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A Comparative Study of the Problem-Based Learning Model and Conventional Learning on the Mathematics Learning Outcomes of Tenth-Grade High School Students

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Abstract: ***This study compares the effectiveness of the Problem Based Learning PBL model with conventional teaching methods in improving the mathematics learning outcomes of tenth grade high school students. A quasi-experimental design was employed, with two groups of 36 students each. The experimental group used the PBL model, while the control group followed conventional methods. Data was collected through tests and observations, with the results analyzed using the Mann Whitney test. The study concluded that the PBL model significantly improves student mathematics learning outcomes compared to conventional teaching methods.***

Keywords: Mathematics Learning Outcomes, Problem-Based Learning, Conventional Learning, High School, Trigonometry

1. Introduction

Education is one of the most critical components in realizing the growth and development of a nation, and it plays a key role in creating an educated society. Education is intended to improve human resources and shape individual character. According to Law No. 20 of 2003 on the National Education System, education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to possess religious spiritual strength, self-control, personality, intelligence, noble character, and the skills needed by themselves, society, the nation, and the state [1].

One of the challenges faced by the educational sector is the inadequate quality of teaching, as modern education requires teachers to create learning processes that prepare students to face the challenges of the 4.0 revolution era. Studies in schools show that students are not encouraged to improve their critical thinking and problem-solving skills during the learning process. Classroom teaching often leads students to memorize and understand concepts without fostering deeper engagement. This indirectly results in many students becoming bored and easily forgetting the information they have acquired [2].

Based on observations of the tenth-grade mathematics class at SMA Negeri 1 Paciran, students were found to be preoccupied with their own tasks and bored with problem-solving during the lessons. This shows that students are still insufficiently engaged in the learning process. When compared to the criteria for learning objectives (KKTP), the students' average scores in daily tests remain low. Therefore, learning outcomes must be improved through the use of learning models and media that enable students to actively participate in learning activities, enjoy the process, and engage in problem-solving.

Based on the results of the pre-test, it was found that the average mathematics learning score of students in the experimental class was 37.61, while in the control class, it was 37.47, both of which are below the learning objectives criteria (KKTP), indicating that the learning outcomes need to be improved. The use of traditional teaching models in the classroom is one of the many factors that contribute to lower student achievement. In conventional models used in schools, students are portrayed as passive recipients of information. This causes most students to pay little attention to what their teachers are teaching. No matter how well teachers master the subject matter, students will not be able to achieve the expected educational goals. To achieve these goals, a learning model is needed that encourages students to develop their own knowledge rather than requiring them to memorize information.

2. Research Methods

A quasi-experimental design was employed in this study, adopting a quantitative methodology as recommended by Sugiyono[3].

Table 1: Research Design

Class	*Pre-Test*	*Treatment*	*Post-Test*
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

The subjects of this study were 324 tenth-grade students from SMA Negeri 1 Paciran during the 2023/2024 academic year.

Table 2: Population of Tenth-Grade Students at SMA Negeri 1 Paciran

Kelas	*Siswa*		*Total siswa*
	M	*F*	
XE-1	12	24	36
XE-2	12	24	36
XE-3	12	24	36
XE-4	12	24	36
XE-5	10	26	36
XE-6	10	26	36
XE-7	10	26	36
XE-8	14	22	36
XE-9	14	22	36

This study involved two groups of students. Thirty-six students from class XE-1 in the experimental group were taught using the problem-based learning model, while thirty-six students from class XE-5 in the control group were taught using conventional methods. The data collection techniques in this research are as follows:

1) Observation Method

The four phases of Problem-Based Learning were assessed using observational techniques to evaluate how and to what extent students engaged in the learning process. In this case, the observer plays a crucial role during the learning process. Observations were conducted by monitoring student involvement during lessons, particularly during group work on the provided student worksheets. During group learning, it was evident which students were active and which were not.

2) Test Method

In this study, five items were used to assess the material being taught. A pre-test was administered to determine the initial learning outcomes. The second test was conducted after the treatment, utilizing the Problem-Based Learning model for the experimental class and the conventional model for the control class.

The development of instruments was necessary in this study to ensure the validity of the instruments used, aligning with the requirements for the research[4]. Validity and reliability assessments were conducted before both test instruments were used to establish their validity and reliability.

Table 3: Research Design

Item Number	*R calculated*	*R table*	*Decision*
1	0,792**	0,4438	Valid
2	0,636**	0,4438	Valid
3	0,704**	0,4438	Valid
4	0,596**	0,4438	Valid
5	0,646**	0,4438	Valid

Table 4: Results of the Validity Test for Post-Test:

Item Number	*R calculated*	*R table*	*Decision*
1	0,623**	0,4438	Valid
2	0,596**	0,4438	Valid
3	0,616**	0,4438	Valid
4	0,721**	0,4438	Valid
5	0,739**	0,4438	Valid

To determine the effectiveness of the problem-based learning model on students' mathematics learning outcomes, statistical calculations and comparisons between the two groups were conducted. The results of the pre-test were used to assess students' initial abilities, while the results of the post-test were utilized to evaluate the research hypothesis. The data analysis included normality tests, homogeneity tests, and independent two-sample t-tests.

3. Results and Discussion

Table 5: Descriptive Data of Initial Ability Scores (Pre-test)

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Experimental Class	6	15,00	63,00	37,6111	2,52708	15,16251
Control Class	6	12,00	59,00	37,4722	2,15859	12,95153

Based on Table 5, the experimental class achieved an average score of 37.61 with a standard deviation of 15.163 and an error margin of 2.53, while the control class obtained an average score of 37.47 with a standard deviation of 12.952 and an error margin of 2.16. The pre-test scores indicate an average difference of 0.19 between the experimental and control classes. The visual presentation of the data can be seen in the histogram in the Figures below.

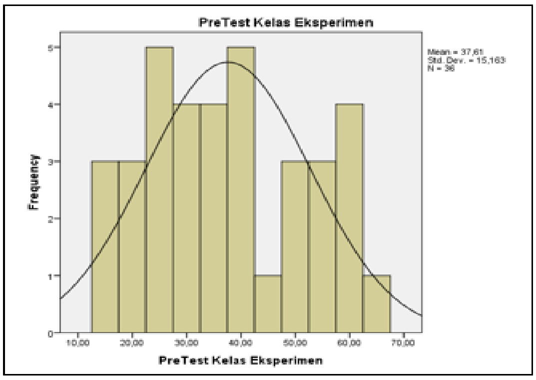

Figure 1: Pretest Experimental Class

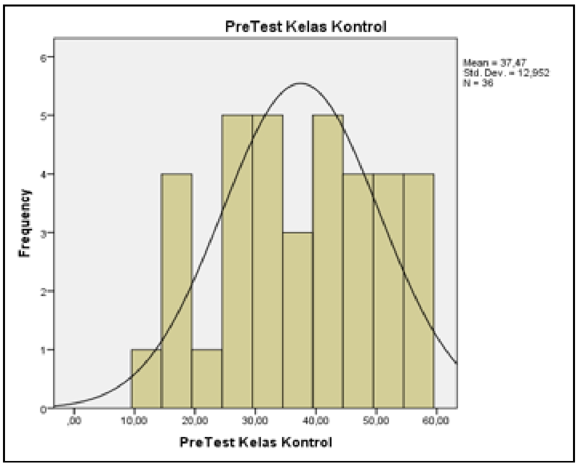

Figure 2: Pretest Control Class

Table 6: Pretest Control Class

Class		Kolmogorov-Smirnov^a			Shapiro-Wilk		
		Statistic	ddf	Sig.	Statistic	df	Sig.
Mathematics Learning Outcome	Experimental Class	,099	6	200*	,943	6	063
	Control Class	,078	6	200*	,967	6	354
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table 6 shows that both datasets follow a normal distribution, as supported by the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests, with significance values greater than 0.05.

This confirms that the assumption of normality is met for both the experimental and control groups, allowing for further statistical analysis, such as t-tests, to be conducted on the data.

Table 7: Homogeneity Test of Initial Ability Data (Pre-test)

		Levene Statistic	df1	df2	Sig.
Mathematics Learning Outcomes	Based on Mean	1,484	1	70	,227
	Based on Median	1,327	1	70	,253
	Based on Median and with adjusted df	1,327	1	68,829	,253
	Based on trimmed mean	1,492	1	70	,226

From Table 7, the obtained value is 0.227. Since 0.227 is greater than 0.05, the null hypothesis (H_0) is accepted, indicating that the data is homogeneous. This means there is no significant difference in the variance of pre-test scores between the experimental and control classes.

Independent Two-Sample t-Test Results for Initial Ability (Pre-test)

Because $-t_{\left(1-\frac{a}{2}\right),(n_1+n_2-2)} \leq t_{calculated\ value} \leq t_{\left(1-\frac{a}{2}\right),(n_1+n_2-2)}$

That is $-1{,}994437 \leq 0{,}042 \leq 1{,}994437$

Then the decision is that H_0 is accepted. The same conclusion and decision are also obtained when using the significance level. From the table, it can be observed that Sig. (2-tailed) = 0.967, which is greater than 0.05, therefore the decision is the same, namely that H_0 is accepted, as can be seen in the table. Thus, it can be concluded that the average initial ability of students in the experimental class and the control class does not differ.

Table 8: Descriptive Data of Final Ability Scores (Post-test)

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Experimental Class	6	66,00	92,00	80,2500	1,03539	6,21231
Control Class	6	48,00	88,00	70,0000	1,97444	11,84664
Valid N (listwise)	6					

Based on Table 8, the experimental class achieved an average score of 80.25 with a standard deviation of 6.212 and an error margin of 1.03, while the control class obtained an average score of 70.00 with a standard deviation of 11.846 and an error margin of 1.97. The difference in average post-test scores between the two classes is 10.25. The histogram presented in the figure shows a visual representation of the data.

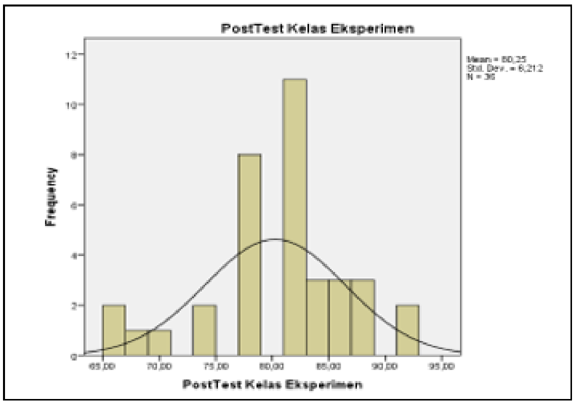

Figure 3: Post-test Results of the Experimental Class

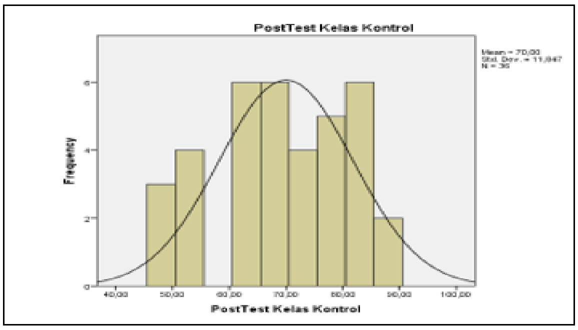

Figure 4: Post-test Results of the Control Class

Table 9. Normality Test of Final Ability (Post-test)

Tests of Normality							
Kelas		Kolmogorov-Smirnov^a			Shapiro-Wilk		
		Statistic	ddf	SSig.	Statistic	df	Sig.
Mathematical Learning Result	Experimental Class	,192	6	,002	,934	6	,032
	Control Class	,092	6	,200*	,948	6	,093
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

From Table 9, it is found that the significance value (Sig.) for the experimental class in both the Kolmogorov-Smirnov and Shapiro-Wilk tests is less than 0.05, while the significance value for the control class is greater than 0.05. However, since the data does not follow a normal distribution, a non-parametric statistical test using the Mann-Whitney test will be conducted.

Table 10. Mann-Whitney Test for Final Ability (Post-test)

Test Statistics[a]
Hasil Belajar Matematika
Mann-WhitneyU 324,000
WilcoxonW 990,000
Z -3,657
Asymp.Sig.(2-tailed) ,000
a. Grouping Variable: Kelas

From Table 10, it can be observed that the Mann-Whitney test statistic, T, is 324.0. Since $n_1 = 36$ and $n_2 = 36$, both values are greater than 20, the Mann-Whitney test quantile table cannot be used, so the z-test statistic is applied.

From Table 10, it is shown that $Z_{calculated} = -3.657$. Because $Z_{calculated} \leq -Z_{table}$, i.e., $-3,657 \leq -1,96$, this indicates that the null hypothesis (H_0) is rejected. This means that the mathematics learning outcomes of students taught using the problem-based learning model differ from those taught using the conventional learning model.

4. Conclussion

There is a difference in the mathematics learning outcomes of 10th-grade high school students who were taught using the problem-based learning model. This conclusion is based on the results of the Mann-Whitney test on the post-test scores, where $Z_{calculated} = -3,657$ is smaller than $-Z_{tabel} = -1.96$, meaning that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This shows that there is a significant difference between the mathematics learning outcomes of students taught using the Problem-Based Learning model and those taught using the conventional learning model.

The mathematics learning outcomes of 10^{th}-grade high school students taught using the Problem-Based Learning model are better than those of students taught using the conventional method. This can be seen from the average post-test scores, where the average score for the Problem-Based Learning model is 80.25, while the average score for the conventional model is 70.00.

The study demonstrates that the Problem-Based Learning model significantly improves mathematics learning outcomes compared to conventional teaching methods. This approach can be widely adopted to foster critical thinking and problemsolving skills in students, thereby addressing the limitations of traditional learning models.

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