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The identification of visual representation ability of junior high school students in solving geometry problems

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Abstract. The student's visual representation ability is the ability to create geometrical drawings in order to clarify the problem and complete it easily. The use of visual representation facilitates students to solve problems. It plays a vital role in mathematics education in terms of developing students' understanding. This study aims to identify the visual representation ability of students in solving geometry problems. The descriptive qualitative method was employed and the research subjects were 33 students from grade 8th of Muhammadiyah 1 Surakarta Junior High School. Data were collected through mathematical representation ability tests and interviews. Data analysis showed that 27.27% of the students were found to possess high visual representation ability. Meanwhile, 33.33% of them had medium visual representation, and 39.40% with low visual representation. Based on the mentioned results, it is obvious that most of the students have low visual representation abilities. This is because they still face difficulties in representing questions in the form of drawings, they are not given the opportunity to represent their own ideas, what made them unable to answer questions that differ from the examples given by the teacher.

1. Introduction
Mathematics is a crucial knowledge that must be mastered by students [1]. Besides the importance of mathematics, the mathematics achievement abilities of Muhammadiyah 1 Surakarta junior high school students is still low. This can be seen from the mathematics average score in the National Examination that is 44.78 with category D. If judged from the tested ability, the geometry, and measurement material is at the lowest position [2]. Geometry material is closely related to everyday life. The teacher must emphasize geometric material in everyday life [3]. Cass, Cates, Smith, & Jackson reveal geometrical material relevant to aspects of everyday life [4]. To prepare for mathematics subjects in the future, all students are expected to learn geometric shapes using visualization to change shapes and apply geometry modeling to solve problems [5].

The teacher plays an important role in the school. He must train students to have the ability to solve mathematical problems, especially in the geometrical material [6]. Without adequate geometry knowledge and problem-solving skills, a student cannot fulfill the requirements for obtaining a diploma [4]. Problem-solving plays an important role in learning mathematics. The main objective of mathematics learning is to have students to be competent in solving problems [7]. Problem-solving is an effort made by students to get the right solution [8]. The problem-solving process will be more successful if students have these skills and make them as their focus in mathematics education [9].
Almost all fields need problem-solving skills [6]. Therefore, students must master problem-solving skills.

Brenner claims that a successful problem-solving process depends on the skill of representing problems [10]. Representation is seen as a center for solving mathematical problems [11]. Siska states that representation as the first step in the problem-solving process [12]. Representation ability is important in understanding mathematics, both when students solve mathematical problems and when students communicate solutions to others [13]. Good representation skills are the key to getting the right solution to solving problems [14]. The ability of students to change a representation will affect their skills in finding solutions to solutions. Without representation, students will not be easy to solve mathematical problems [6].

Students with good problem-solving skills are those who are skilled in performing pictures representations [14]. Forms of representation include visual, symbolic, and verbal representations. Pictures representation is part of visual representation. The use of visual representation in mathematics learning is highly recommended [15]. This is consistent with Yung & Pass's research that revealed that visual representations are important in mathematics learning [16] one of which is to communicate ideas in mathematics [17]. Visual representation can help students to clarify information. Therefore, the teacher must teach and train students' visual representation skills in solving mathematical problems. Visual representation in this study is the students’ ability in creating geometrical drawings to clarify the problem and facilitate its completion.

The results of Hoogland’s research showed that students perform better when using visual representation in the problem-solving process. However, this is only done when the visual (pictures) representation of students is relevant and consistent with the mathematical model needed to solve the problem. When students use less relevant visual representations (pictures), the effect on their performance becomes negative [3]. Based on the results of the relevant study the purpose of this study was to identify the ability of visual representation of junior high school students in solving geometry problems.

2. Methods

This research used the descriptive qualitative method. The results of this study are descriptive data in relation to the identification of students’ visual representation abilities. Sampling was done through purposive sampling technique. The subjects in this study were 33 students from class VIII of Muhammadiyah 1 Surakarta junior high school. Data collection was done through mathematical representation tests and interviews. Interviews were conducted to clarify the data obtained from the tests. Before the data was analyzed the researcher first established the validity of the data by using the triangulation method. After triangulating, then the data were analyzed through three stages, namely data reduction, data presentation, and conclusion drawing. Data reduction was done to classify and dispose of the data that in relation to visual representation. Furthermore, the data is presented in descriptive form before drawing conclusions. Visual representation test assessment guidelines can be seen in Table 1 below.

| Skor | Visual Representation                                      |
|------|-----------------------------------------------------------|
| 0    | There is no answer/answer does not match the question/nothing is right |
| 1    | The created image has no information about size           |
| 2    | The created image size is not appropriate                 |
| 3    | Draw precisely according to size information              |
3. Result and Discussion

The research’s data obtained from the results of the mathematical representation test were analyzed in terms of the visual representation ability. Data that have been obtained from the field were then analyzed and presented in the form of descriptions as a description of the results of the study. the whole data are presented in Table 3, below.

Table 3. Categories of students’ visual representation ability

| Visual Representation | Frequency | (%)   |
|-----------------------|-----------|-------|
| High                  | 9         | 27,27 |
| Medium                | 11        | 33,33 |
| Low                   | 13        | 39,40 |

In Table 3, it can be seen that there are 9 students in the high visual representation ability category, 11 students in the medium visual representation ability category, and 13 students in the low visual representation ability category. Low visual representation categories are higher than the high and medium categories. This is because students are still not used to representing questions in the form of pictures. Students are also transfixed with examples of questions taught by the teacher. The teacher does not train and develop the ability of students’ visual representation in working on questions. The teaching method that is led to develop a visual representation in problem-solving is important [9]. Visual representation serves as a mediator between the level of formal and practical understanding [18]. Students rarely use visual representations (pictures) to help them think about solving problems. Guler and Ciltas stated that representing information visually is considered an efficient representation process in mathematics education, especially in problem-solving [9]. Thus, visual representation has not been used as a tool for thinking and solving problems.

Through problem-solving, students can develop their mathematical representation abilities [6]. Representation greatly influences how students solve problems [19] especially in visual representation [18]. The use of visual representation can enhance conceptual understanding in mathematics learning [16]. It is known that mathematical problems have more than one way. The way given by the teacher will influence the way students solve the same problem [9]. Students are not given the opportunity to represent their own ideas. This causes them to be inclined and unable to answer questions that are not in accordance with the way the teacher explains. Students still do not understand how to represent real-world problems in representation mathematical problems. A person’s ability to change a representation to another representation will affect his ability to find solutions to problem-solving. Some examples of students’ answer to visual representation ability test can be seen in Figures 1, 2, and 3.

3.1. Analysis of subjects with high visual representation ability (S1 and S2)

When solving a given problem, S1 represents in visual form according to the command, which is to make a picture of a kite and trapezoid. S1 reveals that for the first question, S1 immediately builds the
kite first. Then S1 makes a rectangle that is located on the edge of the kite. Build the rectangle made to cover the kite frame. Don't forget to write down the exact size according to the question. In the second problem, S1 reveals too easy in drawing a trapezoidal build. S1 is able to make a trapezoid build correctly and is able to write the measurements according to the question. S1 also reveals not all students are able to draw a trapezoid build properly. This is because if the students are not careful in reading the questions then they will be wrong in placing the measurements so that the built is not right which will also affect the answer. In the first question, S2 drew a kite, but his/her drawing was inappropriate. S2 was not thorough of writing the kite’s size. In the second question, S2 was able to draw a trapezoid appropriately. S2 was able to write the kite’s size based on the instruction in the question. In the second question, both S1 and S2 succeed in drawing a trapezoid appropriately.

In accordance with the guidelines for assessment of visual representation ability tests, in the first and second questions, S1 obtains a score of 3 each, which is able to draw precisely according to the size information. In the first question, S2 got a score of 2, that is the image is made of an incorrect size. In the second question, S2 got a score of 3, which is able to draw precisely according to the size information. The visual representation was enabled to help students developing the concept [20]. Visual representation is used as an exploration tool [11]. In the field of learning and teaching mathematics, visual representation plays an important role as a means to communicate mathematical ideas [21]. Thus the S1 can be said to be successful in representing the problem in a visual form (picture). Meanwhile, S2 succeed in representing the visual (picture) question in the second question.

![Figure 1](image1.png)

**Figure 1.** The students’ answer with high visual representation ability (a) answers of S1 and (b) answers of S2

Besides, when solving problems, S1 can solve both questions correctly. On the other hand, S2 was able to finish appropriately the second question. In the first question, S2 miscounted the width of a rectangle which was on the edge of the kite. This rectangle was used to cover the kite’s frame. Brown and Wheatley reveal that the ability to shape images in mathematics is considered an effective way of solving mathematical problems [18]. Based on the description, the first question S1 can express the form of representation that is the image of kite correctly. Meanwhile, S2 can not express the form of representation that is the image of kite correctly. In the second question, both S1 and S2 can express the form of representation that is the image of trapezoid correctly. This means that S1 and S2 can model concrete things from the real world into abstract concepts. Mathematical representation
is the process of modeling something from the real world into abstract concepts and symbols [14]. Representing a problem in the form of an image first will make it easier to solve the problem. Visual representation facilitates the subject in solving problems. The use of visual representation (images) can provide information needed to solve problems [18]. David and Tomaz state that visual representations (images) are important in completing geometric tasks [22].

3.2. Analysis of subjects with medium visual representation ability (S3 and S4)

In the first question, S3 revealed that he had difficulty in understanding the problem. S3 had difficulty in understanding the phrase "on the edge of the paper extended 4 cm to cover the kite frame". So that the S3 was only capable of making images of kites. Even so, S3 also does not write down the measurements. This is because S3 was not used to including size in drawing. In the first question, S4 showed that did not get any difficulty when understanding the question. However, S4 did not careful to read the question thoroughly. S4 wrote incorrectly the size of “the long diagonal and the short diagonal crossing in a point where this point was located in 18 cm from the end of the longest diagonal.” In accordance with the guidelines for assessing the visual representation ability test, for the first problem S3 obtains a score of 1, that is, the image is made without any size information. Meanwhile, the first question, S4 got a score of 2, that is the image is made of an incorrect size. In the second problem, S3 succeeded in drawing a trapezoid build with its size. But the image is not neat and in drawing the same length. On the other hand, S4 only drew a trapezoid without its sizes. S4 did not write its size because S4 had already understood the question. The visual representation gave a different understanding for the students [17]. Based on the appraisal guidelines for visual representation ability tests, for the second problem S3 got a score of 2, that is the image is made of an incorrect size. Meanwhile, S4 got a score of 1, that is, the image is made without any size information. Viewed in terms of neatness and shape, the image produced by the S4 subject was different from the subject of S3.

When completing the first question, the S3 could only calculate the area of the kite. The S3 was not able to answer questions. This is because the S3 was not able to understand the sentence in the problem. S4 could finish the question but the answer was incorrect. S4 wrote incorrectly the long size crossing with the long diagonal and the short diagonal. S3 and S4 could only answer appropriately
when counting the width of the kite. Individuals who are skilled in problem-solving, in reality depend on visual representation [11]. The visual representation was the core of Mathematics’ understandings [21]. Zhang and Norman show that the use of visual representation can lead to a deeper understanding of students [16]. In the second question, S4 could finish the question appropriately. S4 could calculate the area and the circumference of the trapezoid. Meanwhile, S3 is only able to calculate the area of the trapezoid. S3 didn’t succeed in looking circumference the trapezoid. The S3 was wrong in finding the length of the unknown side using the Pythagorean theorem. The use of visual representation in the problem-solving process is not always effective and can cause the solution to be wrong [9]. This error is because the S3 was not careful in drawing a trapezoid build. If the S3 drawing is correct, it will minimize errors in the calculation process.

3.3. Analysis of subjects with low visual representation ability (S5 and S6)
In the first question S5 and S6 did not succeed in representing the problem in the form of an image. S5 instead represented a problem in the form of a rhombus image. S5 did not understand the different shapes of kites and rhombus. In the answer sheet, S6 did not write any answer for the first question. S6 claimed that got difficulties to understand the intended question. This is because S5 and S6 did not like mathematics, so that S5 and S6 didn't pay attention to the teacher during the learning process. In accordance with Ramdhani's research [23], mathematics is a boring subject. Likewise, Widakdo's research [24] states that 55% of students say that mathematics is difficult. Therefore, S5 and S6 had difficulty in understanding mathematics. Based on the assessment guidelines for visual representation ability tests, for the first question S5 and S6 got a score of 0 that is no answer/answer does not match the question/nothing is right. In the second problem S5 is able to draw a trapezoidal build with its size. The image created by S5 was far from neat. This is because S5 draws not using a ruler, so that the length of one side of the other is almost the same. At the time of the interview S5 claimed to have a ruler, but S5 did not use it for the reason that the time spent in drawing would be longer. In the second question, S6 could draw a trapezoid, but S6 did not write its size. S6 got difficulties in placing the size provided by the question. In accordance with the assessment guidelines for visual representation ability tests, for the second problem, S5 obtained a score of 2, that is, the image is made of an incorrect size. In the second question, S6 got a score of 1 that is, the image is made without any size information.

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![Figure 3](image_url)

**Figure 3.** The students’ answer with low visual representation ability (a) answers of S5 and (b) answers of S6
S5 and S6 could not solve the first problem. S5 and S6 had difficulty understanding what is known in the problem, so the S5 and S6 are unable to answer questions. In the second problem, S5 and S6 have increased. S5 and S6 calculate the area and circumference of the trapezoid, even though the answer is still wrong. To search the trapezoidal S5 and S6 directly add what is known in the problem. S5 and S6 understanding are still lacking in this material. In addition, S5 and S6 apparently still had difficulties in calculating operations. In accordance with Widakdo's [24] study that students have difficulty understanding mathematics, there are two factors: factors from the teacher and factors from students. The factor of the teacher is that the teacher is not clear in delivering the material, while the factor of the student is that students did not like mathematics. The teacher has an important role in this matter that the teacher must change students' perceptions of mathematics. Students with low problem-solving abilities will always experience difficulties in making representations [14].

4. Conclusion
The results of the data analysis showed that there were 27.27% of students with high visual representation, 33.33% of students with medium visual representation, and 39.40% of students with low visual representation. S1 was able to represent questions in the form of pictures. Students with high visual representation abilities are better at representing questions in images than students with medium and low visual representation abilities. Students with medium visual representation abilities are better at representing questions in images than students with low representation abilities. Based on the results it is known that most students have low visual representation abilities. This is because they still have difficulty in representing questions in the form of drawings, there is no opportunity for them to represent their own ideas, students tend to be unable to answer questions that are not in accordance with the examples provided by the teacher.

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