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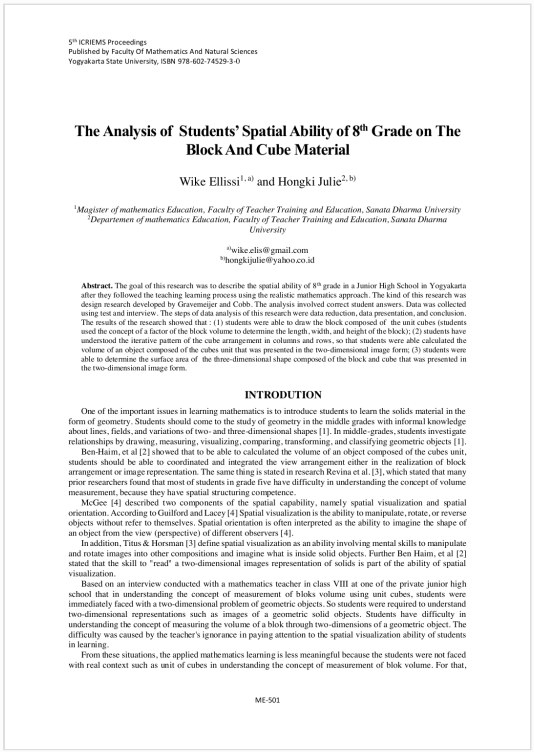

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The Analysis of Students' Spatial Ability of 8th Grade on The Block And Cube Material

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Abstract. The goal of this research was to describe the spatial ability of 8th grade in a Junior High School in Yogyakarta after they followed the teaching learning process using the realistic mathematics approach. The kind of this research was design research developed by Gravemeijer and Cobb .The analysis involved correct student answers. Data was collected using test and interview. The steps of data analysis of this research were data reduction, data presentation, and conclusion. The results of the research showed that : (1) students were able to draw the block composed of the unit cubes (students used the concept of a factor of the block volume to determine the length, width, and height of the block); (2) students have understood the iterative pattern of the cube arrangement in columns and rows, so that students were able calculated the volume of an object composed of the cubes unit that was presented in the two-dimensional image form; (3) students were able to determine the surface area of the three-dimensional shape composed of the block and cube that was presented in the two-dimensional image form.

INTRODUTION

One of the important issues in learning mathematics is to introduce students to learn the solids material in the form of geometry. Students should come to the study of geometry in the middle grades with informal knowledge about lines, fields, and variations of two- and three-dimensional shapes [1]. In middle-grades, students investigate relationships by drawing, measuring, visualizing, comparing, transforming, and classifying geometric objects [1].

Ben-Haim, et al [2] showed that to be able to calculated the volume of an object composed of the cubes unit, students should be able to coordinated and integrated the view arrangement either in the realization of block arrangement or image representation. The same thing is stated in research Revina et al. [3], which stated that many prior researchers found that most of students in grade five have difficulty in understanding the concept of volume measurement, because they have spatial structuring competence.

McGee [4] described two components of the spatial capability, namely spatial visualization and spatial orientation. According to Guilford and Lacey [4] Spatial visualization is the ability to manipulate, rotate, or reverse objects without refer to themselves. Spatial orientation is often interpreted as the ability to imagine the shape of an object from the view (perspective) of different observers [4].

In addition, Titus & Horsman [3] define spatial visualization as an ability involving mental skills to manipulate and rotate images into other compositions and imagine what is inside solid objects. Further Ben Haim, et al [2] stated that the skill to "read" a two-dimensional images representation of solids is part of the ability of spatial visualization..

Based on an interview conducted with a mathematics teacher in class VIII at one of the private junior high school that in understanding the concept of measurement of bloks volume using unit cubes, students were immediately faced with a two-dimensional problem of geometric objects. So students were required to understand two-dimensional representations such as images of a geometric solid objects. Students have difficulty in understanding the concept of measuring the volume of a blok through two-dimensions of a geometric object. The difficulty was caused by the teacher's ignorance in paying attention to the spatial visualization ability of students in learning.

From these situations, the applied mathematics learning is less meaningful because the students were not faced with real context such as unit of cubes in understanding the concept of measurement of blok volume. For that,

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Based on an interview conducted with a mathematics teacher in class VIII at one of the private junior high school that in understanding the concept of measurement of bloks volume using unit cubes, students were immediately faced with a two-dimensional problem of geometric objects. So students were required to understand two-dimensional representations such as images of a geometric solid objects. Students have difficulty in understanding the concept of measuring the volume of a blok through two-dimensions of a geometric object. The difficulty was caused by the teacher's ignorance in paying attention to the spatial visualization ability of students in learning.

From these situations, the applied mathematics learning is less meaningful because the students were not faced with real context such as unit of cubes in understanding the concept of measurement of blok volume. For that,

required a model of learning that begins with real problems so that students are directly involved to construct their own knowledge in understanding the concept of measurement of blok volume. One way that can be done used the realistic mathematics learning approach. The results of research by Revina et al [3] showed that the building blocks activity has helped the students to coordinate the separation of views of the arrays. They need to practice with more concrete tasks of increasing complexity the structure complexity which they can acquire personally constructed view of the organiation of the three-dimensional rectangular arrays [3].

Realistic Mathematics Education (RME) was one of the best learning alternatives to solve the problem because in this learning model students were required to construct knowledge with their own ability through the activities undertaken in learning. This RME refers to Freudenthal's opinion that mathematics is a human activity [5]. According to Freudenthal, mathematics must be related to reality, close to the students and relevant to the community to be meaningful [6]. Basically realistic mathematics learning is the utilization of reality and the environment experienced by students to optimize the process of learning mathematics. In realistic mathematics learning, the role of teachers as mentors and facilitators [7]. Gravemeijer [7] mentions that the role of the teacher must also change, from a validator (stating whether the student's work and answers are right or wrong), becomes a mentor who respects each student's contribution (work and answers).

From the problem above then the problem formulation in this research was how the spatial ability of the students of class VIII SMP after they followed the teaching learning process using the realistic mathematics approach when they solve the surface area and volume problem of bloks and cubes.

RESEARCH METHOD

The type of the research was a design research developed by Gravemeijer and Cobb. The subject of the research were two students of class VIII in one of private junior high school in Yogyakarta. The analysis involved correct student answers. Data was collected by giving test and condutions interviews on the forms of mathematical spatial ability. The instruments used was test sheets and interview sheets. This research process was carried out from designing hypothetical learning trajectory (HLT), implementation of HLT in learning, and spatial ability test. Data analysis used were data reduction, data presentation, and conclusion. Data reduction is done by sorting data from result of student answer sheet and result of interview which is grouped based on indicator of spatial ability of student, then presented based on indicator of spatial ability of student, and finally the researchers could conclude the students' spatial ability analysis and the strategies students used in solving the problem.

Indicators of spatial ability in this research are (a) drawing the blok composed of unit cubes in the field of two-dimensional, (b) determining the volume of an object composed of the cubes unit in a two-dimensional image, and (c) determining the surface area of the three-dimensional shape composed of the block and cube in the field of two-dimensional.

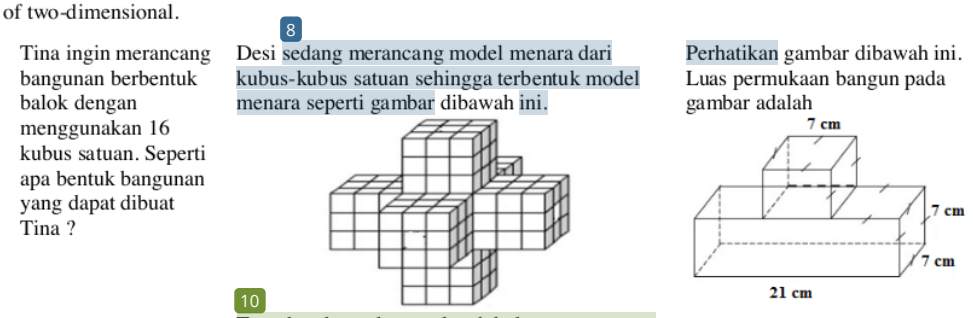


FIGURE 1. Student Test Sheet to Problem Number 1 (a), Problem Number 2 (b), and Problem Number 3 (c)

RESULT AND DISCUSSION

Based on the research process that has been done, explanation of each stages of the research can be describe as follows.

Stage I: **designing hypothetical learning trajectory (HLT).**

The learning objectives are (1) students can rediscover of surface cube and block formulas; (2) students can rediscover of volume of cube and block formulas; (3) students can apply of surface cube and block formulas to

solve mathematic problems; and (4) students can apply of volume of cube and block formulas to solve mathematic problems. Then the researcher built the learning design.

Outline of the learning process using RME approach designed by researchers is to do some learning activities as follows.

Activity I: in the discussion group, students estimated the content of the candy that has been contained a pack of candy. Activity II: In the discussion group, students solved problems about the form of packaging that can be made from 12 candy. Note: researchers have prepare the cubes instead of candy and paper with the size of one unit area as a candy wrapper for each discussion group. Students made presentations, then teachers did a class discussion and guided the discussion so that could construct knowledge about the concept of a factor of the block volume interrelationships between and the length, width and height. Activity III: In the discussion group, students solved the problem of minimal paper needed to wrap 12 candy. Students made presentations, then teachers did a class discussion and guided the discussion so that students could construct knowledge of the block surface area formula. Activity IV: in the discussion group, students solved the problem about the form of candy packaging that can be made from 24 candy. Students made presentations, then teachers did a class discussion and guided the discussion so that students could see some possible answers and students could find the number in each candy was the block volume formula. Then the teacher drew a pack of 24 candy on the black board. The goal was to made the students realize that the packaging is drew on a three-dimensional field and not all parts of candy were look intact. Activity V: in the discussion group, students solved the problem of the content and surface area of the shape three-dimensional composed of unit cubes. Students made presentations, then teachers did a class discussion and guided the discussion so that students could rediscover of the surface area and volume of cube formula. Activity IV: in the discussion group, students solved daily problems by applying of surface and the volume cube and block formulas. Students made presentations, then teachers did a class discussion and guided the discussion so that students could realize that daily problems could be solved by applying of surface and the volume cube and block formulas.

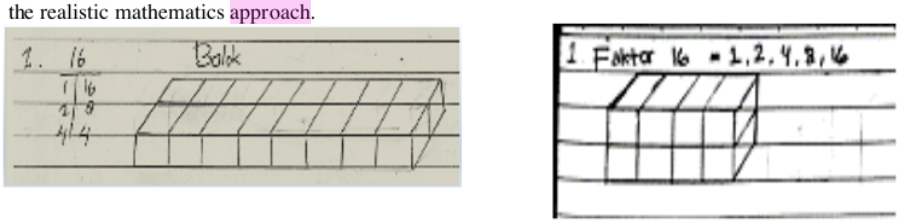
Stage II: **implementation of HLT in learning**.

Implementation of HLT conducted on October 18th and 19th, 2017. The role of teachers in learning activities was as a facilitator and motivator so that students can construct their knowledge.

Stage III: spatial ability test.

The test was given to 21 students on October 20th, 2017. Then the analysis involved two correct student answers. The test results were analyzed based on 3 indicators of spatial ability. Data analysis used were data reduction, data presentation, and conclusion.

Here are the result of spatial ability of students after they followed the teaching learning process using the realistic mathematics approach.



(a) (b)

FIGURE 2. Answers of Student 1 (a) and Student 2 (b) in Problem Number 1

From the **figure 2** shows that the student 1 (S1) and student 2 (S2) were able to draw the blok consisting of cubes unit in the two-dimensions planes. This can be seen from the images that have been made by S1 and S2. Here's one of the student interview transcripts.

P : "What are your steps in solving the first problem?"
S1: "emm, search first factor from 16."
P : "Why are you looking for a factor of 16?"
S1: "to find the length, width, height of the block."

The first step done by S1 and S2 to solve the problem was by first determining factor of 16. Then from that factor determine the length, width and height of blok to be drawn. Based on the results of the answers and interviews it can be concluded that the students were able to draw the block composed of the cubes unit .

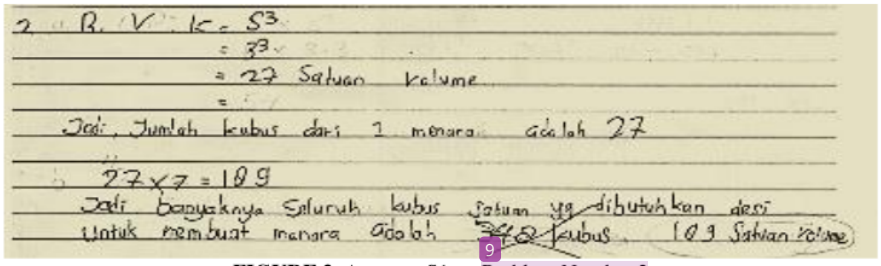


FIGURE 3. Answers S1 on Problem Number 2

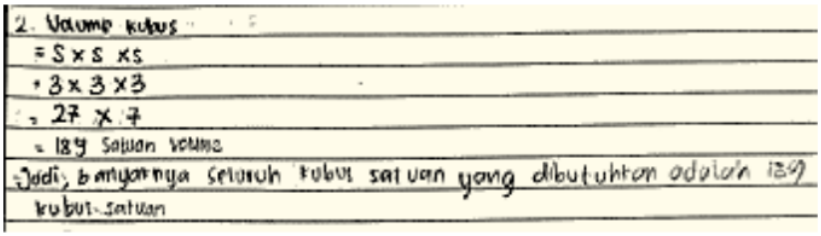


FIGURE 4. Answers S2 on Problem Number 2

Based on the **figure 3** dan **figure 4**, S1 and S2 were able to identify the cube of the tower image. It could be seen when S1 and S2 wrote "27 x 7", meaning that there were 7 cubes of the same with each having the same volume of 27 unit of cubes. Here's the transcript of one of the students:

P: "For the second problem, how did you solve the problem?"

S2: "first search the volume of this tower (pointing to the big cube), the volume is 27 units of volume, then 27 multiplied by the number of towers in this picture there are 7 Mam, this middle tower is not visible".

S1 and S2 were also able to calculate the volume of cubes composed of a unit cube in a two-dimensional plane. This can be seen in the strategy of S1 and S2 to solve problems and interviews. S1 and S2 realized that the unit cube needed to construct the tower that is composed of 7 large cubes with each has a contents of 27 cubes of units

According to Olkun [8], there are three levels of students in calculating the volume of cube consisting of the composition of unit cubes. Which the third level is students understand the arrangement of the cube as an organized cube. At this stage, students understand the iteration pattern of the cube arrangement in columns or rows.

Thus, students can perform jumping calculations such as addition and multiplication of successive iterations. This can be seen when students were able to calculate the units of cubes needed to made towers without counting the cubes of units one by one. Based on the results of student answers and interviews can be concluded that students were able calculate the volume of the three-dimensional shape composed of the block and cube of the two-dimensional field.

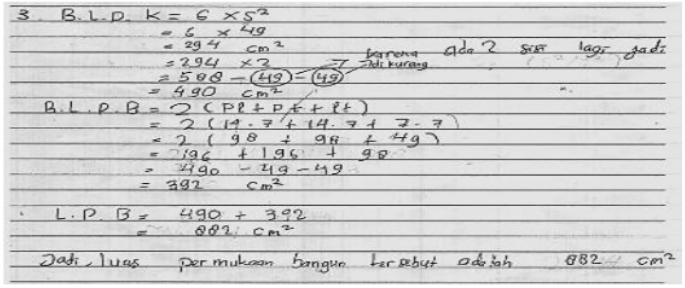


FIGURE 5. Answers S1 on Problem Number 3

From the **figure 5**, the strategy used S1 to determing the surface area of the box was to calculate the surface area of the cube then multiplied by 2 (because students imagine the same 2 cubes) and subtracted the two sides of the cube. Then added to the surface area of the first blok reduced with 2 sides of the side of the blocks. Based on the process that was done, it can be concluded that the way S1 determined the surface area of the box is correct.

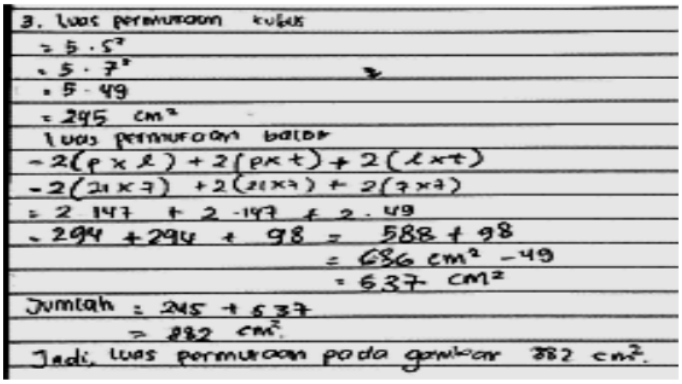


FIGURE 6. Answers S2 on Problem Number 3

From the **figure 6**, the strategy used by S2 to calculate the surface area of the box is to calculate the square area 5 times. Then added to the surface area of the beam which was first deducted with the surface area of one side of the cube. From the process that was done, it can be concluded that the way S2 determined the surface area of the box was correct.

CONCLUSION

From the result of spatial ability analysis seen based on 3 indicators in solving the problem after applied of realistic mathematics learning approach, hence can be made conclusion as follows: (a) Students were able to draw block composed of cubes unit. Students used the concept of a factor of the block volume to determine the length, width, and height of the block. Then the students draw the block in accordance with the length, width, and height that have been obtained; (b) Students have understood the iterative pattern of the cube arrangement in columns and rows, so that students were able calculated the volume of an object composed of the cubes unit that was presented in the two-dimensional image form; (c) Students were able to determine the surface area of the three-dimensional shape composed of block and cube in the two-dimensional image form.

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