Indonesian Journal of Applied Mathematics and Statistics (IdJAMS)

Volume 1 Issue 1 June, 2024, pp. 1-16
https://idjams.com/index.php/jms/index

Cluster Analysis for the Relationship between Mathematical Communication Ability and Student's Problem-Solving Ability

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Article Info

Article history:
Received: June 2024
Revised: August 2024
Accepted: August 2024
Available online: August 2024

Abstract

This study aims to determine how mathematical communication ability with students' problem-solving ability. This research uses a quantitative approach with correlational methods and cluster analysis. The research was conducted at SMPN 1 Rengasdengklok with the population being all class VIII in the 2023/2024 school year. Determination of the sample in this study using purposive sampling technique, where researchers took samples based on the results of consideration to students who had obtained statistical material. Taking the number of samples in this study using the Slovin formula, 83 samples were used in the study. Data collection techniques in this study used mathematical communication ability test instruments and problem-solving skills. This study uses the k-means clustering analysis technique to divide the data into high, medium, and low categories. And analyzed using the Spearman rank correlation test to determine the level of relationship between the entire sample and each cluster. The results of this study show that in cluster 1 30 students have high ability, in cluster 2 as many as 37 students have medium ability, and in cluster 3 as many as 16 students have low ability. The correlation test results for the entire sample have a significant relationship with a contribution of 37.45%. The correlation test results for cluster 1 do not have a significant relationship with a contribution of 7.4%. The correlation test results in cluster 2 have an insignificant relationship with a contribution of 2.2%. The correlation test results in cluster 3 have an insignificant and unidirectional relationship.

Keywords: Spearman Rank Correlation; K-Means; Mathematical Ability

I. Introduction

Mathematics learning has a goal not only to improve students' ability to count and apply formulas in solving routine problems but to understand concepts use reasoning in solving mathematical problems and be able to communicate ideas and solve mathematical problems. So in learning mathematics, it is necessary to develop students' mathematical abilities. According to NCTM [1] the abilities that students must have in the learning process include mathematical connections, mathematical representation, mathematical communication, mathematical problem-solving, and mathematical reasoning. Often students find it difficult to work on mathematical problems because the form of the problem is difficult to understand due to their limited mathematical ability to understand and analyze problems. According to Ariawan and Nufus [2], the focus and need to be mastered in learning mathematics are mathematical communication skills and problem-solving skills. Based on this opinion, mathematical communication skills and problem-solving skills are very important for students to master.

Mathematical communication skills are a person's ability to express ideas both orally and in writing in the form of symbols, tables, and diagrams. So in learning mathematics, mathematical communication skills need to be developed. According to Wardani et al. [3] to develop an understanding of mathematical language and express ideas, images, and symbols orally and in writing can be obtained through mathematical communication skills. However, students do not fully have mathematical communication skills. The fact in the field is that students are still lacking in their mathematical communication skills. In line with research conducted by Ismayanti and Sofyan [4] students' mathematical communication skills are low because students are still unable to express problems with ideas, language, and mathematical symbols properly. The results of research conducted by Ayyasy et al. [5] said that students' mathematical communication skills were low because students still could not understand the purpose and purpose of the problem in problem-solving so they found it difficult to communicate it with mathematical language.

Problem-solving ability is a process to train students in solving problems using the right steps. So problem-solving ability is a person's ability to identify elements, develop strategies, and find what is needed in mathematical problems. Problem-solving ability is not just solving in the usual way but rather emphasizes how to find and use concepts for simplification in solving complex problems [6]. However, there are still many students who do not fully understand the concept of finding solutions and solving a problem. In line with research conducted by Saputra et al. [7] students are still lacking in terms of composing strategies so students' problem-solving skills are still relatively low. The results of research conducted by Selvia et al. [8] said students have difficulty solving mathematical problems if students do not have mathematical communication skills to build knowledge and ways of thinking in solving a problem. Therefore, it is necessary to analyze mathematical communication ability with problem-solving ability.

Each student has different abilities in understanding the same learning, one of the factors for this difference comes from mathematical communication skills in problem-solving. Based on the results of interviews with mathematics teachers at SMPN 1 Rengasdengklok, students who have low mathematical ability still do not fully understand how to solve mathematical problems, this is due to the lack of conceptual understanding of students in explaining ideas using mathematical language, in contrast to students who have high mathematical ability where students already understand enough to solve problems conceptually in explaining using mathematical language correctly even though the calculations sometimes have errors. The results of research conducted by Sarini [9] said that mathematical communication ability has a considerable influence on problem-solving ability, the higher the mathematical communication ability to the learning process, the higher the problem-solving ability and vice versa.

To find out the high and low of an ability can be grouped by category. The grouping of these categories can be analyzed using cluster techniques. Cluster analysis is the grouping of data based on data similarity. Cluster analysis is a grouping of objects into several clusters so that objects that have similarities or similarities with other objects are grouped into one cluster [10]. The process of clustering mathematical communication and problem-solving skills uses the k-means clustering analysis technique. K-means clustering is a method for delimiting and dividing data into one or more groups. In this study, the data into three groups to determine the high, medium, and low categories in students' communication and problem-solving skills. K-means clustering takes a fast time in the process so it is easy to use. In line with the opinion of Sulistyawati and Supriyanto [11] k-means clustering in each process saves more time in clustering and provides effective data grouping. The author aims to provide an overview of how the results of the ability of mathematical communication skills with problem-solving skills are grouped into high, medium, and low categories. And to find out how much the level of relationship between the data that has been grouped with the overall data in the research sample.

Based on the background that has been described, it shows that mathematical communication skills and problem-solving skills are very important for students. The author aims to provide an overview of how the results of the ability of mathematical communication skills with problem-solving skills are

grouped into high, medium, and low categories. And to find out how much the level of relationship between the data that has been grouped with the overall data in the research sample.

II. Method

This study used a quantitative approach with a correlational design and analyzed using k-means clustering. The population in this study amounted to 490 people from all grade VIII students at SMPN 1 Rengasdengklok in the 2023/2024 school year. Sampling in this study used a purposive sampling technique. The purposive sampling technique is sampling based on certain considerations [12]. In this study, the sampling consideration was based on students who had received mathematics learning about statistics. The number of samples in this study was taken using the Slovin formula. Determining the number of samples using this formula is used to facilitate data calculations in research. So based on the calculation of the Slovin formula, the number of samples used in this study was 83 students. This study uses variables of mathematical communication ability and problem-solving ability. The data collection technique was carried out by giving test instruments consisting of description questions from the mathematical communication ability and problem-solving ability test instruments. The test instrument given has been tested for validity, reliability, distinguishing power, and index of difficulty of the test instrument.

Data processing techniques in this study on each instrument are scored with $\frac{Score\ obtained}{maximum\ score} \times 100$. After scoring, the data is analyzed using the k-means clustering stage. Clustering uses k-means clustering to divide data into three categories, namely high, medium, and low. The stages of k-means clustering analysis are as follows:

a) Determine the number of k, this research uses three clusters so the value of K used is 3.
b) Determine the centroid or initial value of the cluster.
c) Calculate data distance using Euclidian distance

$$d(x,y) = \sqrt{\sum_{i=0}^{n}(x_i - y_i)^2}, \quad (1)$$

where $d(x,y)$ is distance between xth data to cluster center y. x_i is x data of i variable, y_i is y cluster centroid for i variable, and n is many variable.

d) Distribute the data into clusters from the minimum distance to the centroid.
e) Determine the new centroid with the formula

$$C_{ij} = \frac{1}{N}\sum_{i=0}^{n} X_{ij}, \quad (2)$$

where C_{ij} is new centroid at iteration k, N is number of data from the k cluster member, and X_{ij} is k data in the cluster.

f) Repeat step 3 until no member in the cluster has changed its cluster location.

After conducting a cluster analysis that divides the data into three categories, namely high, medium, and low. Furthermore, data on all samples and each category is analyzed for the level of correlation using Spearman rank correlation. Spearman rank correlation is a nonparametric statistic, nonparametric statistics are statistics used when data are measured in the form of ranks and the test does not require prerequisite tests [13]. So that in this study the mathematical communication ability test score data with problem-solving ability was analyzed using nonparametric statistics, where nonparametric statistics are free of assumptions, so there is no need to do a prerequisite test. To determine the correlation coefficient in this study, the scores were ranked first and then analyzed using Spearman rank. The calculation of the Spearman rank correlation test will obtain the correlation coefficient value. The correlation coefficient value is obtained to get an answer to the hypothesis statement. The hypothesis in this study is as follows:

H_0: There is no significant relationship between mathematical communication ability and problem-solving ability.
H_1: There is a significant relationship between mathematical communication ability and problem-solving ability.
Hypothesis proving uses a nonparametric statistical test, namely the Spearman rank correlation test as follows:

$$r_s = 1 - \frac{6 \sum di^2}{n(n^2-1)}, \tag{3}$$

where r_s is Spearman rank correlation, n is number of samples, and $\sum di^2$ is the sum of the squares of the difference between the ranks of the two variables.

$$r_s = \frac{\sum x^2 + \sum y^2 - \sum di^2}{2\sqrt{\sum x^2 \sum y^2}}, \tag{4}$$

with $\sum x^2 = \frac{N^3-N}{12} - \sum T_x$, $\sum y^2 = \frac{N^3-N}{12} - \sum T_y$, and $\sum T = \sum \frac{t^3-t}{12}$, where r_s is Spearman rank correlation, x is mathematical communication ability variable, y is problem-solving ability variable, N is number of samples, and t is number of equal data.

The correlation coefficient value can also be used to determine the level of direction of the relationship between the two variables. The following is a table of the direction of the correlation between the two variables based on Guilford's criteria [14].

Table 1. Criteria for the direction of the correlation relationship

Correlation coefficient value (r)	Interpretation
0.00 < r < 0.20	very weak correlation (negligible)
0.20 < r < 0.40	low correlation
0.40 < r < 0.70	medium/sufficient correlation
0.70 < r < 0.90	strong/high correlation
0.90 < r < 1.00	very strong/very high correlation

If the direction of the relationship is positive or unidirectional, it means that the higher the mathematical communication ability, the higher the problem-solving ability, and vice versa. However, if the direction of the relationship is negative or opposite, it means that the higher the mathematical communication ability, the lower the problem-solving ability, and vice versa. To determine the amount of contribution to the two variables, the coefficient of determination was calculated as follows:

$$D = (r_s)^2 \times 100\%, \tag{5}$$

where D is coefficient of determination.

The significance level in this study is 5% or 0.05. To find test statistics in this study using the t-test. The test statistic formula is as follows:

$$t = \frac{r_s\sqrt{n-2}}{\sqrt{1-r_s^2}}. \tag{6}$$

The t-test criteria to determine the relationship between mathematical communication skills and problem solving skills are as follows:
If $t_{statistics} > t_{table}$, then H_0 is rejected,
If $t_{statistics} \leq t_{table}$, then H_0 is not rejected.

III. Result and Discussion

Based on the results of the scoring obtained on 83 samples of students in class VIII of SMPN 1 Rengasdengklok, the author conducted a cluster analysis of the data on mathematical communication ability and problem-solving ability that had been obtained. This data cluster analysis uses k-means clustering, by first dividing the data of mathematical communication ability and problem-solving ability into three categories. Cluster 1 (high ability category), cluster 2 (medium ability category), and cluster 3 (low ability category). Next, determine the centroid value randomly. The determination of centroid values is presented in Table 2.

Table 2. Initial Cluster Center

	Cluster		
	1	**2**	**3**
Mathematical Communication	93	27	33
Problem Solving	90	80	20

Based on Table 2, the determination of centroid values is done randomly where the data of mathematical communication ability is divided into three clusters with centroid values in cluster 1 of 93, cluster 2 of 27, and cluster 3 of 33. The data on problem-solving ability is divided into three clusters with initial center values in cluster 1 of 90, cluster 2 of 80, and cluster 3 of 20.

After determining the centroid, the calculation is then carried out on each data with each cluster center. The calculation uses the Euclidian formula. Proof of the calculation as follows:

Distance of i-th data to cluster center 1

$$d(x_1,y_1) = \sqrt{(90-93)^2 + (78-90)^2} = 12{,}37$$

Distance of i-th data to cluster center 2

$$d(x_1,y_1) = \sqrt{(90-27)^2 + (78-80)^2} = 63{,}03$$

Distance of i-th data to cluster center 3

$$d(x_1,y_1) = \sqrt{(90-33)^2 + (78-20)^2} = 81,,32$$

Perform calculations on all data to get group members in each cluster. After obtaining the cluster members then determine the new cluster center. As proof, the calculation of the new cluster center in cluster 3 for data on mathematical communication ability and problem-solving ability is carried out as follows:

$$C_3KKM = \sum \frac{m}{n} = \frac{47+13+33+43+13+23+23+37+47+10+33+23+33+23}{14} = \frac{401}{14} = 28{,}64$$

$$C_3KPM = \sum \frac{m}{n} = \frac{32+36+20+30+34+34+34+30+30+30+30+34+34+30}{14} = \frac{438}{14} = 31{,}29$$

If the data still moves clusters, then do the next iteration in the same way so that no data moves clusters. In this study, clustering stopped at the 4th iteration. changes in cluster centers at each iteration are presented in Table 3.

Teble 3. Iteratioms

	Cluster Center						Change in Cluster Center		
Iteration	**1**		**2**		**3**		**1**	**2**	**3**
	X1	**X2**	**X1**	**X2**	**X1**	**X2**			
1	93	90	27	80	33	20	18,491	16,724	12,098
2	79,47	77,40	41,26	71,26	28,64	31,29	0,000	0,587	1,384

3	79,47	77,40	41,26	71,26	28,64	31,29	0,000	0,658	1,502
4	79,47	77,40	41,55	71,76	28,73	32,67	0,000	0,000	0,000

Based on the results of the calculation, the iteration stops at the 4th iteration, so there is no more data that has moved clusters. The determination of the cluster group from the 4th iteration is presented in Figure 1.

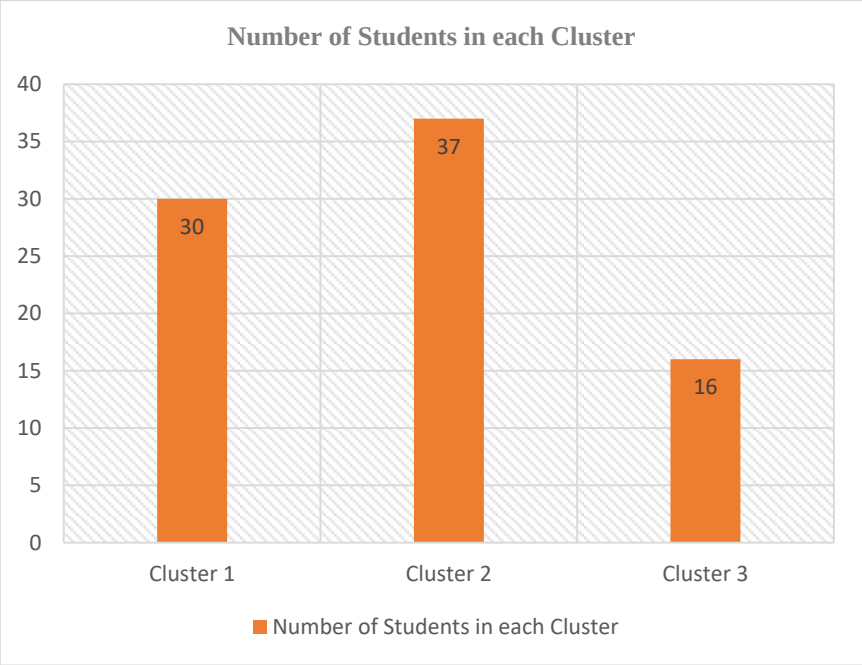

Figure 1. Number of Students in each Cluster

Based on Figure 1, the amount of data on mathematical communication ability and students' problem-solving ability is obtained. In cluster-1 30 students have high ability, in cluster-2 37 students have medium ability, and in cluster-3 16 students have low ability. These results show that the average student's mathematical communication and problem-solving skills are in the medium to high category. So it can be said that many students already have mathematical communication and problem-solving skills in learning.

Furthermore, the researcher will choose one of the samples in each cluster to analyze how the answers are based on indicators of mathematical communication ability and problem-solving ability. Indicators of mathematical communication ability in this study consist of explaining mathematical ideas in visual form (tables and diagrams), explaining mathematical ideas or situations in writing, and expressing ideas or problem situations using mathematical terms, symbols, or models. The problem-solving ability indicators consist of understanding the problem, developing a problem-solving plan, solving the problem, and re-examining the solution results. The samples selected were sample 31 for cluster 1, sample 68 for cluster 2, and sample 3 for cluster 3. The following are the answers to the description test on statistics material from the samples in each cluster.

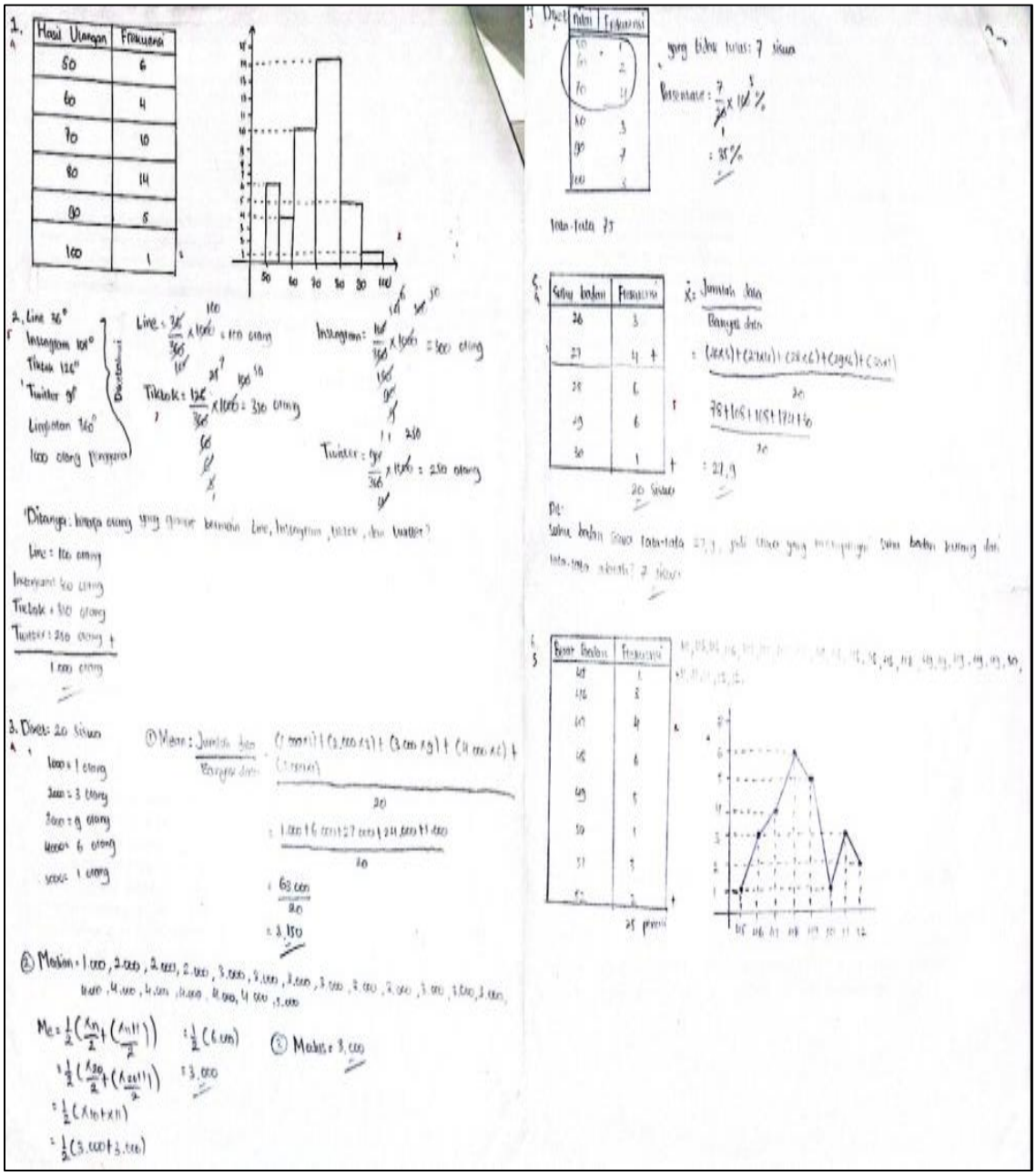

Figure 2. Communication ability tests results of sample 31 cluster 1

The results of sample 31 answers seen in Figure 2 have been able to master their mathematical communication ability. In questions number 1 and 6 which contain indicators of explaining mathematical ideas in visual form, students have been able to answer questions by presenting data in the form of tables and diagrams appropriately and correctly. For questions number 2 and 4 containing indicators of explaining ideas or situations in writing, students have been able to process data from diagram problems for number 2 and have been able to identify data based on the size of the data center in problem number 4 properly and correctly. In questions number 3 and 5 based on the indicator of expressing problem situations using mathematical language, students have been able to read and process data from diagrams to answer problems. From the 6 items, it can be concluded that students in cluster 1 can express and explain problems with mathematical language and symbols.

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https://idjams.com/index.php/jms/index

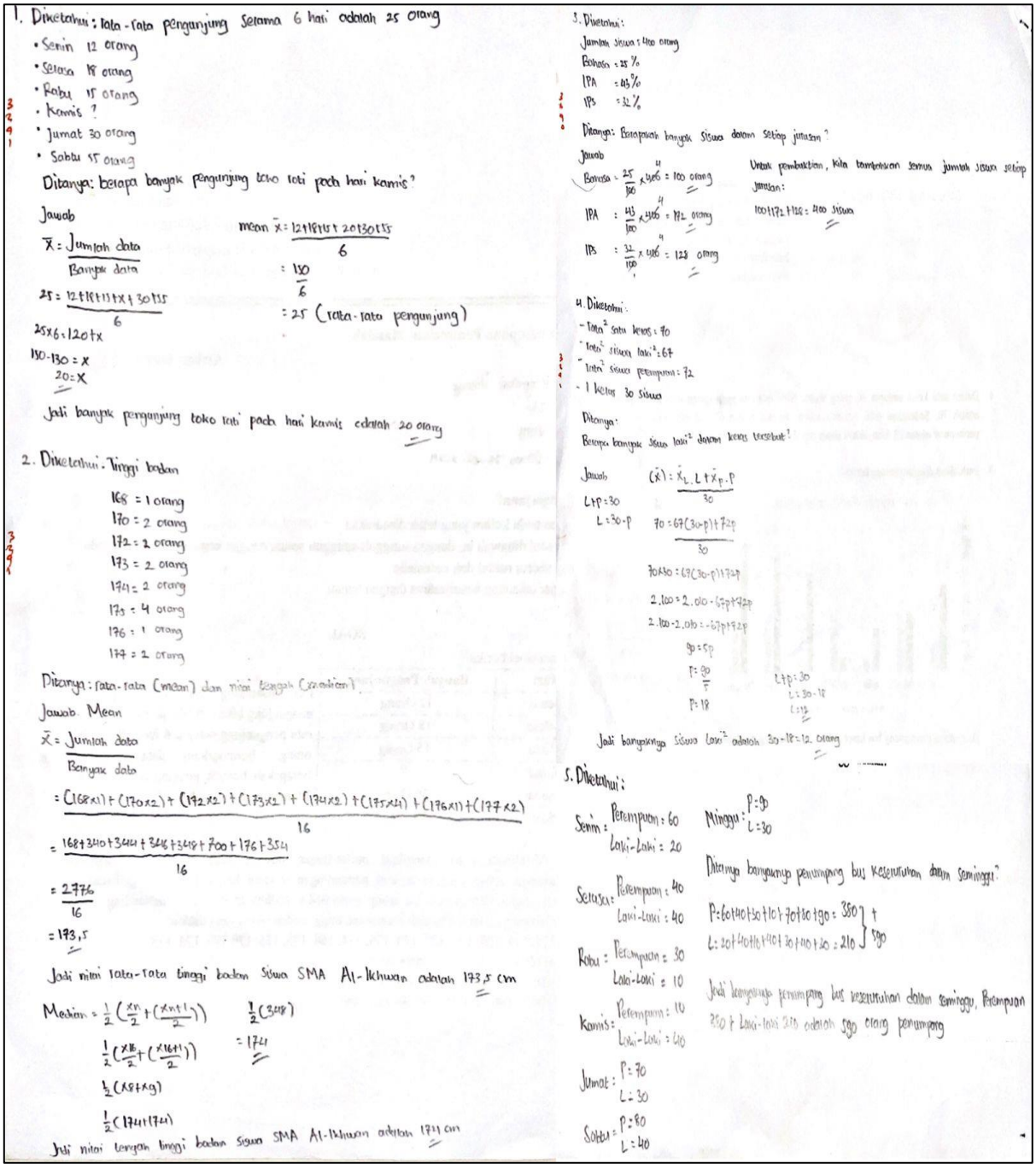

Figure 3. Problem-Solving ability tests results of sample 31 cluster 1

The results of sample 31 answers seen in Figure 3 show that they can master problem solving ability based on indicators. Of the 5 items, students in cluster 1 have fully understood the concept of finding solutions in solving problems coherently by the stages of understanding the problem, developing a problem-solving plan, solving problems, and checking the answer results.

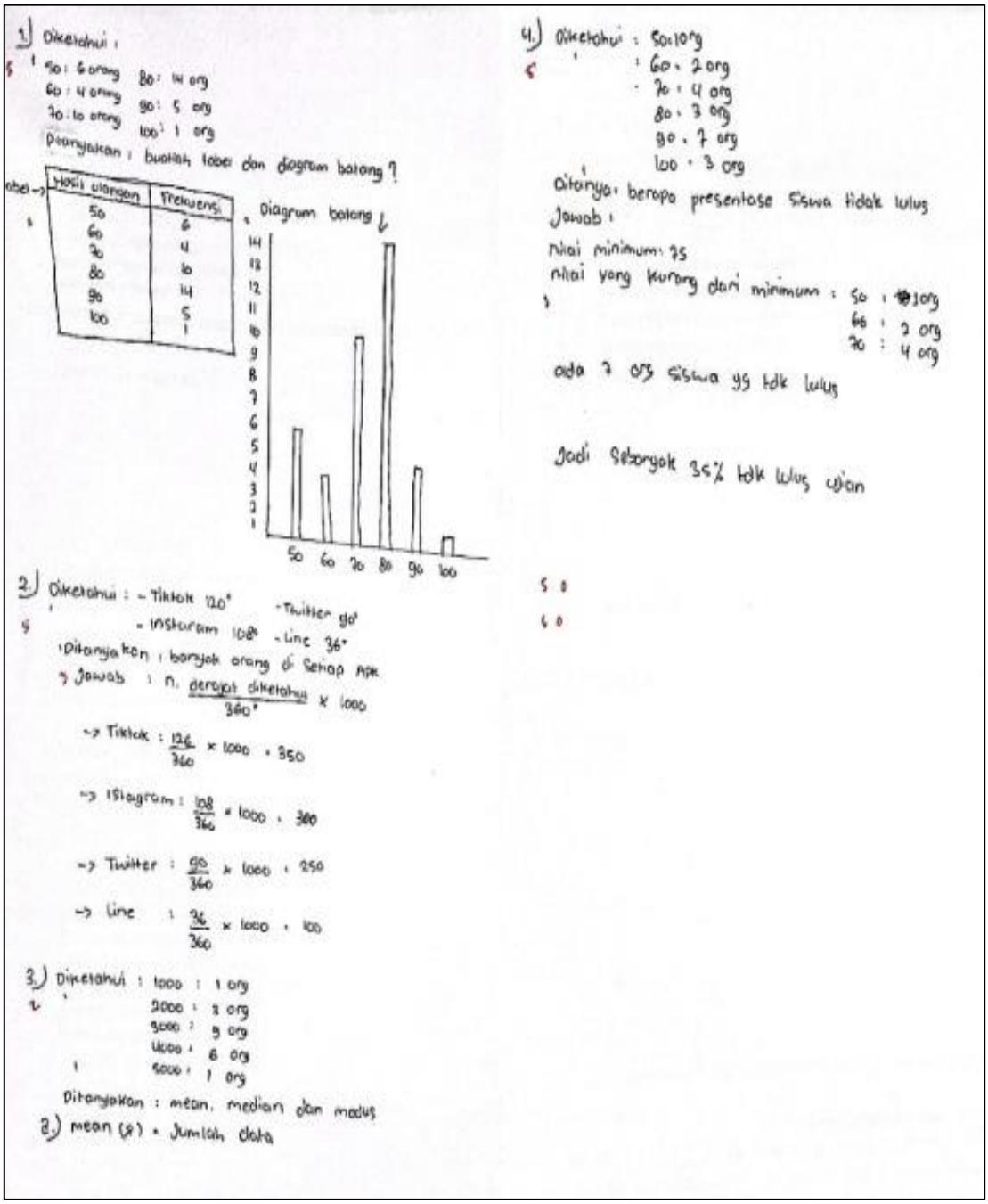

Figure 4. Communication ability test results of sample 68 cluster 3

Based on the answers of sample 68 in Figure 4, students who are in cluster 2 are quite good at mastering their mathematical communication ability. Although based on the results of the sample answers 2 questions are not filled in. Judging from the answers to questions Number 3 and 5, students still cannot answer problems with mathematical language. So that students who have moderate ability still cannot state mathematical problems with good language.

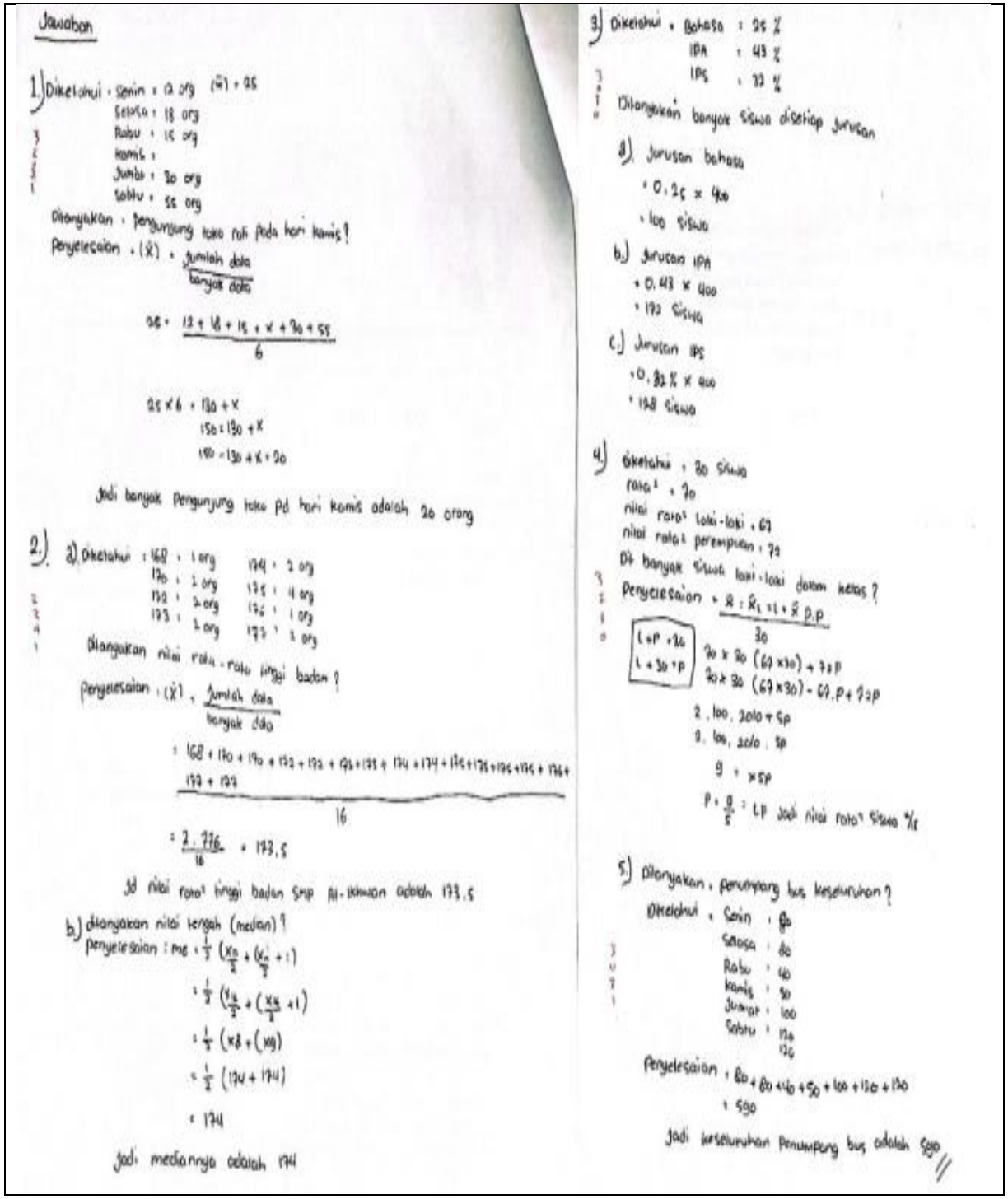

Figure 5. Problem-Solving ability tests results of sample 68 cluster 2

Seen in Figure 5 based on the results of sample answers 68 for students who are in cluster 2 have sufficiently mastered problem-solving ability by the concept of finding and solving a problem. Judging from the 5 items, questions No. 1, 3, and 4 are still not correct in the problem-solving strategy but the answers are correct.

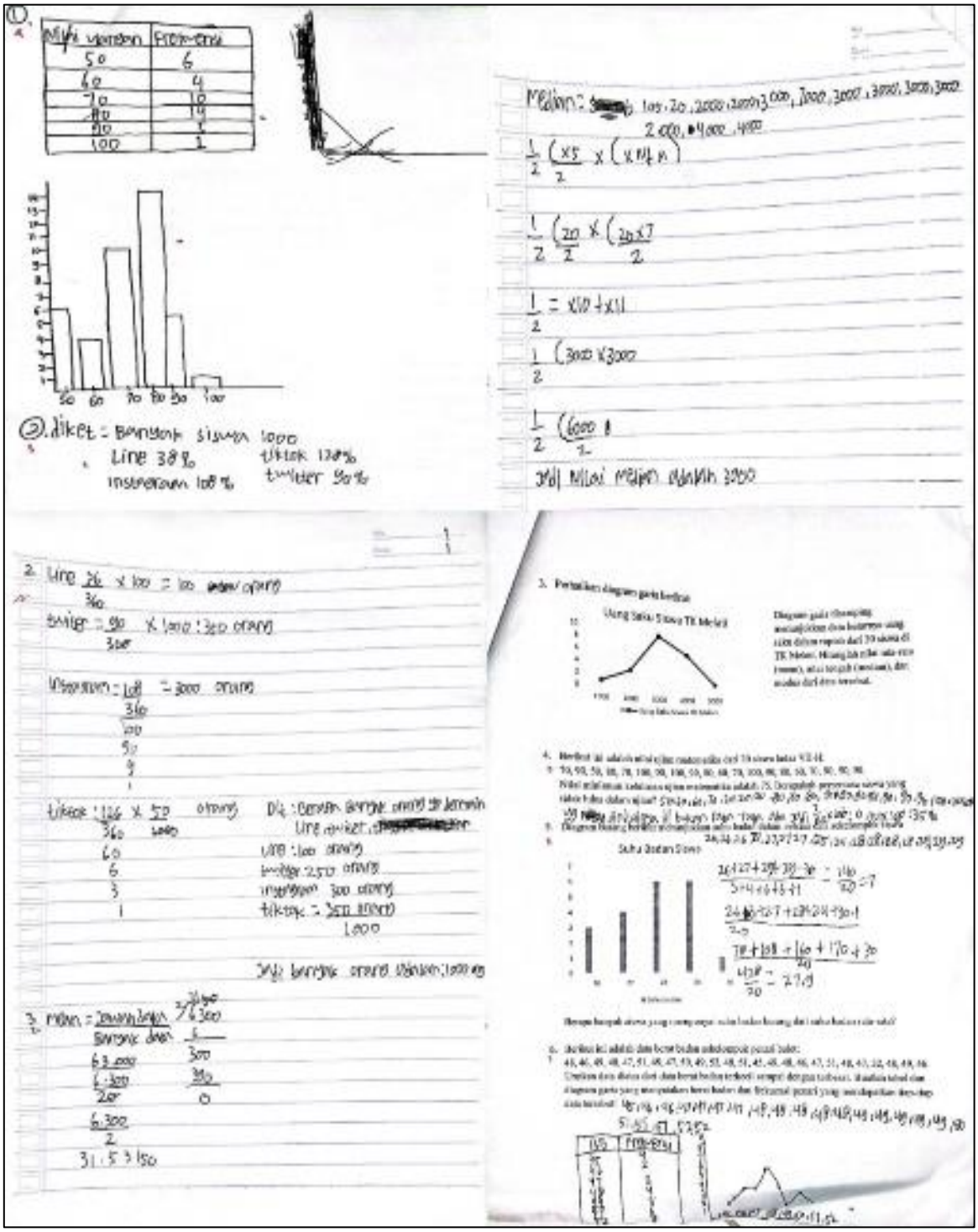

Figure 6. Communication ability tests results of sample 3 cluster 3

Based on the results of sample 3 answers in Figure 6, students in cluster 3 are still unable to explain problems with mathematical language. And have not been able to solve problems based on images, symbols, and mathematical models properly.

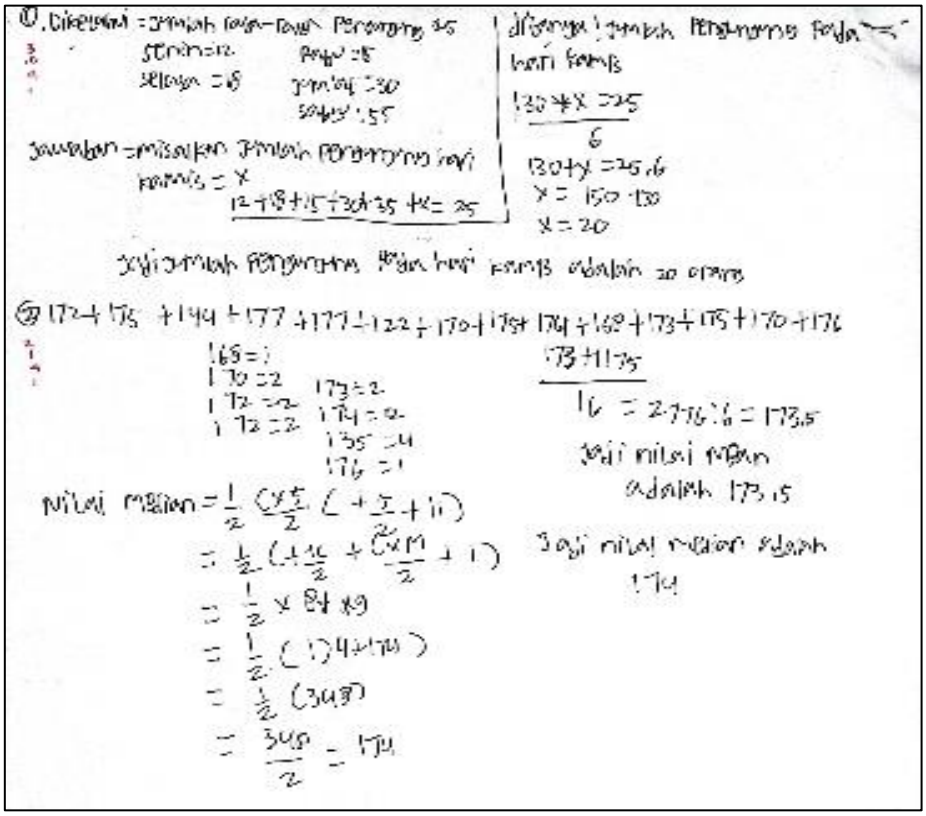

Figure 7. Problem-Solving ability tests results of sample 3 cluster 3

As seen in Figure 7 based on the answers of sample 3, students who are in cluster 3 still have not mastered problem-solving skills well. judging from the answers, students can only fill in 2 problems with the results of their answers students do not fully understand the concept of finding solutions and solving a problem. Students are still unable to develop strategies to solve a problem.

After clustering the data using k-means clustering, furthermore, data on all samples and each cluster are tested using a correlation test. In this study, the correlation test uses the Spearman rank correlation test and test statistics using the t-test. The results of the correlation test on all data in the sample are presented in Table 4.

Table 4. Correlation Results of All Data on Mathematical Communication Ability and Problem Solving

			Mathematical Communication	**Problem-Solving**
Spearman' rho	Mathematical Communication	Correlation Coefficient	1.000	.612
		Sig. (2-tailed)		.000
		N	83	83
	Problem-Solving	Correlation Coefficient	.612	1.000
		Sig. (2-tailed)	.000	
		N	83	83

Based on Table 4, the correlation coefficient value is 0,612. Based on the criteria for the direction of the relationship in Table 1, it shows that mathematical communication skills and problem-solving

skills have a moderate relationship. The magnitude of the correlation coefficient value has a positive relationship direction. Then test the significance of the relationship in the data by looking at the tcount value. If $t_{statistics} > t_{table}$ then H_0 is rejected. The $t_{statistics}$ value based on t-test statistics on 83 is obtained at 6,964. The t_{table} value with a significant level $\alpha = 5\%$ and n = 83 - 2 = 81, then the t_{table} value = 1,989 is obtained. based on the test criteria that have been determined, 6,964 > 1,989 so that $t_{statistics} > t_{table}$. obtained The conclusion that mathematical communication skills and problem-solving skills have a significant relationship.

The amount of contribution given can be calculated by the coefficient of determination (r^2). The coefficient of determination in this data is ($0{,}612^2$) so that it is obtained as 0,3745. This states that the amount of contribution given to the data is 37.45%. Based on the results obtained from the data, there is a significant relationship with a moderate level of relationship and a positive relationship direction. The direction of the positive relationship indicates that the higher the mathematical communication ability, the higher the problem-solving ability, and vice versa. This is in line with research conducted by La'ia & Harefa [15] that there is a significant relationship between mathematical communication ability and problem-solving ability, so these two abilities cannot be separated in mathematics learning and everyday life.

Furthermore, the results of the Spearman rank correlation test in cluster 1 are presented in Table 5.

Table 5. Correlation Results of Cluster 1 on Mathematical Communication Ability and Problem Solving

			Mathematical Communication	**Problem-Solving**
Spearman' rho	Mathematical Communication	Correlation Coefficient	1.000	.272
		Sig. (2-tailed)		.145
		N	30	30
	Problem-Solving	Correlation Coefficient	.272	1.000
		Sig. (2-tailed)	.145	
		N	30	30

The correlation coefficient value in Table 5 for cluster 1 is 0,272. Based on the criteria for relationship direction in Table 6, it shows that communication skills and problem-solving skills in cluster 1 have a low relationship and have a positive relationship direction. To test the significance of the relationship in the data by looking at the $t_{statistics}$ value. If $t_{statistics} > t_{table}$ then H_0 is rejected. The t-count value based on t-test statistics on 30 data is obtained at 1,496. The t_{table} value with a significant level $\alpha = 5\%$ and n = 30 - 2 = 28, then the t_{table} value = 1,701 is obtained. based on the test criteria that have been determined, 1,496 < 1,701 so that $t_{statistics} < t_{table}$. it is concluded that mathematical communication skills and problem-solving skills do not have a significant relationship.

The amount of contribution given can be calculated by the coefficient of determination (r^2). The coefficient of determination in this data is ($0{,}272^2$) so it is obtained as 0,074. This states that the amount of contribution given to the data is 7.4%. Based on the results obtained, there is no significant relationship between a low level of relationship and a positive relationship direction between mathematical communication ability and problem-solving ability in cluster 1.

The results of the correlation test in cluster 2 are presented in Table 6.

Table 6. Correlation Results of Cluster 2 on Mathematical Communication Ability and Problem Solving

			Mathematical Communication	**Problem-Solving**
Spearman' rho	Mathematical Communication	Correlation Coefficient	1.000	.147
		Sig. (2-tailed)		.385
		N	37	37
	Problem Solving	Correlation Coefficient	.147	1.000
		Sig. (2-tailed)	.385	
		N	37	37

Based on Table 6, the correlation coefficient value of 37 data is 0,147. Based on the criteria for the direction of the relationship in Table 1, it shows that the data on mathematical communication ability with problem-solving ability has a very weak relationship with a positive relationship direction. To test the significance of the relationship in the data by looking at the $t_{statistics}$ value. If $t_{statistics} > t_{table}$ then H_0 is rejected. The $t_{-statistics}$ value based on t-test statistics on 37 data is obtained at 0,879. The t_{table} value with a significant level $\alpha = 5\%$ and $n = 37 - 2 = 35$, then the t_{table} value = 2,030 is obtained. based on the test criteria that have been determined, $0.879 < 2.030$ so that $t_{statistics} < t_{table}$. it is concluded that mathematical communication skills and problem-solving skills do not have a significant relationship.

The amount of contribution given can be calculated by the coefficient of determination (r^2). The coefficient of determination in this data is (0.147^2) so it is obtained as 0,022. This states that the amount of contribution given to the data is 2,2%. Based on the results obtained, there is no significant relationship with a low level of relationship and a positive relationship direction between mathematical communication ability and problem-solving ability in cluster 2.

Furthermore, the results of the correlation test on cluster 3 are presented in Table 7.

Table 7. Correlation Results of Cluster 3 on Mathematical Communication Ability and Problem Solving

			Mathematical Communication	**Problem-Solving**
Spearman' rho	Mathematical Communication	Correlation Coefficient	1.000	-.426
		Sig. (2-tailed)		.100
		N	16	16
	Problem-Solving	Correlation Coefficient	-.426	1.000
		Sig. (2-tailed)	.100	
		N	16	16

The correlation coefficient value obtained in Table 7 in cluster 3 is -0,426. Based on the criteria for relationship direction in Table 1, it shows that the data on mathematical communication ability and problem-solving ability in cluster 3 have a very weak relationship and negative relationship direction. The negative direction of the relationship means that if mathematical communication ability is high then problem-solving ability is low, and vice versa. To test the significance value of 16 data, it is calculated based on t-test statistics. The $t_{statistics}$ value of 16 data obtained is -0,979. If $t_{statistics} > t_{table}$ then H_0 is rejected. The t_{table} value with a significant level $\alpha = 5\%$ and $n = 16 - 2 = 14$, then the t_{table} value is obtained = 1,761. Based on the predetermined test criteria, $-0,979 < 1,761$ is obtained so that $t_{statistics} <$

t_{table} then H_0 is not rejected. It is concluded that there is no significant relationship between mathematical communication ability and problem-solving ability in cluster 3.

Following the correlation test results in cluster 1, cluster 2, cluster 3, and all data, there is not always a significant relationship. A summary of all calculations is presented in Table 8.

Table 8. Overall Correlation Test Results

Ability Category	Correlation Coefficient	T Value		Coefficient of Determination	Description
		t_{count}	t_{table}		
Whole Sample	0,612	6,964	1,989	37,45%	H_0 rejected
1st Cluster	0,272	1,496	1,701	7,4%	H_0 not rejected
2nd Cluster	0,147	0,879	2,030	2,2%	H_0 not rejected
3rd Cluster	-0,426	-0,949	1,761	-	H_0 not rejected

Based on the correlation test results, there are differences in hypothesis acceptance between all data and each cluster. The difference shows that all data has a moderate relationship, but the calculated results in cluster 1 and cluster 2 have a low and very weak relationship. The difference also occurs in cluster 3 which has a negative relationship. Based on the results of these calculations, it states that there is no significant relationship between mathematical communication skills and problem-solving. Based on the coefficient of determination, it can be seen that the amount of contribution of both variables can be influenced by other factors. The difference in the results of this calculation needs further study because there are differences in the results of calculations with theoretical concepts. This is in line with research conducted by Ariawan & Nufus [2] which states that there is a significant relationship between mathematical communication ability and problem-solving ability for the entire sample, but there is no significant relationship between mathematical communication ability and problem-solving ability in the high, medium, and low categories. Because the results of statistical calculations show the opposite of the theoretical concept. Therefore, there should be a more in-depth study that is qualitative in nature to examine this phenomenon.

IV. Conclusion

Based on the results that have been analyzed, it can be concluded that the results of grouping data on mathematical communication ability with problem-solving ability for 83 samples using k-means clustering are divided into three clusters. In cluster 1, 30 students have high ability, in cluster 2, 37 students have medium ability, and in cluster 3, 16 students have low ability. Based on the results of the Spearman rank correlation test on the entire sample, there is a significant and positive relationship with the magnitude of the influence of the two variables given at 37.45%. While 62.55% is influenced by other factors.

In particular, the results of the Spearman rank correlation test in cluster 1 do not have a significant relationship with a low and positive level of relationship with the contribution given to the two variables of 7.4%. The results of the Spearman rank correlation test in cluster 2 have no significant relationship with a very weak and unidirectional level of relationship with a contribution of only 2.2%. The results of the correlation test in cluster 3 show that there is no significant relationship with a very weak and unidirectional level of relationship.

The difference in the significance of the relationship that occurs in the entire sample and each cluster is thought to be due to the different amount of data in each cluster, allowing insignificance in the data of each cluster. So it needs a more in-depth study with qualitative for this phenomenon because this research uses a quantitative approach that is only interpreted in the form of numbers and described by the calculated results obtained. The results of statistical calculations on each cluster show the opposite of the theoretical concept. For future research, other populations, samples, and research sites are needed to find out the difference in the level of significance of the relationship between mathematical communication skills and students' problem-solving skills. And other variables are needed to analyze the relationship between students' mathematical abilities.

Acknowledgment

We would like to thank Department of Mathematics Education Universitas Singaperbangsa Karawang for supporting the research.

V. Reference

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