

**JUNIOR HIGH SCHOOL STUDENTS' STRATEGY IN SOLVING GEOMETRY
PROBLEM BASED ON MATHEMATICS ABILITY**

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Abstract

This research aims to describe Junior High School students' strategy in solving geometry problem based on mathematics ability. This is a descriptive research with qualitative approach. Subject was chosen from test of mathematics ability result. Subjects are students in class IX-i SMPN 1 Gresik who already studying 3D figure with flat side material. Data research taken from three subject with high mathematics ability and three subject with medium mathematics ability who are given test of solving geometry problem and interview. Based on data analysis, it found that student with high mathematics ability consider writing an equation or open sentences (WE) strategy, drawing picture, acting it out, and using model (DP) strategy, guessing and checking (GC) strategy and logical reasoning (LR) strategy. While student with medium mathematics ability consider writing an equation or open sentences (WE) strategy, drawing picture, acting it out, and using model (DP) strategy, and guessing and checking (GC) strategy. Based on data analysis, teacher are suggested to create learning activity that can stimulate student in using logical reasoning so that their logical reasoning can be developed.

Keywords: strategy, geometry problem, mathematics ability

INTRODUCTION

The purpose of learning mathematics in Junior High School is problem solving (Permendikbud No. 58 Tahun 2014). Hence in learning mathematics, students may faced so many questions. But not all mathematics questions is a problem. Hudojo (in Sukmawati, 2015) state that a question will be a problem if:

1. The question must be understood by the student and he must feel curious to solve it.
2. The question can't be solved by routine procedure which is already known by student.

From those two requirements, it can be concluded that mathematics problem must be understood by student. Student also have to feel curious to solve it. The time needed to solve a problem is not an essential thing because problem can't be solved with routine procedure. In line with Hudojo, Siswono (2008) define problem as a situation or question that faced by an individual or group when they don't have rule or algorithm that can be used to solve it. Based on the explanation, it can be concluded that mathematics problem is problem that make student curious to solve it but can't be solved by routine procedure.

Based on data of TIMSS 2015, mathematics learning achievement of Indonesia is in rank of 45 from 50

country with score 397 from maximal score 700. In addition to that, result of PISA 2015 shows that Indonesia get score 386 from average score 490. It means that mathematics learning achievement of Indonesia is still low and can affect students in solving mathematics problem, especially for geometry problem. Abdussakir (2010) also stated that geometry learning achievement of Indonesia is still low, especially for 3-Dimensional Figure with Flat Side. It may caused so many student still feel difficulty in understanding geometry concept. If student can't understand a concept of geometry, he will feels difficult to understand the next geometry concept that will be learnt, and it can make him feel difficult to solve geometry problem. Aydogdu states that an important factor that affect student in solving geometry problem is the way to choose and apply strategy (Branca, 1980).

There are some strategy that can be used to solve a geometry problem, such as (a) guess and check, (b) draw picture, act it out, use model, (c) logical reasoning, and (d) write an equation or open sentences. Some strategies can be used to solve a problem, but a strategy also can be used to solve some problems. Problem sloving strategy that used by student may be different based on his experience or prior knowledge (Aydogdu, 2014). One factor that may

be influence student in choosing strategy in solving geometry problem is mathematics ability.

Every student have different mathematics ability. Soemarmo (2010) states that mathematics ability is ability of doing math or solve a mathematics problem. Krutetskii (in Kang, 2012) states that mathematics ability is ability to process mathematics information, ability to logical thinking in qualitative and spasial scope of relationship, number and symbol, ability to think in mathematics symbol, and ability to generalize number, relation, and mathematics object. Based on definition of mathematics ability, it can be concluded that the differentiation of mathematics ability in each student can make student choose different strategy to solve geometry problem.

Based on the explanation above, this research is done to describe junior high school students' strategy in solving geometry problem based on mathematics ability.

METHODOLOGY

This is a descriptive research with qualitative approach that aims to describe junior high school students' strategy in solving geometry problem based on mathematics ability. Test of mathematics ability was given to 30 students of ninth graders in order to determine subject. Problems used were adapted from some problem of National Exam of Junior High School of The Year 2016/2017. It was assumed that all problem is already valid. The problems used were adapted into essay form to give opportunity to explore and write the strategy. From the test, six research subjects were chosen, they are three students with high mathematics ability and three students with medium mathematics ability.

Afterwards, was given test of solving geometry problem. Problem used were arranged by researcher under guidance of lecture and validated by a mathematics lecturer and a mathematics teacher. Problem used were in 'analysis category' of bloom taksonomy, the problems are:

1. Determine length, width, and height of a cuboid which have volume of 8 times volume of cuboid A with dimensions 6 cm × 4 cm × 8 cm.
2. Rani wants to make a net of cuboid from a cardboard in size of 150 cm × 100 cm. Determine maximal size of length, width, and height of a cuboid that can be made by Rani.

In addition, subjects were interviewed to gain uncover information in solving test of solving geometry problem

After all test and interview been done, all the data reduced to sort of the important and unimportant data. The important data then analyzed in order to make conclusion of the research.

RESEARCH RESULT AND DISCUSSION

To describe the strategies used, we classified strategies such as (a) guess and check (GC), (b) draw picture, act it out, use model (DP), (c) logical reasoning (LR), and (d) write an equation or open sentences (WE).

Result of Test of Mathematics Ability

Based on the test of mathematics ability, are found one student with low mathematics ability, 8 students with medium mathematics ability, and 21 students with high mathematics ability. By considering students' ability to communicate and solve test of solving geometry problem, were chosen three student with high mathematics ability and three students with medium mathematics ability.

Interview Result

Based on test of solving geometry problem and interview result, analysis of subjects' strategy in solving geometry problem are presented below.

Subjects with High Mathematics Ability

Here result of test of solving geometry problem number 1 of ST1.

$$\begin{aligned}
 6x \times 4x \times 8x &= 12 \times 8 \\
 192x^3 &= 1536 \\
 x^3 &= \frac{1536}{192} \\
 x^3 &= 8 \\
 x &= \sqrt[3]{8} \\
 &= 2
 \end{aligned}$$

Jadi p x l x t Balok yang baru =

$$\begin{aligned}
 6(2) \times 4(2) \times 8(2) \\
 \Downarrow \\
 12 \text{ cm} \times 8 \text{ cm} \times 16 \text{ cm}
 \end{aligned}$$

Figure 1. Strategy of ST1 in Solving Geometry Problem 1

Based on result of test of solving geometry problem number 1, it can be known that ST1 make an equation to find the value of x (WE). ST1 found that x = 2, so the new cuboid has size 12 cm × 8 cm × 16 cm.

Here interview excerpt of ST1's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?
- ST1 : I have to determine length, width, and height of a new cuboid which have volume 8 times volume of Cuboid A, so I multiplied the length, width, and height of Cuboid A with x and it will be equals 8 times volume of Cuboid A, and finally I got x = 2. So the length, width, and height of the new

WE

- cuboid equals length, width, and height of Cuboid A times 2.
- Q : How do you know that your answer is true or false?
- ST1 : I've been calculate the volume of new cuboid and the answer is equals 8 times volume of Cuboid A.

Based on the interview result above, it can be known that ST1 also use write an equation or open sentences (WE) strategy since ST1 make an equation to find size of the new cuboid.

Here result of test of solving geometry problem number 2 of ST1.

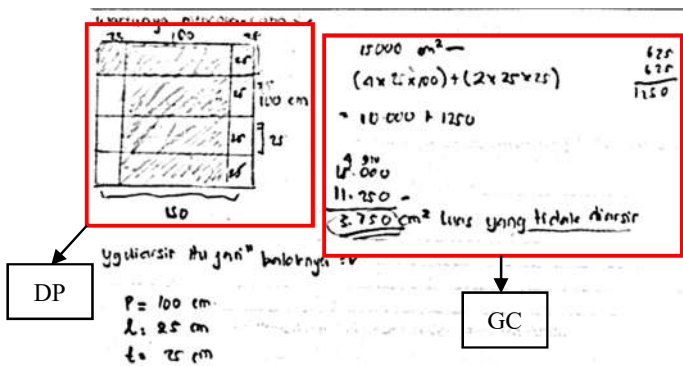


Figure 2. Strategy of ST1 in Solving Geometry Problem 2

Based on the result of test of solving geometry problem number 2, it can be known that ST1 draw the illustration of cardboard, then ST1 draw net of cuboid on it (DP). After that ST1 approximate the size of cuboid that fit it (GC). To check his answer, ST1 subtracting area of cardboard by area of cuboid's net (GC).

Here interview excerpt of ST1's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?.
- ST1 : I have to determine length, width, and height of the cuboid, so I make illustration of the cardboard, then I make net of cuboid on it. After that I determine maximal size of cuboid that fit the cardboard paper.
- Q : How do you that your answer is true or false?
- ST1 : I use my logic, cardboard have size of width 100 cm, while cuboid's net needs 4 rectangles, so I divide 100 with 4 equals 25 cm. So the cuboid have size of width and height 25 cm and size of length 100 cm.

Based on the interview result above, it can be known that ST1 make illustration of the cardboard, then make net of cuboid on it (DP), then by using his logic, ST1 determine maximal size of cuboid that fit the cardboard paper (LR).

Based on the analysis data above, it can be conclude that to solve geometry problem, ST1 consider writing an equation or open sentences (WE) strategy, drawing picture, acting it out, and using model (DP) strategy, guessing and checking (GC) strategy and logical reasoning (LR) strategy.

Here result of test of solving geometry problem number 1 of ST2.

$$V_{\text{balok A}} = 6 \times 4 \times 8 = 192 \text{ cm}^3$$

$$V_{\text{balok baru}} = V_{\text{balok A}} \times 8 = 192 \times 8 = 1536 \text{ cm}^3$$

Panjang : $6 \times 2 = 12 \text{ cm}$

Lebar : $4 \times 2 = 8 \text{ cm}$

tinggi : $8 \times 2 = 16 \text{ cm}$

Figure 3. Strategy of ST2 in Solving Geometry Problem 1

Based on the test of solving geometry problem number 1, it can be known that ST2 find the volume of Cuboid A and the new cuboid. Then ST2 find the size of new cuboid by multiplying length, width, and height of Cuboid A by 2. In the end ST2 check his answer.

Here interview excerpt of ST2's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?
- ST2 : I calculate volume of Cuboid A, then I determine length, width, and height of another cuboid by trying and error. GC
- Q : How do you know that your answer is true or false?
- ST2 : The volume of new cuboid and the answer is equals 8 times volume of Cuboid A. LR

Based on the interview result above, it can be known that ST2 find the size of the new cuboid by trying and error (GC) and ST2 check his answer by using his logic.

Here result of test of solving geometry problem number 2 of ST2.

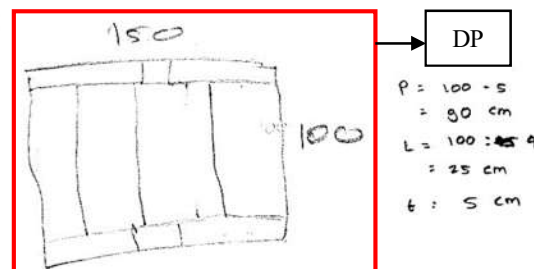


Figure 4. Strategy of ST2 in Solving Geometry Problem 2

Based on the test of solving geometry problem number 2, it can be known that ST2 make an illustration of cardboard and draw net of cuboid on it (DP). After that ST2 determine size of cuboid that fit it.

Here interview excerpt of ST2's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?
 ST2 : I make illustration of the cardboard, then I make net of cuboid on it. After that I determine size of cuboid that fit the cardboard paper.
 Q : How do you that your answer is true or false?
 ST2 : I've been check it.

Based on the interview result above, it can be known that ST2 make illustration of the cardboard, then ST2 make net of cuboid on it (DP). After that I of cuboid that fit the cardboard paper (GC). In the end, ST2 check his answer (GC).

Based on the analysis data above, it can be conclude that to solve geometry problem, ST2 consider drawing picture, acting it out, and using model (DP) strategy, guessing and checking (GC) strategy and logical reasoning (LR) strategy.

Here result of test of solving geometry problem number 1 of ST3.

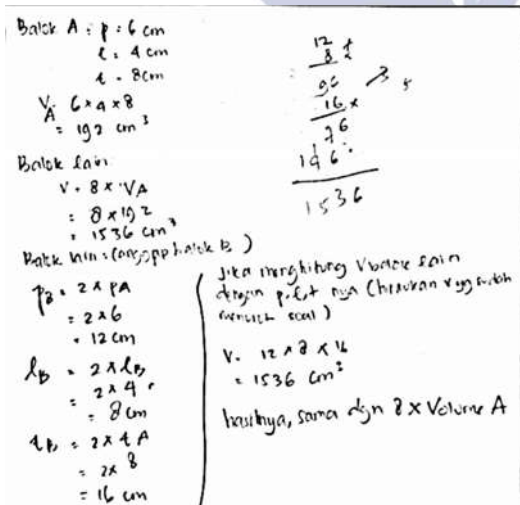


Figure 5. Strategy of ST3 in Solving Geometry Problem 1

Based on the test of solving geometry problem number 1, it can be known that ST3 find the volume of Cuboid A and another cuboid. Then ST3 find the size of new cuboid by multiplying length, width, and height of Cuboid A by 2. In the end ST3 check his answer.

Here interview excerpt of ST3's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?

- ST3 : First, I multiply length, width, and height of Cuboid A by 8 to find length, width, and height of new cuboid. But when I check it, it was false. Then I try again by multiplying length, width, and height of Cuboid A by 4 to find length, width, and height of new cuboid. But when I check it, it was false again. I try again by multiplying length, width, and height of Cuboid A by 2 to find length, width, and height of new cuboid. Finally volume of new cuboid equals 8 times volume of Cuboid A.
 Q : How do you know that your answer is true or false?
 ST3 : I calculate the volume of new cuboid and the answer is equals 8 times volume of Cuboid A.

Based on the interview result above, it can be known that ST3 find the size of the new cuboid by trying and error (GC) and ST3 check his answer by using his logic.

Here result of test of solving geometry problem number 2 of ST3.

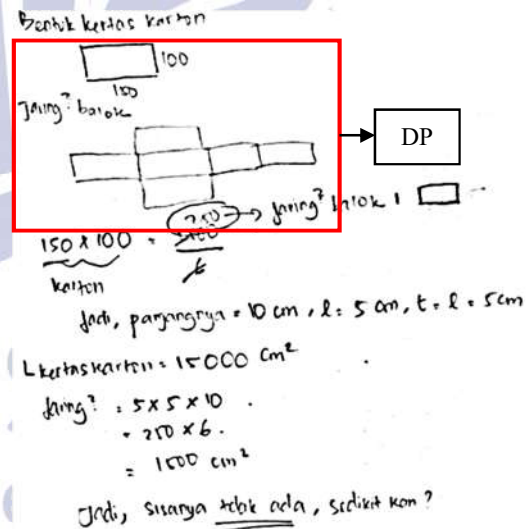


Figure 6. Strategy of ST3 in Solving Geometry Problem 2

Based on the test of solving geometry problem number 2, it can be known that ST3 make illustration of cardboard and net of cuboid (DP). Then ST3 calculate the area of cardboard and divided it by 6 equals 250 cm. After that ST3 find the factors of 250 equals 10 x 5 x 5. So ST3 decide that size of the new cuboid is 10 x 5 x 5 cm. The last, ST3 check his answer.

Here interview excerpt of ST3's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?.

- ST3 : I make illustration of the cardboard and net of cuboid. Then I calculate the area of cardboard and divided it by 6 equals 250 cm. After that I find the factors of 250 equals $10 \times 5 \times 5$. So I decide that size of the new cuboid is $10 \times 5 \times 5$ cm. In the last, I check my answer.
- Q : How do you that your answer is true or false?
- ST3 : I've been check it.

DP

Based on the interview result above, it can be known that ST3 make illustration of cardboard and net of cuboid to determine size of new cardboard (DP).

Based on the analysis data above, it can be conclude that to solve geometry problem, ST3 consider drawing picture, acting it out, and using model (DP) strategy, guessing and checking (GC) strategy and logical reasoning (LR) strategy.

Based on the analysis data of subject with high mathematics ability above, it can be concluded that in solving geometry problem, student with high mathematics ability ST1 consider writing an equation or open sentences (WE) strategy, drawing picture, acting it out, and using model (DP) strategy, guessing and checking (GC) strategy and logical reasoning (LR) strategy.

Subjects with Medium Mathematics Ability

Here result of test of solving geometry problem number 1 of SS1.

diketahui : Berat a = paku-paku 6cm
 lebar = 9cm
 tinggi = 8cm

ditanya : p, l, t ?

dijawab :

Berat A : p = 6cm
 l = 9cm
 t = 8cm

$$V_A = p \times l \times t$$

$$= 6 \times 9 \times 8$$

$$= 152 \text{ cm}^3$$

Berat lain

$$V = l \times p \times t$$

$$= 8 \times 9 \times 2$$

$$= 1036 \text{ cm}^3$$

Berat lain = (angka berat a)

$$p = 2 \times p_A$$

$$= 2 \times 6$$

$$= 12$$

$$l = 2 \times l_A$$

$$= 2 \times 9$$

$$= 18 \text{ cm}$$

$$t = 2 \times t_A$$

$$= 2 \times 8$$

$$= 16 \text{ cm}$$

$V = 12 \times 18 \times 16$
 $= 1036 \text{ cm}^3$
 hasilnya, sama dgn dgn volume A

Figure 7. Strategy of SS1 in Solving Geometry Problem 1

Based on the test of solving geometry problem number 1, it can be known that SS1 find the volume of Cuboid A and another cuboid. Then SS1 find the size of new cuboid by multiplying length, width, and height of Cuboid A by 2. In the end SS1 check his answer.

Here interview excerpt of SS1's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?
- SS1 : First, I write what is known, then I find volume of Cuboid A and the new cuboid. After that I determine length, width and height of new cuboid.
- Q : How do you know that your answer is true or false?
- SS1 : I will open my book or ask to teacher.

GC

Based on the interview result above, it can be known that SS1 find volume of Cuboid A and the new cuboid. After that SS1 determine length, width and height of new cuboid (GC).

Here result of test of solving geometry problem number 2 of SS1.

Buatlah kardus kardus

$100 \times 100 = 10000$

panjang = 10 cm, lebar = 6 cm

L kardus = 10000 cm^2

panjang = $10 \times 6 \times 10 = 600 \text{ cm}^3$

jadi panjang, lebar dan

DP

Figure 8. Strategy of SS1 in Solving Geometry Problem 2

Based on the test of solving geometry problem number 2, it can be known that SS1 make illustration of cardboard and net of cuboid (DP). Then SS1 calculate the area of cardboard and divided it by 6 equals 250 cm. After that SS1 find the factors of 250 equals $10 \times 5 \times 5$. So SS1 decide that size of the new cuboid is $10 \times 5 \times 5$ cm. The last, SS1 check his answer.

Here interview excerpt of SS1's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?
- SS1 : I just calculate the area of cardboard and divided it by 6 then I determine size of the new cuboid.
- Q : How do you that your answer is true or false?
- SS1 : I will ask to mathematics teacher.

Based on the interview result above, it can be known that SS1 calculate area of cardboard then determine size of the new cuboid.

Based on the analysis data above, it can be conclude that to solve geometry problem, SS1 consider drawing picture, acting it out, and using model (DP) strategy and guessing and checking (GC) strategy.

Here result of test of solving geometry problem number 1 of SS2

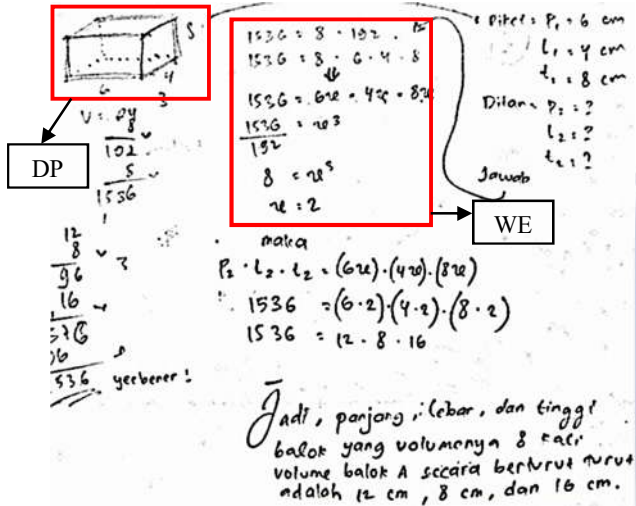


Figure 9. Strategy of SS2 in Solving Geometry Problem 1

Based on result of test of solving geometry problem number 1, it can be known that SS2 draw illustration of cuboid (DP), then SS2 make an equation to find the value of x (WE). SS2 found that $x = 2$, so the new cuboid has size 12 cm \times 8 cm \times 16 cm.

Here interview excerpt of SS1's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?
- SS1 : I multiplied the length, width, and height of Cuboid A with x and finally got $x = 2$. So the length, width, and height of the new cuboid equals length, width, and height of Cuboid A times 2.
- Q : How do you know that your answer is true or false?
- SS1 : I don't know

Based on the interview result above, it can be known that ST1 also use write an equation or open sentences (WE) strategy since SS1 make an equation to find size of the new cuboid.

Here result of test of solving geometry problem number 2 of SS2.

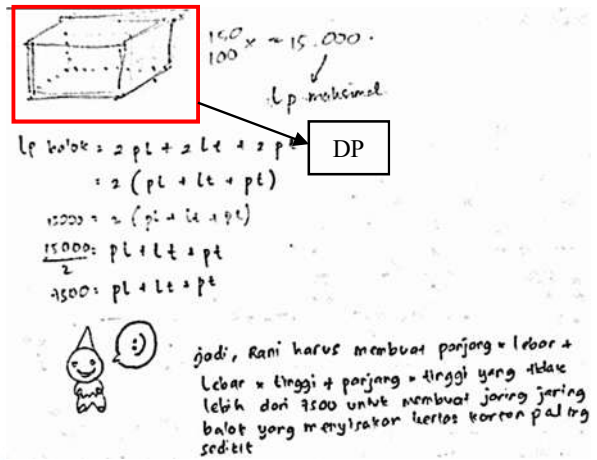


Figure 10. Strategy of SS2 in Solving Geometry Problem 2

Based on the test of solving geometry problem number 2, it can be known that SS2 draw illustration of cuboid (DP), then calculate area of cardboard. By using formula of surface area of cuboid, SS2 find that $pl + lt + pt$ of the cuboid has not greater than 7500 cm^2 .

Here interview excerpt of SS2's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?
- SS2 : I just calculate the area of cardboard, then by using formula of surface area of cuboid, SS2 find that $pl + lt + pt$ of the cuboid has not greater than 7500 cm^2 .
- Q : How do you that your answer is true or false?
- SS2 : I will ask to mathematics teacher.

Based on the interview result above, it can be known that SS2 calculate area of cardboard then find that $pl + lt + pt$ of the cuboid has not greater than 7500 cm^2 .

Based on the analysis data above, it can be conclude that to solve geometry problem, ST1 consider writing an equation or open sentences (WE) strategy and drawing picture, acting it out, and using model (DP) strategy.

Here result of test of solving geometry problem number 1 of SS3.

$$\begin{aligned}
 V &= p \cdot l \cdot t \\
 &= 8 \cdot 9 \cdot 8 \\
 &= 192 \text{ cm}^3 \\
 \\
 V_{\text{balok lain}} &= 492 - V_{\text{balok A}} \cdot 8 \\
 &= 8 \cdot 192 \\
 &= 1536 \text{ cm}^3 \\
 \\
 p &= 6 \cdot 2 \\
 &= 12 \text{ cm} \\
 l &= 9 \cdot 2 \\
 &= 8 \text{ cm} \\
 t &= 8 \cdot 2 \\
 &= 16 \text{ cm}
 \end{aligned}$$

Figure 11. Strategy of SS3 in Solving Geometry Problem 1

Based on the test of solving geometry problem number 1, it can be known that SS3 find the volume of Cuboid A and the new cuboid. Then SS3 find the size of new cuboid by multiplying length, width, and height of Cuboid A by 2. In the end SS3 check his answer.

Here interview excerpt of SS3's strategy in solving geometry problem number 1.

- Q : Can you explain your answer in solving the first problem?
 SS3 : My answer is 1536 cm^3 .
 Q : How do you know that your answer is true or false?
 SS3 : I'm not check it.

Based on the interview result above, it can be known that SS3's answer is 1536 cm^3 .

$$\begin{aligned}
 \text{Lp balok} &= 2 \cdot (p \cdot l + p \cdot t + l \cdot t) \\
 &= 2 (150 \cdot 100 + 150 \cdot t + 100 \cdot t) \\
 &= 2 (15000 + 250 t) \\
 &= 30000 + 500 t \\
 t &= \frac{30000}{2500} = 120 \text{ cm} \\
 &=
 \end{aligned}$$

Figure 12. Strategy of SS3 in Solving Geometry Problem 2

Based on the test of solving geometry problem number 2, it can be known that SS3 use formula of surface area of cuboid and find the height of the cuboid is 120 cm.

Here interview excerpt of SS2's strategy in solving geometry problem number 2.

- Q : For problem number two, can you explain your answer?
 SS2 : My answer for height of cuboid is 120 cm.

- Q : How do you that your answer is true or false?
 SS2 : I still don't understand, but my answer is 120 cm.

Based on the interview result above, it can be known that SS3 find the height of cuboid is 120 cm.

Based on the analysis data above, it can be conclude that to solve geometry problem, SS3 consider guessing and checking (GC) strategy.

Based on the analysis data of subject with medium mathematics ability above, it can be concluded that in solving geometry problem, student with medium mathematics ability ST1 consider writing an equation or open sentences (WE) strategy, drawing picture, acting it out, and using model (DP) strategy, and guessing and checking (GC) strategy.

The Differences of ST and SS's Strategies

In solving test of solving geometry problem, ST and SS use write an equation or open sentences (WE) strategy in solving the first problem, but this strategy is rarely used. ST and SS also use drawing picture, act it out, and uses model (DP) strategy in solving the second problem. In solving the first and second problem, sometimes ST and SS also use guess and check (GC) strategy. ST can use drawing picture and guess and check together and they can get the answer, meanwhile SS still have some wrong guessing. However, ST usually also use logical reasoning (LR) strategy, while SS actually states that he also uses it but in the reality, their logic is not logic. In the end, ST can solve what is asked in the problem although there are some uncorrect answer, meanwhile SS can't solve what is asked in the second problem. This result is in line with Krutetskii (in Kang, 2012) that student with high mathematics ability have better logical reasoning than student with medium mathematics ability.

CONCLUSION AND SUGGESTION

Conclusion

Based on the result of analysis and discussion of test of solving geometry problem and interview, it can be concluded that:

1. Student with high mathematics ability uses write an equation or open sentences (WE) strategy, drawing picture, act it out, and uses model (DP) strategy, guess and check (GC) strategy and logical reasoning (LR) strategy.
2. Student with medium mathematics ability uses write an equation or open sentences (WE) strategy, drawing picture, act it out, and uses model (DP) strategy, and guess and check (GC) strategy.

Suggestion

Based on the conclusion above, it shows that junior high school student can use some strategy in solving geometry problem, but some student still have difficult in use logical reasoning strategy. So in learning mathematics especially for geometry, hopefully teacher can make learning activity that stimulate student to logical reasoning so that their logical reasoning can be developed.

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