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Mathematical Representation of MTs Students in HOTS-based Mathematical Problem Solving

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ABSTRACT

This research is a descriptive qualitative research that aims to describe students' mathematical representations in solving HOTS-based mathematical problems. This research was conducted at MTs Putri Al-Huda, Malang City. The subjects of this study were 2 grade VIII students selected based on high and medium abilities. Written tests and interview guidelines were the instruments in this study. The data analysis technique in this study used the Miles and Huberman method, namely data reduction, data presentation, and conclusion. The research results show that high-ability subjects produced verbal mathematical representations at the stage of understanding the problem and checking again, generate symbolic representations at the planning stages, implementing the plan, and checking again. Meanwhile, subjects with medium abilities produced verbal representations at the stage of understanding the problem, symbolic representations at the stage of making and implementing plans. Subjects with medium abilities did not produce any representations at the stage of checking again.

Keywords: HOTS; problem-solving; representation

INTRODUCTION

One of the goals of learning mathematics is problem-solving (Agustiningtyas, 2024; Badi'ah et al., 2024; Hadi & Radiyatul, 2014). Problem-solving is a person's ability to develop strategies to solve a problem (Özsoy et al., 2015; Parlina et al., 2021; Septian & Maghfirah, 2021). Someone with good problem-solving skills can achieve all goals better (Akhter et al., 2015). Steps for solving problems, according to Polya (1973) include understanding the problem, devising the plan, carrying out a plan, and looking back. Students' mathematical problem-solving can be trained through Higher-Order Thinking Skills (HOTS) questions (Widhiyani et al., 2019). In line with Agustiningtyas (2024), HOTS training is part of the basic skills that must be instilled in students at all levels of education. Solving mathematical problems, which are categorized as HOTS, is an essential aspect of mathematics learning (Liljedahl, et al. 2016). HOTS is an activity that involves high-level thinking based on Bloom's taxonomy of thinking (Sukla & Dungsungneon, 2016). Furthermore, HOTS is the ability to think at a higher level and analyze, evaluate, think critically, creatively, and solve problems (Kuhn et al., 2000; Zohar & Dori, 2003).

Things to pay attention to when solving a problem in mathematics is how to write down the main idea of the problem (Septian & Rahayu, 2021; Setyaningsih & Firmansyah, 2022; Wasqita & Sukoriyanto, 2023). The main ideas in mathematics are usually in the form of words, symbols, graphs and images (Utami et al., 2019). A person's ideas or thoughts can be expressed in a form of representation (Nurfitriyanti et al., 2020). Representation is a

crucial ability that students must have because representation is the process of modeling something concrete in abstract concepts and symbols (Hwang et al., 2007). Students at all levels must have mathematical representation skills to mathematically model various phenomena according to their level (Sabirin, 2014). By using various representations, students can also develop and understand mathematical concepts more deeply (Maryati & Suryaningsih, 2021). Teachers can introduce the use of representations to understand and connect a concept (Nurrahmawati et al., 2019).

Mathematical representation is divided into internal and external representation (Goldin, 2020). Internal representations are images that are in a person's mind and are difficult to explain, while external representations can be communicated, such as pictures, sketches, equations and writing (Mainali, 2021). The external representations students use can be presented as verbal, visual, and symbolic representations (Bossé et al., 2011). Visual representation includes illustrating, showing, or working with ideas mathematics uses diagrams, pictures, number lines, and graphs. Verbal representation includes using language (words and phrases) to interpret, discuss, define or describe mathematical ideas. Symbol representation includes recording or working with mathematical ideas using numbers, variables, tables, and other symbols (Faradibba, 2015). Representation describes how much a student understands the situation faced or studied (Fatqurhohman et al., 2017). Students who frequently receive representation instruction show good abilities in solving mathematical problems (Flores et al., 2015). This is in line with research by Hwang, et al (2007) who state that representational abilities determine the mathematics ability students achieve.

One material that can give rise to representations when solving problems is the System of Linear Equations in Two Variables. Students experience many difficulties when expressing the problem using a mathematical model and applying problem-solving with the planned concepts (Pulungan & Suhendra, 2019). Several researchers have researched students' mathematical representations. Based on the research results of Setyawati et al (2022), mathematical representation is viewed from auditory, visual and kinesthetic learning styles that have different representations. Another study by Novitasari et al (2021) examined students' representational abilities in solving HOTS-based problems in sequential and random thinking styles. The results of the study show that students with each learning style have different representations.

Based on previous research, it can be seen that the mathematical representation of students that emerge is studied further, especially in the context of the Polya problem-solving stage in a more structured manner. Although there have been several studies that have examined mathematical representations, there have not been many studies that have specifically analyzed how students mathematical representations emerge and develop at each stage of Polya problem-solving when facing HOTS-based problems. It is also important to know the location of the difficulties or types of mistakes that students make when translating information from math problems into various forms of representation. Therefore, researchers need to conduct research that examines the mathematical representation of MTs students in HOTS-based problem-solving by paying attention to each stage of problem-solving according to Polya.

RESEARCH METHODS

This research is descriptive with a qualitative approach that aims to describe students' mathematical representations in solving HOTS-based mathematical problems. This research was carried out at MTs Putri Al-Huda, Malang City with 22 prospective subjects who were studying the material on the system of linear equations of two variables. The subject selection process was carried out using a purposive sampling method based on high and medium categories in solving problems. In addition, researchers also considered suggestions from teachers and student communication methods. The research instruments were written tests and interview guidelines. The test instruments in this research are:

1. Mia dan Vena memiliki beberapa baju, selisih dari banyak baju mereka adalah 6. Saat acara perpisahan di sekolah, Mia dan Vena masing-masing menyumbangkan 2 bajunya. Setelah menyumbangkan bajunya, jumlah baju mereka adalah 20. Jika baju Mia lebih banyak dari baju Vena, maka apakah dapat disimpulkan bahwa banyak baju Mia adalah 16 dan banyak baju Vena adalah 10? Jelaskan

Figure 1. Research Issues

Data collection techniques in this research used tests and interviews. This research uses indicators developed by Rangkuti and Nizar, (2014).

Table 1. Description of Mathematical Representation in Problem Solving

Problem Solving Stage	Representation	Description
Understand the problem	Visual	Represent data using diagrams, graphs, or tables
	Verbal	Determine what is known and asked using words or written text
Make a plan	Symbolic	Create mathematical equations or models from the given problem
	Verbal	Plan problem-solving strategies using words or written text
Implement the plan	Visual	Implement problem-solving strategies using diagrams, graphs, or tables
	Symbolic	Implement problem-solving strategies involving mathematical expressions
	Verbal	Implementing problem-solving strategies involving written text or words
Check again	Symbolic	Recheck the answers by involving mathematical expressions
	Verbal	Recheck the answers using words or written text
	Visual	Review answers using diagrams, graphs, or tables

Data analysis techniques use the Miles and Huberman methods of data reduction, data presentation, and inference.

RESULT AND DISCUSSION

Based on the test results, one student was selected from each of high and medium abilities: HAS (High-ability Subject) and MAS (Medium-ability Subject)

Mathematical Representation of High-Ability Students

The results of the written test for problems given to subjects with high abilities are presented in Figure 2.

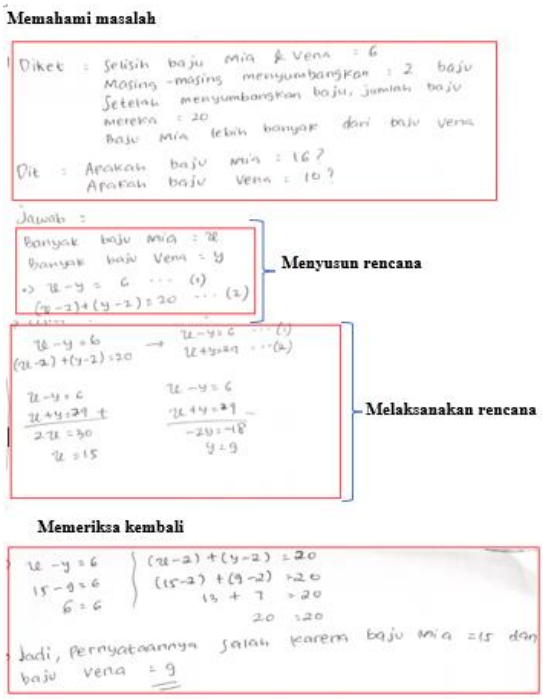

Figure 2. HAS Work Results

Based on Figure 2, HAS could understand problems by using verbal representation in the form of words, namely writing down the information he knew and asking in detail. Next, HAS draws up a plan using symbolic representation, namely, for example, x there are a many of Mia's clothes, and y there are a many of Vena's clothes. HAS created a mathematical model from this example by connecting the information to the problem. After that, HAS uses symbolic representation to carry out the solution plan, namely finding the values x, y, and carrying out calculations correctly. HAS chose the elimination method to solve the problem. When checking again, HAS uses symbolic and verbal representations. HAS shows the symbolic representation to enter values into the equation, while HAS shows the verbal representation to make appropriate conclusions.

Mathematical Representation of Medium-Ability Students

The results of the written test for problems given to subjects with moderate abilities are presented in Figure 3.

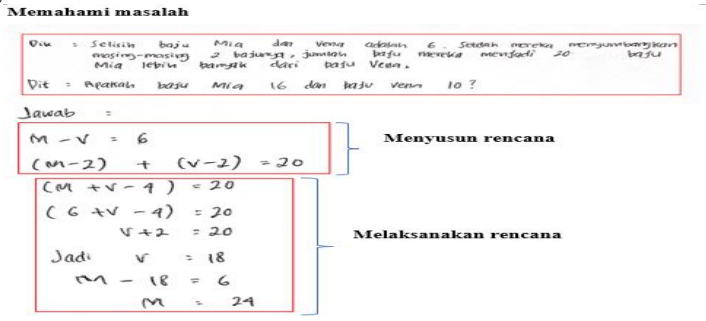

Figure 3. MAS Work Results

Based on Figure 3, MAS understands the problem by using verbal representation in words, namely, writing down the known information and asking about the problem. Next, MAS prepared a solution plan using symbolic representation, creating a mathematical model. The mathematical model created by MAS is based on the problem given so that MAS can carry out the solution plan. In carrying out the plan, MAS uses symbolic representation to find values M and V uses the substitution method. MAS substitutes M = 6 to the equation M + V - 4 = 20 becomes 6 + V – 4 = 20, should MAS substitute M = 6 + V and become 6 + V + V – 4 = 20. This error causes the final results obtained by MAS to be incorrect. MAS also did not recheck the results of the answers, so at the rechecking stage, MAS did not use any representation. The following is an excerpt from the interview with MAS :

P : What information is there on that question?
MAS : It is known that the difference between Mia and Vena's clothes is 6, after they donated two clothes each, their total number of clothes became 20. Mia's clothes are more than Vena's clothes.
P : So what was asked?
MAS : Can it be concluded that Mia's clothes are 16 and Vena's clothes are 10
P : OK, let's pay attention to your answer, M and V what do you consider this to be?
MAS : I assume that many of Mia's clothes are M and many of Vena's clothes are V
P : Why didn't you write this example in your answer?
MAS : I'm in a hurry
P : Then, why did you substitute it M = 6 into the equation M + V – 4 = 20
MAS : Yes, I got that from the difference between Mia and Vena's clothes, which is 6, (M – V = 6), I took out the M, M = 6 + V and substituted it into the equation M + V – 4 = 20. Oh yes, I just realized that my answer was wrong.

Based on the interview results, it can be concluded that MAS is like rereading questions to understand the problem. The mathematical examples and models created are based on the information in the issue. MAS just realized that the results he got needed to be corrected, this was because MAS did not recheck the answers before collecting them.

Based on the results presented, students have different mathematical representations in the high and medium categories in problem-solving. Students in the high category can produce verbal representations, namely writing down information that is known and asked about with words or written text. In line with research by Puspitasari & Susanah (2022), the ability of students to express verbal representations at the stage of understanding the problem. Thus, written results from high-ability students show that students can realize issues well. Students in the high category create symbolic representations, namely developing mathematical models of the problems given. Next, students can use mathematical models to solve problems. This is in line with the results of research by Lutfi & Khusna (2021), on symbolic representation, students involve mathematical expressions in solving issues, and research by Anwar & Rahmawati (2017) that symbolic representation is characterized by the use of mathematical symbols in solving problems. At the rechecking stage, high-ability students generate verbal and symbolic representations to write

conclusions from the answers given. Meanwhile, students in the medium category produce verbal representations, namely writing down the information they know and asking questions about the problem correctly.

Students in the medium category produce symbols representation indicators, creating mathematical models to solve problems correctly. After that, students use mathematical models to solve problems. However, students could have done better in the calculations, which caused the final results to be wrong. As per the research results of Lutfi & Khusna (2021), students in the medium group could solve questions with mathematical expressions. Still, they found calculation errors at the end of the answer. At the rechecking stage, students did not come up with any representations. Students who have moderate mathematical abilities skip the reflection stage (Vilianti et al., 2018).

CONCLUSION

Based on the results of the research and discussions carried out, the following conclusions can be obtained. High-ability students use verbal representations to understand problems, with writing down what is known and asked and rechecking answers using words or written text. High-ability students use symbolic representations to prepare and implement plans and review them, namely making examples and equations or mathematical models, implementing problem-solving strategies involving mathematical expressions, and writing conclusions correctly.

Meanwhile, students with moderate ability produce verbal representations when understanding problems, with determining what is known, and asking questions using written text. Symbol representation appears when preparing and implementing a plan, with creating and involving a mathematical model to implement a solution strategy. When determining the solution, students with moderate ability make mistakes in calculating, so the final answer result needs to be corrected. They should also have brought up representations when checking again.

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