Students' Mathematical Communication Abilities (MCA) in Relation to Learning Styles in Problem-Based Learning (PBL) with GeoGebra-assisted

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Abstrak

This research aims to describe students' Mathematical Communication Abilities (MCA) according to their preferred learning methods and to evaluate the effectiveness of using the GeoGebra-assisted Problem-Based Learning (PBL) paradigm to improve students' mathematical communication skills. The investigation led to the following conclusions: (1) The PBL paradigm with assistance from algebra can help students' MCA. (2) Students can grasp two mathematical communication markers, depending on their preferred learning approach. (3) Convergent learners are capable of mastering all the indicators. (4) Nevertheless, accommodator learners are only able to grasp one indicator.

Keywords: Mathematical Communication, Kolb's Learning Styles, Problem-Based Learning, GeoGebra

1. Introduction

Five mathematical skills must be included in today's mathematics curriculum. According to NCTM (2000), these skills include connections, reasoning, communications, problem-solving, and representations. Communication, as mentioned by NCTM (National Council of Teachers of Mathematics), is a crucial aspect of mathematics learning. It enables teachers to grasp students' comprehension of the mathematical concepts and processes they have learned (Wardhana & Lutfianto, 2018). Communication also influences students' learning outcomes, as good communication skills positively correlate with better academic achievements (Astuti & Leonard, 2015). MCA of students can be assessed through the following methods: Translating Real-Life Problems into Mathematical Models: (1) The ability to convert real-world problems into mathematical representations, (2) Translating Statements into Symbols, Models, or Mathematical Language, (3) Identifying information from statements and representing it using symbols, models, or mathematical language (Ahmad & Nasution, 2018).

Based on the observation results of mathematics teachers at MTs Tahfidh Putri Yanbu'ul Qur'an 2 Muria, it was found that the teaching process still relies on conventional methods, mainly lecture-style teaching. The mathematics teachers at the school only use chalkboards to deliver their materials. Another fact shows that the students' mathematical communication at MTs Tahfidh Putri Yanbu'ul Qur'an 2 Muria in Kabupaten Kudus is still not optimal. On mean, the students are hesitant to express their ideas, resulting in many of them achieving math learning outcomes far below the minimum passing grade (KKM). Looking at the daily assessment scores, only around 35% of the students in a class managed to achieve the KKM passing score.

The learning style of each student can influence their MCA (Ardani & Purwaningsih, 2018). According to Brenner as cited in (Fatkhiyyah *et al.*, 2019), a teacher can assess the mathematical capabilities of each student based on their learning styles, as they have different ways of communicating mathematical problems.

2. Research Problems

Based on the problem identification above, the researcher can formulate the following research questions: (1) How does the quality of implementing the PBL model with GeoGebra assistance impact the enhancement of students' mathematical communication skills? (2) How do students' MCA vary based on their learning styles in classrooms that use the PBL model with GeoGebra assistance?

3. Methodology of Research

The research method employed in this study is a mixed method. Specifically, the researcher utilized a sequential model, as the quantitative and qualitative methods were used in a sequential order. The chosen sequential type is sequential explanatory, where the quantitative method is conducted first, followed by the qualitative method (Sukestiyarno, 2020).

4. Sample and Data Collection

The population in this research consists of 7th-grade students at MTs Tahfidh Putri Yanbu'ul Qur'an 2 Muria for the academic year 2022/2023. The sample for this study includes Class VII A as the experimental group and Class VII C as the control group. The research subjects were selected as 3 students with a diverger learning style, 3 students with an assimilator learning style, 2 students with a converger learning style, and 2 students with an accommodator learning style.

The learning style data was obtained through a learning style questionnaire designed based on David Kolb's learning style indicators. Data on students' MCA were collected from pretest and posttest scores, organized according to the indicators of students' mathematical communication skills.

5. Finding/Results

5.1 Quality of Implementing PBL with GeoGebra Assistance in Improving Students' MCA

a. Initial Data Analysis

1) Normality Test

In this research, the normality test for the data was conducted using the Kolmogorov-Smirnov test with the assistance of SPSS 20. The hypotheses to be tested are as follows:

H_0: The data is derived from a population that follows a normal distribution

H_1: The data is derived from a population that does not follow a normal distribution

By using SPSS 22, the test criteria can utilize a significance level of 5%. If the p-value (sig) from the normality test is greater than 0.05, then H_0 (null hypothesis) is accepted, which means the data is derived from a population that follows a normal distribution (Kadir, 2015).

One-Sample Kolmogorov-Smirnov Test

		Pretest
N		78
Normal Parameters[a,b]	Mean	60.40
	Std. Deviation	15.431
Most Extreme Differences	Absolute	.100
	Positive	.100
	Negative	-.089
Test Statistic		.100
Asymp. Sig. (2-tailed)		.053[c]

Table 1 Results of Initial Normality Test for the Data

The obtained p-value (sig) is 0.053 > 0.05, which means that H_0 is accepted. Therefore, the data is derived from a population that follows a normal distribution.

2) Homogeneity Test

The data used to test the homogeneity of the initial data is the data from the pretest results of students' MCA. The following is the hypothesis that has to be verified:

H_0 : ${\sigma_1}^2 = {\sigma_2}^2$ (The population's variances are uniform)

H_1 : ${\sigma_1}^2 \neq {\sigma_2}^2$ (The population's variances are not uniform)

Description:

${\sigma_1}^2$: The variance of the experimental group

${\sigma_2}^2$: The variance of the control group

This research tested homogeneity using the Levene Test with the assistance of SPSS 22. The hypothesis testing criterion is that H_0 is accepted when the p-value (sig) is greater than 0.05 (Kadir, 2015).

Test of Homogeneity of Variances

Pretest

Levene Statistic	df1	df2	Sig.
.083	1	76	.773

Table 2 Results of Homogeneity Test for the Initial Data

The obtained p-value (sig) is 0.733 > 0.05, which means that H_0 is accepted. Therefore, the data is derived from populations with homogeneous variances.

3) Test of Equality of Initial Means

The statistical hypothesis for the test of equality of means is as follows

H_0: $\mu_1 = \mu_2$ (In all classes, the initial ability means for students is the same)

H_1: $\mu_1 \neq \mu_2$ (In all classes, the initial ability means for students is not the same)

Description:

μ_1: The experimental group's initial means of students' mathematical communication skills

μ_2: The control group's initial means of students' mathematical communication skills

In this research, the test of equality of means is conducted using the 2-sample t-test with the assistance of SPSS 22. The hypothesis testing criterion is that H_0 is accepted if the p-value > 0.05, indicating that the means of both groups are the same. (Kadir, 2015).

Independent Samples Test

		Levene's Test for 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
Pretest	Equal variances assumed	.083	.773	1.913	76	.060	6.574	3.437	-.271	13.419
	Equal variances not assumed			1.910	75.091	.060	6.574	3.442	-.283	13.430

Table 3 Results of the Test of Equality of Initial Means

The obtained p-value (sig) is 0.060 > 0.05, which means that H_0 is accepted. Therefore, the initial ability means for students is the same in all classes.

b. Final Data Analysis

1) Normality Test for the Final Data

The normality test in this research is conducted using the Kolmogorov-Smirnov test with the assistance of SPSS 22. The hypothesis used is as follows:

H_0 : The data is derived from a population that follows a normal distribution

H_1 : The data is derived from a population that does not follow a normal distribution

This test uses the criterion that H_0 is accepted if the p-value (sig) > 0.05, indicating that the data is derived from a population that follows a normal distribution. The results of the test can be seen in the following table.

One-Sample Kolmogorov-Smirnov Test

		Posttest
N		78
Normal Parameters[a,b]	Mean	67.18
	Std. Deviation	15.837
Most Extreme Differences	Absolute	.085
	Positive	.068
	Negative	-.085
Test Statistic		.085
Asymp. Sig. (2-tailed)		.200[c,d]

Table 4 Results of Normality Test for the Final Data

In Table 4, the obtained significance value is 0.200 > 0.05, which means that H_0 is accepted. Therefore, the data is derived from a population that follows a normal distribution.

2) Homogeneity Test for the Final Data

The homogeneity test in this research is conducted using the Levene Test with the assistance of SPSS 22. The hypothesis used is as follows:

H_0 : ${\sigma_1}^2 = {\sigma_2}^2$ (The population variances are homogeneous)

H_1 : ${\sigma_1}^2 \neq {\sigma_2}^2$ (The population variances are not homogeneous)

This test uses the criterion that H_0 is accepted if the p-value (sig) > 0.05, indicating that the variances of the populations are homogeneous. The following table shows the test results.

Test of Homogeneity of Variances

Posttest

Levene Statistic	df1	df2	Sig.
2.901	1	76	.093

Tabel 5 Results of Homogeneity Test for the Final Data

In Table 5, the obtained significance value is 0.093 > 0.05, which means that H_0 is accepted. Therefore, the data is derived from populations with homogeneous variances.

3) Test of Mean Attainment (Hypothesis 1)

This test uses the one-sample t-test with the assistance of SPSS 22. The hypothesis for the test of mean attainment is as follows:

H_0 : $\mu \leq 65$ (The mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is not reaching 65)

H_1 : $\mu > 65$ (The mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is reaching 65)

The testing criterion is that H_0 is accepted if the p-value (sig) > 0.05, which means that the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is not reaching 65. The following table shows the test's result.

Table 6 Results of Test of Mean Attainment

One-Sample Test

	Test Value = 65					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Eksperimen	4.891	39	.000	9.475	5.56	13.39

Based on Table 6, the obtained p-value (sig) is 0.000 < 0.05, which means that H_0 is rejected, and H_1 is accepted. Therefore, the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance reaches 65.

4) Classical Mastery Test (Hypothesis 2)

The following is the hypothesis:

H_0 : $\pi \leq 65\%$ (The proportion of students' mastery in the class that uses the PBL model with GeoGebra assistance is less than or equal to 65%)

H_1 : $\pi > 65\%$ (The proportion of students' mastery in the class that uses the PBL model with GeoGebra assistance is greater than 65%)

The classical mastery test uses the z-statistic with the following formula:

$$z = \frac{\frac{x}{n} - \pi_0}{\sqrt{\frac{\pi_0(1-\pi_0)}{n}}}$$

The testing criterion is as follows: If the calculated $z_{score} \geq z_{0,5-\alpha}$ then H_0 is rejected, and H_1 is accepted. This means that the proportion of students' mastery in the class that uses the PBL model with GeoGebra assistance is greater than 65%. The results of the test can be seen in the following table.

x	n	π_0	Z_{hitung}	Z_{tabel}
32	40	0,65	1,98	1,73

Table 7 Results of Classical Mastery Test

Based on Table 7, the calculated z_{score} = 1,98 ≥ $z_{0,5-\alpha}$ = 1,73, which means that H_0 is rejected, and H_1 is accepted. Therefore, the proportion of students' mastery in the class that uses the PBL model with GeoGebra assistance is greater than 65%.

5) Test of Mean Difference (Hypothesis 3)

The hypothesis used in the test of mean difference is as follows:

H_0 : $\mu_1 \leq \mu_2$ (the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is less than or equal to the mean of students' MCA in the class that uses the expository teaching model)

H_1 : $\mu_1 > \mu_2$ (the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is greater than the mean of students' MCA in the class that uses the expository teaching model)

The test is conducted using the Independent Samples T-Test with the assistance of SPSS 22. The testing criterion is that H_0 is accepted if the p-value (sig) > 0.05, which means that the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is less than or equal to the mean of students' MCA in the class that uses the expository teaching model.

One-Sample Test

	Test Value = 65					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference: Lower	Upper
Eksperimen	4.891	39	.000	9.475	5.56	13.39

Table 8 The Results of the Test of Mean Difference

Based on Table 8, the obtained p-value (sig) is 0.000 < 0.05, which means that H_0 is rejected, and H_1 is accepted. Therefore, the mean of students' MCA in the class that uses the PBL model with GeoGebra assistance is greater than the mean of students' MCA in the class that uses the expository teaching model.

6) Test of Proportion Difference (Hypothesis 4)

The hypothesis for the test of proportion difference is as follows:

H_0 : $\pi_1 \leq \pi_2$ (the proportion of students' MCA in the class that uses the PBL model with GeoGebra assistance is less than or equal to the proportion of students' MCA in the class that uses the expository teaching model)

H_1 : $\pi_1 > \pi_2$ (the proportion of students' MCA in the class that uses the PBL model with GeoGebra assistance is greater than the proportion of students' MCA in the class that uses the expository teaching model)

The test of proportion difference uses the z-statistic with the following formula:

$$z = \frac{\pi_1 - \pi_2}{\sqrt{\hat{p}\hat{q}\left\{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\right\}}},$$

This test uses a significance level of $\alpha = 0{,}05$, and the criterion for rejecting H_0 is if $z \geq z_{0,5-\alpha}$. This means that the proportion of students' MCA in the experimental class is greater than the proportion in the control class.

π_1	π_2	$\hat{p}$	$\hat{q}$	Z_{tabel}	Z_{hitung}
0,8	0,36	0,589	0,411	1,73	3,947

Table 9 Results of Test of Proportion Difference

Based on Table 9, the calculated $z_{score} = 3{,}947 \geq z_{0,5-\alpha} = 1{,}73$, which means that H_0 is rejected, and H_1 is accepted. Therefore, the proportion of students' MCA in the class that uses the PBL model with GeoGebra assistance is greater than the proportion in the class that uses the expository teaching model.

7) Test of Mean Improvement in Students' MCA (Hypothesis 5)

The hypothesis is as follows:

H_0: $\mu_{g1} \leq \mu_{g2}$ (The mean improvement in students' MCA in the class that uses the PBL model with GeoGebra assistance is less than or equal to the mean improvement in the class that uses the expository teaching model)

H_1: $\mu_{g1} > \mu_{g2}$ (The mean improvement in students' MCA in the class that uses the PBL model with GeoGebra assistance is greater than the mean improvement in the class that uses the expository teaching model)

The testing is conducted using the Independent Samples T-Test with the assistance of SPSS 22. The testing criterion is that H_0 is accepted if the p-value (sig) > 0.05, which means that the mean improvement in students' MCA in the class that uses the PBL model with GeoGebra assistance is less than or equal to the mean improvement in the class that uses the expository teaching model. Prior to testing, the Gain index calculation is performed, with the following results:

Experiment Class		Control Class	
Gains Index	0,31	**Gains Index**	0,07
Criteria	Medium	**Criteria**	Low

Table 10 Results of Gain Index Calculation

Based on Table 10, it can be observed that the Gain index for the experimental class is 0.31, which falls under the moderate criteria. Meanwhile, the Gain index for the control class is 0.07, which falls under the low criteria. Next, the test of mean improvement is conducted, with the following results:

Independent Samples Test

		Levene's Test for 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
NGain_Persen	Equal variances assumed	19.823	.000	8.498	76	.000	24.76657	2.91441	18.96202	30.57113
	Equal variances not assumed			8.666	50.158	.000	24.76657	2.85781	19.02695	30.50620

Table 11 Results of Mean Test Improvement in Student Mathematical Communication Skills

According to table 11, a value of sig that is 0.000 < 0.05 indicates that hypothesis H_0 is not valid whereas hypothesis H_1 is valid. Therefore, the mean improvement in the class's capacity for mathematical communication using the GeoGebra-assisted PBL learning approach is higher than the growth in the class's capacity for mathematical communication using the comprehensive learning model.

5.1 The Students' MCA in Relation to Their Individual Learning Styles

The selection of research subjects was carried out by looking at the results of the learning style questionnaire distributed to students. The results of learning style anget can be seen in the following table.

No	Types of Learning Styles	The number of students	Percentage
1	Divergers	12	30%
2	Assimilator	11	27.5%
3	converger	9	22.5%
4	Accommodator	8	20%

Table 12 The Learning Style by David Kolb

four students belonging to the divergent learning style, three students belonging to the assimilator learning type, two students belonging to the converger learning type, and two students belonging to the accommodator learning style.

No	Code	Types of Learning Styles
1	E-9	Divergers
2	E-29	Divergers
3	E-40	Divergers
4	E-5	Assimilator
5	E-7	Assimilator
6	E-14	Assimilator
7	E-21	converger
8	E-22	converger
9	E-2	Accommodator
10	E-32	Accommodator

Table 13 Selected Research Subjects

The outcomes of students' mathematical ability to communicate exams and interviews have previously been documented. The following is an outline of the findings of David Kolb's mathematics communication ability exam in the Learning Style.

Indicator of MCA	Diverger Learning Styles		
	E-9	E-29	E-40
Express everyday events in mathematical language	Capable of expressing ordinary happenings in mathematical terms	Capable of expressing ordinary occurrences in mathematical terms.	Capable of expressing ordinary happenings in mathematical terms.
Presenting pictures, graphs or mathematical models	Capable of presenting images, graphs, or mathematical models	Unable to show visuals, graphs, or mathematical models	Capable of effectively presenting visuals, graphs, or mathematical models
Write down mathematical symbols and formulas in solving problems	Insufficiently capable of appropriately using mathematical	They are still unfamiliar with the right use of mathematical formulae in the	Not proficient in comprehending the application of symbols and

	formulae in the process of issue solving	process of problem solving	formulas in mathematics to solve problems

Table 14 Summary of MCA Analysis in terms of Diverger Learning Styles

Indicator of MCA	Assimilator Learning Style		
	E-5	E-7	E-14
Express everyday events in mathematical language	Capable of expressing commonplace occurrences in mathematical language	Capable of expressing commonplace occurrences mathematically	Capable of expressing commonplace events mathematically
Presenting pictures, graphs or mathematical models	Utilizing the ability to present images, diagrams, or mathematical models	Capable to effectively present images, diagrams, or mathematical models	Competent to effectively present images, diagrams, or mathematical models
Write down mathematical symbols and formulas in solving problems	Competent to accurately apply mathematical formulas when solving problems	Insufficiently able to accurately apply mathematical formulas to problem solving	Insufficiently able to accurately solve problems using mathematical formulas

Table 15 Summary of MCA Analysis in terms of Assimilator Learning Styles

Indicator of MCA	Converger Learning Styles	
	E-21	E-22
Express everyday events in mathematical language	Capable of expressing commonplace occurrences in mathematical language	Capable of expressing commonplace occurrences in mathematical language
Presenting pictures, graphs or mathematical models	Capable of effectively presenting images, diagrams, or mathematical models	Capable of presenting images, graphs, or mathematical models effectively
Write down mathematical symbols and formulas in solving problems	Competent to accurately apply mathematical formulas when solving problems	Capable of solving problems using mathematical formulas accurately

Table 16 Summary of MCA Analysis in terms of Converger Learning Styles

Indicator of MCA	Accommodator Learning Style	
	E-2	E-32
Express everyday events in mathematical language	Capable of expressing commonplace occurrences in mathematical language	Capable of expressing commonplace occurrences mathematically
Presenting pictures, graphs or mathematical models	Unable to provide visuals, diagrams, or mathematical models	Insufficient of presenting images, diagrams, or mathematical models.
Write down mathematical symbols and formulas in solving problems	Insufficiently able to accurately apply mathematical formulas to problem solving	Insufficiently able to accurately solve problems using mathematical formulas

Table 17 Summary of MCA Analysis in terms of the Accommodator's Learning Style

1. **Discussion**

6.1 Quality of learning

GeoGebra-assisted PBL learning models for improving students' mathematical communication skills. The outcome of the analysis at the stages of planning, implementation, and evaluation reveal the quality of the learning. At the planning stage all learning tools were declared valid with good criteria, the student learning style questionnaire was declared valid with good criteria and the test questions for students' MCA were also said to be valid with good criteria, reliable, with moderate difficulty levels, good and sufficient discrimination.

At the learning implementation stage, there is compatibility between the delivery of material and the learning tools prepared and good classroom management. This can be seen from the mean quality of learning obtained at each meeting is 79.5%, so that the criteria for implementing learning at each meeting are good. The implementation of learning in this study was measured by observers when learning activities took place using observation sheets for the quality of learning. Student responses to the applied learning were also positive and the learning tools prepared were practical to use. This is evident from the efficiency mean of 67%, so it can be concluded that the learning device meets the practicality criteria.

This study's assessment phase included the outcomes of students' MCA examinations. The MCA test results were then evaluated and analyzed to ascertain the efficacy of the GeoGebra-assisted PBL model for enhancing students' mathematical communication skills. First, it was determined whether the mean MCA of pupils using the PBL paradigm with GeoGebra was greater than actual completion limit (ACL) = 65. After assessment, it was determined that the mean MCA of students in classes using the PBL learning model with GeoGebra assistance was 65. The second test determines whether or not the mean MCA of students utilizing the GeoGebra-assisted PBL model is equivalent to or greater than ACL, reaching at least 65 percent of ACL. The second test revealed that more than 65 percent of students mastered the material in classes using the GeoGebra-assisted PBL model. The third test will compare the GeoGebra-assisted PBL model's mean MCA to that of the expository learning model. The mean value of the experimental group's MCA on this third test is greater than that of the control group. The fourth test evaluates whether the proportion of GeoGebra-assisted PBL students who demonstrate mastery of mathematical communication skills is greater than that of the expository model learning proposition. The results of this test indicate that the proportion of students with mathematical communication skills is greater in the GeoGebra-assisted PBL learning model class than in the expository learning model class. The fifth test examines whether students' mathematical communication skills have improved after learning the GeoGebra-assisted PBL model, and the results indicate that students' mathematical communication skills have improved. On the basis of the five assessments of hypotheses, it is possible to conclude that the GeoGebra-assisted PBL model is effective at enhancing students' MCA.

6.2 Description of students' MCA in terms of learning styles

a. **Diverger Learning Styles**

The subjects E-9, E-29, and E-40 represent the MCA of pupils with divergent learning styles. The three subjects were able to satisfactorily complete the indicators describing daily events in mathematical language. In terms of the second indicator, namely the ability to exhibit images, diagrams, or mathematical models, subjects E-9 and E-40 performed admirably, whereas subject E-29 did not. Regarding the final indicator, namely the ability to write mathematical formulas and symbols when solving problems, none of the three test subjects performed adequately. Several calculation errors were made.

Based on this explanation, it can be concluded that students with a diverse learning style are only capable of mastering two indicators. Indicators present images, diagrams, or mathematical models, and describe daily events using mathematical language.

b. **Assimilator Learning Style**

The students' mathematical communication skills from the assimilator learning style are represented by subjects E-5, E-7, and E-14. In the first indicator , namely stating daily events in the language of mathematics, the three subjects were able to complete them well. In the second indicator, namely presenting pictures, graphs or mathematical models, the three subjects were also able to solve them correctly. As for the last indicator, namely writing mathematical symbols and formulas in solving problems, subject E-5 was able to solve them quite well, but subjects E-7 and E-14 had not been able to solve them properly and correctly, there were several mistakes made including in calculations and errors in giving units.

Based on the explanation, in general it can be concluded that students with an assimilator learning style are only able to master two indicators. That is, indicators describe daily events in mathematical language and indicators present pictures, graphs or mathematical models.

c. **Converger Learning Styles**

The students' mathematical communication skills from the converger learning style are represented by E-21 and E-22 subjects. In the first indicator, namely stating daily events in the language of mathematics, both subjects were able to complete them well. In the second indicator, namely presenting pictures, graphs or mathematical models, the two subjects can also complete them correctly. As for the last indicator, namely writing mathematical symbols and formulas in solving problems, subjects E-21 and E-22 were also able to solve them quite well.

Based on the explanation described above, in general it can be concluded that students with a converger learning style are able to master all indicators of students' MCA. Both indicators state daily events in mathematical language, indicators present images, graphs or mathematical models, as well as indicators write mathematical symbols and formulas in solving problems.

d. **MCA in terms of Accommodator Learning Style**

The students' mathematical communication skills from the accommodator learning style are represented by subjects E-2 and E-32. In the first indicator, namely stating daily events in the language of mathematics, both subjects were able to complete them well. In the second indicator, namely presenting pictures, graphs or mathematical models, the two subjects have not been able to present the images correctly. As for the last indicator, namely writing mathematical symbols and formulas in solving problems, subjects E-2 and E-32 were also not able to solve them properly.

Based on the explanation described above, in general it can be concluded that students with the accommodator learning style are only able to master one indicator of students' mathematical communication skills. That is an indicator stating everyday events in the language of mathematics. For indicators presenting pictures, graphs or mathematical models, and indicators for writing mathematical symbols and formulas in solving problems cannot be solved properly.

2. Conclusion

The following quantitative research findings were derived from this study: (1) The mean MCA of pupils using the GeoGebra-assisted PBL model is greater than 65. (2) The mean MCA of GeoGebra-assisted PBL pupils is complete or greater than 65 percent. (3) The GeoGebra-assisted PBL model has a higher mean MCA than the expository model. (4) The proportion of GeoGebra-assisted PBL model mastery of MCA is greater than the proportion of the expository learning model. (5) Using the GeoGebra-assisted PBL model, communication skills in mathematics improve.

The following are the results of the qualitative study: (1) Students with a divergent style of learning possess adequate mathematical communication skills, as they are only able to acquire two indicators of such skills. (2) Students with the assimilator learning style have adequate mathematical communication skills, as they have mastered only two of the three indicators of students' MCA. (3) Students with a convergent learning style have excellent mathematical communication skills, as they are able to conquer all mathematical communication skill indicators. Because they can only acquire one indicator of students' MCA, (4) students with the accommodator learning style have fewer mathematical communication skills.

3. Recommendations

MCA indicators can measure the extent to which a student's ability to communicate mathematical problems. Learning styles can also affect students' communication skills. Effective learning can help to improve students' MCA. Teachers need to know students' Mathematical Communication Skills so they can provide an evaluation of the learning that is being carried out. The assessment carried out by the teacher must also be in accordance with the students so that students can follow the learning well.

4. Limitations

Researchers realize that this research still has many limitations, consists of:

a. Researchers only use limited research subjects.
b. Researchers only used data from MCA test results and questionnaire results with limited statements.
c. Researchers conduct research in a short time so they cannot dig deeper into the problem.

5. Acknowledgments

Thanks to the lecturers at Universitas Negeri Semarang, teachers and students of MTs Tahfidh Putri Yanbu'ul Qur'an 2 Muria and all parties who have participated in this research so that this research can be completed properly.

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