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An analysis of primary school students' representational ability in mathematics based on gender perspective

Kowiyah[1] and I Mulyawati[1]

[1]Universitas Muhammadiyah Prof DR. HAMKA, Jakarta, Indonesia

E-mail: kowi_agil@yahoo.co.id

Abstract. Mathematic representation is one of the basic mathematic skills that allows students to communicate their mathematic ideas through visual realities such as pictures, tables, mathematic expressions and mathematic equities. The present research aims at: 1) analysing students' mathematic representation ability in solving mathematic problems and 2) examining the difference of students' mathematic ability based on their gender. A total of sixty primary school students participated in this study comprising of thirty males and thirty females. Data required in this study were collected through mathematic representation tests, interviews and test evaluation rubric. Findings of this study showed that students' mathematic representation of visual realities (image and tables) was reported higher at 62.3% than at in the form of description (or statement) at 8.6%. From gender perspective, male students performed better than the females at action planning stage. The percentage of males was reported at 68% (the highest), 33% (medium) and 21.3% (the lowest) while the females were at 36% (the highest), 37.7% (medium) and 32.6% (the lowest).

1. Introduction

In the process of doing mathematical problems, students can change an object into a verbal, symbolic, tabular, or graphical form in order for the process to contain information that can be used to solve the problems. Students rarely produce their own representations [1]. Students more often follow the steps their teacher use to solve problems. For example, to solve a mathematical problem, students need to write down what information is provided and what needs to be solved. This process requires mathematical representation.

Representation is defined differently by several experts. Fuad [2], for example, saw representation as a problem solver for students where a precise mathematical representation will ease students in solving problems. Hwang [3] viewed that students' ability in problem solving will be exceptional if they are able to manipulate verbal representations, picture representations (figures, graphs), and formal representations (sentences, equations, phrases). Meanwhile, Kartini [1] viewed representation as a combination of three components, which are symbols (writing), real objects, and mental pictures. According to Mustangin [4], the variety of representations that are most often used to convey mathematics are (1) visuals, such as tables, figures, graphs; (2) mathematical equations or notations and; (3) written text. According to Dahlan and Juandi [5], mathematical representations can be formulated from problems, such as visual mathematical representations in the form of figures and tables, mathematical expressions or equations, descriptions, or statements.

Fuad, Hwang, Mustangin, Dahlan and Juandi, and Kartini [2,3,4,5,1] pointed out that mathematical representations are related to problem solving. Those five studies interpreted representations as tools to present mathematical ideas. In this research, representation is defined as a method to communicate

mathematical ideas through visual means in the form of figures or tables, mathematical expressions, and equations.

NCTM [6] stated that representations formulated by students while solving problems and delving into mathematical ideas play an important role in helping students understand, solve problems, and provide a meaningful way to outline other methods. For students, mathematical representations are important not only for studying conventional representations, but also for building and using their own representations for studying mathematics [7]. However, in reality, the ability of students in presenting mathematics is still considered low. A study conducted by Purnomo, Kowiyah, Aliyani, and Assiti [8] shows that students' mathematical representation skill towards the value of 1.25% is still low. This shows that students experience misconceptions with the presentation of numbers.

Mathematical representation abilities between male and female students in answering problems are different to each other. Male students are more dominant in spatial abilities, while females are more dominant in logical reasoning [9]. This is in line with the research by Mairing, Budayasa, and Juniati [10] who expressed the difference in problem solving schemes used by male and female students. There are several studies (for example, Fryer & Levitt, [11]) that showed that male and female students are not different when entering school at kindergarten level where they have equal abilities in mathematics and reading. However, by the end of fifth grade, it is shown that females have a standard deviation of 0.2 higher than males. Other than that, females also have a way of thinking and a way of receiving information that is different from males.

Several studies had been done regarding the difference in problem solving between males and females. For example, studies were done by Fuad, Asis et al, and Mairing et al [2,9,10]. These studies tend to describe differences in mathematical achievement between male and female students. Fuad [2] described in detail the mathematical representation used by high school students in solving problems viewed by differences in gender. However, there are still only a few studies that describe primary school students' mathematical representations in problem solving based on gender. Other than that, this research also discusses mathematical representations towards problem solving among high-, middle-, and low- ability male and female students.

This research was done by primary school students in number sense. Number sense is a part of primary school curriculum that is tied to everyday life. Several studies that had been done showed that student mathematical representation skills are low. In a research conducted by Fuad [2] where a problem was given to several individuals, several responses with different ways of problem solving were observed. This is caused by the difference in students' representation abilities while solving the problem. Other than that, student mastery of numbers is also considered low [12]. This is similar to a study conducted by Japa [13] that indicates the lack of problem solving skills among primary school students.

2. Methods

This research used mixed methods by using quantitative and qualitative methods to determine whether a single understanding would emerge from the problem being researched.

2.1. The Participants

The subjects of this research were fifth graders at an Integrated Islamic Elementary School in East Jakarta consisting 30 male and 30 female students. The school has their classes divided, separating the male and female students.

2.2. Data Collection

2.2.1. Instruments. The data collection technique was done using problem solving ability tests, assessment rubric, interviews, and documentation. During the initial stage, a problem solving ability test was given to the male and female students of the school. Mathematical representations generally are made up of three representations which are visuals in the form of figures or tables, mathematical expressions or equations, and descriptions or statements. Indicator representation visual in form of figure

and table is present data or information from a representation in the form of a table, diagram, graph, etc.; a variety of visual representations; elaborate a geometrical pattern figure; draw from a geometrical figure. Indicator mathematical expression or equations is find the relation in a mathematical pattern; formulate an equation from a different representation; formulate a conjecture from the pattern found; solve a problem with a mathematical equation. Indicator descriptions or statements is state everyday problems into words or written text; write the solution to a problem through written sentences.

2.2.2. Procedure. The main procedure of this research was to administer a problem solving ability test to fifth-grade students at the Integrated Islamic Elementary School, East Jakarta in order to measure their problem solving abilities. The steps undergone in this research were as follow: (1) Provided a problem solving ability representation test that was adapted from Polya's approach; (2) Analyzed and converted the result of problem solving ability tests into three categories which are 27% for the high-ability group, 27% for the low-ability group, and the other percentage goes to the middle-ability group; (3) Determined the subject for the interview by grouping the students into groups with high, middle, and low- problem solving abilities; (4) Conducted thorough interviews to generalize the problem solving abilities of the students. The interview involved 8 male and 8 female students that represented 3 students from the high-ability group, 3 from the middle-ability group, and 2 from the low-ability group. The subjects were interviewed regarding the results of their work; (5) Analyzed students' answers and interview results to draw a conclusion.

3. Results and Discussion

The result of individual analysis of the mathematical representation indicator on problem solving based on gender is shown in Table 1 below.

Table 1. Percentage of the Respondents' Correct Answer on Mathematical Representation

Representation	Percentage	Males	Females
Visuals in the form of - Figures - Tables	62.3%	69.17%	55.35%
Mathematical expressions or equations	22.3%	22.57%	22.08%
Descriptions or statements	8.6%	10.56%	6.67%

Table 1 above shows that the highest representation aspect is visual in the form of figures and tables (62.3%). The lowest representation aspect is descriptions or statements (8.6%). Regarding representations that are constructed by the students, the result of the analysis of students' answers shows that the ability to visually represent figures and tables is higher than other representations. This is in line with the research by Van Ganderen [14] that visual representations are more often used by students for solving problems.

Table 2. Percentage of Respondents' Correct Answer on Mathematical Representation Towards Solving Mathematical Problems

Mathematical Representation	Problem Solving Aspect	Males			Females		
		High	Middle	Low	High	Middle	Low
Visuals in the form of figures and tables	Understanding problems	84%	70%	58%	78%	72%	55%
	Problem solving planning	96%	78%	61%	78%	60%	46%
	Solving the problem	86%	67%	57%	76%	50%	40%
	Checking answers	74%	46%	33%	64%	28%	13%
Mathematical exploration/ mathematical equation	Understanding problems	56%	24%	5%	30%	30%	21%
	Problem solving planning	66%	15%	3%	38%	25%	10%
	Solving the problem	56%	13%	1%	35%	23%	10%
	Checking answers	44%	7%	0%	24%	10%	0%
Description or Statements	Understanding problems	28%	7%	0%	0%	11%	22%
	Problem solving planning	42%	7%	0%	0%	10%	9%
	Solving the problem	24%	3%	0%	0%	9%	9%
	Checking answers	28%	4%	0%	0%	0%	0%

From the table above we can observe that visual representations in the form of figures and tables are higher among males than females. The highest mathematical representation on problem solving for males is the aspect of problem solving planning, which is 68% in the high-ability group, 33% in the middle-ability group, and 21.3% in the low-ability group. Meanwhile, the highest mathematical representation on problem solving for females is the aspect of understanding problems, which is 36% in the high-ability group, 37.7% in the middle-ability group, and 32,6% in the low ability group. The findings of this study confirm the study by Fuad (2016) that males are able to do mathematical representations well and are able to correctly answer the questions. The visual representation aspect in the form of figures and tables for the indicator of representing data or information into a table, diagram, or graphical form for male and female students at the high-ability groups are shown in Figure 1 and Figure 2 below.

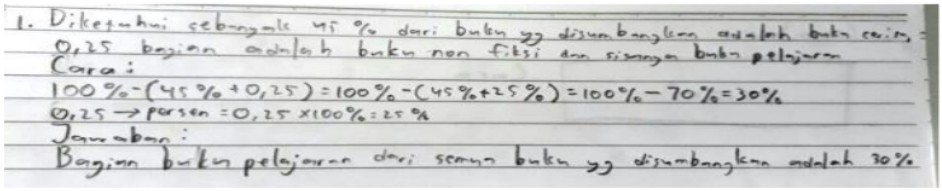


Figure 1. The Work of a High-ability Male Student

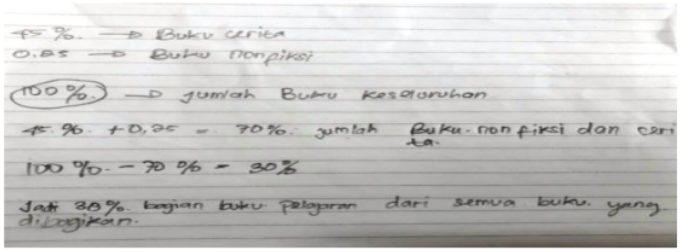


Figure 2. The Work of a High-ability Female Student

During the process of understanding the question, the male student of the high-ability group wrote down what was known, which was that 45% of books donated were story books, 0.25 of that were non-fiction books, and the rest were school books. Meanwhile, the female student also wrote down what was known, but did not write down what was being asked the question. During the interview, the students expressed what was known and were being asked the question. The representation formulated by both male and female students were in the form of words, or written text.

While planning to solve the problem, the male student changed the decimal form into a percentage form, in this case, the non-fiction books, which was written as 0.25, was changed to 25%. Other than that, during the interview, the male student stated that the total number of books donated was 100%, while the female student wrote down that the total number of books donated was 100%. This meant that the male student used a verbal representation, while the female student used a written representation.

When solving the problem, the male student directly counted that the number of school books was 100% subtracted by 45% and 0.25. The male student interpreted the result as "the number of school books out of the total number of books donated is 30%". The female student counted that the number of non-fiction and school books was 70% and used subtraction to count the school book as 100% - 70% equalling 30%. The representation formulated by both the male and female student was by using written words in the form of symbol manipulation. This is in line with the research by Fuad (2016) where during the problem solving stage, male students used verbal words, while female students used written words as representations.

For the checking the answers stage, it was observed that the male and female student did not re-check their answers and therefore no representation was used. This is different from the research by Fuad (2016). In Fuad's (2016) research, it was found that while the male students did not check their answers, the female students checked their answers through verbal words.

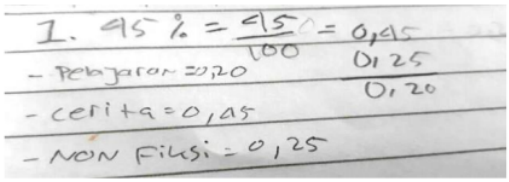


Figure 3. The Work of a Middle Class Male Student

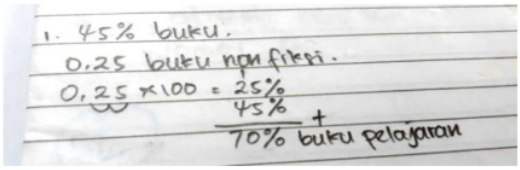


Figure 4. The Work of a Middle Class Female Student

While understanding the problem, both the male and female student did not completely write down what was known and what was asked the question. During the interview process, the students described what they know from the question. The male student wrote down 0.45 story books and 0.25 non-fiction books without writing down what was being asked the question. Meanwhile, the female student wrote down 45% books and 0.25 non-fiction books without writing down what was being asked the question. The representation used by both the male and female student was in the form of words and the representation was not perfectly written down.

In the problem solving planning stage, the male student changed the percentage form into a decimal form, or from 45% books to 0.25. Other than that, during the interview, the student stated that the total number of school books is 0.45 subtracted by 0.25. At the same time, the female student changed the decimal form into a percentage, or from 0.25 to 25%. During the interview, the students stated that to count the number of school books, they need to add up the number of story books and non-fiction books. This mistake in planning will have an influence on the outcome of the problem. This mistake on the hand of the students was caused by the student not knowing that the total number of books donated was 100%. This showed that both the male and female student used a verbal representation.

During the problem solving stage, the male student right away counted the number of leftover school books as 0.45 subtracted by 0.25. The male student did not interpret the result of the problem by writing down "the acquired result". The female student calculated that the number of school books was 70%, acquired from adding the number of non-fiction books (25%) and story books (45%). This mistake in answering was caused by the students not understanding the problem well. The representation formulated by the male and female students were in the form of text without writing down the acquired result so that the representation is not complete.

During the checking the answer stage, both male and female students did not check their answers so that no representation was done.

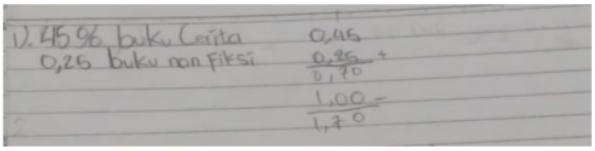
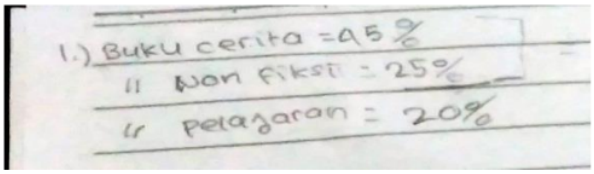


Figure 5. The Work of a Low Class Male Student



FIigure 6. The Work of a Low Class female Student

During the process of understanding the problem, the male and female student of the low-ability group only wrote down what was known from the problem without stating what was asked. The representation that was formulated by both the male and female student was in the form of incomplete writing.

While planning to solve the problem, both the male and female student did not formulate a strategy to complete the problem. During this stage, the students tend to directly attempt to solve the problem. Neither the male or female student did a representation.

During the problem solving stage, neither the male or female student was able to finish the problem as there were some students that did not realize that the total number of books donated by the donator was 100%. As a result, there were still students who counted wrongly by counting the number of school

books as the number of story books subtracted by the number of non-fiction books. Other mistakes were when the students counted the number of school books by adding the total of story books and non-fiction books. They did not know that the correct way of calculating the number of school books is by calculating 100% - (the number of story books added by the number of non-fiction books). The main cause of all this was that the students were not able to understand the problem well.

During the stage of checking the answer, neither the male or female student checked their answer. Therefore, there was no representation done during this stage.

4. Conclusion

The highest representation aspect was done visually in the form of figures and tables as much as 62.3%. The lowest representation aspect was through descriptions or statements as little as 8.6%. The mathematical representation of problem solving towards male students is the highest during problem solving planning, which is, consecutively, 68%, 33%, and 21.3% at the high-, middle-, and low-ability group. Meanwhile, mathematical representation on problem solving towards female students is the highest at the understanding the problem stage, which is, consecutively, 36%, 37.7%, and 32.6% at the high-, middle-, and low-ability group.

Representations of problem solving during the (1) understanding the problem solving stage show that both male and female students in the high-ability group described what they knew and what was being asked by the question, and the representation formulated was in the form of words, or written text. Meanwhile, male and female students in the middle-ability group did not fully write what was known and what was being asked from the question and formulated their representation in the form of words. On the other hand, male and female students in the low-ability group only wrote down what was known from the problem, but not what was being asked. The representation formulated by the male and female students was in the form of incomplete written texts; (2) during the problem solving planning stage, the representation formulated by high-ability male students was in the form of verbal words, while the representation of female students was in the form of written words. In the middle-ability group, the representation of both male and female students was in the form of verbal words. In the low-ability group, both male and female students did not formulate a representation; (3) During the problem solving stage, the representation made by male and female students of the high-ability group was by words or written text in the form of manipulated symbols. In the middle-ability group, the representation formulated by the male and female students were written texts that did not include the final result and therefore the representation process was incomplete. In the low-ability group, many errors occurred due to the lack of understanding of the question; (4) for the stage of checking the answer, none of the high, middle, or low-ability students checked their final answer.

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