Visualization Profile of Junior High School Students in Solving Geometry Problems Viewed from Gender Differences

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Abstract. In solving mathematical problems, visualization has an important role in developing thinking, mathematical understanding, helping the transition of concrete thinking to abstract. This study aimed to describe the visualization process of junior high school students in solving geometry problems viewed from gender differences. The description of the student visualization process was based on the aspects of generation, inspection, transformation, and use. The methods of data collection in this study were conducted through test and interview. The result of the research showed that in generation aspect, male and female students made the picture according to the information of the problem which was given by relating it to the knowledge they had. In inspection aspect, male and female students applied the rules of Pythagoras theorem to determine one of its elements. In transformation aspect, female student changed the pattern of visual ideas into square shapes by translating the elements, while male student changed the pattern of visual ideas into triangular shapes. In use aspect, female student used a picture to check the result of the operation, while the male student did not use a picture to check the result of the operation. Thus, this visualization process was expected to provide information for teachers about the visualization process of junior high school students either male or female so as to assist teachers in designing learning.

1. Introduction
In learning mathematics, especially in solving mathematical problems, students are expected to be able to manage the cognitive to become more complex. Dealing with solving mathematical problems, visualization has an important role in the process of solving mathematical problems. According to [1], the important roles of visualization in the process of solving mathematical problems are developing thinking, mathematical understanding, and helping the transition of concrete thinking to abstract. Visualization can help teachers to see students' understanding of the given problem [2]. And it is needed by the students to manage the interpretation and manipulate information in the mastery of mathematical word problem solving [3].

According to [4] visualization refers to mental processes that describe visual or spatial information. Visualization is also defined as the process of building and transforming visual images and all representations of spatial characters that can be used in drawing, building or manipulating (images and symbolic) with pencil and paper [5]. Furthermore, according to [6], visualization is a process that is the result of the creation, interpretation, reflection of images, diagrams, in our minds embodied in paper or technology tools with the aim of describing and communicating information, mind about...
developing idea that is not known in advance to gain a higher understanding. In addition, [7] defining visualization in mathematics is as the process of forming images (mentally) using pencil and paper and effective implementation of the use of images that have been formed for mathematical discovery and understanding.

Because of the importance of visualization in solving problems, as according to [8] using diagrams or images can help students to understand the problem before they find solutions to the problem, mainly solve word-problem in geometry material. Therefore, students' visualization skill in solving problems is important to teachers' concerns, especially the visualization skill of junior high school students. Based on the research [9], the researchers advised the teachers of Junior High School to develop mathematical visualization skills, especially about geometry using various contexts. This is because the junior high school students based on Piaget cognitive development stage are in the formal operation stage (12 years and over), and at this stage the children have started to think abstractly and the children's understanding is needed as capital to learn mathematics in advanced level. In addition, many studies have also revealed students' difficulties in visual problems, difficulties encountered such as understanding problems, producing or drawing accurate diagrams that fit the problem situation, reading the graph correctly [6, 10, 11, 12].

In solving problems, each individual has different abilities, especially when viewed through sex differences. It is in line with the opinion of [13] that gender differences gave differences in spatial performance in geometry. Meanwhile [14] reveals that women's abilities are better than men's in terms of verbal and visual solution methods whereas in terms of quantitative reasoning men's abilities are better than women's. Further [15] explains that the development of cognitive sources is influenced by biological factors and experience. The intended cognitive source refers to the ability and speed of processing information, biological factor refers to gender, and experience refers to the frequency of a person in processing information. Thus, it can be said that the number of experiences of a person in processing visual problems will speed up a person in processing problems, and gender can affect the process of visualization of a person in solving the problem. [14] and [15] show that gender influences visual problems and methods of verbal and visual solutions of a person so that the researcher is interested to know more about the process of visualization of male and female junior high school students.

2. Method
This research was descriptive research with qualitative approach. Description of the visualization process in this study was viewed from the aspect of the visualization process presented by [16] including generation, inspection, transformation, and use. Furthermore, by qualitative approach, the data that had been collected from research subjects were arranged, simplified, organized, described in the form of words and concluded. The subject in this study was a group of students of grade VIII. A group of students was given a mathematics ability test to determine the mathematical ability of each subject. From the results of the mathematics ability test obtained, then 1 male subject and 1 female subject who had equivalent mathematical ability were selected. Furthermore, both selected subjects were given a visualization test. The results of the visualization tests obtained were then searched in depth through semi-structured interviews linked to every aspect of visualization.

3. Results
In this research, visualization process is a mental process for building and transforming visual ideas (images) in order to translate, communicate, and develop ideas in mind through the aspects of generation, inspection, transformation, and use. Therefore, the visualization process of male and female students described is seen from the aspect of generation, inspection, transformation, and use. The male and female students had equivalent mathematical abilities based on the results of the mathematical ability tests obtained.

3.1. Generation Aspect
3.1.1. Male Student
The first step of the male student in answering the problem was given by carefully reading the information in the given problem and marking the important thing in the problem that would determine the image to be formed by it. A picture of male student’s answer result in describing the information of the given problem shown in Figure 1 below.

![Figure 1. The Answer of Male Student in The Visualization Test](image1)

Having been searched further through the interview, the reason for describing the position of the circle as seen in the worksheet, the male student revealed that because in the problem, it was said that all the sides of the square intersected with the circle. If it was made in a row of circles in a square then there was a square side that did not intersect with the circle. He also revealed if it had to intersect with the circle in a lined position, then it formed a rectangle. The male student in his reasoning also related it to the characters of the square.

3.1.2. Female Student
The first step taken by female student in answering the given problem was identifying the information of the given problem by imagining the position of the two circles, in which the fingers of both hands formed a circle as an example of the two intended circles. Then the female student began to describe the position of the circle that might be based on the information from the given problem. A picture of female student’s answer result in describing the information of the given problem shown in Figure 2 below.

![Figure 2. The answer of Female Student in Visualization Test](image2)

After being searched through the interview, the reason for drawing the position of the circle as depicted in the worksheet, the student revealed if the position of the circle lined then it formed a rectangle, whereas in the problem, the requested one was a square. The student revealed the character of the square namely all sides were equal in length.

3.2. Inspection Aspect
3.2.1. Male Student
In Figure 1, the male student determined his solving strategy by observing the center point of each circle and connecting it to one of the square vertices to form diagonal. The same was done for both circles. To find the diagonal length, the male student applied the rule of Pythagoras theorem. After
being searched through an interview, the reason for applying Pythagoras's theorem rule, he revealed that by forming the diagonal the image formed was a right-angled isosceles triangle. He then tried to check the shape of a triangle he made by marking the triangles: 3 cm for the base and 3 cm for the height and he obtained $\sqrt{18}$ for the aslant side. Then he mentioned that the square of aslant side of the triangle was equal to the sum of square of the right angle so that his strategy was correct.

3.2.2. Female Student
The female student determined the solving strategy using Pythagoras theorem by visualizing the visual objects that were made into small rectangular shapes and then creating a diagonal line like Figure 3 below. She then checked the visual form created by marking the size of the small square created. She then applied Pythagoras theorem rule to determine the square diagonal and obtained the result of $3\sqrt{2}$.

![Figure 3. Female Student's Answer in Inspection Aspect](image)

After being searched through an interview, the reason for using the Pythagoras theorem, the female student revealed because if a diagonal was created on a square forming a right triangle, Pythagoras theorem could be applied.

3.3. Transformation Aspect
3.3.1. Male Student
To get a solution, the male student made a pattern change on the image created by forming a new right triangle. He revealed that the aslant side was formed from the diagonal made in the inspection process which obtained $\sqrt{18}$ cm with a diagonal formed by connecting both points of the circle so that the result obtained was 6 cm. Then he summed up those elements namely $\sqrt{18} + 6 + \sqrt{18} = 6 + 6\sqrt{2}$. Next, to get the right angle that was not yet known he symbolized it with variable $x$. Then he used Pythagorean Theorem to obtain the value of $x^2 = 54 + 36\sqrt{2}$ $cm^2$. He revealed that the result of $x^2$ obtained was the result of the square area in question. However, in this process he did not make a change or give a different name to the formed structure. The picture made by the male student to get a solution shown in Figure 4 below.

![Figure 4. The Answer of Male Student in Transformation Aspect](image)
3.3.2. Female Student

To obtain a solution, the female student made a change on the picture she made into a new square shape obtained by translating on the length size on the new square side. On the length size of the new square side she revealed that the length side of the new square could be shifted from the original square diagonal part obtained on the inspection aspect namely $3\sqrt{2}$ cm. Furthermore, she did translation on the size of the radius of the circle. The female student revealed that the distance between the centre point of the circle to the side of the square was equal to the distance between the auxiliary points that had been made to the square side so that the distance of the auxiliary point to the square side was 3 cm. To obtain the length of the square side, she added up the elements that had been obtained, that was $3 + 3\sqrt{2} + 3 = 6 + 3\sqrt{2}$. Next, to get the square area, she used the square area formula, which was the square of the side length, that was $6 + 3\sqrt{2}$, so that it was obtained $54 + 36\sqrt{2}$ cm$^2$. In addition, she also assigned a different name to the new square formed with square PQRS. A picture of the answer from the female student in transformation aspect shown in Figure 5 below.

![Figure 5. The Answer of Female Student in Transformation Aspect](image)

3.4. Use Aspect

3.4.1. Male Student

Further, at the end of the solution, the male student did not write how to check the result of the operation obtained and when being searched through an interview, the male student did not check the picture obtained to check the result of operation. He just revealed that his calculation was correct while checking the calculation.

3.4.2. Female Student

At the end of the solution, the female student did not write how to check the correctness of the result obtained but when being searched in the interview the student revealed that to know if the result of the square area obtained was correct, then the correctness of the result of the length side of square obtained also needed to be checked. Then she connected the picture with the operation result of length side of square. She connected it by labeling the result of length side of square $6 + 3\sqrt{2}$ in the picture and checking the correctness of the result of length side of square by relating it to the Pythagoras theorem and the right triangle. She revealed that if the sum of quadrate of the square side was equal to the diagonal quadrate formed then the result was definitely correct.

4. Conclusion and Discussion

Based on the results obtained, it can be concluded on visualization process on female student: aspects of generation, inspection, transformation, and use have been carried out by the subject in solving geometry problems, while the male student only does three aspects: aspects of generation, inspection and transformation in solving geometry problems. [14] Reveals that women's abilities are better than men's in terms of verbal and visual solution methods. This is in accordance with the result
obtained about the visualization process in female student, the four aspects of visualization had been done in solving the problem of geometry by the female student while the male student only did three aspects of visualization in solving geometry problems.

[15] Explains that the development of cognitive sources is influenced by biological factors and experiences. The intended cognitive source refers to the ability and speed of processing information, biological factor refers to gender, and experience refers to the frequency of a person in processing information. Thus it can be said that the number of a person’s experiences in processing visual problems will speed up a person in processing problems, and gender can affect the process of visualization of a person in solving the problem. It is also in accordance with the results of the research that both male and female students had high mathematical skills as proven by the TKM scores obtained by both of them so as to show the effect on their good visualization process because of their large learning experience especially in the visual problem. Finally, the results of the visualization process are expected to provide information for teachers about the visualization process of junior high school students, either male or female, so as to help teachers in designing learning.

5. References
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