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Comparison of Mathematics Learning Outcomes Between Students Taught Using Direct Teaching and Discovery Learning Models

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ABSTRACT

Purpose of the study: To determine the differences in learning outcomes between students taught using the direct teaching model and students taught using the discovery learning model.

Methodology: The research method used is quasi-experimental design. The population in this study were students of grade VII of State Junior High School 1 Wonomulyo and 2 classes were randomly selected as experimental classes for the study. The study was conducted by giving two different treatments to two groups of students. First, experimental class I received teaching using a direct teaching model, then experimental class II used a discovery learning model. Data collection was carried out by giving tests to students at the beginning and end of the study.

Main Findings: The research results show that there is a significant difference in improving the learning outcomes of students taught using the direct teaching model with students taught using the discovery learning model.

Novelty/Originality of this study: This study offers new insights into the effectiveness of direct instruction models compared to discovery learning in improving students' mathematics learning outcomes.

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1. INTRODUCTION

Mathematics is one of the most important fields of study in everyday life. Almost all of our life activities are related to mathematics, so it is necessary to have proper mastery of this field of study. However, it is ironic when we see the situation in the field, most students consider mathematics to be a difficult field of study [1],[2]. This arises because of the abstractness of mathematics which is sometimes difficult for students to digest [3]. Coupled with the lack of teacher knowledge in using learning models in sharing their knowledge, so that this one lesson sometimes makes students need more time to understand it [4].

The low achievement of student learning outcomes is also reflected in the low achievement of Indonesian students both at the national and international levels. The achievements of Indonesian students at the international level are still lagging behind compared to other countries. In general, the learning model commonly used by teachers today is the direct teaching model [5]. Direct instruction or direct teaching can be interpreted as a learning model that aims to help students learn basic skills and acquire knowledge that can be taught gradually step by step [6],[7]. The learning approach used in the direct teaching model is the teacher-centered approach, where the teacher

presents the material directly and in a structured manner using the lecture, expository, question and answer, presentation/demonstration models carried out by the teacher [8].

This model is the main choice applied to students because of its advantages, including relatively large amounts of material delivered, easy-to-manage learning time, and for procedural matters, this model will be relatively easy to follow. In addition to several advantages, the direct teaching model also has disadvantages which according to researchers are very vital to the learning process itself, namely that students tend to wait for raw answers from the material presented by the teacher [9]. Students are unable to construct their own answers. As a result, students become passive in the learning process activities [10].

Efforts to overcome these difficulties include teachers must be aware of the need to understand various approaches to learning. One of the teaching models that uses the student-centered approach system is the discovery learning model [11]-[13]. The discovery learning model is an inquiry-based learning technique and is considered a constructivist approach to education [14]. This is supported by the work of learning theory and psychologists Jean Piaget, Jerome Bruner, and Seymour Papert [15]. Although this form of instruction has great popularity, there is some debate in the literature regarding its efficacy

Discovery learning itself occurs when individuals are involved, especially in using their mental processes to discover some concepts and principles [16],[17]. By using this model, students are required to carry out various activities to collect information, compare, categorize, analyze, integrate, reorganize material and make their own conclusions. In the Discovery Learning model, students are expected to be more active in processing information and mathematical concepts [18]-[20]. Students are also able to draw conclusions from the learning material that has been taught.

Gap analysis of this research with previous research conducted by Kartika et al [21] That is, previous research focused on developing students' mathematical understanding through the application of the discovery learning model, with the main objective of improving students' mathematical concept understanding skills in depth. While the current research aims to compare the mathematics learning outcomes between students who are taught using the direct teaching model and students who use the discovery learning model. The main difference between the two studies lies in the focus of the research: previous research is more oriented towards the process of improving conceptual understanding, while the current research focuses on comparing the effectiveness of the two learning methods on mathematics learning outcomes. This gap shows that the current research focuses more on evaluating the comparative effectiveness of learning methods than on developing mathematical understanding.

The novelty of this study lies in its focus on directly comparing the effectiveness of two different learning approaches on students' mathematics learning outcomes. Unlike previous studies that may have only examined one method independently, this study provides a comparative view that can help educators choose a more effective method according to the learning context and students' needs. The urgency of this study is driven by the need to improve mathematics learning outcomes amidst the variety of teaching methods available, especially with the challenge of understanding complex mathematics material. The results of this study can provide guidance for teachers and policy makers in determining the most effective learning strategies to achieve optimal learning outcomes.

Based on the explanation above, the purpose of this study is to determine the difference in learning outcomes between students who are taught using the direct teaching model and students who are taught using the discovery learning model.

2. RESEARCH METHOD

2.1. Type of Research

The type of research conducted in this study is experimental research. The experimental method is a research method that attempts to find the relationship between certain variables and other variables under strictly controlled conditions [22]-[24]. Experimental research is one of the most powerful studies that researchers can use. The type of experiment in this study is a quasi-experiment. This quasi-experiment is also called a pseudo-experiment [25],[26]. Quasi-experiments are chosen because researchers want to apply an action or treatment but environmental conditions that can affect the results of the study cannot be controlled. The research design used in this study is Pretest-Posttest Control Group Design.

2.2. Population and Sample

The population in this study were all students of grade VII of junior high school 1 Wonomulyo totaling 252 students consisting of 7 classes. Sampling in this study for each group used the Cluster Random Sampling technique. 2 classes were randomly selected as the experimental class of the study.

2.3. Data Collection Techniques

Research instruments are tools used by researchers to collect and measure research variables [27]-[29]. The research instruments used in this study were learning outcome tests and learning implementation observation sheets.

2.4. Data Analysis Techniques

In quantitative research, data analysis is an activity after data from all respondents or data sources are collected. The data that has been collected in this study will be analyzed descriptively and inferentially.

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistics

3.1.1. Mathematics Pretest Statistical Data of Students Taught with Direct Instruction Model

Table 1. Descriptive Statistics of Mathematics Pretest of Students Taught with Direct Instruction Model

Statistic	Statistical values
Sample Size	32
Mean	16.125
Median	17
Standard Deviation	7.567
Variance	57.274
Minimum	4
Maximum	35
Std. Error of Skewness	0.414
Std. Error of Kurtosis	0.809

Based on the table above, it can be concluded that the students' pretest mathematics scores before the implementation of the direct teaching model in class VII C of State School 1 Wonomulyo on the material of flat shapes are in the very low category with an average score of 16.125 with an ideal score of 100 that can be achieved by students.

If the mathematics pretest scores of students in experimental class I are grouped into five categories of learning outcomes, then the frequency and percentage distributions obtained are as shown in the following table:

Table 2. Frequency and Percentage of Mathematics Pretest Scores of Students Taught with the Direct Teaching Model

No	Interval	Category	Frequency	Percentage (%)
1.	≤ 54	Very Low	32	100%
2.	55 - 69	Low	0	0%
3.	70 – 79	Medium	0	0%
4.	80 – 89	High	0	0%
5.	90 – 100	Very High	0	0%
Amount			32	100%

Based on the table above, it can be seen that the number of students in the Very Low category is 32 students (100%), and there are no students who achieved a score above 54.

3.1.2. Description of Mathematics Pretest Scores of Students Taught with the Discovery Learning Model

The statistical results relating to students' initial scores before the discovery learning model was applied are presented in the following table:

Table 3. Descriptive Statistics of Mathematics Pretest of Students Taught with Discovery Learning Model

Statistic	Statistical values
Sample Size	32
Mean	22.218
Standard Deviation	12.103
Variance	146.49
Minimum	5
Maximum	58
Std. Error of Skewness	0.414
Std. Error of Kurtosis	0.809

Based on the table above, it can be concluded that the mathematics pretest scores of students taught using the discovery learning model in class VII A S Negeri 1 Wonomulyo on the flat shape material are in the very low category with an average score of 22.21 with an ideal score of 100 that students might achieve.

If the mathematics pretest scores of students in experimental class II are grouped into five categories of learning outcomes, the frequency and percentage distributions are obtained as shown in the following table:

Table 4. Frequency and Percentage of Mathematics Pretest Scores of Students Taught with Discovery Learning

No	Interval	Category	Frequency	Percentage (%)
1.	≤ 54	Very Low	31	97%
2.	55 - 69	Low	1	3%
3.	70 – 79	Medium	0	0%
4.	80 – 89	High	0	0%
5.	90 – 100	Very High	0	0%
Amount			32	100%

Based on the table above, it can be seen that the number of students in the Very Low category is 31 students (97%), in the Low category there is 1 student (3%) and no students got a score above 69.

3.1.3. Description of Mathematics Posttest Scores of Students Who Have Been Taught with the Direct Teaching Model

Description of learning outcomes using the direct teaching model is presented in the following table:

Table 5. Descriptive Statistics of Mathematics Posttest of Students Who Have Been Taught with the Direct Teaching Model

Statistic	Statistical values
Sample Size	32
Mean	66.093
Standard Deviation	13.829
Variance	191.249
Minimum	43
Maximum	90
Std. Error of Skewness	0.414
Std. Error of Kurtosis	0.809

Based on the table above, it can be concluded that the posttest value or mathematics learning outcomes of students taught using the direct teaching model in class VII C of State School 1 Wonomulyo on the material of flat shapes are in the moderate category with an average value of 66.093 with an ideal score of 100 that students might achieve.

If the posttest mathematics scores of students in experimental class I are grouped into five categories of learning outcomes, then the frequency and percentage distributions obtained are as shown in the following table:

Table 6. Frequency and Percentage of Mathematics Pretest Scores of Students Taught with the Direct Teaching Model

No	Interval	Category	Frequency	Percentage (%)
1.	≤ 54	Very Low	7	22%
2.	55 - 69	Low	12	38%
3.	70 – 79	Medium	7	22%
4.	80 – 89	High	3	9%
5.	90 – 100	Very High	3	9%
Amount			32	100%

Based on the table above, it can be seen that the student scores in the Very Low category are 7 students (22%), in the Low category there are 12 students (38%), in the Medium category there are 7 students (22%), in the High category there are 3 students (9%) and in the Very High category there are 3 students (9%).

3.1.4. Description of Mathematics Posttest Scores of Students Who Have Been Taught Using the Discovery Learning Model

Description of learning outcomes using the discovery learning model is presented in the following table:

Table 7. Descriptive Statistics of Mathematics Posttest Scores of Students Who Have Been Taught Using the Discovery Learning Model

Statistic	Statistical values
Sample Size	32
Mean	78.093
Standard Deviation	9.508
Variance	90.410
Minimum	63
Maximum	93
Std. Error of Skewness	0.414
Std. Error of Kurtosis	0.809

Based on the table above, it can be concluded that the posttest value or mathematics learning outcomes of students taught using the discovery learning model in class VII A of State Junior High School 1 Wonomulyo on the material of flat shapes are in the high category with an average value of 78.093 with an ideal score of 100. If the students' mathematics posttest scores are grouped into five categories of learning outcomes, the frequency and percentage distributions are obtained as shown in the following table:

Table 8. Frequency and Percentage of Mathematics Pretest Scores of Students Taught with the Discovery Learning Model

No	Interval	Category	Frequency	Percentage (%)
1.	≤ 54	Very Low	0	0%
2.	55 - 69	Low	9	28%
3.	70 – 79	Medium	6	19%
4.	80 – 89	High	14	44%
5.	90 – 100	Very High	3	9%
Amount			32	100%

Based on the table above, it can be seen that the number of students in the Low category is 9 students (28%), in the Medium category there are 6 students (19%), in the High category there are 14 students (44%) and in the Very High category there are 3 students (9%).

3.2. Inferential Analysis

3.2.1. Normality Test

Before testing the hypothesis, the analysis requirements test is first carried out on the research data. The first requirement test is the normality test. The normality test aims to determine whether the population is normally distributed [30],[31]. The test statistic used in the normality test is Kolmogorov-Smirnov. The results of the normality test can be seen in the table below:

Table 9. Results of the Kolmogorov-Smirnov Normality Test

	Statistic	df	Sig.
Pretest Direct Teaching Model	0.129	32	0.192
Posttest of Direct Teaching Model	0.102	32	0.200
Pretest Discovery Learning Model	0.128	32	0.199
Pretest Discovery Learning Model	0.141	32	0.105
N-gain Value of Direct Instruction Model	0.106	32	0.200
N-gain Value of the Discovery Learning Model	0.149	32	0.067

The calculation results obtained for the pretest value in experimental class I, namely the Direct Teaching model $P_{value} > \alpha$ (significance level $\alpha = 0.05$) are $0.192 > 0.05$ and the calculation results obtained for the pretest value in experimental class II are $0.199 > 0.05$. The testing criteria are that the data is normally distributed if $P_{value} > \alpha$ so that it can be concluded that the pretest values of the two experimental classes are included in the normal category.

The calculation results obtained for the learning outcome or posttest scores in experimental class I with the Direct Teaching model $P_{value} > \alpha$ (significance level $\alpha = 0.05$) are $0.200 > 0.05$ and the calculation results obtained for the posttest scores in experimental class II are $0.105 > 0.05$. The testing criteria are that the data is normally distributed if $P_{value} > \alpha$ so that it can be concluded that the posttest scores of the two experimental classes are included in the normal category.

The calculation results obtained for the improvement of learning outcomes or gain values in experimental class I with the Direct Teaching model $P_{value} > \alpha$ (significance level $\alpha = 0.05$) are $0.200 > 0.05$ and the calculation

results obtained for the posttest value in experimental class II are 0.067 > 0.05. The testing criteria are that the data is normally distributed if $P_{value} > \alpha$ so that it can be concluded that the gain values of the two experimental classes are included in the normal category.

3.2.2. Homogeneity Test

Based on the results of the population normality test, it turns out that both experimental groups have normally distributed data, so the homogeneity test is continued. The homogeneity test aims to determine whether the variance of the two populations is homogeneous (the same) [30]-[33]. Homogeneity testing can be calculated using the Lavene's Test.

Based on the results of data analysis using Lavene's Test, the calculation results for the n-gain score $P_{value} > \alpha$ (significance level $\alpha = 0.05$) are 0.404 > 0.05. So it can be concluded that there is no difference in variance between the two groups.

3.2.3. Hypothesis Testing

Next we will test the hypothesis statistics using the t-test. Previously, normality and homogeneity tests were conducted on both experimental classes and it was concluded that both classes were normally distributed and the variances of both classes were homogeneous.

Based on data analysis using the Independent sample t-test for gain values, the results can be seen in the following table:

Table 10. Testing Scores for Improving Students' Mathematics Learning Outcomes

		Levene's Test 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
n gain	Equal variances assumed	.706	.404	-3.201	62	.002	-.12206	.03813	-.19827	-.04584
	Equal variances not assumed			-3.201	59.826	.002	-.12206	.03813	-.19832	-.04579

From the table above, the probability value is 0.002. Because 0.002 < 0.05, then inferentially the gain value (increase in learning outcomes) of the two classes is significantly different.

In addition, based on data analysis using the Independent sample t-test for the posttest value, the results can be seen in the following table:

Table 11. Testing of Students' Mathematics Learning Outcome Scores (Posttest)

		Levene's Test 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
n gain	Equal variances assumed	3.064	.085	-4.045	62	.000	-12.00000	2.96679	-17.93053	-6.06947
	Equal variances not assumed			-4.045	54.956	.000	-12.00000	2.96679	-17.94569	-6.05431

From the table above, the probability value is 0.000. Because 0.000 < 0.05, inferentially the learning outcomes (posttest) are also significantly different.

Pretest was conducted in experimental class I and experimental class II to determine students' initial abilities regarding the material to be taught. From the results of the analysis of the pretest data, it shows that both groups have the same initial abilities or are not different. The pretest results in both experimental groups have a small average and are included in the very low category. This shows that the mastery of the initial concepts of both experimental groups before participating in the learning is low. This is a reasonable condition considering that the material has never been presented to them before.

In contrast to the results of the students' pretest, students' mastery of concepts after participating in learning became better. This can be seen from the results of the posttest in experimental class II which were higher and included in the high category. Based on the results of the study that have been described previously, descriptively, the results of the posttest in experimental class I which followed learning with a direct teaching model varied with an average of 66.09 with a standard deviation of 13.82 in the interval 43-90. Meanwhile, seen from the increase in students' mathematics learning outcomes after the application of the direct teaching model using gain normalization, this class is in the moderate category with an average score of 0.532 and a standard deviation of 0.166.

Descriptively, it is also known that the posttest results of experimental class II students who participated in learning with the discovery learning model varied with an average of 78.09 with a standard deviation of 9.50 in the interval 63-93. Meanwhile, seen from the increase in students' mathematics learning outcomes after the application of the discovery learning model using gain normalization, this class is in the high category with an average score of 0.714 and a standard deviation of 0.137.

The difference in the average gain index between experimental class I and experimental class II shows that the concept mastery of students taught using the discovery learning model is better than that of students taught using the direct teaching model.

In terms of inferential statistical analysis, the normalized gain value of students' mathematics learning outcomes is obtained $Pvalue$ = 0.002 for α = 0.05, so statistically the hypothesis $H0$ is rejected and $H1$ is accepted. In addition, the inferential calculation for the posttest value is obtained P_{value} = 0.000 for α = 0.05, so inferentially the learning outcomes (posttest) are also significantly different.

Based on the results of the analysis, descriptively and inferentially, there is a difference in the increase in mathematics learning outcomes between students in experimental class I who participated in learning with a direct teaching model and students in experimental class II who participated in learning with a discovery learning model.

Based on the explanation above, there is a significant difference in learning outcomes, this is due to the use of the discovery learning model which is one of the learning models that involves many students in teaching and learning activities, but in the learning process students still get help or guidance from the teacher, so that they are more focused on both the learning process and the goals achieved are carried out well. By implementing the discovery learning model, it can lead to interaction in the teaching and learning process. This interaction can also occur between students in both small groups and large groups (classes). This condition, in addition to influencing students' mastery of the material, can also improve students' social skills. By using this discovery learning model, it is possible that the construction of knowledge will be greater and students can reach the expected conclusions, and students' understanding will be embedded in students' minds for a relatively long period of time.

This study has a significant impact in providing a deeper understanding of the effectiveness of these two approaches on student learning outcomes. The findings of this study can help teachers, schools, and policy makers in determining more appropriate teaching methods to improve academic achievement, especially in mathematics. In addition, this study can also provide a basis for developing a more adaptive curriculum according to the characteristics and needs of students. However, this study has several limitations, such as the potential for variability in results influenced by other factors, such as differences in students' basic abilities, teacher experience, or learning environments. In addition, comparative studies such as this may only provide results that are limited to certain contexts or samples, so the generalization of the results may not be fully applicable to all educational conditions.

4. CONCLUSION

In the inferential analysis with independent sample t test, it shows that there is a significant difference between the improvement of learning outcomes of the two experimental classes. So descriptively and inferentially, there is a difference in the mathematics learning outcomes of students who follow learning with a direct teaching model and students who follow learning with a discovery learning model. Recommendations for further research are suggested to explore other factors that influence the effectiveness of both methods, such as the role of students' initial abilities, learning styles, or learning motivation in determining mathematics learning outcomes.

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