THE ABILITY OF MATHEMATICAL REPRESENTATION ON JUNIOR HIGH SCHOOL STUDENTS IN RECTANGULAR AND TRIANGLE BASED ON GENDER

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Abstract

The ability of representation mathematical is an ability to express or model the mathematical idea into other forms such as words, pictures, and symbols. A study on the ability of mathematics representation is required for the students; therefore, they can express their idea easily by interpreting their thought relating to mathematics problems. This research is a descriptive qualitative method which aimed to find out the description of student' ability of the mathematical representation on rectangular and triangle based on gender. The subjects of this research are 26 students of eight grades consisted of 11 female students and 15 male students. The technique of collecting data was done by using the test method and interview. The test instrument used is 6 essay tests. The data analysis technique is by analyzing the results of the test data. The research result showed that students' mathematical representation ability are categorized well enough. From the results of the data obtained, it can be concluded that the ability of mathematical representation for male students is evenly distributed because there are results for each category. As for the female students, the average has a high mathematical representation ability.

***Keyword**: Representation, ability of mathematics, gender, rectangular, triangle*

PENDAHULUAN

Mathematics is a science that deals with numbers, symbols, and formulas. Mathematics is a logical thought pattern in organizing ideas using terms represented by symbolic language (Suherman, 2001). Therefore, in learning mathematics there needs to be a skill that develops students that can easily convey ideas and mastery of those containing mathematical symbols, this ability is a representation.

According to NCTM, five basic abilities are provided as standards in the mathematics learning process, namely the ability to solve problems, the ability of reasoning and proof, communication skills, connection skills and the ability to represent (NCTM, 2000). Any of the mathematical capabilities that students need to master with the ability to represent. " Representations are useful tools that support mathematical reasoning, enable mathematical communication, and convey mathematical thought" (Kilpatrick, Swafford , & Findell , 2001). Representation is one of the key mathematical communication skills (Mudzakir, 2006).

Representations consist of writing, mathematical symbols, diagrams and other visual displays (David, Tomaz , & Ferreira , 2014). More specific representation that representation is an abstract coding and presentation of information in the form of tables, formal notations, and diagrams (Cheng, 2016). Accordingly, representation is the ability to model mathematical thinking into other forms in mathematics such as pictures, numbers, symbols, algebra, tables, or graphs. Objects in mathematics are abstract so to study and understand abstract ideas requires further understanding. One branch of mathematics related to abstract ideas is Geometry. Geometry is one branch of mathematics that has more quantities than any other in a mathematics curriculum. The tendency to study geometry can improve problem-solving skills (Andini, Fitriana, & Budiyono , 2018). In line with this opinion, geometry is an environment for studying mathematical structures that present various approaches to solving problems such as images, diagrams, coordinate systems, vectors, and transformations (Andini, Fitriana, & Budiyono , 2018), ".... geometry is a basic skill to be mastered. It is important in architecture and design in engineering and various aspects of construction work ", geometry is the basic skill of an expert (Abdullah & Zakaria, 2013). It becomes very important for architecture and design in engineering workers and various aspects of the world of construction (Abdullah & Zakaria, 2013).

However, in learning geometry students are explained about definitions, theorems, assignments of problems and their proofs, they have no experience of finding geometrical relationships or finding other mathematics (Sariyasa, 2016). A study revealed that most teachers had difficulty in conveying several geometrical concepts (Sariyasa, 2016). In other studies, one of the problems in learning geometry is that students have a poor foundation in understanding mathematics, students cannot solve problems even when given an example (Adolphus, 2011). students are most inclined to pursue advanced geometry when equipped with a profound grasp of its concepts and the capacity to mentally picture geometric properties at the foundational level (Hardianti, Priatna, & Priatna , 2017) (Abu, Ali, & Hock, 2012). Correspondingly, based on the report of The Third International Mathematics and Science Study, it is known that the ability of Indonesian Middle School students in representing mathematical ideas or concepts in the material division of numbers, algebra, geometry, data representation, analysis, and opportunities is low (Mudzakir, 2006).

The van Hiele theory, pioneered by Dutch educators Pierre Marie van Hiele and Dina van Hiele-Geldof, is a learning theory that has been specifically advanced in the context of geometry education. Its positive impact on the cognitive processes involved in geometry thinking has already been recognized (Andini, Fitriana, & Budiyono , 2018). Van Hiele's theory suggests that individuals progress through five stages in the development of their thinking when learning geometry. The five stages/levels of development of Van Hiele thinking are level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), level 4 (rigor). The levels of geometrical thinking in Van Hiele's theory are hierarchical, sequential, and gradual from level 0 to rigor level.

Previous research that discussed about the implementation of van Hiele was research on the analysis of students' geometry skills in addressing geometry problems using van Hiele's cognitive levels, by concluding that students at the level of one visual skill could only determine the types of rectangular fields based on shapes; students at level two can convey the characteristics of the shape of the picture, and students at the tertiary level can articulate the connections among various categories of rectangles, considering their overarching characteristics (Nur'aini, 2014).

Van Hiele's theory of levels of geometric thinking posits that the five levels are sequential and hierarchical (Yıldız, Aydın, & Köğce, 2009). In the initial stage (Visualization), students acquire a foundational understanding of geometry through visualization. During this phase, a child can distinguish a rectangle from a square based on their shapes. At this level, students identify and manipulate shapes (such as squares, triangles, etc.) and other geometric elements (e.g., lines, angles, grids, etc.) primarily relying on visual characteristics (Ma, Lee, & Lin, 2015). Moving on to the second level (Analysis), students develop the ability to recognize opposite sides and may become aware of concepts such as diagonals of rectangles and congruence, but they do not focus on understanding how rectangles connect to squares or triangles. Students examine visual characteristics, such as recognizing that "rectangles share the same diagonal" and "a rhombus has identical sides." Despite this analysis, they do not explicitly establish numerical connections through empirical reasoning and rely on a certain method to solve problems (Ma, Lee, & Lin, 2015). Upon reaching the third level (Informal Deduction), a student achieves an understanding of why every square qualifies as a rectangle. However, they may struggle to articulate the rationale behind congruent diagonals in rectangles, for instance (Sariyasa, 2016).

There are 5 basic skills in learning geometry, namely visual skills, drawing skills, verbal skills, logic skills, and applied skills (Armadan , Somakim, & Indaryanti , 2017). This means that all kinds of mathematical representation abilities are contained in geometry skills, which indirectly affect the ability to think geometry based on Van Hiele theory. With the level of student thinking it will be easier and more creative in solving mathematical problems about rectangles that are interpreted in the form of images, symbols, and words as an answer to the problem. The way to present students' answers will differ depending on the level of thinking of students themselves (Armadan , Somakim, & Indaryanti , 2017).

Gender is a gender that refers to the socio-cultural dimension of a person as male or female. The concept of gender is a trait inherent in men or women that is formed by social and cultural factors Santrock (Santrock , 2010). Gender is a social concept that is differentiated according to the position, function, and role of each in various fields of life and development (Handayani & Sugiarti, 2017). Related to the ability of geometry, each student has different abilities. Differences between men and women, one of which is in spatial and verbal abilities (Friedman & Schustack, 2008). Spatial ability is an abstract concept that includes the ability to observe object position relations in space, a frame of reference, projective relationships, distance conservation, spatial representation and mental rotation (Musdalifah, 2015). In addition to influencing geometry, gender differences also have an influence on the representation ability of students, because the presentation of the forms of representation of female and male students is very different, where men tend to be spatially while women are verbal, so it cannot be denied that there are differences in representing their ideas. Girls are generally superior in language and writing, while boys are superior in spatial areas (Kartini, 2009). Male is superior in mathematics compared to female. Generally, a male has better spatial abilities compared to females, while a female is superior in verbal abilities compared to males (Santrock , 2010).

From the explanation above, the researcher wants to research to describe the students' mathematical representation ability in solving geometry problems based on the achievement of van Hiele's theory of thinking in terms of gender differences in class VIII of SMP Negeri 2 Mojolaban. thinking in terms of gender differences in class VIII of SMP Negeri 2 Mojolaban.

METHOD

The method employed in this research is the descriptive method. In the descriptive method, descriptive statistics are used to process data obtained within the research process. Descriptive statistics are statistics about how to describe or decipher data to elaborate it (Siregar, 2010). The subjects of this study were the eighth-grade students of SMP Negeri 2 Mojolaban, totaling 26 students with 11 female students and 15 male students.

The method employed for gathering data involves the use of a written examination. The test used was a descriptive test that is a matter of 6 rectangular triangles. Data obtained from the test results are then assessed based on assessment criteria with the following steps.

1. Data obtained from test results are scored based on scoring criteria for students' mathematical representation abilities, then calculated using the formula (Armadan , Somakim, & Indaryanti , 2017) :

$$N_i = \frac{x_i}{s_i} \times 100$$

N_i : Value of student representation ability
x_i : Number of scores obtained by students
s_i : Maximum number of scores

2. To determine the category of student representation ability level in completing test questions. Student representation ability scores were converted into qualitative qualifications by taking into account the categorization guidelines in Table 1. (Kemendikbud, 2015)

Table 1. Categories of Mathematical Representation Ability

Nilai	Category
$0 - 55$	Low
$56 - 70$	Medium
$71 - 85$	High
$86 - 100$	Very high

Furthermore, students' answers will be analyzed according to Table 2. with indicators of achieving mathematical representation ability referring to van Hiele's theory.

Table 2. Indicators of Achieving Mathematical Representation Ability refer to van Hiele's Theory

Aspect of Representation Ability	Levels of Thinking van Hiele's Theory	Description of Achievement Indicators
Visual	0	Students can recognize rectangular and / or triangular shapes through drawing/shapes without knowing the properties possessed by the shapes
	1	Students can group quadrilateral and triangle shapes based on the same mathematical properties of some of the shapes
	2	Students can group quadrilateral and triangle shapes based on the relationship between the several shapes
Verbal	0	- Students cannot mention the definition of a rectangular or triangular shape provided - Students only form definitions relating to the description of the properties of quadrilateral and triangle shapes
	1	- Students can mention the definition of rectangular shapes and triangles provided but still do not understand the properties of the shape - Students can form definitions by memorizing all mathematical properties of the shape
	2	Students can make definitions of quadrilateral and triangle shapes by paying attention to the sufficient requirements and requirements of the shapes
Expression/ Symbolic	0	Students haven’t been able to apply mathematical symbols from quadrilateral and triangle shapes for problem-solving
	1	Students have been able to apply the symbols of a given problem by developing a geometry model and using it in problem-solving even if it is not finished completely
	2	Students have been able to apply the symbols of the problems given by developing geometry models and using them in solving problems precisely and correctly

RESULT AND DISCUSSION

The outcomes of the evaluation of the representation skills test of SMP Negeri 2 Mojolaban consisting of 11 female students and 15 male students are presented in Table 3. and Table 4. below.

Table 3. Frequency Distribution of Mathematics Representation Tests for Female Gender

No	Skor	Frequency	Percentage (%)	Category
1	0 – 55	0	0 %	Low
2	56 – 70	2	18.18%	Medium
3	71 – 85	8	72.73 %	High
4	86 – 100	1	9.09 %	Very High
Total		11	100 %	

Table 4. Frequency Distribution of Mathematics Representation Tests for Male Gender

No	Skor	Frequency	Percentage (%)	Category
1	0 – 55	1	6.67 %	Low
2	56 – 70	5	33.33 %	Medium
3	71 – 85	7	46.47 %	High
4	86 – 100	2	13.33 %	Very High
Total		15	100 %	

From Table 3. it can be seen that from 11 female students who took the test of the ability of the mathematical representation of rectangles and triangles, 1 student (9.09%) had a very high mathematical representation, 8 students (72.73%) had a high mathematical representation ability, 2 students (18.18%) has moderate mathematical representation ability and for low mathematical representation ability does not exist. While from Table 4. it can be seen that of the 15 male students who took the quadrangular and triangle mathematical representation ability, 2 students (13.33%) had very high mathematical representation, 7 students (46.47%) had high mathematical representation ability, 5 students (33.33%) had moderate mathematical representation and 1 student (6.67%) had low mathematical representation. These results indicate that the ability of the quadrilateral and triangular mathematical representation of class VIII students of SMP Negeri 2 Mojolaban for the majority of female and male genders has a high mathematical representation ability.
Furthermore, the achievement of students' mathematical representation ability according to van Hiele's theory is shown in Table 5. for female gender and Table 4. for the male gender.

Table 5. Achievement of the Mathematical Representation Ability of Female Students at Van Hiele's Theory Level

Level van Hiele	Percentage of Mathematical Representation Ability Achievement		
	Visual Aspect	Expression/symbolic Aspect	Verbal Aspect
0	0 %	0%	72.7 %
1	4.5 %	63.6 %	22.7 %
2	95.5 %	36.4 %	4.5 %

Table 6. Achievement of the Mathematical Representation Ability of Male Students at Van Hiele's Theory Level

Level van Hiele	Percentage of Mathematical Representation Ability Achievement		
	Visual Aspect	Expression/symbolic Aspect	Verbal Aspect
0	16.6 %	16.6 %	40 %
1	20 %	36.6 %	50 %
2	63.3 %	46.6 %	10 %

Based on from the level of van Hiele theory in Table 5. for visual aspects with indicators in the form of using visual representations to solve problems and draw pictures to clarify problems and facilitate resolution, the percentage of female students as much as 95.5% has reached level 2 in van Hiele theory and as many as 4.5 % has reached level 1. So that for the female gender, the achievement of mathematical representation ability at the level of van Hiele theory does not reach level 0. Furthermore, for aspects of symbolic expression with indicators in the form of making mathematical equations/models of other representations given and solving problems involving mathematical expressions, the percentage of female students as much as 36.4% have reached level 2 in van Hiele theory, as many as 63.6% reached level 1 and 0% for those who only reached level 0. Furthermore, for verbal aspects with indicators writing steps to solve mathematical problems with words and answer questions using words or texts, the percentage of 72.7% female students who only reached level 0, as many as 22.7% reached level 1 and only 4.5% reached level 2.

Based on from the level of van Hiele's theory in Table 6. for the visual aspect with indicators in the form of using visual representations to solve problems and draw pictures to clarify problems and facilitate resolution, the percentage of 63.6% male students has reached level 2 in van Hiele's theory, as many as 20% have reached level 1 and 16.6% only reached level 0. Furthermore, for aspects of symbolic expression with indicators in the form of making mathematical equations/models from other representations given and solving problems involving mathematical expressions, the percentage of male students is as much 46.6% had reached level 2 in van Hiele's theory, 36.6% had reached level 1 and 16.6% for those who had only reached level 0. Furthermore, for the verbal aspect with indicators writing steps to solve mathematical problems with words and answering questions using words or text, the percentage of female students 10% reached level 2, 50% reached level 1 and only 40% reached level 0. From the explanation above, it is seen that female students are superior to male students in the ability of mathematical representation of visual aspects because female students who have reached level 2 are more than male students. Whereas for the verbal aspect of mathematical representation ability, female students who reach the theory of van Hiele thinking level 2 only reached 4.5% and there are still many who only reach level 0 (72.7%), whereas for male gender, students who have reached van thinking theory Hiele are 10% and those reaching level 0 are 40%. From the data, it is known that male students are superior to female students in verbal aspects. This is not in line with existing research, which says that girls are generally superior in the fields of language and writing, while boys are superior in their spatial fields [21]. Men are superior in mathematics compared to women. Generally, men have better spatial abilities compared to women, while women are superior in verbal abilities compared to men [17].
Some student answers can be seen in the picture below.

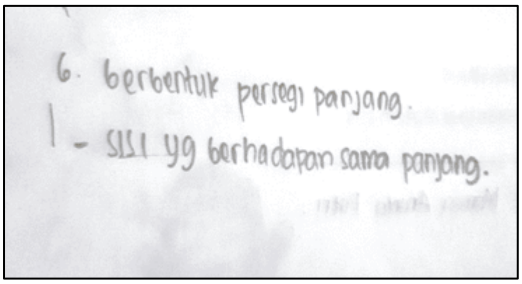


Figure. 1 Female student's answer on verbal representation

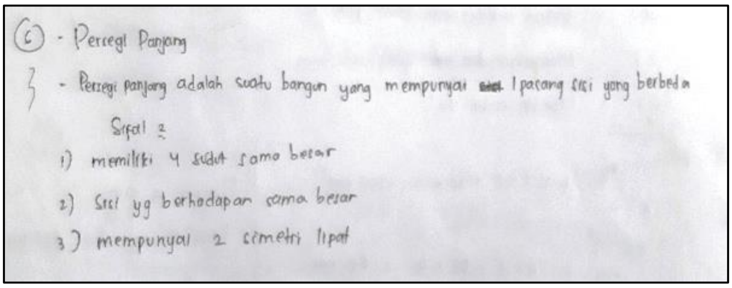


Figure. 2 Male student's answer on verbal representation

Figure 1 illustrates the answers of female students who have the category of moderate representation profiency and Figure 2 illustrates the answers of male students who have a high category of representation ability. The second picture is a matter of verbal aspect representation that asks students to write down the notion of a rectangular shape and its properties. In Figure 1, female students have difficulty in writing the definition of rectangles and their properties, from the picture it appears that students only answer with "the sides facing the same length" which is not clear that is the answer to the understanding of its properties. Female students in verbal questions include having low levels of thinking or only reaching level 0 in van Hiele's theory. Because students are not able to define flat shapes that are asked and are not able to mention their properties. Whereas in Figure 2 male students can write down the understanding and properties of rectangles well even though it is not too precise, but it is correct. Male students in this verbal question included having a high level of thinking and reaching level 2 in van Hiele's theory. Because students have been able to define the requested figure and can mention the properties of the figure correctly.

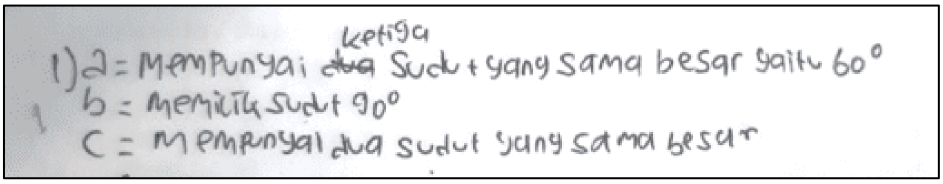

1) a = Mempunyai ~~dua~~ ketiga Sudut yang sama besar yaitu 60°
b = Memiliki Sudut 90°
c = Mempunyai dua sudut yang sama besar

Figure. 3 Male student's answer on visual representation

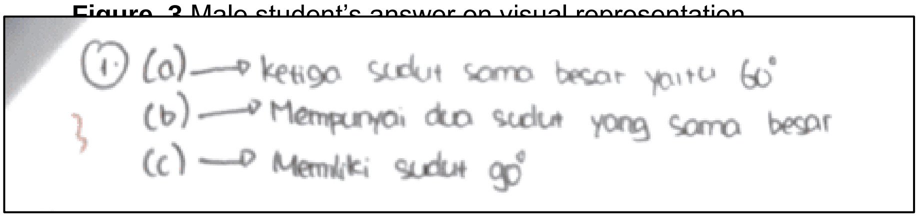
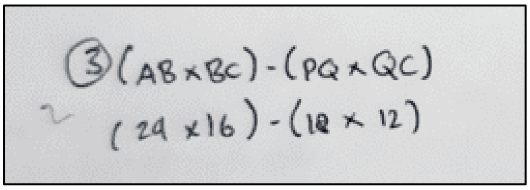
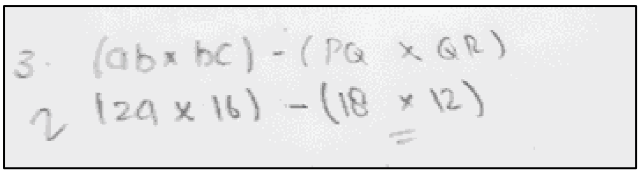

1. (a) → ketiga sudut sama besar yaitu 60°
(b) → Mempunyai dua sudut yang sama besar
(c) → Memiliki sudut 90°

Figure. 4 Female student's answer on visual representation

Figure 3 and Figure 4 are students' answers to the problem of representation of visual aspects that ask students to match 3 triangle images with their randomized properties. Figure 3 illustrates the answers of female students who have a high category of representation ability. In the picture, students have no difficulty in matching 3 triangles that have been invited and can answer correctly and correctly for the whole triangle in question. Students discovering in this visual problem have reached level 2 thinking in van Hiele's theory because students have been able to classify triangle shapes by analyzing their pictures correctly and precisely. While Figure 4 illustrates the answers of male students who have a low ability to represent categories. In the figure, it can be seen that the students' answers are still wrong because of the difficulty and confusion in matching triangles that match their properties. Students are only able to match one triangle with the right properties, and for 2 other triangles students are still wrong. In this case, the male student in this visual problem includes having a low level of thinking or only reaching level 0 in van Hiele's theory because students can recognize the shape of a


3 (AB×BC) - (PQ×QC)
(24×16) - (18×12)


3. (ab×bc) - (PQ×QR)
(24×16) - (18×12)

triangle through drawings/shapes but do not know the properties possessed by the shape.

Figure 5 and Figure 6 are students' answers to the problem of representation of the

Figure. 5 Male student's answer on symbolic representation

Figure. 6 Female student's answer on visual representation

expression / symbolic aspects that ask students to write mathematical equations in determining the area of the shaded area. Figure 5 and Figure 6 illustrate the answers of female and male students who are in the category of moderate mathematical representation abilities. In both pictures, it appears that students only write down the name of the side to be searched for, without writing down what they are looking for. The answer is correct but not exact and complete. Female and male students in this expression / symbolic problem include having moderate or level 1 thinking in van Hiele's theory because students have been able to apply symbols of the given questions but are not complete.

The overall results of students' mathematical representation analysis shows that there are differences in representation when viewed in terms of gender, where male students are superior in representing answers in words to define a flat figure. While women are superior in representing in the visual aspect and easier to understand the illustrations from a given picture and the results of the illustration of the questions poured into the form of drawings of female students are better than men because it uses stationery and the addition of information to the drawing drawn.

The ability of mathematical representation is important for students in learning mathematics because the way to convey ideas is different from students to other students. This is relevant to research which states that the ability of representation can help students to understand and communicate the concepts they have learned (Djaali & Muljono , 2008). Representing information visually is considered an efficient representation process in mathematics education, especially in problem-solving (NCTM, 2000). Based on Owens & Clements in the visualization of Guler & Ciltas it has an important role in understanding the problems it seems, guiding problem-solving methods and influencing mental structure significantly (Guler & Ciltas, 2011). Students learning about how to use mathematical representations in aspects of symbolic expressions and visual aspects can help students to write explanations written in the form of words (Utami, Mardiyana, & Triyanto, 2019).

CONCLUSION

Based on the results of research in class VIII of SMP Negeri 2 Mojolaban, a description of students' mathematical representation ability is well categorized, while the details are as follows: for the mathematical representation ability of 11 female students the proportion of students demonstrating a very high level of representation ability stands at 9.09%, the percentage of students with ability high representation 72.73%, percentage of students with moderate representation ability 18.18% and none for the low category. Whereas for the 15 male students who took the mathematical representation ability test the percentage of students with very high representation ability was 13.33%, the percentage of students with high representation ability was 46.47%, the percentage of students with moderate representation ability was 33.33% and the percentage of students with low representation ability was 6.67%. The percentage of achievement of students' mathematical representation ability according to van Hiele's theory in visual aspects the percentage of female students as much as 95.5% reached level 2 in van Hiele theory and as many as 4.5% had reached stage level 1. Furthermore, for the aspect of symbolic expression, the percentage of female students was 36.4% already reached level 2, as much as 63.6% reached level 1. Furthermore, for the verbal aspect, the percentage of female students was 72.7% who reached level 0, as many as 22.7% who reached level 1 and as many as 4.5% who reached level 2. Whereas for male sex for visual aspect the percentage of male students as much as 63.6% reaches the level 2 stage, as much as 20% reaches the level 1 stage and as much as 16.6% reaches the level 0 stage. Furthermore for the symbolic expression aspect, the percentage of male students as much as 46.6% have reached level 2, as many as 36.6% reached level 1 and 16.6% reached level 0. Furthermore, for the verbal aspect, the percentage of female students 10% reached level 2, 50% reached level 1 and 40% reached level 0.

Based on result, it is know that most students have achived high mathematical representation abilities and some still have low mathematical representation abilities. Male students less visual representation and female students less verbal representation. The research has implications that teachers must continue to train students to deveop multiple mathematical representation abilities (visual, symbolic, verbal) in learning or assignments.

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