Gagasan Pendidikan Indonesia, Vol.3, No.2, 2022, pp. 107-120
p-ISSN 2721-9240, e-ISSN 2722-0982

Didactic Phenomenon-based Learning through Scientific Approach to Improve Students' Communication Skills

Submitted 11 December 2022 Revised 19 December 2022 Accepted 19 December 2022

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DOI: 10.30870/gpi.v3i2.18166

Abstract

One of the abilities to think mathematically is the ability to communicate. This ability is an important part of education. This research started with the mathematics teaching materials used that did not facilitate students to have the opportunity to explore, make conjectures and test these conjectures. Learning mathematics based on didactic phenomena through a scientific approach based on students' initial mathematical communication skills (MCS) will greatly determine the achievement of learning objectives. This study aimed to determine differences in the achievement of mathematical communication skills between students who receive didactic-based mathematics learning through a scientific approach and students who receive conventional mathematics learning. Also, to find out that there are differences in self-confidence between students who receive didactic-based mathematics learning through a scientific approach and students who obtain mathematics learning with a conventional approach. This study used a quantitative research method with a quasi-experimental research design with the type of Pretest – Posttest Control Group Design. The results of this study are the analysis of the mathematical communication abilities of students who receive didactic-based mathematics learning with conventional learning.

Keywords: Communication, didactic phenomena, self-confidence

INTRODUCTION

The real challenge of the 21st century is the increasing need for education that can respond to global demands, requiring individuals to appear intelligent. In other words, education in the 21st century is the development of intelligence so that individuals can solve problems in their lives with the provision of intelligence. Suryadi (2011) revealed that human resources who can face challenges in the information and globalization era are those who can think mathematically. Hence, they can face various life challenges independently with full confidence.

One of the abilities to think mathematically is the ability to communicate. This ability is an important part of education. Stacey & Turner (2015) argues that Communication skills contribute to and determine student success in problem solving. The importance of communication skills in learning mathematics is also illustrated by the inclusion of this skill as a process standard in the Principles and Standards for Schools Mathematics published by the National Council of Teachers of Mathematics (NCTM) (National Council Teacers of Mathematics, 2014). National Council Teachers of Mathematics (2014) suggests that communication skills rank third in process standards. Other abilities included in the standard process, according to NCTM, are problem-solving, reasoning, connection, and a positive attitude toward mathematics.

Based on reports on the PISA tests (OECD, 2013) and TIMSS (2011), the quality of learning mathematics in Indonesia has remained the same. The quality of learning mathematics in question is the ability to think mathematically and communicate. According to NCTM (Izzati & Suryadi, 2010), Communication is the way in which students express their ideas in writing using objects that they represent algebraically or using mathematical symbols. Sumarmo, Hidayat, & Zukarnaen (2012) state that Indicators of these communication skills include: 1) describing situational pictures diagrams or real objects as word symbols ideas or mathematical symbols; 2) explaining thought situations and mathematical relationships orally and in writing; 3) listening discussing and counting. Writing 4) Read and understand written mathematical representations 5) Make inferences Make arguments Define and generalize 6) Revise statements or mathematical units into their own language.

The ability to communicate ideas, thoughts, or opinions is very important, so NCTM (1989) states that learning programs from kindergarten to high school stage must provide opportunities for students to: 2) interpret and evaluate mathematical concepts in words and other visual forms; 3) Ability to present ideas using notation terms and to describe the structure of mathematical relationships and model situations.

Teachers should provide opportunities for students to develop their ability to convey mathematical concepts so that their communication skills develop appropriately during the learning process. To improve the learning process and results teachers should encourage students to participate actively in discussions guide students to ask and answer questions think critically explain each answer given and give reasons for each answer given (Sumarmo et al., 2002). The learning given emphasizes the use of discussion strategies, both discussions in small groups and discussions in the class as a whole.

A learning process based on didactic events through a scientific approach is designed in such a way that students actively observe (identify or discover problems) formulate problems propose hypotheses or collect data to be conceptualized. formulate laws or principles. . Analyze data with various techniques to draw conclusions and communicate conceptual laws or principles. Students discover through phenomena around students that can be appointed as learning resources, such as the concept of integers at temperature or the temperature of various objects, function concepts at taxi fares, and so on. So, the learning process feels more memorable, and students are expected to remember the concept longer. The didactical-based mathematics learning process through a scientific approach is guided by the steps of scientific learning: observing, asking, exploring, associating, and communicating. Simply put, didactic phenomenon-based learning through a scientific approach uses didactic phenomena teaching materials with scientific learning stages.

Didactical Phenomenology from Freudenthal (2002), such as how to introduce the concept of linear equations and there are still many phenomena that can be raised for students to understand mathematics. In didactic phenomenon-based learning through a scientific approach, students' initial ability will greatly determine the achievement of learning objectives. A student's initial ability is the ability or knowledge possessed by students before learning takes place. This is based on the view of constructivism in learning that masters communication. That is, to construct new knowledge, it must involve previous knowledge. This is also in line with the material taught in schools, which has a related and sustainable nature. For example, to understand the material on a system of three-variable linear equations, it is necessary to master the material on one-variable linear equations and two-variable equations. Or other field material. The purpose of this study was to determine whether there were differences in the achievement of communication skills between students who were built through learning with didactic phenomena and nuanced teaching materials through a scientific approach and students who studied using conventional learning. We also determine whether there were differences in the achievement of communication skills between students who built through learning with teaching materials nuanced didactic phenomena through a scientific approach in terms of students' initial mathematical abilities (high, moderate, and low).

METHOD

This study examined didactic phenomenon-based learning through a scientific approach to improve communication skills. Therefore, this study uses a quasi-experimental method or quasi-experimental. In this quasi-experiment, the subjects were not randomly grouped, but the condition of the subjects was accepted as they were (Ruseffendi, 2015). This is due to the need for researchers to take research subjects directly. According to Cresswell (2010), the experimental and control classes were selected without a random procedure for a quasi-experimental design with a non-equivalent pretest and posttest control group design. This study uses the Non-equivalent Control Group Design (Sugiyono, 2013) in Table 1.

Table 1. *Non-equivalent Control Group Design*

Group	Pretest	Treatment	Postest
Experimental	O	X	O
Control	O		O

Information :

O : Pretest and Posttest communication skills

X : didactic phenomenon-based learning through a scientific approach

...... : taking classes is not randomly.

This study involved students' initial mathematical communication skills (MCS) to see the effect of didactic phenomenon-based learning through a scientific approach to improving students' Communication Skills and Self Confidence. The instruments used in obtaining research data used two types of instruments: tests and non-tests. The instrument in the form of a test consists of a set of test questions to measure communication skills. Instruments in the form of non-test, namely the Self-Confidence scale, observation, and interviews

The instrument for testing students' communication skills was developed from related material, namely the material on a three-variable system of linear equations, and adapted to indicators of communication skills. So that communication skills can be seen clearly, the test will be made in the form of a description. This communication skills test consists of an initial test (pretest) and a final test (postest). The test is given to all students, and pretest and posttest questions are made similar/relatively the same. The initial test was carried out to determine the similarity of students' initial abilities in both classes (experimental and control). It was used as a benchmark for improving communication skills before getting learning. In contrast, the final test was carried out to determine the acquisition of learning outcomes and whether or not changes in communication skills after learning. Furthermore, the pretest and posttest results will be seen as N-gain or an increase in students' communication skills.

The indicators of students' communication skills that will be measured are as follows: 1) Stating a situation with pictures or graphics (drawing); 2) Expressing a situation in a mathematical model (a mathematical expression); 3) Explain an idea or situation from an image or graphic that is given in your own words in written form. To provide an objective assessment, the scoring criteria for the Communication Skills Test are guided by the Holistic Scoring Rubrics proposed by Cai, Lane, and Jakabcsin (1996). The observation sheets in this study were used to obtain data related to teacher and student activities in carrying out the learning process at each meeting. The purpose of this guideline is as a reference in reflections on the learning process and the implementation of learning. The observer filled out the provided observation sheet. The ones who act as observers are the teachers.

RESULTS AND DISCUSSION

Mathematical Communication Skills (MCS) is divided into high, moderate, and low MCS. The data presented are the results of data analysis of tests given before learning (pretest), tests after learning (posttest), N-gain (g), and the scale given after learning (final scale). The data was analyzed quantitatively with descriptive and inferential statistics. We assisted by SPSS 22 for Windows and Microsoft Excel 2016 software. The self-confidence scale is an ordinal scale. Therefore, before the data is calculated using SPSS 22 for windows, the research data is first transformed into interval scale data to fulfill some of the requirements for parametric analysis using the Method of Successive Interval (MSI).

1. Early Mathematical Communication Skills (MCS)

The MCS grouping is based on the average student achievement on the early mathematical ability test score. MCS grouping is determined for each class based on the average and standard deviation criteria (Arikunto, 2013). The MCS test in this study was obtained using MCS questions that math teachers had validated at the subject matter teacher assosiation in Lebak Regency. The initial proficiency test is in the form of multiple choice questions consisting of 13 items which are prerequisite material before studying the system of three-variable linear equations material.

The MCS test's purpose is to categorize students based on high, moderate, and low abilities. The MCS test was given to students in the experimental class and control class. The results of calculating of MCS data for students in the class that received the didactical-based mathematics learning model (experimental class) and the class that received the conventional learning model (control class) obtained a combined average of 75.55 and a combined standard deviation of 5.80. Based on these calculations, the MCS grouping criteria are presented in Table 2.

Table 2. MCS Category Placement Criteria

MCS Category	Criteria
High	MCS score ≥ 80.44
Moderate	70.65 ≤ MCS score < 80.44
Low	MCS score ≤ 70.65

Based on the results of determining the MCS grouping criteria in Table 2, the number of student distributions for each MCS category is presented in Table 3.

Table 3. Distribution of Students Based on MCS

MCS Category	Experimental Class	Control Class	Total
High	7	6	13
Moderate	17	16	34
Low	6	8	13
Total	30	30	60

Based on Table 3, students can be grouped into high, moderate, and low MCS categories. There were more in the experimental class for the high MCS category, while for the low MCS category, there were more in the control class. In the MCS category, there were more in the experimental class.

2. Mathematical Communication Skills (MCS)

Descriptive analysis of mathematical communication ability test data obtained through pretest, posttest, and N-gain. The pretest aims to determine the similarity of students' initial mathematical communication abilities between classes given didactic-based mathematics learning and classes given ordinary learning. Posttests were given to both didactic-based and regular learning classes to determine students' communication skills after learning. Pretest and posttest data were obtained from the results of students' answers in working on a package of 6 descriptive questions according to indicators of mathematical communication ability. Pretest and posttest questions are similar questions that have been tested for validity and reliability.

Table 4 presents descriptive statistics on pretest and posttest scores for students' mathematical communication skills in the didactic learning class (experimental class) and conventional learning class (control class).

Table 4. Descriptive Statistics Mathematical Communication Skills Pretest Scores

Class	Number of Students	Minimum score	Maximum score	Mean	Standard deviation
Experimental	30	5	20	10.56	4.52
Control	30	3	20	9	3.79

Table 4 provides information that the pretest mean of mathematical communication skills based on MCS of students who receive didactic-based mathematics learning, and those who receive conventional learning have little difference, namely experimental class students = 10.56 and control class = 9. This shows that the increase in mathematical communication skills of students in the experimental class (those who receive didactic learning) is better than students in the control class (conventional learning).

Table 5. Descriptive Statistics Posttest Score Mathematical Communication Skills

Class	Number of Students	Minimum score	Maximum score	Mean	Standard deviation
Experimental	30	3	24	19.767	4.768
Control	30	8	23	13.567	4.125

For the posttest mean of the mathematical communication skills of the experimental class students = 19.767, higher than that of the control class students = 13.567 in terms of all students. Furthermore, the pretest and posttest scores are used to calculate the normalized gain (N-gain) of mathematical communication skills in both the experimental and control classes. The average n-gain result obtained from this calculation illustrates the increase in students' mathematical communication skills in the experimental and control classes. Table 6 shows the

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p-ISSN 2721-9240, e-ISSN 2722-0982
descriptive statistics of the N-gain score.

Table 6. Descriptive Statistics Mathematical Communication Skills (MCS) N-gain Score

Class	Number of Students	Minimum score	Maximum score	Mean	Standard deviation
Experimental	30	-31.34	100	72.8485	28.74
Control	30	0	87,88	31.5339	22.15

The N-gain score test show that the average value of the N-gain score for the experimental class (didactic-based mathematics learning) is 72.8485 or 72.8%, included in the fairly effective category. Meanwhile, the average N-gain score for the control class (ordinary learning) was 31.5339 or 31.5%, which was included in the ineffective category. Didactic-based mathematics learning improves students' mathematical communication skills in the mathematics subject matter of system of three-variable linear equations in class X students at one vocational high school in Bayah, Indonesia. In comparison, using ordinary/conventional methods is ineffective in improving students' mathematical communication skills in the mathematics subject matter of system of three-variable linear equations. The average N-gain score for students in the experimental class is higher than that of the control class. This means that the distribution of the average N-gain scores in the control class is more varied than that of the experimental class students. The following presents a comparison of the MCS N-gain score in Figure 1.

The comparison of MCS N-gain scores as a whole for students in Figure 1 shows that the difference between classes that receive didactic-based mathematics learning and classes that receive conventional learning is quite high. However, the interpretation of the MCS N-gain for the two classes is in the same category, namely moderate.

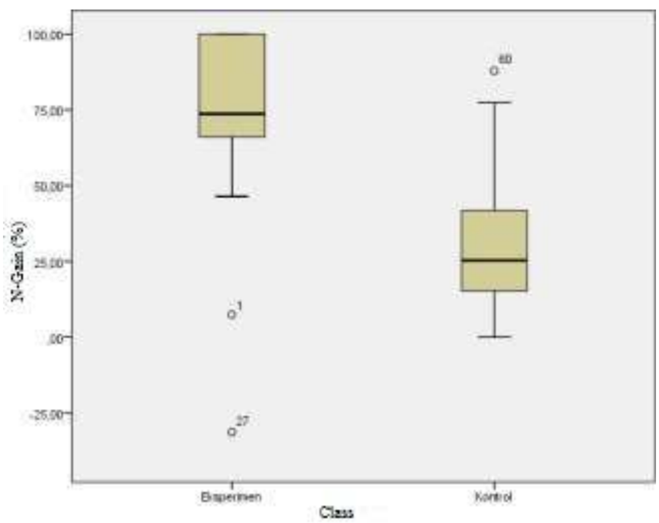

Figure 1. Comparison of Students' Overall Mathematical Communication Skills (MCS) N-gain Scores

3. MCS pretest data analysis

Tests were carried out to determine the equality of students' mathematical communication skills between classes that received didactical-based mathematics learning (experimental) and classes that received conventional learning (control) before different learning was carried out. Following are the steps for testing the pretest data.

Normality Test

The test begins with testing the normality of the data. The normality test results using the Shapiro-Wilk test are presented in table 7.

Tabel 7. Results of the Normality Test of the MCS Pretest Data for the Experiment and Control Class

Class	Pretest				
	N	Minimum score	Maximum score	Mean	Standard deviation
Experimental	30	20	5	10.567	4.523
Control	30	20	3	9.00	3.797

From Table 8 using the Shapiro – Wilk test, the significance of the pretest value data for the experimental class is 0.016, and the significance of the pretest value data for the control class is 0.023 for both groups <0.05. This indicates that the experimental and control classes are not normally distributed. For more details, see the Q–Q Plot diagram. In contrast, the Q-Q Plot results are obtained in Figures 2 and 3.

Table 8. Output of Pretest Normality Test for Experimental and Control Class

Class	*Shapiro – Wilk*		
	Statistic	Df	Sig
	.911	30	.016
Pretest Control Experiment	.916	30	.022

If the data distribution is normal, the data will be spread around the line (Trihendradi, 2008). Figures 2 and Figure 3 show that the pretest score data of the experimental class and control class students are around the line and do not spread around a straight line. This can be interpreted as the pretest score data for the experimental and control classes or samples coming from populations that are not normally distributed.

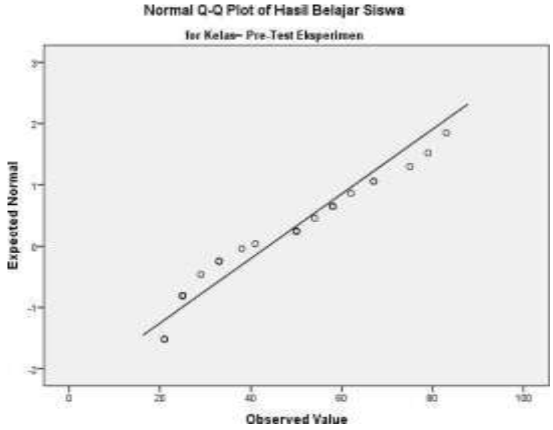

Figure 2. Normality Test with Q–Q Plot for Experimental Class Pretest Scores

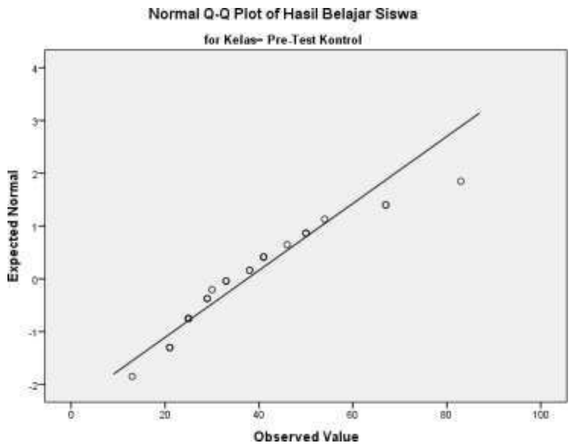

Figure 3. Normality Test with Q–Q Plot for Control Class Pretest Scores

Wilcoxon Non-Parametric Test

Because the data normality test results are not normally distributed, the next step is to analyze the data using the Wilcoxon test.

Based on the statistical test output, it is known that Asymp.Sig.(2-tailed) has a value of 0.000. Because the value of 0.000 is smaller than .0.05, it can be concluded that the hypothesis is accepted. This means there is a difference between the results of learning mathematics for the Pre-Test and Post-Test. It can also be concluded that there is an influence on the use of didactic-based mathematics learning on the mathematical communication skills of class X vacational high school students.

Average Difference Test

Based on the data normality test results, the MCS pretest and posttest data included data that were not normally distributed, so it was continued with a two-mean difference test using the Mann-Whitney test. Based on the statistical test output, it is known that the value of Asymp.Sig. (2-tailed) of 0.000 <0.05. Then it can be concluded that the Hypothesis is Accepted. Thus, there are differences in mathematical communication skills between the experimental class and the control class. Because there is a significant difference, it can be said that the use of didactic mathematics learning affects students' mathematical communication abilities in class X vocational high school.

MCS N-Gain Data Analysis

The N-gain data was analyzed using inferential statistics to test the difference in the average of MCS N-gain that received didactical-based mathematics learning models and conventional learning. The recapitulation of the test results can be seen in Table 4. The test begins with the normality test and MCS N-gain for the experimental class and the control class.

Normality Test

The MCS N-gain score normality test uses the Shapiro Wilk test. The results of the normality test calculations are presented in Table 9.

Table 9. MCS N-gain Normality Test Results

	Class	*Shapiro Wilk*			Information
		Statistic	Df	Sig.	
Pretest	Experimental	0,090	30	0.710	HO accepted
	Control	0,134	30	0.326	HO accepted

HO: Data is normally distributed, $H1$: Data is not normally distributed

Based on the results of the N-gain normality test in Table 9, the sig. In the experimental class, 0.710 is more than 0.05, so Ho is accepted. This shows that the N-gain data for classes that receive didactic-based mathematics learning is normally distributed. In addition, the results of the N-gain normality test for classes receiving conventional learning obtained sig. 0.326 is more than 0.05. So Ho is accepted. In this way, the N-gain data of students who receive conventional learning include normally distributed data so that they meet the requirements for the next test with a parametric test.

Homogeneity Test

Based on the N-gain data normality test results for MCS data, both classes include data originating from normally distributed populations. The data is tested using the parametric test with the Independent sample t-test, which begins with a homogeneity test. The results show the data is homogenen with the p-value is 0.950 > 0.05.

Average Difference Test

Based on the previous prerequisite test results, the MCS N-gain data for the experimental class and control class included normally distributed and homogeneous data. This way, the average difference test is carried out using a parametric test (Independent sample t-test). The results of the test can be seen in Table 10.

Table 10. MCS N-Gain Average Difference Test Results

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p-ISSN 2721-9240, e-ISSN 2722-0982

Statistic	Score	Information
T	0.72	H_0 accepted
Df	68	
Asymp Sig.(2-tailed)	0.474	

Based on the results of the average MCS N-gain test for students in Table 10, information is obtained that the Asymp Sig.(2-tailed) value of 0.474 is greater than 0.05. So the average N-gain mathematical communication skills of students who receive didactic-based mathematics learning is better than that of conventional learning.

MCS N-Gain Data Analysis based on MCS

Data analysis of N-gain mathematical communication skills (MCS) is analyzed in the form of data normality tests based on student's MCS categories through pre-test analysis. Data tested for normality was the N-gain of students mathematical communication skills. The following describes N-gain data test results based on student MCS. Moderately high MCS. In contrast, the N-gain data of mathematical communication abilities in low MCS do not meet the parametric test requirements. The results of the normality test from the N-gain data in terms of the students' MCS are presented in Table 11.

Tabel 11. MCS N-gain Normality Test Results based on MCS

KAM	Class	Shapiro-Wilk			Information
		Statistics	Df	Sig.	
High	Didactic	0.159	6	0.852	H_0 accepted
	Conventional	0.228	8	0.779	H_0 accepted
Moderate	Didactic	0.148	25	0.493	H_0 accepted
	Conventional	0.117	22	0.772	H_0 accepted
Low	Didactic	0.148	4	0.98	H_0 accepted
	Conventional	0.117	5	0.276	H_0 accepted

Based on the data normality test results in the table above, it provides information that in terms of the experimental class and the control class, all MCSs fulfill the parametric requirements test, obtaining sig. More than 0.05 so that the null hypothesis is accepted. That way, the N-gain data of mathematical communication ability in terms of MCS will be tested using a parametric test, namely the Independent Sample T-test. The test results can be seen in Table 12.

Table 12. Independent Sample t-test results

MCS	Statistic	F	Sig.	t	Df	Sig.(2-tailed)	Information
High	Equal Variances Assumed	2.342	0.152	0.842	12	0.416	H_0 accepted
	Equal Variances Not Assumed			0.894	11.89	0.389	

Moderate	Equal Variances Assumed	0.104	0.749	0.933	45	0.356	H_0 accepted
	Equal Variances Not Assumed			0.942	44.989	0.351	
Low	Equal Variances Assumed	2.680	0.146	0.71	7	0.946	H_0 accepted
	Equal Variances Not Assumed			0.77	5.993	0.941	

Based on the information in the table above, it shows that the results of the test for differences in the average N-gain in the high MCS category are 0.416 more than 0.05, moderate is 0.356 more than 0.05, and low is 0.946 more than 0.05 so that the null hypothesis is accepted. This means that the increase in mathematical communication skills of high, moderate, and low MCS students who receive didactic-based mathematics learning is not significantly higher than that of conventional learning.

Data analysis for increasing Mathematical Self-Confidence (MSC)

Mathematical self-confidence (MSC) data were tested for differences in mean with inferential statistics to determine whether the increase in mathematical self-confidence of experimental class students was significantly better than that of control class students. The results of the mathematical Self Confidence (MSC) data analysis are presented in Table 13.

Table 13. MSC Mean Difference Test results

Statistics	F	Sig.	T	Df	Sig.(2-tailed)	Information
Equal Variances Assumed	0,372	0,544	0,234	68	0,816	H_0 accepted
Equal Variances Not Assumed			0,234	67,148	0,816	

Based on the calculations in Table 16, the test results for the difference in the achievement scores of Self Confidence inferentially obtained a sig. (1-tailed) value of 0.816/2, namely 0.408 greater than 0.05 and sig. (p-value) 0.544 greater than 0.05. This shows that the null hypothesis is accepted, so it can be concluded that there is no significant difference in the achievement of Self Confidence in classes that receive didactic-based mathematics learning with students who receive conventional learning.

CONCLUSION

The improvement of students' mathematical communication skills (MCS) who received didactic-based mathematics learning did not differ significantly from students who received ordinary learning in terms of high, moderate, and low initial mathematical abilities. There is no interaction between the learning model and students' initial mathematical abilities toward improving students' mathematical communication skills (MCS). This is shown by the test results of students' mathematical communication skills (MCS) who receive didactic-based mathematics learning, which is always higher than in ordinary learning classes. Increasing the self-confidence of experimental class students is better than control class students. The increase in the self-confidence of the experimental class students was not significantly different from that of the control class students in terms of high, moderate, and low initial mathematical abilities. There is no interaction between the learning model and students' initial ability to increase students self-confidence (MSC). The increase in students' self-confidence (MSC) in the experimental class is always higher than in the control class.

SUGGESTIONS

In the application of didactic-based mathematics learning, it can only be applied to some subjects. It is because it is not always easy to understand, and for low MCS students, it is pretty difficult to make a mathematical model of the problems created. In the application of the conventional learning model, it can be given to all MCSs categories (high, medium, and low) because the presentation of the content of the material is given directly by the teacher and students get practice questions given by the teacher.

ACKNOWLEDGEMENT

Authors thank Universitas Sultan Ageng Tirtayasa which funded this research.

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