. Decisions regarding validity are made based on this comparison, where if the value of r count ≥ r table, then the data is considered valid. Based on the analysis in Table 2, it can be concluded that questions 9, 11, 12, and 16 do not meet the validity criteria.

Table 3. Reliability test

Correlation Between Forms		.696
Spearman-Brown Coefficient	Equal Length	.821
	Unequal Length	.821
Guttman Split-Half Coefficient		.807

Reliability testing was carried out using the split-half method using the Spearman-Brown approach. An instrument is considered reliable if the Spearman-Brown reliability coefficient value exceeds the threshold of 0.70 (r table > 0.70). Based on the results from table 3, it can be concluded that the research instrument is reliable. Descriptive analysis summarises and describes research data, such as mean, median, and standard deviation, which are presented in visual summary formats such as tables and histograms (Agus Supriyadi et al., 2023; Arztmann et al., 2023). After the descriptive analysis, the research continued with an inferential analysis to conclude sample data related to the broader population. Inferential analysis uses the T-test test, with the first step being pre-requisite tests such as normality and homogeneity tests.

If the data meets the requirements of normal and homogeneous distribution, then proceed with the T-Test analysis (Hake, 1998).

3. Results and discussion

3.1 Descriptive statistical analysis results

The results of descriptive analysis regarding students' cognitive mastery are presented in Table 4. The number of students in the experimental group was 15, and in the control group was 13. Although the mean score of the pre-test of the experimental group was slightly higher than that of the control group, the difference was insignificant, about 6.66. However, in the post-test, there was a significant increase in the mean score of the experimental group students compared to the control group, with a mean score of about 12.18. The standard deviation on the post-test of the control group was higher than that of the experimental group, indicating a more significant variation in scores among the control group students. Conversely, the scores of the experimental group students were more evenly distributed.

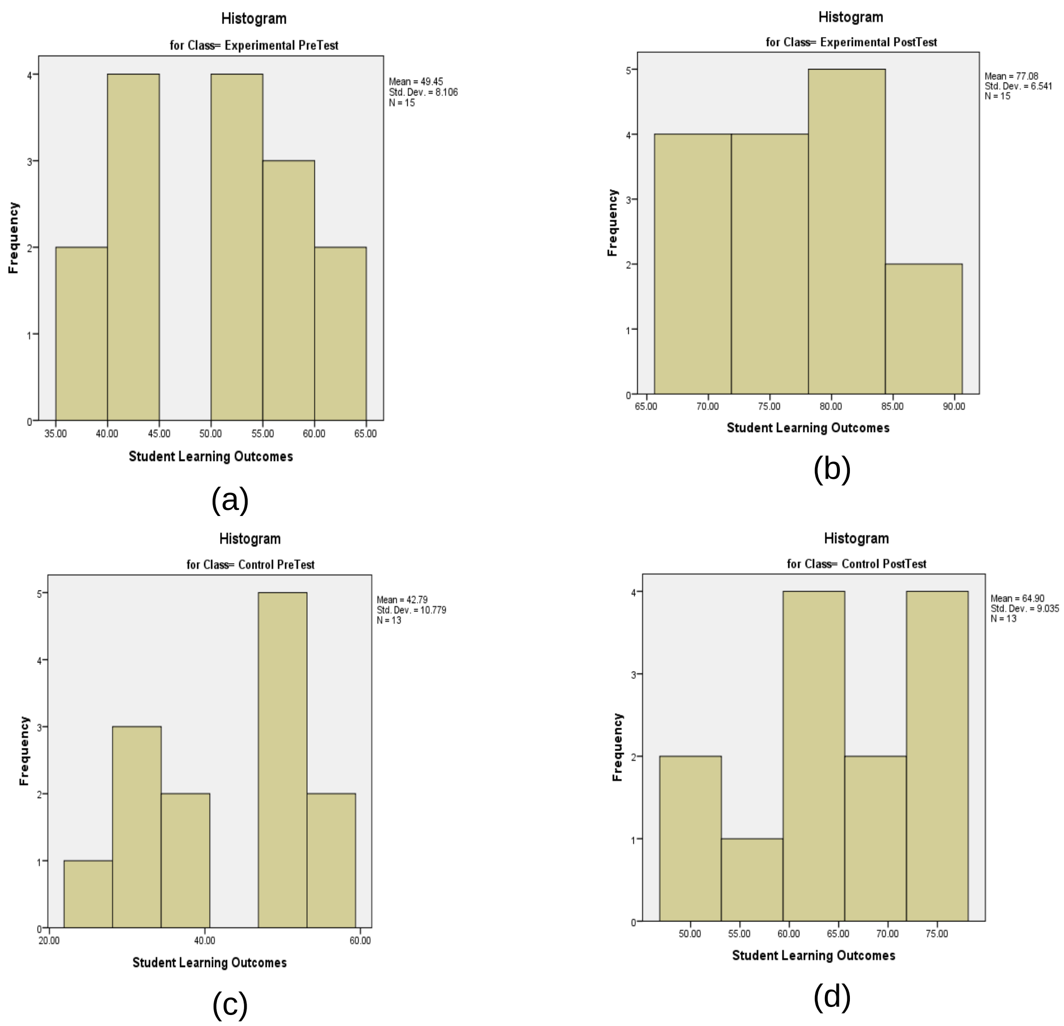


Figure 3. (a) Experimental group pre-test histogram (b) Experimental group post-test histogram (c) Control group pre-test histogram and (d) Control group post-test histogram

Table 4. Descriptive statistical analysis

		N	Mean	Median	SD	Minimum - Maximum
Experiment Group	Pre-test	15	49.45	50.00	8.106	37.50 – 62.50
	Post-test	15	77.08	75.00	6.541	68.75 – 87.50
Control Group	Pre-test	13	42.79	50.00	10.778	25.00 – 56.25
	Post-test	13	64.90	62.50	9.035	50.00 – 75.00

3.2 Results of inferential statistical analysis

The normality test is carried out to assess whether the variables are normally distributed. In this study, the normality test used the Shapiro-Wilk method because of the limited number of samples ($n < 50$) (Avram & Mărușteri, 2022). If the significance value (sig) > 0.05, then the data is considered normally distributed (O. Emmanuel et al., 2020). The results of Table 5 show that the pre-test and post-test data of students' cognitive mastery in both groups have a significance value (sig) > 0.05, so it can be concluded that the data in both groups are normally distributed.

Table 5. Normality test

		Shapiro-Wilk			Description
		Statistic	df	Sig.	
Experiment Group	Pre-test	0.926	15	0.236	Normal
	Post-test	0.882	15	0.052	Normal
Control Group	Pre-test	0.870	13	0.053	Normal
	Post-test	0.882	13	0.075	Normal

The homogeneity test is used to evaluate the data similarity between two groups. The decision was taken based on the significance value (sig) in the test of homogeneity of variances with a significance level of 0.05. Based on the analysis results in Table 6, the significance value for the pre-test is 0.056, and for the post-test is 0.229. Since both significance values are more significant than 0.05 (sig > 0.05), it can be concluded that the data in this study shows homogeneity between the two groups.

Table 6. Homogeneity test

Group	Nilai sig	Description
Pre-test	0.056	Homogenous
Post-test	0.229	Homogenous

The analysis in this study used the independent sample t-test method to assess the significance of the data between the two groups. If the significance value (sig value, 2-tailed) > 0.05, there is no significant difference between the two groups. Conversely, if the sig value (2-tailed) < 0.05, there is a significant difference between the two groups (Inderanata & Sukardi, 2023). The results of the independent sample t-test test on the pre-test of both groups showed a sig value (2-tailed) = 0.074, meaning there was no significant difference between cognitive mastery in the experimental and control groups. However, on the post-test, the sig value (2-tailed) = 0.000, indicating a significant difference between cognitive mastery in the experimental and control groups based on the data observed from Table 7.

Table 7. Independent sample t-test

Pre-test		**t**	**df**	**Sig. (2-tailed)**
Value	Equal variances assumed	1.863	26	0.74
	Equal variances not assumed	1.825	22.096	0.81
Post-test		**t**	**df**	**Sig. (2-tailed)**
Value	Equal variances assumed	4.125	26	0.000
	Equal variances not assumed	4.030	21.564	0.001

3.3 Discussion

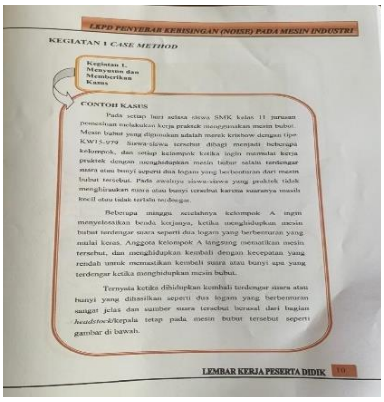
This study involved two groups with different learning treatments. The experimental group learned using the case method, while the control group learned using the lecture method. The lecture method in the control group involved explaining the material by the teacher using a slide presentation in front of the class, followed by giving assignments to students. The results of learning with the lecture method are considered less effective, as seen from the low level of understanding and learning outcomes of students, as illustrated by the average score of students in the post-test of the control group.

(a) (b)

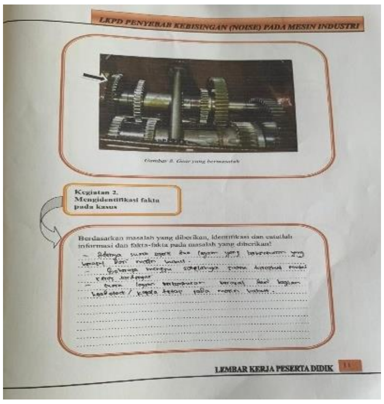
Figure 4. (a) Case method learning process (b) Lecture method learning process

In the experimental group, learning is carried out using the case method. After providing learning materials, students will be divided into several groups to discuss the cases following the material studied, presented in the form of LKPD. Students discuss with group members, analyze the causes of the case or problem, and find solutions to the given case. Students will write the causes and solutions of the case on the LKPD given. After completing the group discussion, the teacher will discuss with the students and conclude the causes and solutions to the cases they discussed.

Based on the research findings, it was found that the application of the case method learning method in the experimental group was effective in improving students' cognitive mastery compared to the use of the lecture method in the control group. The case method allows students to develop their ability to solve cases through group discussions. This discussion encourages active learning, where students seek information and share views to find solutions to the given cases while deepening their understanding. The results of this study are consistent with previous findings by (Yang et al., 2023), which showed significant improvement in student learning outcomes through similar methods.



(a)



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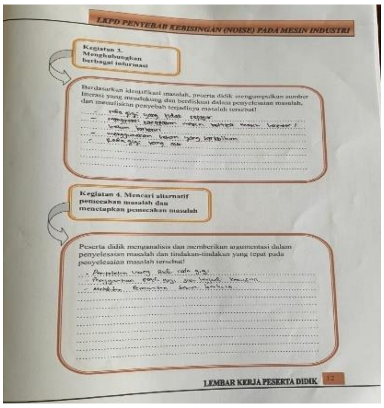

(c)

(d)

Figure 5. (a-c) Case method assignment on LKPD (d) Maintenance on the lathe gearbox

Implementationg of the case method learning not only increases students' participation but also makes the learning process more enjoyable, arouses students' learning spirit, and develops their ability to analyze and solve problems. Through this learning, students will be better prepared to face practical challenges in the field, where they need to analyze and find solutions to problems that arise in industrial machines.

4. Conclusion

The results showed a significant difference in students' cognitive mastery between the group using case method learning as an experiment and the control group using the lecture method. The application of the case method is proven effective in improving students' cognitive mastery, which allows optimal learning objectives. This method encourages student activeness, primarily through discussion, and strengthens the interaction between students and teachers. The teacher is a facilitator who directs the discussion and learning process and conducts good evaluation. In addition, the case method also supports students in dealing with field practice, such as analyzing problems in industrial machines and developing solutions.

Acknowledgements

The authors would like to thank the State Vocational School 1 West Sumatra for allowing to carry out research on case method learning in industrial mechanical machinery subjects.

Declarations

Author contribution

Rendy Dwi Putra: Writing – review & editing, Writing – original draft, Conceptualization, Data curation, Visualization, Sofware. Waskito: Writing – review & editing, Formal analysis, Methodology, Supervision. Andril Arafat: Writing – review & editing, Formal analysis, Resources, Validation, Visualization. Juan Luis Cabanillas García: Investigation, Writing – review & editing, Methodology, Validation. Firas Tayseer Mohammad Ayasrah: Writing – review & editing, Data curation, Formal analysis, Software, Visualization, Resources.

Funding statement

This research has not been funded by any person or organisation.

Competing interest

The authors declare no conflict of interest in this study.

Ethical clerance

This research has been approved by the West Sumatra Education Office with letter number 420.02/0539/PSMK-2024. This research was conducted according to the Declaration of Helsinki.

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