

Students' Mathematical Communication Abilities And Self-Confidence

Virda Nur Candra ¹ Baiq Rovina Arvy ² Ahmad Nasrullah ³

Mathematics Education Study Program, Faculty of Education and Teacher Training, State Islamic University of Mataram,

correspondensi penulis: ahmadnasrullah@uinmataram.ac.id

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ABSTRACT

Mathematical communication skills and self-confidence are two important aspects in mathematics learning, but both are still relatively low in junior high school students. One effort to overcome this is the application of the Problem Based Learning (PBL) model assisted by technology-based learning media. This study aims to determine the effect of PBL assisted by Desmos on students' mathematical communication skills and self-confidence . This study uses a quantitative approach with a quasi-experimental design. The population of this study was all eighth-grade students of SMP Negeri 3 Lopok, with a sample of two classes selected using a purposive sampling technique, namely the experimental class and the control class. The research instruments were a mathematical communication skills test and a self-confidence questionnaire that had met the validity and reliability tests. Data were analyzed using the normality test, the homogeneity test, the independent sample t-test, and MANOVA. The results showed that PBL assisted by Desmos had a significant effect on students' mathematical communication skills and self-confidence , both partially and simultaneously. Thus, PBL assisted by Desmos can be used as an effective learning alternative to improve the quality of mathematics learning in junior high schools.

Keywords: Problem Based Learning , Desmos, mathematical communication, self-confidence

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INTRODUCTION

Mathematics is an essential subject that plays a role in developing students' logical, critical, analytical, and creative thinking skills. In addition to mastering concepts, mathematics learning also aims to develop mathematical communication skills, namely students' ability to express ideas, reasoning, and mathematical solutions orally, in writing, and visually. Mathematical communication skills enable students to express ideas systematically, interpret mathematical representations, and connect concepts to contextual problems.

However, various international studies show that Indonesian students' mathematical communication skills remain relatively low. The 2022 Programme for International Student Assessment (PISA) results showed Indonesia's mathematical literacy score of 366, below the OECD average of 472. These findings indicate that students still experience difficulties explaining mathematical ideas, interpreting graphs or tables, and relating mathematical concepts to real-world situations. In addition to cognitive aspects, affective self-confidence is also a significant issue in mathematics learning. The 2019 Trends in International Mathematics and Science Study (TIMSS) results indicate that most Indonesian students have low self-confidence in learning mathematics.

These problems were also identified based on initial observations at SMP Negeri 3 Lopok. Students still struggled to translate contextual problems into mathematical models, use symbols appropriately, and explain the solution steps coherently. Furthermore, students tended to hesitate and lacked confidence when asked to express their opinions or present their work to the class. The lecture-based learning method resulted in students being less actively involved, thus hindering their mathematical communication skills and self-confidence from developing optimally.

One learning model that has the potential to address these issues is Problem-Based Learning (PBL). PBL places students at the center of learning by presenting contextual problems that encourage students to conduct

investigations, discuss them in groups, and present solutions. This process provides students with opportunities to actively communicate mathematical ideas and build understanding through social interaction.

For optimal PBL implementation, technology-based learning media support is needed. One relevant medium is Desmos, a free, web-based application that enables dynamic and interactive visualization of mathematical concepts. Desmos helps students explore relationships between variables, manipulate parameters, and present mathematical ideas through clear visual representations. The use of this interactive visual media not only improves conceptual understanding but also reduces math anxiety, potentially boosting student self-confidence.

Several previous studies have shown that the implementation of PBL has a positive effect on students' mathematical communication skills and self-confidence. Lubis's (2023) study reported that PBL significantly improved students' mathematical communication skills and self-confidence. Yulianti and Putra's (2023) study found that using Desmos helped students understand mathematical concepts visually and communicate ideas better. However, research specifically examining the effect of Desmos-assisted PBL on mathematical communication skills and self-confidence simultaneously is still limited, especially at the junior high school level. Therefore, this study is important to fill this research gap.

METHOD

This study used a quantitative approach with a quasi-experimental design. The research design used was a non-equivalent pretest-posttest control group design. The study population was all eighth-grade students of SMP Negeri 3 Lopok. The study sample consisted of two experimental classes and one control class, each consisting of 20 students.

The experimental class was given treatment in the form of Problem Based Learning assisted by Desmos, while the control class was given conventional learning. The research instruments consisted of mathematical communication skills and a self-confidence questionnaire. The mathematical communication skills test was compiled based on indicators of mathematical communication skills, while the self-confidence questionnaire was compiled based on indicators of student confidence in mathematics learning. Both instruments have been tested for content validity by experts and tested for reliability using the Cronbach Alpha coefficient.

The data obtained were analyzed through a normality test using the Shapiro-Wilk test, a homogeneity test using the Levene test, an independent sample t-test to determine the partial effect, and a MANOVA test to determine the effect of Desmos-assisted PBL simultaneously on students' mathematical communication skills and self-confidence. The research design is described as follows.

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Information:

O_1, O_3 : Pretest (initial test of mathematical communication skills and self-confidence questionnaire)

X: Treatment with the Problem-Based Learning model assisted by Desmos

O_2, O_4 : Posttest (final test of mathematical communication skills and self-confidence questionnaire)

FINDING AND DISCUSSION

The data for this study were derived from pretest and posttest scores, as well as normalized gain. Pretest scores were used to describe students' initial abilities before the treatment was administered, while posttest scores indicated their abilities after participating in the learning process. Normalized gain was used to measure improvements in students' mathematical communication skills, calculated by comparing the difference between pretest and posttest scores to the difference between the ideal maximum score and the pretest.

Based on these data, the average value and standard deviation were obtained for each class. To facilitate the analysis process, the pretest, posttest, and normalized gain data were then presented in the form of descriptive statistics containing the achievements of students' mathematical communication skills in the experimental and control classes.

Table 1. Statistical Description of Students' Mathematical Communication Abilities

Variables		Experimental Class			Control Class		
		Pretest	Posttest	N-Gain	Pretest	Posttest	N-Gain
Students' Mathematical Communication Skills	N	20	20	20	20	20	20
	X_{max}	56	100	1.00	50	95	0.90
	X_{min}	34	69	0.45	35	69	0.38
	$\bar{X}$	48.90	85.40	0.72	44.90	81.15	0.65
	%	48.90	85.40	72.00	44.90	81.15	65.00

	<i>S</i>	7.32	7.76	0.15	4.36	5.91	0.12
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The results analyzed in this study include two main things, namely:

1. The achievement of mathematical communication skills of students who received learning using *the Problem Based Learning approach* assisted by Desmos compared to students who took conventional learning.
2. Increased *self-confidence* of students who learn through *the Problem Based Learning approach* assisted by Desmos compared to students who receive regular learning.
3. Achievement of mathematical communication skills and increased *self-confidence* of students who learn through *the Problem Based Learning approach* assisted by Desmos compared to students who receive conventional learning simultaneously.

To prove the truth of this hypothesis, this study first conducted a series of prerequisite analysis tests which will be explained in the following section:

a. Pretest and Posttest Data Analysis of Mathematical Communication Ability and *Self-Confidence* of Univariate Prerequisite Test

1) Univariate Normality Test

A normality test is conducted to ensure whether the data obtained in the study originates from a population with a normal distribution. In this study, the data normality testing process was conducted using the Shapiro-Wilk test, because this test is considered appropriate for a relatively small sample size. The decision-making criteria for the Shapiro-Wilk test are as follows: if the value is **Sig. > 0,05**, then the data is declared normally distributed with a confidence level of 5%. Conversely, if the value is **Sig. ≤ 0,05**, then the data is declared not normally distributed. The implementation of the normality test in this study was carried out with the help of the SPSS version 23 application using the Shapiro-Wilk method on residual data. The results of the normality test are then presented in the following output form:

Table 7
Normality Test Results (Xwith Y₁)

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Kontrol	.126	20	.200 [*]	.970	20	.752
Posttest Kontrol	.215	20	.016	.933	20	.176
Pretest Eksperimen	.176	20	.105	.925	20	.121
Posttest Eksperimen	.135	20	.200 [*]	.961	20	.573

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the results of the normality test presented in Table 7, **Sig.**the Shapiro-Wilk test values were obtained for all data for both the control and experimental classes, both pretest and posttest > 0,05. This indicates that the residual data in this study **is normally distributed**.

Table 8
Normality Test Results (Xwith Y₂)

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Angket Kontrol	.104	20	.200 [*]	.968	20	.720
Posttest Angket Kontrol	.180	20	.089	.954	20	.425
Pretest Angket Eksperimen	.180	20	.089	.954	20	.425
Posttest Angket Eksperimen	.106	20	.200 [*]	.969	20	.723

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the results of the normality test displayed in the Table 8, it is known that the value *on the Sig. Shapiro-Wilk* test for all data for both the control and experimental classes, as well as at the pretest and posttest stages > 0,05. This study shows that the residual data in this study **is normally distributed**.

2) Homogeneity Test

The homogeneity test in this study was conducted to determine whether the sample groups had the same variance or were homogeneous. The homogeneity of variance test was conducted using the *Levene test*, which aims to ensure equality of variance between groups before conducting parametric statistical

analysis. The results of the homogeneity of variance test in the sample classes were obtained through the *Levene test calculation* and are then presented in the following table:

Table 9
Homogeneity Test Results (Xwith Y₁)

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	1.530	1	38	.224
	Based on Median	1.182	1	38	.284
	Based on Median and with adjusted df	1.182	1	35.629	.284
	Based on trimmed mean	1.567	1	38	.218

Based on the results of the homogeneity of variance test using the *Levene test* presented in the Table 9, the value obtained is *Sig.* is equal 0,224 to the degrees of freedom $df_1 = 1$ and $df_2 = 38$. The significance value is > from 0,05, so the null hypothesis is accepted and both sample classes have the same variance (homogeneous).

Table 10
Homogeneity Test Results (Xwith Y₂)

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	2.531	1	38	.120
	Based on Median	2.623	1	38	.114
	Based on Median and with adjusted df	2.623	1	30.540	.116
	Based on trimmed mean	2.339	1	38	.134

Based on the results of the homogeneity of variance test using the *Levene test* shown in the Table 10, the value obtained is *Sig.* as large 0,120 as the degrees of freedom $df_1 = 1$ And $df_2 = 38$. The value *Sig.* > from 0,05, so that the null hypothesis is accepted or the variance of the two sample groups is homogeneous.

b. Pretest and Posttest Data Analysis of Mathematical Communication Ability and *Self-Confidence* of Multivariate Prerequisite Test

1) Multivariate Normality Test

Multivariate normality tests are conducted to ensure that the research data simultaneously meets the assumptions of normal distribution and to detect multivariate outliers. Data are said to meet the assumptions of multivariate normality if most of the values $D^2 < \text{nilai Chi-Square } x^2 \text{ table}$.

Table 11
Multivariate Normality Test Results for the Control Class Pretest

Correlations			
Mahalanobis Distance	Pearson Correlation	Mahalanobis Distance	qi
	Sig. (2-tailed)		
	N	20	20
qi	Pearson Correlation	.806**	1
	Sig. (2-tailed)	<.001	
	N	20	40

** . Correlation is significant at the 0.01 level (2-tailed).

Based on the results of the multivariate normality test for the control class pretest, Table 11 shows the *Pearson correlation value* between *Mahalanobis Distance* and *qi* as big as 0,806 with *Sig. p* < 0,001 This positive and significant correlation indicates that the data distribution follows a Chi-Square distribution , so the data is multivariately normally distributed.

Table 12
Results of the Multivariate Normality Test for the Control Class Posttest

Correlations			
		Mahalanobis Distance	qi
Mahalanobis Distance	Pearson Correlation	.815**	
	Sig. (2-tailed)	<.001	
	N	20	20
qi	Pearson Correlation	.815**	1
	Sig. (2-tailed)	<.001	
	N	20	40

** . Correlation is significant at the 0.01 level (2-tailed).

Based on the results of the multivariate normality test on the control class posttest in the Table 12, the *Pearson correlation value* obtained was 0,815 *Sig. p* < 0,001. This indicates that the data does not experience significant multivariate deviations and meets the assumptions of multivariate normality.

Table 13
Results of the Multivariate Normality Test for the Experimental Class Pretest

Correlations			
		Mahalanobis Distance	qi
Mahalanobis Distance	Pearson Correlation	.898**	
	Sig. (2-tailed)	<.001	
	N	20	20
qi	Pearson Correlation	.898**	1
	Sig. (2-tailed)	<.001	
	N	20	40

** . Correlation is significant at the 0.01 level (2-tailed).

The results of the multivariate normality test for the experimental class pretest in Table 13 show a *Pearson correlation value* of 0,898 with *Sig. p* < 0,001. This value indicates a very strong and significant relationship, so the data is declared multivariately normal.

Table 14
Results of the Multivariate Normality Test for the Experimental Class Posttest

Correlations			
		Mahalanobis Distance	qi
Mahalanobis Distance	Pearson Correlation	.623**	
	Sig. (2-tailed)	.003	
	N	20	20
qi	Pearson Correlation	.623**	1
	Sig. (2-tailed)	.003	
	N	20	40

** . Correlation is significant at the 0.01 level (2-tailed).

the *Pearson correlation value* based on the results of the multivariate normality test in Table 14 are 0,623 with *Sig. p* = 0,003. although lower than the other groups, the correlation remains significant so that the data still meets the assumption of multivariate normality.

So the pretest and posttest data in the control and experimental classes showed a multivariate normal distribution, so it was suitable for further analysis using MANOVA.

2) Homogeneity of Variance-Covariance Test

In addition to the multivariate normality test, MANOVA analysis also requires equality of covariance matrices between groups. To ensure that this assumption is met, this study uses the *Bax's M*.

Table 15
Results of the Homogeneity of Covariance Test

Box's Test of Equality of Covariance Matrices ^a	
Box's M	7.924
F	2.491
df1	3
df2	259920.000
Sig.	.058

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Kelas

Based on the test results *Box's M* Table 15 shows a significance value of $0,058 > 0,05$, so it can be concluded that the covariance matrix between groups is homogeneous. Thus, the MANOVA assumption regarding the similarity of the covariance matrix has been met.

3) Hypothesis Testing

a) Sample *T-Test*

Hypothesis testing in this study was carried out using the test *Independent Sample T-Test* in order to determine whether or not there is a difference in the average value between the control group and the experimental group, because the data comes from two independent groups and has fulfilled the assumptions of normality and homogeneity of variance.

Table 16
Rata-rata nilai posttest Kemampuan Komunikasi Matematis

→ T-Test

[DataSet1] C:\Users\ACER\Documents\SKRIPSI ICI 2025\Data Uji Hipotesis

Group Statistics					
Kelas	N	Mean	Std. Deviation	Std. Error Mean	
N2 Posttest Tes Kelas Kontrol	20	81.15	4.731	1.058	
Posttest Tes Kelas Eksperimen	20	85.40	6.204	1.387	

Table 17
Results of the *Independent Sample T-Test* of Mathematical Communication Ability

Independent Samples Test		
t	df	Sig. (2-tailed)
-2.436	38	.020
-2.436	35.513	.020

Based on the results of the independent sample T-Test in Table 16 & Table 17, the average post-test score of students' mathematical communication skills in the experimental class (85,40) was higher than that of the control class (81,15) with a homogeneous variance between the two groups based on the test. *Levene* ($Sig. = 0,224 > 0,05$). Test results *independent sample t-test* shows the value $Sig. (2 - tailed) = 0,020 < 0,05$, so there is a significant difference between the two groups and the treatment has an effect on students' mathematical communication abilities.

Table 18
Rata-rata nilai posttest Angket *Self-Confidence*

→ T-Test

Group Statistics					
Kelas		N	Mean	Std. Deviation	Std. Error Mean
Nilai	Posttest Angket Kontrol	20	56.60	11.128	2.488
	Posttest Angket Eksperimen	20	81.05	6.403	1.432

Table 19
Independent Sample T-Test Questionnaire Results

Independent Samples Test		
t	df	Sig. (2-tailed)
-8.517	38	.000
-8.517	30.338	.000

Based on the results of the independent sample T-Test in Table 18 & Table 19, the average score *self-confidence* The students in the experimental class (81,05) were higher than those in the control class (56,60) with the variance of both groups being homogeneous based on the *Levene test* ($Sig. = 0,120 > 0,05$). The results of the *independent sample t-test* shows the value $Sig. (2 - tailed) = 0,000 < 0,05$, so there is a significant difference between the two groups and the treatment given has an effect on students' *self-confidence*.

b) MANOVA test

The MANOVA test is used to determine the effect of a treatment on several dependent variables simultaneously. In this study, MANOVA was applied to test the differences in outcomes between the control and experimental classes by considering all dependent variables simultaneously.

Table 20
MANOVA Test Results

Multivariate Tests ^a					
Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.994	3154.266 ^b	2.000	37.000
	Wilks' Lambda	.006	3154.266 ^b	2.000	37.000
	Hotelling's Trace	170.501	3154.266 ^b	2.000	37.000
	Roy's Largest Root	170.501	3154.266 ^b	2.000	37.000
Kelas	Pillai's Trace	.658	35.580 ^b	2.000	37.000
	Wilks' Lambda	.342	35.580 ^b	2.000	37.000
	Hotelling's Trace	1.923	35.580 ^b	2.000	37.000
	Roy's Largest Root	1.923	35.580 ^b	2.000	37.000

a. Design: Intercept + Kelas

b. Exact statistic

Based on the MANOVA test results in Table 20, it shows that the class factor has a significant influence on the dependent variable simultaneously. This can be seen from the significance value of all multivariate test statistics (*Pillai's Trace*, *Wilks' Lambda*, *Hotelling's Trace*, and *Roy's Largest Root*) which are valued $0,000 < 0,05$, so it can be concluded that there is a significant multivariate difference between the control class and the experimental class.

CONCLUSIONS

Based on the results of research on efforts to improve junior high school students' mathematical communication skills through the application of *the Problem Based Learning* (PBL) approach assisted by Desmos, it can be concluded that learning with this approach provides better results than conventional learning. Students who participated in PBL learning assisted by Desmos showed higher achievement and improvement in mathematical communication skills, both in expressing ideas, using mathematical representations, and explaining the problem-solving process logically and systematically. In addition, this approach also has a positive impact on student *self-confidence*, because active involvement in problem solving, discussions, and the use of Desmos media can foster self-confidence in expressing opinions and thoughts. Thus, the implementation of *Problem Based Learning* learning

steps assisted by Desmos is effective in developing mathematical communication skills while increasing students' *self-confidence*, so it is worthy of being used as an alternative for mathematics learning at the junior high school level.

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