Student’s Geometric Thinking in Understanding Volume with Three–Dimensional Images of Cubes and Nets

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Abstract. This study aimed at describing the thinking skills of junior high school students in solving problems about the volume of cube and cuboid presented in the form of images of nets and solid figure geometry. This research was a descriptive study with a qualitative approach. This research was conducted at eighth grade class in Islamic Junior High School (MTs) Nurul Huda, Sidoarjo, Indonesia. The research subjects were two students, male and female in the same class of seven classes. The instruments used in this study were geometry test and interview. Geometry test was designed to determine student’s thinking in understanding volume with three-dimensional images of cubes and nets. Interview was used to make the researcher easier to explore how the students completed the given geometry test on the problem of the volume of cube and cuboid. Student’s thinking ability was explained based on three abilities according to Sternberg. The results showed that the female student had analytic and creative abilities in understanding images for the volume of cube and cuboid, but the male student tended to be more thoughtful towards abstract concepts. For practical ability, the male student had practical ability better than the female student.

1. Introduction

This study investigates the relationship between gender and students' thinking abilities in understanding the volume presented with three-dimensional images of cubes and nets of space. Image presentation is a solution to support the goal of problem solving in mathematics, so that it can help shape students' reasoning thinking. Facts that occur during this time students are still experiencing difficulties in mathematics, mathematical problems that are used not as problems from real life, so that the reality and situations of reasoning students are forced, or students do not have the right meta-cognitive skills to solve problems. Liljedahl [1] argued that problem solving not only requires logical and deductive reasoning but also requires extra-logical processes of creativity, insight and illumination to produce solutions. The fact that has happened so far is that students still have difficulties in mathematics specially in problem solving. Students often experience difficulties with word problems used in mathematical statements, mathematical problems that are used not as real-life problems. Such obstacles are often ignored, so the reality and situation are forced, or students do not have the right meta-cognitive skill to solve the problem [2]. In addition, Verschaffel [3] said that the most reported difficulty is that students base their analysis and calculations on a loose association of certain salient quantitative elements of the problem situation with certain mathematical operations. Based on Pattimukay’s research results [4], there are also still many prospective teachers who find it difficult to teach problem solving to their students.
Solso [5] states that, "Problems solving is thinking that is directed toward the solving of a specific problem that involves both the formation of responses and the selection among possible responses." Thus, the understanding of mathematical problem solving in this research is the effort of students to solve mathematical problems with respect to logic and problems in calculations.

There is research evidence showing that the representation of the shape of solid figure geometry can have various impacts on the students' reasoning process. Parzysz in Pittalis [6] says that students' reasoning problems can be influenced by representations of the shape image of solid figure geometry and the image of the plane figure will be displayed. According to Mesquita in Pittalis [6] presentation of image-shaped tasks will provide support for geometry intuition, which in some situations can be very strong in helping individuals "to understand the relationship between geometric objects". The use of images to represent situation problems has a better chance of safeguarding students in solving mindset problems than returning to answers to mindset. Images are more easily associated with real life situations, and can be said to feel more authentic for students, and therefore it is possible that the language of images better illustrates problem situations so that it can reduce the difficulty of understanding the text. A good understanding of text is needed by students in building concepts both in mathematics and other subjects. The ability to understand concepts plays a major role in determining student's learning outcomes in mathematics learning. With the abilities possessed by students, this will facilitate learning and solving mathematical problems.

A number of research studies in mathematics education provide evidence from various types of images, which are used in Indonesia in different situations and with different effects on students' mathematical performance. Student's thinking ability to understand, interpret, and build representations of the shape of solid figure geometry will involve stimulation of good performance. However, this does not always mean that students conceptualize the information presented to them. The study of Hanifah[7] showed that In terms of the sex differences, male students imagined the figures yet female students needed the media to solve the problem about spatial.

Thinking can be defined as the process of producing new mental representations through information transformation involving complex interactions among mental attributes such as abstraction assessment, imagination, and problem solving. Solso [5] reveals that, "thought processes occur new mental representation is formed through the transformation of information by a complex interaction of mental attributes of judging, abstracting, reasoning, imagining, and problem solving". In this study, thinking ability is the ability to process the information received and turn it into an idea that produces a decision.

Sternberg [8] in his theory "successful intelligence" states there are three types of abilities, namely analytic, creative, and practical. Student's analytic ability means investigating namely their ability to analyze, compare, evaluate, and assess. Furthermore, student's creative ability means showing namely student's ability to make, find, imagine, and predict. And student’s practical ability means using that is the ability of students to apply, use, practice, apply, employ and present practically what they know.

The expected benefits of the results of this study are to find out the extent to which male and female students' thinking abilities based on images of nets and solid figure geometry for the concept of cube and cuboid volume, so that they can be taken into consideration in preparing learning assignments. In addition, it is also as a reference in preparing students' logical thinking regardless of gender differences which serves as the basics in mathematical concepts besides cube and cuboid so that the learning objectives are expected to be achieved.

In this study, the researchers chose to examine the students' thinking ability of class VIII in solid figure geometry, namely cube and cuboid in the form of images of nets and solid figure geometry. So far, the class solves problems in the form of story questions about volume and students are used to using the existing formulas without knowing how to find out the concept of volume by themselves. The purpose of this study is describing the thinking ability between male and female students in solving volume problems in the form of images of nets and solid figure geometry.
2. **Research Method**

This type of research was descriptive research with a qualitative approach. The research subjects were the students of eight grade class of Islamic Junior High School (MTs) Nurul Huda, Sidoarjo, Indonesia. The subjects in this study were one male student and one female student. The reasons for choosing these two subjects were to represent each student's thinking ability and as a comparison between male student and the other. Information about the selection of subjects based on this commensurate level of ability was got through an interview with the mathematics teacher who taught eight grade class. The mathematics teacher knew more the level of daily ability of students in the learning process which was supported by daily math test scores.

The instruments used in this study were geometry tests and interview. The geometry test was a written test designed to identify student’s thinking ability in solving geometry problems especially cube and cuboid. Interview is designed to make the researchers easier to explore information about student’s thinking on geometry test given in understanding the concepts of cube and cuboid. The type of interview used in this study was an unstructured interview. Unstructured interview is a free interview where researchers do not use interview guidelines that are arranged systematically and completely for data collection.

The data collection technique used was written test in the form of images of nets and solid figure geometry that was given to the subjects to be worked on, then interviews were conducted to the subjects. The written test used consisted of three items. Data analysis was carried out by comparing the geometry test result and interview data. Thinking ability was described based on three types of abilities according to Sternberg, namely analytic, creative, and practical abilities by considering the results of interviews with the subject.

3. **Results and Discussion**

3.1 Results

This research was conducted at MTs. Nurul Huda Sidoarjo to eight grade class students by taking a population of eighth-level students is thirty students. The researchers selected two subjects consisting of male and female student from 12 male students and 18 female students in that class. Selection of class and subjects were based on mathematical abilities that are commensurate given by the math teacher who taught eighth grade class.

The results of student work in problem solving based on images of nets and geometry can be seen from the results of the work of the two students as follows.

- **Figure 1.** Male student’s answer (S1)
- **Figure 2.** Female student’s answer (S2)
3.1.1 Male student’s

The male student's answer in determining the volume of the net image (question no.1) was that student’s thinking ability was influenced by many considerations in a more detailed direction. It means that it was analytic ability is the ability to compare, assess but without evaluating the problem namely without paying attention to the statement of the problem. For question no. 2 the answer of male student was thinking more abstractly in drawing a set of cube unit. It means that it was creative ability namely making, discovering and imagining. However, in terms of imagining, this student could not imagine whether a cube arrangement could be arranged without a base under the cube unit. While for question no. 3 determining the cubes that were needed to fill the cuboid for practical ability namely using, practicing, applying what they knew with the cube unit of male student’s answer showing thinking using the concept of volume obtained from prior knowledge.

To know better the thinking ability of the male student (S1) in solving problems given, below are excerpts of interview with S1

P : After you read the question number 1, what did you do?
S1 : observing the area of a square by looking at the large square of the image, then comparing.
P : Why should you compare?
S1 : To choose the largest area.
P : Then what steps did you take?
S1 : Answering what was asked.
P : Then for question no. 2, what did you imagine?
S1 : Arranging 8 unit cubes
P : What kind of arrangement did you have in mind?
S1 : Interrelated arrangements of the 8 cubes.
P : What do you do if real cubes can be arranged, not fall?
S1 : I don't think the cubes are real.
P : For question no. 3, how did you determine which cubes were needed for the cuboid?
S1 : By counting many cubes for length, width, height and then multiplying continuously minus the many cubes that are already in the beam.

3.1.2 Female student’s

Based on the answer of the female student in determining the volume of the net images (question no.1), student’s thinking ability by comparing images with others and evaluating what had been answered, it meant that the analytic ability of the female student was the ability to compare and evaluate the answers to the question. For question no. 2, the answer of the female student was simple thinking in drawing a set of unit cubes. It meant that it was the creative ability of making, finding and imagining unit cubes that had to be used so that cubes arrangement could be arranged with a sturdy base. Question no. 3 was determining the cubes needed to fill the cuboid in practical ability of using, practicing, applying what they knew with eight cubes. The answer of the female student used a count of what she saw from the image so that the main factor of accuracy was used.

To find out more about the thinking ability of the female student (S2) in solving problems given, the following is the excerpts of interview with S2

P : After you read the question number 1, what did you do?
S2 : comparing by counting the number of squares of the picture, then rating the number.
P : Why should it be calculated?
S2 : To choose the most.
P : What steps did you take?
S2 : Answer what was asked.
P : Then for question no. 2, what did you imagine?
S2 : Arrangement of unit cubes consisting of eight cubes.
P : What kind of arrangement did you have in mind?
S2 : Neat and not easily broken.
P: Why did you put together neatly?
S2: So that the cube in the topmost arrangement did not fall down.
P: For question no. 3, how did you determine the cubes needed for the cuboid?
S2: By observing the image then counting the number of cubes needed.

3.2 Discussion

This study showed the ability of male and female students to solve problems based on images of nets and solid figure geometry. The results showed that based on the answers of male and female students above (Figures 1 and 2), the thinking ability of male and female students was different on the answers generated in terms of analytic ability, creative ability and the ability to use previously known concepts. In question no. 1 the male student, in thinking ability in term of analytic had not evaluated what he had answered and evaluated the statement of the question, while based on the answer of the female student, the thinking ability for analytic started from comparing one image to another, assessing and evaluating the answers to what she wrote with a statement from the question, by calculating the number of unit squares and using the square area concept and the answer already showed the correct one.

In question no. 2 for male and female students, the creative thinking ability showed that in terms of making, arranging and imagining, the male student tended to think abstractly, while the thinking ability in term of the creative one, the female student was more real.

For question no. 3 the answer of the male student showed that the thinking ability was using the concept that had been obtained before so that he could answer easily, while the female student was by counting the number of cubes in the cuboid image without thinking using the concept of volume.

It shows that thinking ability between male and female students is really different. This also corresponds to the results from Pullo's study [9], which showed that 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. Fujita et.al [10] also showed that they found different types of thinking when the students solved 3D geometric problems.

4. Conclusion

The results of research on student’s thinking ability to solve the problem of volume of cubes and cuboids based on the image of solid figure geometry show that the thinking ability of male student for analytical and creative abilities has been able to compare, arrange but not in the direction referred to in the basic concept of cube and cuboid volume, namely in determining the volume of net images he does not understand the intent of the statement so that he only observes the image and in arranging the unit cube he still leads to the abstract direction without evaluating the statement of the problem. Furthermore, the thinking ability of male student is already capable in practical ability, namely having applied and used the previous knowledge owned.

The female student’s thinking ability shows that analytical and creative abilities have been able to solve problems of images of nets and solid figure geometry, but in practical ability she has not used the previous concepts owned. It is different from the answers of male student because the female student uses counts both in determining the volume of the net images and the volume of cuboid with unit cubes. However, in arranging unit cuboid, the female student thinks that the resulted image can be in the form of a solid figure geometry that is formed and which can stand sturdily as it is done when compiling a pile of books or toy cubes in daily reality.

For other researchers who are interested in studying the student’s mathematical thinking ability in solving research problems it can be continued with the use of wider problem solving than just geometry tests in the form of images. It can be ‘HOTS’ questions, story problems, using everyday problems or contextual with another material. Planning of problem-solving tasks helps students understand mathematical concepts. Research can also be done at senior high school level. It is also hoped that further research can accommodate students ‘abilities while conducting research using subjects based on students’ cognitive abilities.
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