Proceeding – CAMIC

Cirebon Annual Multidisciplinary International Conference (CAMIC 2024)

The Ability of Student's Mathematical Representation in Contextual Problems Solving of Circle Material based on Mathematical Communication Ability

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***Abstract*—Students in grade XI.11 of SMA Negeri 7 Cirebon City still have difficulty representing information into mathematical images and symbols on contextual problems, so it is important to understand their mathematical representation skills where this is influenced by one of the factors of students' abilities, namely mathematical communication. This study aims to analyze the mathematical representation ability of students in solving mathematical contextual problems, especially in the inner circle and outer circle of triangles based on mathematical communication skills. The type of research is descriptive with a qualitative approach. The results of the study showed that: 1) the students with high mathematical communication skills were able to do well in symbolic and verbal representation. On visual representations, they are quite good although there are some mistakes in visualizing information; 2) the students with middle mathematical communication skills are quite good in symbolic representation. However, in visual and verbal representations, they are still lacking in visualizing information and expressing ideas or reasoning against material concepts; and 3) the students with low mathematical communication skills are quite good at symbolic representation even though there are shortcomings in writing formulas. In visual and verbal representations, they still have difficulty explaining ideas or ideas from information in contextual problems.**

Keywords— ***mathematical representation; contextual problems; mathematical communication***

I. INTRODUCTION

Mathematics is one of the branches of science in education that has an important role in the development of modern technology and various disciplines so that it can advance human thinking. As conveyed by Kowi and Fakhriyana, mathematics is interpreted as a basic science for the development of science which has an important position and contribution to the development of human mindset [1]. Mathematics is an abstract subject so that students cannot easily understand it [2]. This is relevant to the opinion of Bujung, et al. that mathematics subjects have abstract object characteristics, thus causing students to have difficulty understanding the subject [3]. Therefore, if an object or study of mathematics is abstract, then there needs to be a form of representation that helps make it easier for students to understand abstract mathematical ideas and make them more concrete and easy to understand [2].

Representation is defined as a form or arrangement that can describe, represent, or symbolize something in a way. Thus the

ability to represent can be interpreted as the ability to represent notations, symbols, tables, figures, graphs, diagrams, equations or other mathematical expressions into other forms [4]. This ability has urgency in helping students to come up with and display mathematical ideas in solving problems [5]. As according to NCTM (National Council of Teachers of Mathematics), this mathematical representation ability is one of the skills that must be possessed by students because it provides support in understanding mathematical concepts and their relationships [6]. The indicators of mathematical representation ability are divided into three forms as presented in Table I [7].

TABLE I. MATHEMATICAL REPRESENTATION INDICATORS

Representation	Description
Symbolic	Able to express statements in the form of numbers, symbols, mathematical operations or mathematical modeling.
Visual	Able to express statements in the form of images.
Verbal	Able to express ideas, ideas, or statements in the form of words in writing or orally.

The results of previous research by Handayani showed that overall the mathematical representation ability of students only got 47%, which can be categorized as very low [8]. As Mulyaningsih said, not all students are able to meet the indicators for achieving mathematical representation abilities [9]. According to Inayah and Dasari, the mathematical representation ability that is least mastered by students is pictorial representation [5]. It is related to the results of observations made by researchers in Class XI.11 of SMA Negeri 7 Cirebon City that students still have difficulty converting information into images. Apart from that, based on the results of interviews, students still have difficulty expressing information in the form of mathematical symbols or mathematical modeling.

Students' difficulty in representing these mathematical concepts is when solving contextual problems in circle material, especially related to the concept of inner circles and outer circles of triangles. The reason researchers use contextual mathematics problems is with the aim of providing students with a more meaningful learning experience, because the questions they solve are directly related to their daily lives. As Siregar, et al argue, with everyday mathematics problems students can answer questions in a way that relates directly to real life so that mathematics learning becomes more meaningful [10]. However, in reality students still experience confusion or difficulty in representing these contextual problems. This condition is a concern and the main basis for researchers to conduct this research.

The difficulty of students in representing mathematical concepts is because the mathematical representation abilities of each student are different [11]. One of the factors that influences mathematical representation abilities is students' mathematical communication. Mathematical communication skills are the ability that students have to express their ideas or thoughts into mathematical ideas and symbols [12]. The reason mathematical communication skills are one of the factors that influence students' mathematical representation abilities is because these two abilities are interconnected in helping solve mathematical problems. Based on the results of research conducted by Tiara regarding "The Relationship between Mathematical Communication Skills and Mathematical Representation" shows that there is a direct relationship between mathematical communication skills and mathematical representation with a p-value of 0.000 [13].

The urgency of mathematical communication skills in the representation of mathematical concepts is to help students express understanding of mathematical concepts and processes, express ideas, and clarify understanding so that it is easier for them to solve mathematical problems [12]. According to Dewi and Nuraeni, indicators of mathematical communication skills are divided into four forms which researchers summarized into 3 indicators because they avoid duplication and make it easier for researchers to know students' ability. The indicators are 1) Expressing a situation, picture, diagram in symbolic language or mathematical modeling; 2) Explain mathematical ideas in writing or orally; and 3) Expressing mathematical information back into one's own language [14]. Students are said to have mathematical communication skills if they are able to express a mathematical problem into images, ideas, symbols and everyday language [12].

Based on the description above, this research focuses on activities to analyze students' mathematical representation abilities based on mathematical communication abilities. The focus of discussion in previous studies only focuses on looking at the influence and relationship of these two abilities. There has been no discussion regarding the analysis of students' mathematical representation abilities in solving contextual problems based on mathematical communication abilities. Therefore, this study seeks to fill the gap by examining more deeply the relationship between mathematical representation and mathematical communication, especially in the material of the inner circle and outer circle of a triangle.

II. METHOD

This research is a type of descriptive research with a qualitative approach. This research was carried out in class XI.11 of SMA Negeri 7 Cirebon City. The research subjects were selected based on the purposive sampling technique by distributing questionnaires related to the mathematical communication skills of students selected with certain criteria, such as knowledge, activeness, and the highest score. The results of the analysis are categorized into three criteria, namely high, medium, and low mathematical communication skills. To find out these criteria, the researcher analyze by doing calculations based on the following formula [15]:

$$P = \frac{F}{N} \times 100$$

Description:
$P =$ The value obtained by students
$F =$ The total score obtained by students
$N =$ Maximum score

To determine the level of students' mathematical communication skills, the researcher used high, medium, and low scales using the following criteria [16]:

TABLE II. MATHEMATICAL COMMUNICATION ABILITY SCORE CRITERIA

Criteria	Description
$P \leq 50{,}10$	Low
$50{,}10 < P < 72{,}82$	Middle
$P \geq 72{,}82$	High

Data collection techniques are in the form of questionnaires, written tests, observations, interviews, documentation, and literature studies. Then the data credibility test was carried out using a triangulation technique consisting of triangulation techniques and time. Triangulation techniques used by the researcher are written test techniques and interviews on the solution of LKPD contextual problems of circle material (inner circle and outer circle of triangle). Meanwhile, time triangulation, which is the time for research on students' mathematical representation skills, is carried out at different times when carrying out the process of working on questions, interviews, and distributing questionnaires.

After the data is collected, data analysis is carried out in several stages, namely data reduction, data presentation, and conclusion drawn. Data reduction in this study was carried out by taking data related to the study of students' mathematical representation ability in solving contextual problems of circle material (inner circle and outer circle of triangle). Less relevant data will be reduced and separated with appropriate data. The presentation of data was carried out by describing the results of the mathematical representation ability of the research subjects. Meanwhile, the conclusion drawn in this study explains how the description or description of students' mathematical representation skills for each criterion of high, medium, and low mathematical communication skills.

III. RESULTS AND DISCUSSION

Result

This study involved 36 students in class XI.11 of SMA Negeri 7 Cirebon City. Based on the purposive sampling technique, the researcher obtained as many as 9 students with high mathematical communication skills, 19 students with medium ability, and 8 students with low ability. The details of the research subject can be shown in Table III below.

TABLE III. RESEARCH SUBJECT

No	Names	Mathematical Communication Ability Score	Criteria
1	FMI	77,08	High
2	MYW	81,25	High
3	SDA	83,33	High
4	SZE	76,04	High
5	SR	78,13	High
6	FN	85,42	High
7	LA	76,04	High
8	ZIS	77,08	High
9	S	72,92	High
10	AS	62,50	Middle
11	MR	60,42	Middle
12	RZ	54,17	Middle
13	NDAM	58,33	Middle
14	SF	58,33	Middle
15	MRH	59,38	Middle
16	ASP	51,04	Middle
17	CMI	66,67	Middle
18	DOA	54,17	Middle
19	KS	64,58	Middle
20	MAM	59,38	Middle
21	NAB	53,13	Middle
22	CHAD	66,67	Middle
23	EMAZ	70,83	Middle
24	IFA	67,71	Middle
25	IFS	68,75	Middle
26	RBDA	69,79	Middle
27	SUN	66,67	Middle
28	SRA	70,83	Middle
29	AM	48,96	Low
30	AC	38,54	Low
31	ATAF	47,92	Low
32	ARM	38,54	Low
33	FR	43,75	Low
34	HMR	44,79	Low
35	HPP	41,67	Low
36	NA	40,63	Low

Based on Table III, the following is a description of the analysis of students' mathematical representation skills from each criterion of mathematical communication skills in solving contextual problems of circle materials (inner circle and outer circle of triangles).

1. Mathematical Representation Ability of Mathematical Communication Research Subjects High Criteria (SH)

Based on the mathematical representation ability test, it is known that students with high criteria (SH) mathematical communication skills in symbolic representation are able to express information well in the form of numbers or symbols. Students can also solve contextual problems well. This can be shown in Figure I below.

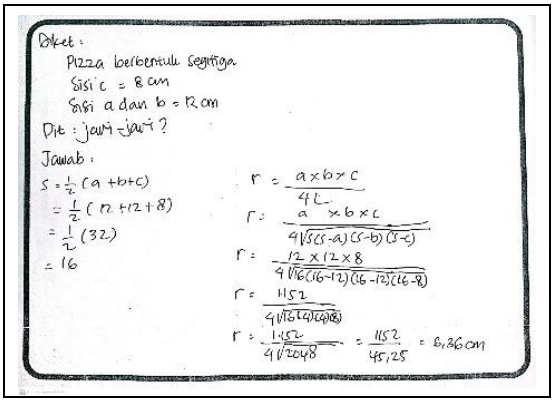


Figure I. Symbolic Representation Answer SH

In visual representation, SH has been able to express information on the question quite well in the form of pictures. In visualizing information, SH has been able to describe according to the problem in question, but SH has not been able to draw appropriate or realistic information according to known lengths such as side length c = 8 cm, and side length a = b = 12 cm. In addition, SH has also not shown the image of the fingers asked in the question into the picture. This can be shown in Figure II below.

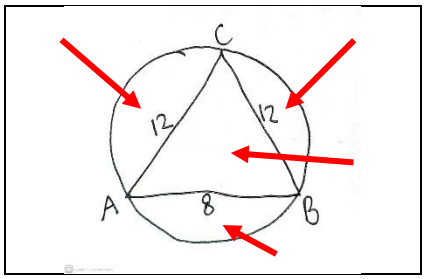


Figure II. Visual Representation Answer SH

Finally, at the verbal representation stage, SH is able to express ideas or thoughts well in written words. SH has been able to explain the concepts well in the problems being solved. Apart from that, SH has also provided good and appropriate conclusions. This can be shown in Figure III below.

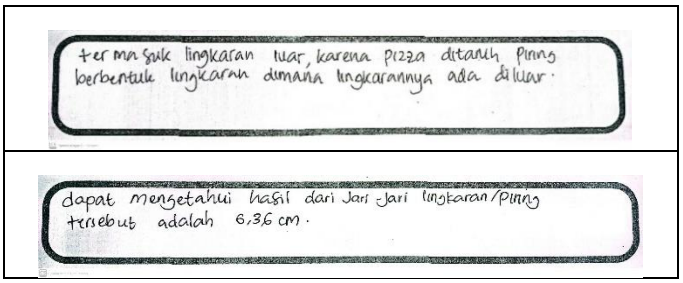


Figure III. Verbal Representation Answer SH

2. Mathematical Representation Ability of Mathematical Communication Research Subjects Middle Criteria (SM)

Based on the mathematical representation ability test, it is known that students with middle criteria (SM) mathematical communication skills in symbolic representation are able to express information well in the form of numbers or symbols. Students can also solve contextual problems well. This can be shown in Figure IV below.

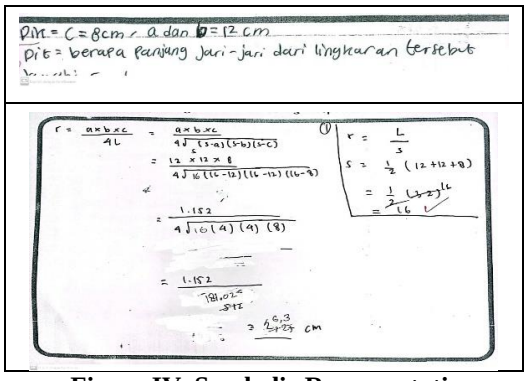


Figure IV. Symbolic Representation Answer SM

In visual representation, SM was able to express the information in the questions quite well in the form of images. In visualizing the information, SM has been able to describe it according to the problem in the question, but SM has not paid attention to the known side lengths and there is still a lack of writing in writing the side lengths. Apart from that, SM also hasn't shown a picture of the fingers asked about in the question. This can be shown in Figure V below.

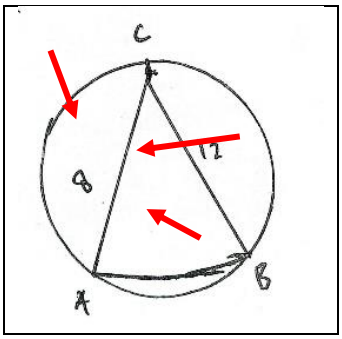


Figure V. Visual Representation Answer SM

Finally, at the verbal representation stage, SM was quite good at expressing ideas or suggestions in written form. SM was able to explain the concept of the problem being solved quite well. However, SM has not explained the reasons for the concepts mentioned in the problems being resolved. Then SM has provided a good and appropriate conclusion. This can be shown in Figure VI below.

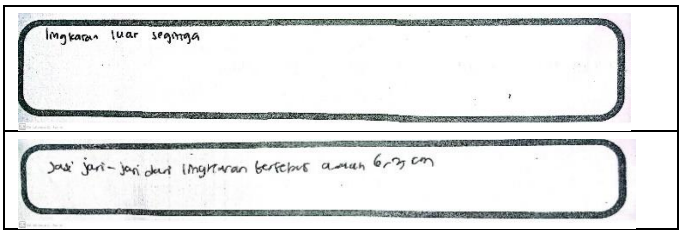
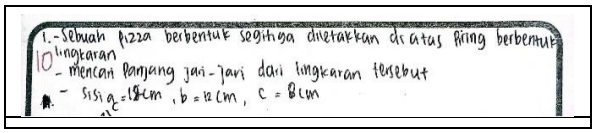


FIGURE VI. VERBAL REPRESENTATION ANSWER SM

3. Mathematical Representation Ability of Mathematical Communication Research Subjects Low Criteria (SL)

qBased on the mathematical representation ability test, it is known that students with low criteria (SL) mathematical communication skills in symbolic representation are able to express information quite well in the form of numbers or symbols. However, students are not yet able to solve contextual problems well, because there are still deficiencies in writing the formulas used. This can be shown in Figure VII below.



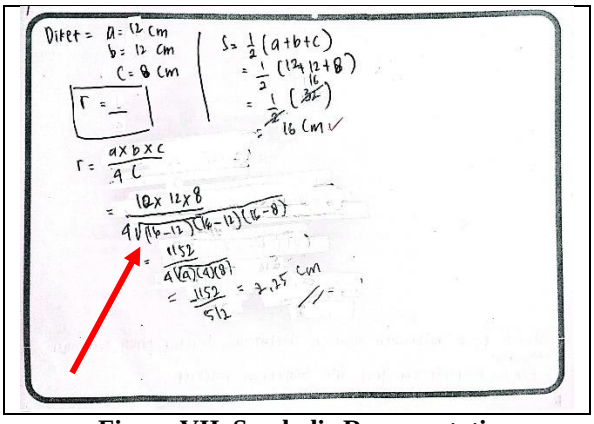


Figure VII. Symbolic Representation Answer SL

In visual representation, SL is able to express the information in the questions in the form of images. However, in visualizing the information, SL was not able to describe it according to the problem in the question. SL is not yet capable enough to understand the information on the problem given, so the form of the visualized image is not appropriate. This can be shown in Figure VIII below.

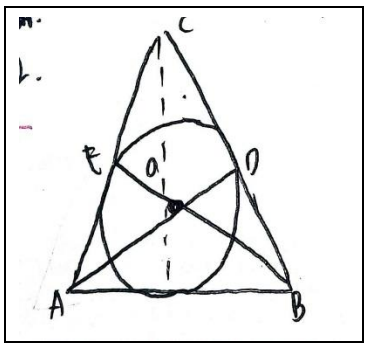


Figure VIII. Visual Representation Answer SL

Finally, at the verbal representation stage, SL is able to express ideas or ideas in written form. However, SL has not been able to explain the concepts related to the problems being solved. Apart from that, SL is able to provide very complex conclusions, but it is not yet in accordance with the correct calculation results. This can be shown in Figure IX below.

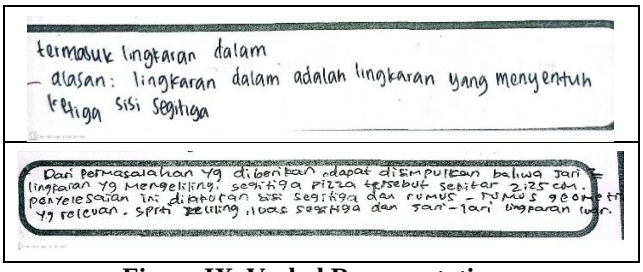


Figure IX. Verbal Representation Answers SL

Based on the results of the analysis above, researchers can explain the differences in students' mathematical representation abilities in solving contextual problems with circle material (inner circle and outer circle of triangle) based on mathematical communication abilities with high, medium and low criteria as follows:

TABLE IV. DIFFERENTIATION OF STUDENTS ABILITY

Mathematics Representation Ability	Communication Mathematics Ability		
	High	Middle	Low
Symbolic Representation	MB	MB	CMB
Visual Representation	CMB	CMB	CM
Verbal Representation	MB	CMB	CM

Description: *MB states that the subject is quite capable of the indicator, CMB states that the subject is quite capable of the indicator even though there are notes such as errors or deficiencies, and CM states that the subject is quite capable of the indicator even though there are notes such as errors or deficiencies.*

Discussion

The mathematical representation abilities of research subjects who have high mathematical communication skills are already good at symbolic representation indicators. Students are able to express ideas or thoughts from information into the form of mathematical modeling and can solve the problems given well. It is related to the research conducted of Harman, et al that students with high mathematical communication skills are able to analyze calculations to get correct results [17]. In the visual representation indicator, students are quite capable of representing information in the form of images because there are still errors or deficiencies. It is related to the research of Ginoga, et al's research that students are able to explain ideas or solutions to mathematical problems in the form of images [18]. Then in the verbal representation indicator, students are able to express ideas well in written form. It is related to the research conducted of Harman, et al that students are able to plan the steps that will be used to find solutions to mathematical problems and their reasons well [17]. It is related to the research of Ginoga, et al.'s research that students are able to explain ideas or solutions using their own language [18].

Based on observations, several factors that influence this are understanding concepts, self-confidence, high motivation, and the ability to find creative ideas that are relevant to the problems faced. A deep understanding of concepts will make someone have the ability to explain ideas or solutions to a problem or image using their own language. Self-confidence provides encouragement to dare to make appropriate ideas or ideas. Meanwhile, high motivation encourages someone to continue to identify what is known, ask questions and explain how to find answers. Apart from that, the ability to find creative ideas is an important factor in finding ideas or solutions to mathematical problems in the form of images, expressing problems or everyday events in mathematical model language and being able to draw conclusions from a mathematical problem. These factors not only facilitate the process of exploring information, but also help in expressing ideas clearly. The information that has been created is then represented in visual form. It is related to the research conducted by Mariana and Mulyani which stated that people who have high self-efficacy in mathematics tend to try

hard to solve mathematics problems. When solving problems in the form of patterns, symbols, images and numbers, their mathematical communication skills are very good [19]. Rangkuti also stated that if students have high mathematical communication skills, then students tend to be able to create a variety of diverse representations so that they can find alternative solutions to various mathematical problems [20].

The mathematical representation abilities of research subjects who have middle mathematical communication skills are already good at symbolic representation indicators. Students are able to express ideas or thoughts from information into the form of mathematical modeling and can solve the problems given well. It is related to the research conducted by Harman, et al. that students with middle mathematical communication skills are able to analyze calculations to get correct results [17]. In the visual representation indicator, students are quite capable of representing information in the form of images because there are still errors or deficiencies. It is related to the research of Ginoga, et al. that students are able to explain ideas or solutions to mathematical problems in the form of images, even though they have difficulty in representing them [18]. Then in the verbal representation indicator, students are quite capable even though there are still errors or deficiencies in explaining the reasons for the concepts in the problems being solved. It is related to the research of Harman, et al that students are not yet capable enough to plan the steps that will be used to find solutions to mathematical problems and their reasons [17].

Based on observations, the factors that influence this are the skills and self-confidence of students, where students are less skilled and confident in developing their mathematical ideas, so that students are not yet fully able to represent information into visual representations and verbal representations. It is related to the research conducted by Kurniati, et al which shows that internal factors, such as skills and self-confidence, influence students' representation abilities. This research found that students still made mistakes in presenting the information contained in the questions [21].

The mathematical representation abilities of research subjects who have low mathematical communication skills are quite good because there are still errors or deficiencies in solving problems, but they are able to write information on contextual problems into symbols or mathematical modeling. It is related to the research of Harman, et al. that students with low mathematical communication skills are less able to mention the information contained in the problem but are unable to complete the calculations to get the correct results [17]. In the visual representation indicator, students are quite capable of representing information in images, although there are still errors or deficiencies. It is related to the research of Mulyaningsih, et al.'s research that students have not been able to create a picture or graph correctly to solve the problem given according to what is instructed in the question [9]. Then in the verbal representation indicator, students are quite capable even though there are still errors in explaining the concepts related to the problems being solved. It is related to the research of Nurtiana, et al which shows that students do not write down information based on the results of their conceptual understanding of the story questions given [22].

Based on observations, the factor that influences this is lack of self-confidence in learning mathematics. Students with low mathematical communication often feel afraid of making mistakes when explaining or conveying their mathematical ideas. This causes obstacles to exploration and expression through various forms of representation, namely verbal, visual and symbolic. It is related to the research conducted by Nurmala, et al which shows that students with mathematical representation abilities and low self-confidence tend to have a negative attitude towards learning mathematics. Most of them do not like mathematics lessons and are not confident in the learning process. One of the main characteristics is the fear of asking or answering questions asked by the teacher. Apart from that, students consider mathematics lessons to be uninteresting, difficult, monotonous, and there are too many formulas that have to be memorized. This makes students reluctant to participate in discussions or use various forms of representation to understand concepts so that their mathematical communication skills do not develop, which ultimately affects their overall mathematical representation abilities [23].

IV. CONCLUSIONS

Based on the results and discussion that have been presented, it can be concluded that: 1) the mathematical representation abilities of students with high mathematical communication skills are good at symbolic representation and verbal representation. Then in visual representation, students are quite capable because there are still errors or deficiencies in visualizing information; 2) the mathematical representation abilities of students with middle mathematical communication skills are good at symbolic representation. Then the visual representation and verbal representation are quite good because there are still deficiencies in visualizing information and expressing ideas or concepts regarding the reasons for material concepts in contextual problems; and 3) the mathematical representation ability of students with low mathematical communication skills is quite good at symbolic representation because there are still deficiencies in writing down the formulas used. Then the visual and verbal representations are quite capable because there are still errors in explaining ideas or thoughts from information on contextual problems.

The implications of the above findings indicate that improving mathematical communication abilities can contribute to strengthening students' mathematical representations, especially in visual and verbal aspects. Therefore, in learning mathematics, it is necessary to develop learning strategies that emphasize the integration of mathematical communication and representation. This study has several limitations, including the limited number of samples and the scope of material that only focuses on the inner circle and outer circle of a triangle. Future research could expand the material coverage and explore more effective learning approaches to improve both abilities simultaneously.

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