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Comparative Analysis between the Problem-Based Learning Model and the Discovery Learning Model on Students' Learning Outcomes

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Abstract
This research seeks to compare the effectiveness of the Problem-Based Learning (PBL) model with that of the Discovery Learning (DL) model in enhancing students' learning outcames. The study was conducted with Grade XI learners at SMA Negeri 1 Siantar and utilized a quantitative method through a quasi-experimental design. Data were obtained through a post-test consisting of five essay items assessing cognitive learning outcomes. The instrument's validity and reliability were assessed through product–moment correlation and Cronbach's Alpha procedures. The results of the study showed that students taught using the PBL (Problem-Based Learning) model achieved higher average scores (mean = 74.26, SD = 14.29) than those taught using the discovery learning model (mean = 65.52, SD = 15.91). The t-test findings revealed a meaningful difference between the two groups ($t_h = 2.51 > t_t = 1.995$, $\alpha = 0.05$). This result indicated that Problem Based Learning outperforms Discovery Learning in improving students'learning outcames
Keywords: Problem-Based Learning, Discovery Learning, Mathematical Problem-Solving, Learning Outcomes.

1. Introduction

One of the main objectives of classroom learning is to create opportunities for students to gain essential knowledge and skills while attaining optimal academic achievement. The learning process itself involves various interrelated components that function systematically such as the education system, school management, curriculum, teachers, learning materials, instructional methods, students, and school facilities each with its own characteristics depending on the learning context. Among these components, teachers, learning materials, and students are the core elements in every instructional process, while the learning model acts as an integrative bridge that connects and harmonizes these three components (Abidin, 2014). The learning model plays a crucial role as a conceptual and procedural framework for planning and implementing effective teaching strategies. Selecting an appropriate model can help students understand the subject matter more deeply, develop stronger problem-solving and analytical skills, and integrate the knowledge and skills they acquire factors that contribute directly to the improvement of learning outcomes (Abidin, 2014).

Mathematics, as a mandatory subject across all levels of education, serves a vital function in developing students' abilities to think in a way that sharpens higher-order thinking and fosters collaborative learnin (Nahdi, 2018). These competencies enable students to obtain, manage, and apply information effectively, which is vital for adapting to the rapidly changing, uncertain, and competitive conditions of the modern world. The success of mathematics instruction depends largely on how teachers design and conduct the learning process, including their ability to select and apply effective learning models. A well-planned instructional approach is expected to create an atmosphere of learning that is active, creative, effective, and enjoyable, while promoting a more meaningful understanding of mathematical concepts. Rahmawati (2018) problem based learning and discovery learning are especially relevant and effective in mathematics education.

According to Santoso (2018) In this approach, students learn by working through situations that mirror real-life issues. Such learning experiences guide them to analyze problems, formulate solutions, and gradually construct a solid grasp of the underlying concepts. Similarly, Shoimin (2016) describes several core characteristics of PBL, including (1) learning centered on the student, (2) the use of authentic problems as the organizing focus of instruction, (3) developing new knowledge through self-directed learning, (4) collaborative learning in limited-size groups, and (5) the teacher's role as a facilitator who monitors progress and supports learners in achieving instructional objectives. PBL is an active learning approach that fosters creativity, independence, collaboration, and the enhancement of students' problem-solving and critical thinking abilities (Hsu et al., 2016). The PBL process typically consists of five stages: presenting problems, organizing students, conducting group investigations, developing and presenting results, and evaluating findings (Ali & Setiani, 2018). Previous studies have demonstrated that PBL has been successfully implemented in a range of subjects, including mathematics (Tuti, 2021), geography (Salsabilah et al., 2014), and bussines class (Saepuloh et al., 2021). Furthermore, its application has shown a positive impact on students' learning outcomes (Mahnaz Khatiban, 2014). These results indicate that the PBL approach can be a useful instructional guide for teachers who seek to improve the effectiveness of their teaching.

Beyond PBL, *Discovery Learning* offers an alternative model that emphasizes active cognitive engagement through exploration, observation, and investigation. This approach encourages students to discover and construct knowledge independently, leading to longer retention of learning outcomes (Tanjung et al., 2020). *Discovery Learning* helps students develop their mindset by engaging in processes that allow them to uncover new concepts or theories (Ertikanto et al., 2018). By doing so, students analyze and solve problems independently, which fosters curiosity and a sense of challenge in the learning process (Yurniwati & Hanum, 2017). Moreover, the model stimulates students' active participation and enthusiasm, which contributes to the achievement of learning objectives (Asriningsih et al., 2021). According to (Masek & Yamin, 2011) Discovery Learning progresses through a sequence of steps, from initial stimulation and problem recognition to gathering, analyzing, and confirming information before forming conclusion. Both discovery learning and problem based learning rely on student-centered instruction, with teachers acting primarily as facilitators (Sari et al., 2017). This perspective is in line with Munawaroh & Masruri (2019), who assert that learners are expected to formulate their own questions, design and carry out investigations, and present their findings.

The implementation of these two learning models aims to address challenges related to improving students' learning outcomes. Nevertheless, studies comparing PBL and DL have reported varied results. (Tanjung et al., 2020) found that PBL was more effective than DL in improving cognitive, affective, and psychomotor learning outcomes among grade 8 social studies students, while Gani et al (2021) similarly concluded that PBL produced better results in social studies instruction. In contrast, Wardani et al (2018) found that *Discovery Learning* was more effective in certain cases, whereas Ulva et al (2020) reported significant differences between the two approaches, with PBL showing superior results in experimental classes. Overall, previous studies indicate that both models can effectively enhance students' achievement depending on the subject matter and instructional context.

In essence, both *Problem-Based Learning* and *Discovery Learning* encourage systematic thinking, creativity, and independent inquiry in solving problems. While *Discovery Learning* focuses more on the process of exploring and constructing knowledge, *Problem-Based Learning* emphasizes active engagement with real-world problem-solving. Each approach provides distinct advantages *Discovery Learning* promotes curiosity, independence, and critical reasoning, whereas *Problem-Based Learning* develops analytical skills, creativity, and the ability to tackle complex problems. Based on the explanation above, this study aims to compare how effective problem-based learning and discovery learning are in the mathematics learning outcomes of class X students at SMA Negeri 1 Siantar.

2. Methods

This study uses an experimental approach involving an experimental class and a control class. The purpose of using this design was to observe how a particular teaching intervention could influence students' learning results. In this study, the focus was on comparing two instructional approaches problem-based learning and discovery learning to see how each one affected students' mathematics achievement. By examining the outcomes of both groups, the study aimed to identify which model offered greater benefits in improving students' performance. The study adopted a True Experimental Design employing a Pretest-Posttest Control Group format. The main characteristic of this design is the use of random sampling from the same population and the inclusion of both an experimental and a control group (Sugiyono, 2018).

The research began by giving both groups a pretest to determine their starting level in mathematics. The experimental group received treatment in the form of a problem-based learning model, while the control group was taught with discovery learning. After the instructional treatments, both groups completed a posttest to see how their results had changed. The layout of the pretest posttest control group design is shown in the table below.

Table 1. Pretest and Posttest Assessment Experimental Design

Group	Pretest	Treatment	Posttest
Experimental	T_1	X_1	T_2
Control	T_3	X_2	T_4

This study was carried out at SMA Negeri 1 Siantar. The population included all Grade X students, with the sample selected through probability cluster random sampling was used, resulting in Class X-2 as the experimental group and Class X-3 as the control group. The research instrument consisted of a mathematics achievement test composed of multiple-choice questions developed according to specific learning outcome indicators. Prior to implementation, the test instrument was validated and tested for reliability to ensure its accuracy and quality.

Table 2. Validity Test Results (SPSS 25 for Windows)

		N	%
Cases	Valid	30	100
	Excluded[a]	0	0
	Total	30	100

Based on Table 2, all ten test items given to 30 students were declared valid with a total validity rate of 100%. The reliability test produced the following result.

Table 3. Measurement Reliability Results

Cronbach's Alpha	N of Items
0.931	10

The Cronbach's Alpha coefficient of 0.931 indicates that the test instrument was highly reliable. According to Budi (2006), reliability levels are interpreted as follows: 0.00–0.20 (less reliable), 0.21–0.40 (slightly reliable), 0.41–0.60 (fairly reliable), 0.61–0.80 (reliable), and 0.81–1.00 (very reliable).

The pretest and posttest results were examined using both descriptive and inferential methods. Before testing the hypothesis, the data were checked for normality and homogeneity to ensure they met the conditions for parametric analysis. Once these assumptions were fulfilled, an Independent Sample t-test was applied to compare the average learning outcomes of students taught with discovery learning and students taught with problem-based learning. An N-Gain analysis was also used to assess the improvement from pretest to posttest. Through these procedures, the study aimed to identify which model problem-based learning or discovery learning provided greater gains in mathematics achievement for Grade X students at SMA Negeri 1 Siantar.

3. Result and Discussion

Result

The results of this study show a significant difference between the control and experimental classes. This difference appears in the descriptive analysis of students' scores after both groups received their respective treatments. Using SPSS 25 for Windows, the descriptive statistics were presented in tables to compare learning outcomes between the two groups. The analysis includes pretest scores, which reflect students' initial abilities, and posttest scores, which indicate their performance after the learning models were applied. The descriptive results are shown in Table 4.

Table 4. Statistical Description of the Experimental Group

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Eksperimen	30	48	79	70.78	7.342
Posttest EKsperimen	30	79	89	83.41	3.578
Valid N (listwise)	30				

Based on Table 4, the mean pretest score of the experiment class before being given treatment through the problem-based learning model was 70.78 with a standard deviation of 7.342. After the application of the problem-based learning model, the mean score increased to 83.41. The highest score before treatment was 79 and the lowest score was 48, while after treatment the highest score was 89 and the lowest score was 79.

Table 5. Statistical Description of the Control Group

	N	Minimum	Maximum	Mean	Std. Deviation
Pretes Control	30	40	75	69.98	7.521
Posttest Control	30	77	80	76.72	4.980
Valid N	30				

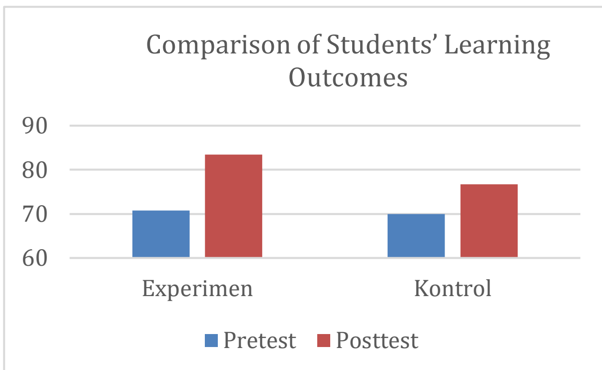
According to Table 5, the control class obtained a mean pretest score of 69.98 with a standard deviation of 7.521 prior to receiving instruction through the discovery learning model. After the treatment, the mean score increased to 76.72. Before receiving treatment, the highest score was 75 and the lowest score was 40, whereas after receiving treatment the scores became 80 and 77. The comparison of the mean scores is shown in Table 6.

Table 6. Students' Learning Outcome Comparison

Measurement	Comparison of Students' Learning Outcomes Avarage Score *(Mean)* Experimen	Control	Differences
Pretest	70.78	69,98	0,81
Posttest	83.41	76,72	6,69

Based on Table 6, the pretest mean difference between the two groups was 0.81, suggesting that both groups began with relatively comparable abilities. After receiving treatment, the average difference in the posttest increased to 6.69, indicating that students taught using the discovery learning model obtained lower scores than students taught using the problem-based learning model. The comparison between the two groups is depicted in Figure 1.

Figure 1. Comparison of Students' Learning Outcomes



From the diagram above, it can be observed that both groups experienced gains in their learning outcomes. This improvement was more visible in students who were taught using the Problem-Based Learning model compared to students who were taught using the Discovery Learning model. The data analysis also involved conducting a normality test with SPSS 25 for Windows. The outcomes showed in Table 7.

Table 7. Normality Test Results

Class		**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**		
		Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Students's Learning Outcames	Pretes Experimen *Problem Based Learning*	0.167	30	0.189	0.989	30	0.055
	Prates Control *Discovery Learning*	0.187	30	0.111	0.978	30	0.133
	Posttest Experimen *Problem Based Learning*	0.123	30	.200*	0.956	30	0.336
	Posttest Control *Discovery Learning*	0.167	30	0.189	0.943	30	0.199

In Table 7 above, it shows that the data is normally distributed and significant at 0.05. Table 8 shows the results of homogeneous data using the Levene test.

Table 8. Homogeneity Examination Before Intervention

		Levene Statistic	**Df 1**	**Df 2**	**Sig.**
Student's Learning Outcames	Based on Mean	1.469	1	58	0.342
	Based on Median	1.417	1	58	0.342
	Based on Median and with adjusted df	1.417	1	44.876	0.213
	Based on trimmed mean	1.431	1	58	0.245

Based on Table 8, the significance value of 0.342 (> 0.05) indicates that the data were homogeneous before treatment, meaning that both groups had similar variances. The homogeneity test results after treatment are presented in Table 9.

Table 9. Homogeneity Test After Treatment

		Levene Statistic	**Df 1**	**Df 2**	**Sig.**
Student's Learning Outcames	Based on Mean	0.057	1	58	0.879
	Based on Median	0.087	1	58	0.908
	Based on Median and with adjusted df	0.089	1	55.760	0.876
	Based on trimmed mean	0.043	1	58	0.765

The significance value of 0.879 (> 0.05) confirms that the data were also homogeneous after treatment. Table 10 presents the results of the independent sample t-test.

Table 10. Results of the Independent Samples t-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Student's Learning Outcames	Equal variances assumed	0.033	0.856	6.108	60	0.000	4,980	1.987	4.879	7.879
	Equal variances not assumed			5.675	58.532	0.000	4.980	1.987	4.880	7.897

From the preliminary test, the data were normally distributed, and both the pretest and posttest met the homogeneity requirements. After that, an Independent Samples t-test was carried out. The analysis, processed using SPSS 25, produced a t-value of 5.675 with a significance level of 0.000. This study shows that the control group obtained lower scores than those who learned through problem-based learning. This showed that the discovery learning model is not more effective than the problem-based learning model.

Discussion

This study utilized an experimental design to compare mathematics learning outcomes between two homogeneous classes at SMA Negeri 1 Siantar. The descriptive analysis of the students' initial abilities (pretest) showed that students taught with the problem-based learning model obtained an average score of 70.78, whereas those students taught with the discovery learning model recorded an average of 69.98, indicating that both groups began with relatively low initial performance. The pretest t-test produced a t-value of 6.108. Since this value was still below the t-table limit, H_0 was accepted, indicating that there was not significant between the two classes before the treatment. This shows that both groups started with similar levels of prior knowledge before being taught with the discovery learning models and problem-based learning, making them appropriate to use as research samples. This conclusion is consistent with the normality and homogeneity test results, which also confirmed that the data met both assumptions.

The inferential analysis of the posttest data using a t-test demonstrated that t-value > t-table value means (2.03 > 1.99), This shows that there was a meaningful difference in the mathematics outcomes of students in experimental class after the use of the discovery learning models and problem-based learning. This result is in line with Agustin (2015), who also found that students' skill-related performance differed significantly between classes taught with discovery learning and those taught with problem-based learning. Both learning models were found to significantly enhance mathematics learning outcomes among Grade X students at SMA Negeri 1 Siantar.

Although discovery learning also contributed to improving students' conceptual understanding, the differences in outcomes can be attributed to the nature of the discovery learning approach, which emphasizes exploration and investigation. In this model, students are encouraged to independently search for solutions rather than relying primarily on structured discussions or direct teacher guidance, as often occurs in problem-based learning. Discovery learning provides students with wider opportunities to explore, gather information, identify patterns, and connect ideas, thereby promoting higher-order thinking skills and deeper comprehension through self-directed learning. Wardani et al (2018) From the results of his research, discovery learning produces significantly higher results than problem-based learning among elementary school students. Similarly, Ariyani et al., (2020) found that in learning problem-solving skills, the discovery learning model was no more effective than problem-based learning

4. Conclusion

This study aims to see the differences between discovery learning and problem-based learning on students' mathematics learning outcomes at SMA Negeri 1 Siantar. The findings clearly show that both learning models can improve students' understanding and performance, but the extent of improvement differs between them. Students who learned through the discovery learning model obtained lower posttest scores compared to students who were taught using the problem-based learning model. Based on the statistical results, a significant difference was obtained that problem-based learning had a stronger impact on students' mathematics learning outcomes. The reason behind this result lies in the nature of the two approaches. This process encourages active participation and deeper understanding because students are not just memorizing formulas, they are using them in meaningful contexts. On the other hand, discovery learning gives students more freedom to explore and construct knowledge on their own. While this independence can increase curiosity and self-confidence, it sometimes leads to uneven progress, especially for students who still need more structured guidance during learning. This research also supports previous research which shows that PBL can develop learning outcames. In conclusion, although both models have positive effects, the problem-based learning approach proved to be more effective in improving students' mathematics learning outcomes. Teachers may consider adopting or integrating PBL more broadly, problem-oriented classroom teaching helps students connect mathematics to real-life situationsDiscovery learning can still complement this approach by encouraging exploration and independent thinking, ensuring that learning remains both structured and student-centered.

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