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Examining the effect of PBL in improving the students' learning outcomes: A case in a private vocational school

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Abstract

Vocational education plays a strategic role in increasing the competitiveness of the national workforce. With a work-based learning approach, vocational high schools are expected to be able to bridge the needs of industry through an adaptive curriculum, competency certification, and direct partnerships with the business/industry world. This study aims to describe the procedure for implementing problem-based learning (PBL) in the light vehicle engine maintenance subject, to analyze the improvement in learning outcomes after PBL, and to analyze the extent of the improvement in learning outcomes after the implementation of PBL in the light vehicle engine maintenance subject at SMK Muhammadiyah 1 Moyudan, a private vocational high school in Yogyakarta. This study uses a quantitative quasi-experimental approach (non-equivalent control group design). The PBL was tested on a sample of 60 students. Data were collected through tests and analyzed descriptively, independent t-test, and normalized gain. The results of this study showed a significant difference (sig. 0.004 < 0.05) between the PBL and control groups. The average N-Gain value is 0.54 (medium category). In addition, there is a significant increase in the average value of learning outcomes of class XI TKR B students who use the PBL model to 82, where previously the average value of students only reached 58. The results of this study explain that although both groups experienced an increase, the PBL group showed a greater and more consistent increase than the control group. It proves the significant effectiveness of the PBL in improving the students' learning outcomes.

Keywords: vocational education, problem-based learning, learning outcomes

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INTRODUCTION

One of the official secondary education programs in Indonesia, Vocational High Schools (SMK) seeks to help students improve their knowledge and competencies to keep pace with advances in science and technology. According to Samsudi & Sudana,(Budiastuti et al., (2021) Students' mastery of knowledge, skills and attitudes must refer to the needs of the industrial world. Irwanto (2021) stated that the implementation of vocational schools must be more focused and directed towards programs in order to guide and provide readiness to individuals for work.

Based on OECD (2023) Vocational education at vocational schools plays a strategic role in increasing the competitiveness of the national workforce. According to European Training Foundation (2021) With a competency-based and work-based learning approach, vocational schools are expected to be able to bridge industry needs through an adaptive curriculum, competency certification, and direct partnerships with the business/industrial world.

In addition, according to Chau et al., (2025) Vocational education plays a role in developing professional attitudes, work ethic, and specific technical skills, which are the main assets for graduates in facing a rapidly changing job market. This is reinforced by Ridwvan Arslan et al., (2023) which states that in the era of technological transformation, for example the shift from gasoline-powered vehicles to hybrid and electric systems, the role of vocational education is becoming increasingly crucial to ensure that graduates have the latest technical skills required by industry.

Halim (2022) states that 21st-century educational competencies emphasize the development of multidimensional skills, including critical thinking, problem-solving, innovation, and creativity. Furthermore, the ability to communicate effectively, collaborate in teams, and master technology adaptively are also key foundations. These skills are designed to prepare students to respond to evolving global dynamics. Critical thinking skills are an important foundation in dealing with complex problems. Kamilah (2023) Students who are able to analyze information, evaluate arguments, and draw logical conclusions will be better prepared to make appropriate decisions in various situations. This aligns with the demand for problem-solving skills, where students are expected to find innovative solutions to problems that arise both in the school environment and in society.

Current learning methods encourage students to actively participate. Therefore, the teacher's role in this process is to create a learning atmosphere by acting as a facilitator and mediator. This is expected to encourage students to be active during the classroom learning process. Therefore, to teach learning material, a teacher does not need to stand in front of the class and lecture. Instead, teachers can facilitate learning by creating an environment that motivates students to learn and actively participate in acquiring knowledge through applied learning.

While many learning models currently encourage students to think creatively, some teachers still employ a teacher-centered learning system. An example of monotonous, teacher-centered learning is an authoritarian teacher who is unfriendly to students. This can lead to students feeling bored and uninterested in learning. To address this, teachers must continually improve their professionalism by providing students with learning opportunities and engaging them effectively in their learning. Therefore, teachers can implement appropriate learning models. Implementing appropriate learning models will have a direct impact on students' understanding of the material presented and will encourage critical thinking and student engagement.

Based on observations made in the theoretical learning of Light Vehicle Engine Maintenance in class XI TKR A SMK Muhamadiyah 1 Moyudan, learning is still centered on the teacher (Teacher Center). So from the results of observations in class XI TKR A, many students were found to be passive because they did not interact much with the teacher. This can be seen from the fact that many students were involved in other activities unrelated to the lesson such as using cellphones, doing homework not according to the lesson schedule, and there were even some students who fell asleep during class hours. In class XI TKR A, which consists of 30 students, less than 14 students actively participated in learning activities in the subject of Light Vehicle Engine Maintenance.

Furthermore, observations revealed that most students were not actively responding to questions posed by the teacher during the lesson. This phenomenon indicates a problem in the interaction between teacher and students during the learning process. Furthermore, observational findings confirmed that students' understanding of the material was not optimal.

Adnyana and Yudaparmita (2023) states that ineffective and inefficient learning models can lead to imbalances in the development of students' knowledge, attitudes, and practical skills. This creates an imbalance between theoretical understanding, attitudinal development, and practical abilities. Students do not always understand the material being taught, and when given the opportunity to ask questions, they prefer to remain silent. Furthermore, Khauro et al. (2020) indicates that the dominant use of lecture techniques in learning often creates obstacles in the teaching and learning process.

This one-way approach tends to make students passive, resulting in incomplete understanding of the material presented by the teacher. Consequently, students struggle to grasp the material, potentially reducing learning motivation and critical thinking skills. These findings emphasize the importance of a variety of interactive and participatory learning strategies to ensure competency achievement. Objective evidence from midterm exam results indicates that 40% of 11th-grade TKR students have not met the minimum completion criteria. This reflects a gap in academic achievement that requires attention in evaluating the learning process.

The right learning model will help address this problem. If teachers want to create a more active and conducive learning environment, then an appropriate learning model will be very helpful. Research conducted by Rehani & Mustofa, (2023) stated that the use of less varied learning models results in a lack of critical thinking and student learning outcomes, so creative and innovative learning models are needed. Some The learning model that facilitates students to think critically during the learning process is the Problem Based Learning learning model. This was put forward by Yusri, (2020) explains that the Problem Based Learning model is a learning method that utilizes contextual problems as a basis for students to develop critical thinking skills and skills in formulating solutions.

While in the Teacher-Centered Model, students simply listen to the teacher's explanations, the PBL Model divides students into study groups to discuss problems presented by the teacher. This gives students the opportunity to solve problems based on their knowledge. This is supported by research. Denizhan, (2020) states that group learning activities to solve problems or cases encourage students to think based on their knowledge, identify the information needed, search for more relevant information, and analyze and evaluate to develop a problem-solving flow.

This study presents a novelty by adapting PBL specifically for light vehicle engine maintenance material in vocational high schools, in contrast to previous PBL studies that were predominantly in the fields of health or general engineering. This approach is designed to align learning problems with real-life cases in automotive workshops, such as engine troubleshooting or routine maintenance. Therefore, the purpose of this study is to examine the effectiveness of problem-based learning in improving learning outcomes in light vehicle engine maintenance learning for class XI students at SMK Muhammadiyah 1 Moyudan.

RESEARCH METHOD

This type of research uses a quantitative experimental research approach with a quasi-experimental method that uses a non-equivalent control group design. The location of this research is a Muhammadiyah 1 Moyudan Vocational High School. The population in this study amounted to 60 students. Using a saturated sampling technique, the entire population was sampled without selection, where Class XI TKR B (30 students) was designated as the experimental class that received the Problem Based Learning (PBL) model, while Class XI TKR A (30 students) acted as the control class. Furthermore, a pretest was conducted in both classes to measure students' initial abilities in the Light Vehicle Engine Maintenance (PMKR) subject. After that, a learning intervention was implemented, where the experimental class underwent PBL and the control class did not receive any intervention. After the intervention, a posttest was conducted to measure the improvement in learning outcomes. Data were then collected from the pretest-posttest scores of both groups. Based on the explanation, the research design is presented in Figure 1.

R	0_1	X	0_2
R	0_3		0_4

Figure 1. Research design

R : experimental and control groups
O1 & O3 : pretest observation group to find out initial results
O2 : student learning outcomes after implementing PBL
O4 : learning outcomes of the control group that was not given PBL
X : treatment.

The sampling technique used saturated sampling. Data were collected using pretests and posttests. The data analysis techniques used were descriptive analysis, independent t-tests, and normalized gain tests.

RESULTS AND DISCUSSION

Pre-requisite test

Test the level of difficulty of the test items

Testing item difficulty is a process used to determine the extent to which a question can differentiate between students who have mastered the material and those who have not. Typically, this test is conducted by calculating the percentage of students who answered a question correctly out of the total number of students who completed the test. A high percentage indicates the question is relatively easy. Conversely, a low percentage indicates the question is relatively difficult.

The ideal difficulty level for exam questions is usually between 0.3 and 0.7, where the questions are neither so easy that there is no differentiation, nor so difficult that almost all students cannot answer correctly. The criteria for item difficulty levels can be seen in the following figure.

The pre-test were administered to 60 11th-grade TKR students. It was then then analyzed for difficulty, the results of which are presented in Table 1.

Table 1. Distribution of difficulty levels of pre-test problems

Level of difficulty	Criteria	Number of problems	F	(%)
Difficult	Level of difficulty < 0.3	3, 5, 20, 22, 30, 38	6	12%
Intermediate	0.3 ≤ level of difficulty ≤ 0.7	2, 6, 7, 8, 10, 11, 12, 13, 16, 17, 18, 19, 21, 23, 24, 25, 26, 33, 35, 36, 37, 39, 40, 41, 42, 43, 45,47, 48, 49, 50	31	62%
Easy	Level of difficulty > 0.7	1, 4, 9, 14, 15, 27, 28, 29, 31, 32, 34, 44, 46	13	26%
Total			50	100%

Based on Table 1, it can be seen that from the 50 pretest questions used in the research, there are 31 questions at a medium level of difficulty with an index of 0.3 ≤ difficulty level ≤ 0.7 and there are 13 questions at an easy level of difficulty with an index of difficulty level > 0.7. Apart from that, there are 6 questions that are at a difficult level of difficulty with a difficulty level index <0.3.

Normality test

A normality test was conducted to determine whether the research data was normally distributed. In this study, the Kolmogorov-Smirnov test was used. The basis for making the decision is that if the sig value is > 0.05, the research data is normally distributed. The results of the normality test using SPSS 22 can be seen in Table 2.

Table 2. Normality test results

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Pre-test XI TKR B	.099	30	.200*	.978	30	.764
Pre-test XI TKR A	.089	30	.200*	.965	30	.413
Post-test XI TKR B	.113	30	.200*	.974	30	.662
Post-test XI TKR A	.146	30	.100	.945	30	.123

Based on the normality test table conducted using two methods, namely Kolmogorov-Smirnov and Shapiro-Wilk. The normality criteria are met if the significance value is > 0.05. In the pre-test and post-test groups of the problem-based learning model (XI TKR B), the Kolmogorov-Smirnov significance value is 0.200 for all categories, while the Shapiro-Wilk value is 0.764 (pre-test) and 0.662 (post-test). For the pre-test group that does not use problem-based learning (XI TKR A), the Kolmogorov-Smirnov and Shapiro-Wilk values are 0.200 and 0.413, respectively. As for the post-test, the Kolmogorov-Smirnov value is 0.100 and Shapiro-Wilk 0.123. All of these values are above 0.05, so it is concluded that the data for all groups is normally distributed.

Homogeneity test

The homogeneity test aims to determine whether the variance of two or more groups is homogeneous (the same) or heterogeneous (different). The basis for making this decision is that if the sig value is > 0.05, the research data is considered homogeneous (the same). However, if the sig value is < 0.05, the research data is considered heterogeneous (different). The results of the homogeneity test using SPSS 22 are shown in Table 3.

Table 3. Homogeneity test results

		Levene Statistics	df1	df2	Sig.
learning outcomes	Based on Mean	2,084	1	58	.154
	Based on Median	.910	1	58	.344
	Based on Median and with adjusted df	.910	1	57,531	.344
	Based on trimmed mean	2.108	1	58	.152

Based on the homogeneity of variance test table using Levene's statistic, the significance values consistently exceed 0.05 for all approaches, namely 0.154 (based on the mean), 0.344 (based on the median), 0.344 (with degrees of freedom correction), and 0.152 (based on the trimmed mean). This indicates that the data variance between groups is homogeneous. Thus, the assumption of homogeneity is met.

Data analysis test

Independent sample t-test

In this study, an independent sample t-test was applied to analyze the significant differences between the problem-based learning model and the conventional model on student learning outcomes in the subject of light vehicle engine maintenance in class XI of SMK Muhammadiyah 1 Moyudan. This statistical method was used to test the hypothesis whether the two learning models have a statistically different impact on student learning outcomes. The results of the analysis are presented in Table 4.

Table 4. Independent sample T-test results

	Kelas	N	Mean	Std. Deviation	Std. Error Mean
Hasil belajar	Post test kelas eksperimen	30	82.13	5.457	.994
	Post test kelas kontrol	30	78.27	4.631	.845

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hasil belajar	Equal variances assumed	2.084	.154	2.959	58	.004	3.867	1.307	1.251	6.482
	Equal variances not assumed			2.959	56.505	.004	3.867	1.307	1.250	6.484

From the table above in the equal variances not assumed section, it can be seen that the Sig (2-tailed) value is 0.004 < 0.05, which means there is a difference between problem-based learning and conventional learning models on learning outcomes. The class using PBL achieved an average of 82.13 with a standard deviation of 5.442, while the class not using problem-based learning obtained an average of 78.27 and a standard deviation of 4.631. The Sig. (2-tailed) value of 0.004 (smaller than α = 0.05) indicates that the difference in the average is statistically significant, so the null hypothesis (no difference between the two models) is rejected. Although the average difference is only 3.93, strong statistical significance (p < 0.05) confirms that this difference does not occur randomly, but is influenced by the superiority of the PBL model.

Both classes showed good homogeneity in their scores, marked by a relatively low standard deviation, with PBL at 5.442 and conventional at 4.631. This reflects the consistency of student learning outcomes across both groups.

However, the higher mean in the PBL class indicates that the problem-based approach is more capable of fostering collective student academic achievement. Although both groups experienced improvement, the group using PBL showed significantly greater and more consistent improvement than the control group. This proves that PBL is effective in significantly improving student learning outcomes.

Based on the description above, the hypothesis is accepted, namelythere was a significantly greater increase in learning outcomes in the experimental group (PBL) than in the control class.PMKR subjects in class XI of Muhammadiyah 1 Moyudan Vocational School.

Normalized gain test

The N-Gain (Normalized Gain) test is a statistical method used to measure learning effectiveness by analyzing the increase in student understanding before (pretest) and after (posttest) a learning intervention. The N-Gain test aims to answer the extent to which the implementation of problem-based learning is effective in improving student learning outcomes. Table 5 presents the results of the normalized gain test.

Table 5. Normalized gain test results

	Class		Statistics	Std. Error
N Gain	Mean		53.6325	3.71749
Percent	95% Confidence Interval for Mean	Lower Bound	46.0294	
		Upper Bound	61.2356	
	5% Trimmed Mean		55.0943	
	Median		57.5712	
	Variance		414,592	
	Standard Deviation		20.36153	
	Minimum		.00	
	Maximum		83.33	
	Range		83.33	
	Interquartile Range		21.75	
	Skewness		-1,357	.427
	Kurtosis		1,791	.833
	Kurtosis		5,213	.845

Based on the results of the N-Gain analysis, an average value of 0.54 was obtained, which is included in the moderate improvement category. This indicates that the implementation of problem-based learning has a significant impact on improving student learning outcomes. Although the overall improvement has not reached the high category, there is variation in achievement among students, where some showed quite high improvements with N-Gain reaching 0.76, while most students were in the moderate improvement range. It can be concluded that the implementation of PBL has proven effective in improving student learning outcomes when compared to the initial conditions (pre-test).

Discussion

Procedures for implementing PBL in the Light Vehicle Engine Maintenance subject

The first step is problem orientation. In this phase, the teacher begins by asking provocative questions related to the basic material on the EFI system to stimulate students' activeness and curiosity. This stage serves as the initial step for students to understand the context of the problem to be solved. The teacher also explains the basic material as a foundation of knowledge before students dive into real-world problems. The next step is organizing students into groups. Students are divided into small groups to facilitate collaboration between students. The teacher distributes Student Worksheets (LKPD) as a guide for problem solving. At this stage, students are given clear work procedures and time allocations, so they can organize their tasks in a structured manner.

The next step is for students to study the worksheet independently or in groups, identify problems, and gather information related to solutions. The teacher acts as a facilitator by monitoring student progress, providing guidance if difficulties arise, and ensuring the investigation proceeds according to targets. After the investigation, students discuss their findings in groups and then present their solutions to the class. The teacher monitors student engagement during the discussion and evaluates the project's success. This stage fosters students' communication and argumentation skills.

The final step is for the teacher to administer a written test to gauge students' conceptual understanding and encourage them to reflect on the learning process. Reflection includes identifying obstacles, student difficulties, and the level of learning completion. This stage provides feedback for future PBL strategies.

Student learning outcomes after implementing PBL in the class XI of SMK Muhammadiyah 1 Moyudan

Based on the learning outcomes data of class XI TKR B students after the implementation of the problem-based learning model, the average is categorized as very good. Table 6 presents the improvements in learning outcomes after the implementation of the PBL.

Table 6. Student learning outcomes after implementing PBL

Test	Minimum value	Maximum value	Average
Pre-test	38	80	58
Post-test	72	90	82

It can be seen that there was a significant increase in the average value of learning outcomes to 82, where before the implementation of the PBL learning model the average value of class XI TKR B students only reached 58. The minimum and maximum values before the implementation of the PBL model were 38 and 80. Then after the implementation of the problem-based learning model (PBL) the minimum value increased to 72, and the maximum value to 90. Based on this explanation, it can be concluded that there was an increase in overall learning achievement.

Based on the results of class XI TKR A which did not use PBL, there was also a significant increase in the average score to 78 which was previously only 61. In addition, the minimum score increased to 70, and the maximum score to 90. Although both groups experienced an increase in scores, the group using PBL showed a much greater and consistent increase compared to the control group. This proves that PBL is effective in significantly improving student learning outcomes.

This finding is relevant to the research results reported by Ghufron & Ermawati (2021) conveyed that the goal of the problem-based learning model is to develop students' ability to solve problems critically, creatively, and independently through a learning process centered on real-world problems. The Problem-Based Learning (PBL) model is designed to develop students' critical thinking skills, including the ability to analyze, evaluate, and synthesize information, through their involvement in learning scenarios that require the search for innovative and relevant solutions. This approach also aims to strengthen cooperation between students by conditioning them in discussion groups, where they jointly formulate strategies, exchange ideas, and solve problems collaboratively. Thus, PBL not only focuses on strengthening cognitive aspects, but also builds an interactive learning environment.

Furthermore, the results of research conducted by Kamaludin (2024) Regarding the effectiveness of problem-based learning models in improving the achievement of vocational high school students, the results showed that problem-based learning is effective and able to improve student learning outcomes in the subject of Basic Automotive Engineering Hand Tool material in class X TKR SMK N Situraja. In the context of this study, the increase in post-test scores does not only reflect technical mastery of the material, but also the possibility of increasing analytical, collaborative, and problem-solving skills that are the focus of Problem Based Learning. Therefore, the findings of this study not only explain the increase in grades, but are also consistent with the theoretical framework and empirical evidence showing that PBL is able to strengthen cognitive aspects while building an interactive and practical application-oriented learning environment.

The effectiveness of the problem-based learning model on learning outcomes

The results of the research that has been carried out, show that there is an increase after the implementation of the PBL learning model in the PMKR subject, the increase is categorized as effective for student learning outcomes. Based on the N-Gain analysis, an average value of 0.54 was obtained. This value is in the moderate improvement category, indicating that the implementation of the Problem Based Learning (PBL) model has succeeded in increasing student understanding or competence substantially, although it has not yet reached the high category. This N-Gain finding quantitatively shows a significant positive impact of the PBL model on student learning outcomes. Furthermore, the results of the Independent Sample t-test statistical test strengthen this finding. In the test, a significance value (Sig.) was obtained that was smaller than 0.05 ($\alpha = 0.05$). Based on statistical decision-making criteria, this firmly rejects the proposed Null Hypothesis (H0). This rejection of H0 has important implications, namely that there is a statistically significant difference in learning outcomes between the group using PBL and the comparison group (control). Thus, it can be concluded convincingly that the Problem Based Learning (PBL) learning model has proven effective in improving the learning outcomes of students in class XI Light Vehicle Engineering (TKR).

Unlike the conventional approach previously used in class XI TKR, the implementation of the PBL model has been proven to increase active student participation in learning, thus significantly impacting learning outcomes. This model shifts the learning paradigm from teacher-centered to student-centered, with an emphasis on exploring problems that require solutions. Through direct involvement in the problem-solving process, students develop not only understanding but also application skills, making learning more relevant to real-world needs.

The effectiveness of the problem based learning model has been studied by Kamaludin (2024) Regarding the PBL model in improving the achievement of vocational high school students, the results showed that PBL learning is effective and able to improve student learning outcomes in the subject of Basic Automotive Engineering Works, hand tool material in class X TKR SMK N Situraja. The results of the research that has been carried out provide reinforcement that the Problem Based Learning (PBL) model is effective in improving learning outcomes in the subject of Light Vehicle Engine Maintenance. The data shows a significant increase in the average value of class XI TKR B (PBL class) from 58 to 82. Class XI TKR A (non-PBL class) also experienced an increase, but smaller, namely from 68 to 78. Although both groups experienced progress, a much greater and consistent increase occurred in the group that implemented PBL. These findings prove the significant effectiveness of the PBL model in improving student learning outcomes.

From a constructivist perspective, Problem-Based Learning (PBL) encourages students to actively construct knowledge through direct engagement with contextual problems. This approach positions students as problem solvers who organize, integrate, and reconstruct new information based on their prior experiences, thereby deepening understanding. This aligns with Piaget's (1952) theory, which states that learning is an active process in which students construct new knowledge based on prior experiences and schemas.

Furthermore, from Vygotsky's (1978) social-constructivist perspective, PBL learning practices that emphasize group work and social interaction provide scaffolding in the form of cognitive and social support. Through collaboration and guidance from peers and facilitators, students in the Zone of Proximal Development (ZPD) can reach levels of understanding and performance previously beyond their comprehension. This mechanism may explain the improved achievement of students with previously low abilities. Furthermore, the activity pattern in PBL aligns with Kolb's (1984) experiential learning cycle: concrete experience, reflection, conceptualization, and active experimentation. This cycle facilitates the transformation of problematic experiences into theoretical concepts and practical applications, thus strengthening the transfer of knowledge to applied skills. This is certainly very relevant in the context of vocational education, which demands mastery of technical competencies and the ability to apply them in the field.

CONCLUSION

This study confirms that the Problem Based Learning (PBL) learning model successfully improves student learning outcomes, particularly in class XI TKR B for the Light Vehicle Engine Maintenance subject. This belief is strengthened by the independent sample t-test (significance <0.05, H0 rejected) and the average N-Gain score of 0.54, which is included in the moderate category. In other words, the implementation of PBL has a significant impact on improving the effectiveness of learning outcomes.

As a result, there was a significant increase in the average value of the learning outcomes of class XI TKR B students who used the problem based learning model to 82, where before the implementation of the PBL learning model the average value of class XI TKR B students only reached 58. Likewise, the learning outcomes of class XI TKR A after the post-test, there was a significant increase in the average value of learning outcomes to 78, where previously the average value of students only reached 61. Although both groups experienced an increase in scores, the group using PBL showed a much greater and consistent increase compared to the control group. This proves that PBL is effective in significantly improving student learning outcomes.

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