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MATHEMATICS ANALOGY REASONING ABILITY OF JUNIOR HIGH SCHOOL STUDENTS IN SOLVING PROBLEMS OF PYRAMID

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ABSTRACT

Mathematical analogy reasoning ability is a skill in drawing conclusions based on the similarities between the two things being compared. This study aims to describe students' mathematical analogy reasoning abilities on pyramid material in grade eight junior high school students. This research is qualitative with a case study approach. The subject of this study was grade eight at one of the junior high school students in the city of Bandung, totaling 20 students. The research instrument used in this study was essay test of the mathematical analogy reasoning abilities and has been tested for feasibility. The results of this study were that there was two students who mastered 4 indicators, 2 students mastered 3 indicators, 5 students mastered 2 indicators, 5 students mastered one indicator, and there were 6 students who did not master any of the indicators. Furthermore, 5 out of 20 students were able to identify source problems by looking for the characteristics or structure of the problem (Encoding), 13 out of 20 students were able to find relationships or solve source problems (Inferring), 3 out of 20 students were able to find the same relationship between source problem with target problem and build conclusions from the similarity of the relationship between problem one and question two (Mapping), 8 out of 20 students were able to select the correct answer and were able to explain the analogy or similarity used between the source problem and the problem targets (Applying).
Keywords: Analogical Reasoning Ability, Mathematics, Problem Solving

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PRELIMINARY

Reasoning is a systematic and logical thinking process. Reasoning ability is an important aspect in learning mathematics. this is evidenced in the applicable curriculum in Indonesia mentioned in (BSKAP decision Number 008/KR/2022) one of the objectives of learning mathematics set by the Indonesian government is for students to use reasoning on patterns and characteristics. Reasoning ability in mathematics is a part that influences the pattern of logical, analytical and critical thinking (Magdaş, 2015). Reasoning ability in mathematics is an ability to use rules, properties or mathematical logic to get a correct

conclusion (Izzah & Azizah, 2019). reasoning ability is something that must continue to develop and have different life stages for each individual and this is important in knowledge (Destiana et al., 2020). One type of reasoning in mathematics is analogical reasoning.

According to Kariadinata one of the efforts to grow reasoning and explore memory is to provide a form of learning that places more emphasis on mathematical analogies (Rahmawati, 2017). Genter stated that analogical reasoning is a type of reasoning that applies between specific examples or cases, where what is known about one example is used to infer new information about other examples (Gentner, 2013). Meanwhile, Diane said that analogical thinking is the skill of thinking about something new that is obtained from something that was previously known, taking into account the similarities between the two things. Furthermore, he said that a good analogy can facilitate understanding and recall of something learned. Likewise analogies in mathematics, Syamsul (2012) says that the ability to make mathematical analogies is a skill in drawing conclusions from two different things based on similarities (Agusantia & Juandi, 2022).

Analogical reasoning ability is important to discuss because it is very influential for students' success in understanding and solving mathematical problems but the facts show that students' mathematical analogy abilities are still low. This can be seen in the research that has been conducted by Fatimah & Imami (2021) the results of the research show that students' analogous reasoning is classified as low. In line with this , the results of a Global Institute survey of students in Indonesia regarding reasoning abilities, it is known that only 5% of students in Indonesia are able to answer high-category questions that require reasoning. Meanwhile, as many as 78% of students in Indonesia are able to work on questions that require memorization (Daniarti et al., 2015).

Analogy can be used as an explanation or as a basis for reasoning. How to compare two problems in analogy thinking using source problems and target problems. The source problem is a problem that has been studied before which is related to the next material to be studied. The target problem is the problem to be solved by looking for similarities from the source problem. Solving problems using analogical reasoning needs to involve components of analogical reasoning. Several studies have discussed the components of analogical reasoning to solve a mathematical problem. There are 4 components of analogical reasoning, namely encoding, inferring, mapping, and applying (Sternberg, 1977). In Agusantia & Juandi (2022) suggests the analogy thinking process includes activities: (1) encoding is identifying source problems and target problems by looking for

the characteristics or structure of the problem, (2) inferring is looking for links that exist in the source problem or it is said searching, (3) mapping is looking for links between the source problem and the target problem in terms of building conclusions from the similarity of the relationship between the two problems, (4) applying is selecting the right answer, useful for providing the appropriate concept (building a balance) between the source problem and the target problem.

Previous research regarding mathematical analogy reasoning was conducted by Nurhalimah (2021); Fatimah & Imami (2021) has not described students' mathematical analogy reasoning abilities in each indicator, researchers only grouped students' analogical reasoning abilities into three levels of high, medium, and low analogical reasoning abilities. So in this study will describe the reasoning ability of mathematical analogy of pyramid on grade VIII junior high school students based on each indicator as proposed by Stenberg.

Based on the description that has been presented, it is important to conduct further investigations regarding students' mathematical analogy reasoning abilities . So that in this study, the scope studied was the four stages of the mathematical analogy of class VIII junior high school students in the material of pyramids.

METHODS

The research method used in this research is qualitative with a case study approach. The aim of this study was to describe the ability to think mathematically analogy in junior high school students in solving pyramidal problems. The research subjects in this study were 20 grade VIII B of the junior high school students in the city of Bandung. Data collection techniques in this study were test techniques and direct communication techniques (interviews). The instruments used in this study were analogical reasoning ability tests and interviews. The analogical reasoning ability test aims to determine students' analogical reasoning abilities in the pyramid material. The research data that has been collected is then analyzed descriptively based on test results and interviews. Interviews were conducted with two students as subject samples aimed at obtaining data that were not revealed through analogical reasoning ability tests. while two students were selected based on students whose answers were closest to the indicators and did not meet the indicators. The data collection tool used is a question of mathematical analogy reasoning ability tests adopted from (Safrina, 2016) which have been validated and interview guidelines. The mathematical analogy reasoning test questions are in the form of

a written test that is used to find out how mathematical analogy reasoning is made in the material of pyramids for class VIII junior high school students which consists of 4 questions. The preparation of the test is based on problem solving indicators using analogical reasoning put forward by Stenberg (1977). The indicators used in this study are from Stenberg (1997):

Table 1. Indicators of Analogical Reasoning Ability

No question.	Analogy Reasoning Indicator	
1.	*Encoding*	Students are able to identify source problems and target problems by looking for the characteristics or structure of the problem
2.	*Inferring*	Students are able to look for relationships or solve source problems
3.	*mapping*	Look for the same relationship between problem one (source problem) and question two (target problem) or build conclusions from the similarity of the relationship between problem one and problem two. Identify relationships.
4.	*Applying*	Students are able to select answers, solve the target problem correctly and can explain the analogy (similarity) used between question one and question two. Identify relationships.

Data analysis techniques in this study consisted of data collection, data reduction, data presentation, and drawing conclusions. The data collected in this study are the results of mathematical analogy reasoning abilities of Grade VIII students of junior high school obtained through tests of analogy abilities and interview results. The results of the interviews were used to obtain in-depth information about students' analogy reasoning abilities. After the data is collected, the data is reduced, namely where the research data is summarized, the main information is selected, and the focus is on information that is important and data that is considered not to need to be reduced. The data and information obtained from the data reduction stage are then presented in the form of tables and narrative text to make it easier for researchers to understand the data and make it easier to draw conclusions based on the results of the research that has been done. The final step is drawing conclusions that aim to clarify the findings obtained by researchers. To test the validity of the data, technical triangulation was used, namely by comparing the analysis of students' analogical reasoning abilities obtained from the answers of research subjects with the results of interviews with research subjects.

RESULT AND DISCUSSION

This study aims to describe students' mathematical analogy reasoning abilities on the topic of pyramids based on the indicators proposed by Stenberg (1977). To find out students' mathematical analogy reasoning abilities, the researcher tested 4 questions on

subjects where each of these questions represented one indicator. The findings from this study were that there were 2 students who mastered 4 indicators, 2 students mastered 3 indicators, 5 students mastered 2 indicators, 5 students mastered one indicator, and there were 6 students who did not master any of the indicators. Furthermore, 5 out of 20 students were able to identify source problems by looking for the characteristics or structure of the problem (Encoding), 13 out of 20 students were able to look for relationships or solve source problems (Inferring), 3 out of 20 students were able to find the same relationship between problem one (source problem) with problem two (target problem) and build conclusions from the similarity of the relationship between problem one and problem two (Mapping), 8 out of 20 students were able to select the correct answer and were able to explain the analogy (similarity) used between the source problem and the problem target (Applying). The following is a description of students' mathematical analogy reasoning abilities based on each indicator:

Encoding : Identifying source problems by looking for the characteristics or structure of the problem

This indicator is represented by a problem regarding the properties of squares and triangles. The questions presented are in the form of a figure of a square with side lengths of the square and a picture of a triangle with a known height and base. Students are required to mention the properties or characteristics of squares and triangles in the form of words obtained through observing square and triangle figure. The encoding stage requires students to be able to understand each problem and the elements in it.

Figure I. to answer questions (a) and (b)

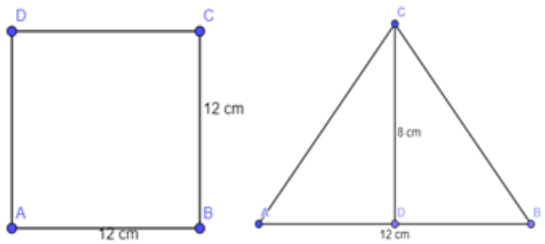


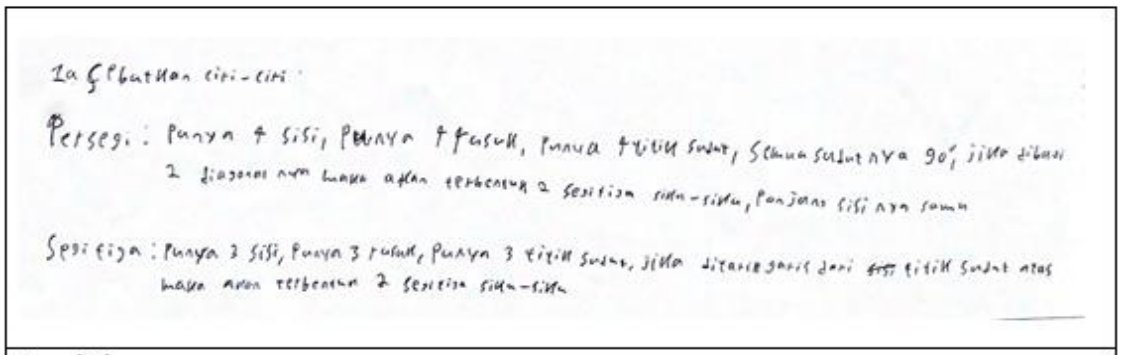
Figure I

(a) Mention the characteristics of the two flat shapes!

Figure 1. First Indicator Question

Based on the results of the analysis of student answers, it was found that only 5 out of 20 met the Encoding indicator , which means students were able to identify the source problem by looking for the characteristics or structure of squares and triangles in the questions. While the other 15 students were only able to mention one or two properties of a rectangle but were not able to mention these properties specifically. For example, students

only mention "4 equal angles" but do not mention the angles value are. From the answers of these 15 students, the most dominant characteristic mentioned was having sides that are the same length and some students did not mention the properties of triangles. This is in line with Zamawi (2014) Encoding is a process in which students identify (coding) known information, information that is asked, as well as information that is explicitly unwritten which is useful in solving source problems and target problems. For students who do not meet the encoding indicator, it means that students cannot find the information listed, as well as explicit information that is not written.



Translation:
Mention the characteristics:
Square: has 4 sides, has 4 edges, has vertices, all angles is 90°, if 2 diagonals are made, 2 right triangles will be formed, side lengths are the same
Triangle: has 3 sides, has 3 edges, has 3 vertices, if a line is drawn from the upper vertex, 2 right triangles will be formed

Figure 2. Results of Subjects' Answers that Meet the First Indicator

Based on Figure 2, it can be seen that students are able to mention the properties of squares and triangles in the form of words obtained through observing the given square and triangle. Confirmed through interviews as follows.

Researcher : Have you studied the materials for flat shapes and geometric shapes?

Subject : Already

Researcher : What plane shapes are listed in the problem and can you mention the characteristics of the two plane shapes?

Subject : First there is a square, the characteristics of which are four sides and four vertices and have the same size on each side. and a triangle that has three sides, three edges, and three vertices.

Based on the interview results, students are able to define and know what is in the picture so that they are able to mention the properties of squares and triangles is correctly.

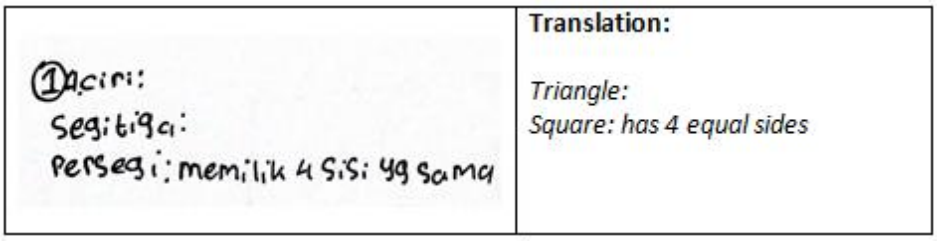


Figure 3. Results of Subjects' Answers that Did Not Meet the First Indicator

Based on Figure 3, it can be seen that students are able to name the shape of the flat shapes presented, but have not been able to mention the properties of the figure that is presented. Students only wrote "has 4 equal sides " for a square shape while for a triangle the students did not write any properties. Student difficulties are confirmed through interviews as follows.

Researcher : Has the material been studied?
Subject : Some have and some haven't
Researcher : What kind of space is contained in the problem?
Subject : Square and triangle
Researcher : Can you mention the characteristics of the flat shape?
Subject : A square has four equal sides
Researcher : Is there anything else?
Subject : Corner

when asked students are still very difficult to mention the characteristics that exist in square and triangular flat shapes. This is in accordance with research by Utami et al. (2020); (Suningsih & Istiani, 2021) which stated that students' verbal abilities were still deficient.

Inferring : looking for relationships or solving source problems

This indicator is represented by a question about the area of squares and triangles presented in the same image as problem a, where the length and width of the square are known, the height and base of the triangle are also known. Students are required to apply the concept of the area of a square and triangle to calculate the area of the flat shape. The inferring stage focuses on determining the solution to the source problem (Iqlima & Susanah, 2020). So that at this stage the ability of students to determine the mathematical concepts used to solve the given problem will be seen.

Figure I. to answer questions (a) and (b)

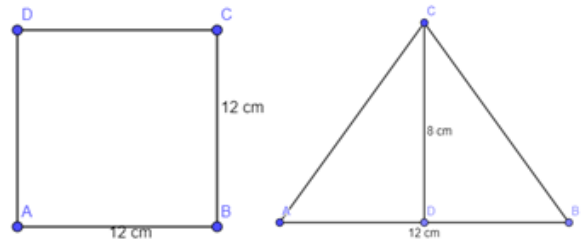


Figure I

(b) Calculate the area of the two flat shapes!

Figure 4. Second Indicator Question

Based on the analysis of students' answers to these questions, it was found that 13 out of 20 students met the Inferring indicator , which means students were able to solve the source problem in question b correctly. Students can calculate the area of squares and triangles using square and triangle formulas correctly. The other 7 students have not fulfilled the Inferring indicator.

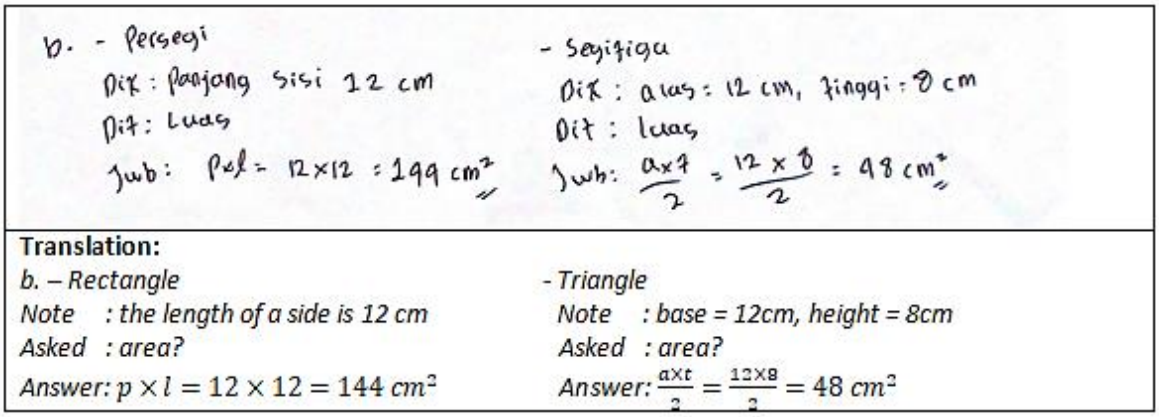


Figure 5. Results of Subjects' Answers that Meet the Second Indicator

Based on Figure 5, it can be seen that students have been able to solve the source problem correctly, students can find the area of squares and triangles by first writing down what is known in the problem, being asked, and calculating the area of squares and triangles using the formulas they have learned before. It can be seen that the students' calculations are also correct, so the students have fulfilled the second indicator, namely inferring. And confirmed through interviews as follows.

Researcher : How do you do the problem?

Subject : Using the area of the square formula, which is 12×12 equals 144. To find the area of a triangle using the formula $\frac{a \times t}{2}$, the result is 48 out of $\frac{12 \times 8}{2}$

Researcher : Before searching, have you memorized the formula?

Subject : At first I tried and finally remembered the area formula.

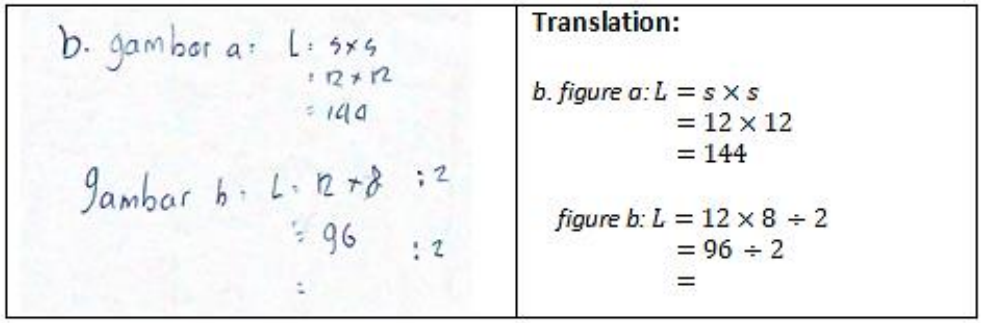


Figure 6. Results of Subjects' Answers that Did Not Meet the Second Indicator

Based on Figure 6, it can be seen that the students' work was not preceded by writing down the elements that were known and asked. Students who do not write down the elements that are known and asked do not know the purpose of the questions given (Sakinah & Hakim, 2023)and also have difficulties in solving problems (Fadilah & Hakim, 2022). For a rectangular shape, the sides are correct by using the formula $s \times s$ to find the area of a square, the calculation results are also correct, it's just that the students don't write down the units for the area of the flat shape. In line with the research findings (Fauzi & Arisetyawan, 2020) that students did not pay attention to the unit area, they did not include the unit. This error is called a fact error.

Students do not complete the calculation for the area of a triangle and do not write down the formula for a flat triangle. Based on the results of interviews that students do not memorize the flat shape formula presented. Confirmed through interviews as follows.

Researcher : How do you solve the following questions?
Subject : Forgot
Researcher : Forgot the formula?
Subject : Yes
Researcher : Why don't you solve the area of the triangle?
Subject : I don't know, like my brain doesn't work.

In line with research findings (Rusmita et al., 2017) the factors that cause errors are students not memorizing formulas of two-dimentional figure. So it can be said that students have not fulfilled the second indicator, namely they have not been able to solve the source problem correctly (inferring).

Mapping : look for relationships and draw conclusions

This indicator is represented by one item regarding the relationship between the source problem and the target problem. In line with the statement (Sakinah & Hakim, 2023) This indicator relates to students' ability to build conclusions from the similarity of

the relationship between the source problem and the target problem. Mapping can be done if students can see a higher relationship between the two problems and then conclude their similarities. The questions presented are in the form of a pyramid shape and the process of forming rectangular pyramid nets. Students are required to look for similarities between Figure I and Figure II, as well as provide conclusions obtained from Figure II in accordance with the Mapping indicator where students can look for relationships in order to create student analogical reasoning to help solve target questions.

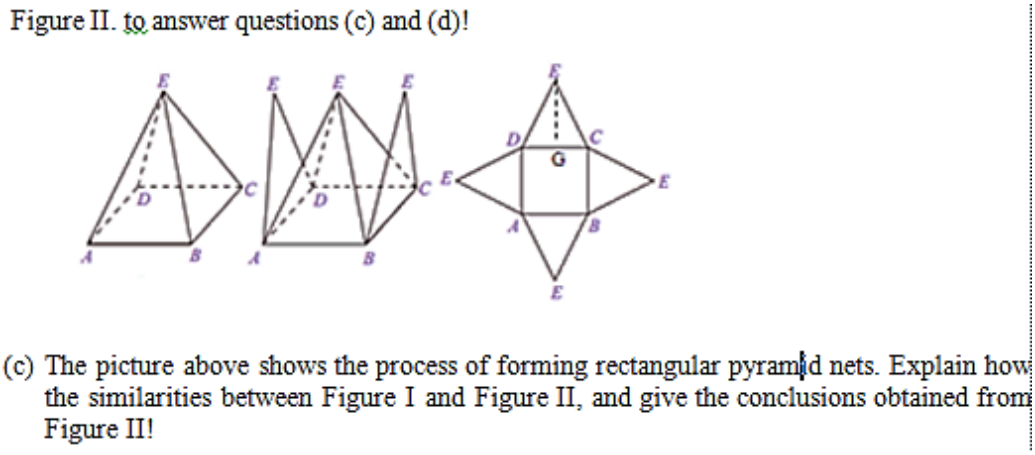


Figure 7. Problem of the Third Indicator

Based on the results of the analysis of student answers. it was found that only 3 out of 20 students were able to find the same relationship between figure I (source problem) and figure II (target problem) and build conclusions from the similarity of the relationship between source problems and target problems (mapping) . The other 15 students were not yet precise in making conclusions about the similarity of the relationship between the source problem and the target problem. Like just mentioning that the similarity of the two "both have sides and angles". While 2 other students did not answer questions on the third indicator. The following is a description and discussion of some of the student answers:

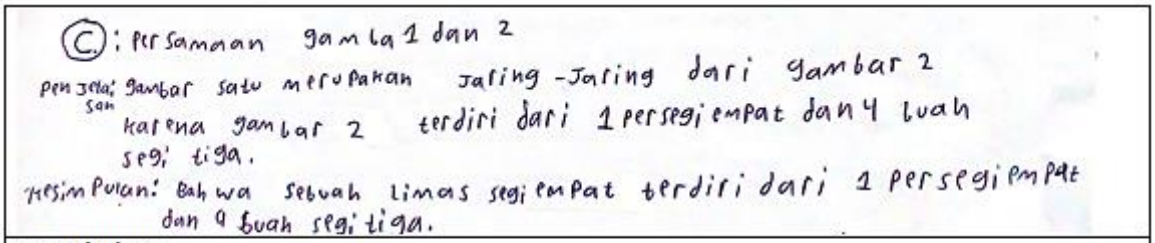


Figure 8. Results of Subjects' Answers that Meet the Third Indicator

Based on Figure 8, it can be seen that the students wrote down the explanation first and then concluded it correctly, namely that a rectangular pyramid consists of 1 square and 4 triangles. students have fulfilled the third indicator (Mapping) in which students know that there is the same structure and information between the questions from the source problem and the target problem questions and can map the relationship between the two information. Confirmed through interviews as follows.

Researcher : Are there similarities in Figure 1 and Figure 2, Figure one is a rectangular and triangular shape, while Figure 2 is a pyramid net and a pyramid shape?

Subject : Yes. on the pyramid there are square and triangular flat shapes, on the base there is a square like picture 1 and there are four triangles that are the same as picture a, namely isosceles triangles

Researcher : What can you conclude?

Subject : So the pyramid consists of one square and four isosceles triangles.

Based on interviews students are able to see the relationship between source problems and target problems so students can mention analogies in questions.

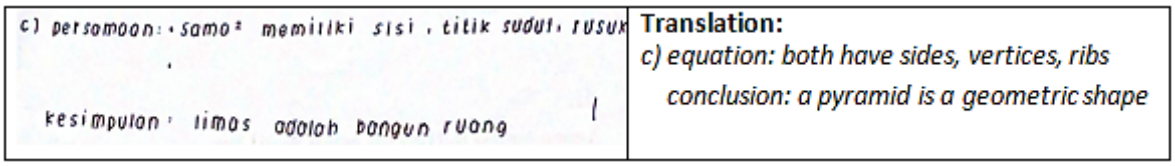


Figure 9. Results of Subjects' Answers that Did Not Meet the Third Indicator

Based on Figure 9, it can be seen that students can mention some basic equations by writing down the properties of flat shapes such as having sides, vertices and edges. However, the students did not mention the names of the flat shapes in figure I and figure II. It can also be seen that students wrote inaccurate conclusions, namely "a pyramid is a geometric shape" it is true that Figure II is a pyramid shape, but students have not fulfilled the analogy thinking process to see what the relationship between Figure I and Figure II is. Based on interviews students could not see the relationship between the source problem and the target problem. Kurniasih & Hakim (2019) argue that the inability of students to draw the right conclusions is because it is difficult to check information.

Applying : choosing the right answer and being able to explain the analogy (similarity) used between the source problem and the target problem

This indicator is represented by a question about the area of the pyramid which is presented in the same image as question c, knowing the length of the sides and the height of the triangle. Students are required to apply the analogy to the concept of the area of a

square and triangle that was previously worked on in question b and apply it to calculate the area of the pyramid.

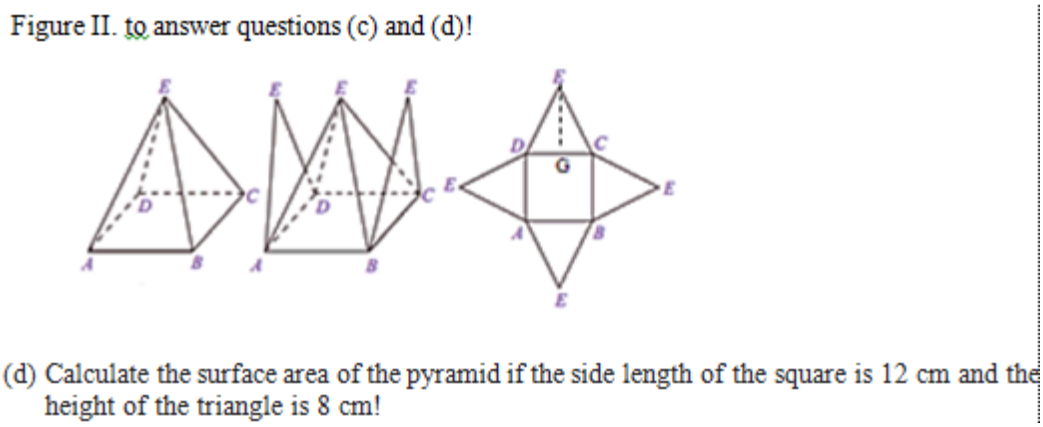


Figure 10. Fourth Indicator Question

Based on the results of the analysis of student answers, it was found that 8 out of 20 students were able to choose the right answer and be able to explain the analogy (similarity) used between the source problem and the target problem (applying). 8 other students did not fulfill the fourth indicator correctly. For example, students only write down the formula for the surface area of a pyramid without first writing down the solutions for the areas of squares and triangles. According to Hakim & Daniati (2014) students must master concepts in solving problems and use them in dealing with new situations by combining the skills acquired. While the other 4 students did not answer the fourth indicator question. Here are some descriptions of student answers:

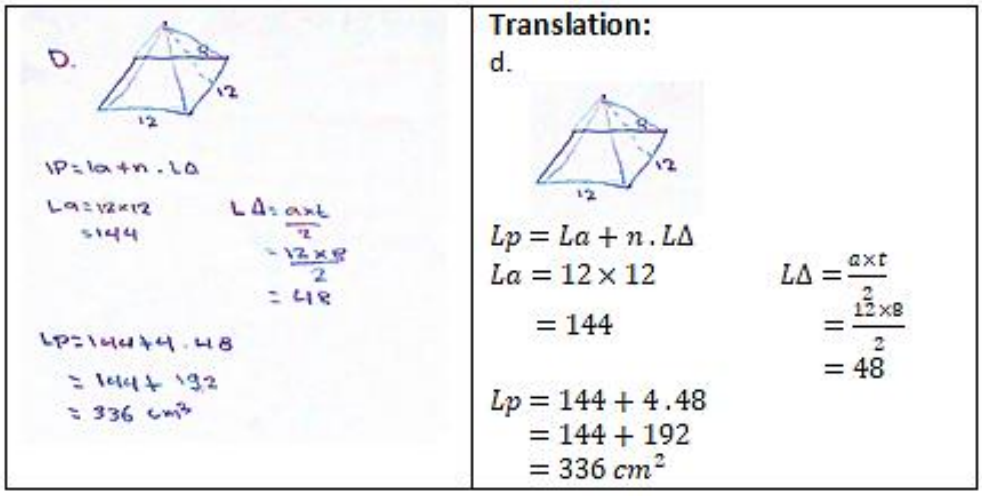


Figure 11. Results of Subjects' Answers that Meet the Fourth Indicator

Based on Figure 11, it can be seen that students have been able to visualize the questions given in the form of pictures and then calculate the surface area of the pyramid obtained by first finding the area of the square and the area of the triangle as in question b

and analogizing it to problem d and then get the pyramid formula, namely the area of a square plus 4 times the area of the triangle. students fulfill the indicators by selecting the correct answer and being able to explain the analogy (similarity) used between the source problem and the target problem (Applying).

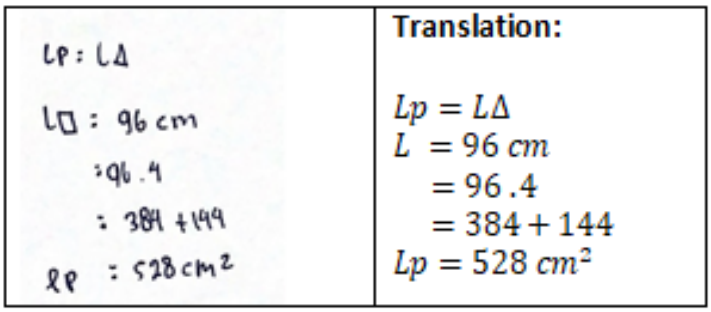


Figure 12. Results of Subjects' Answers that Did Not Meet the Fourth Indicator

Based on Figure 12, it can be seen that students are still making mistakes in doing calculations and it can be seen that students do not understand how to find the surface area of a pyramid and apply the formula to find the surface area of a rectangular pyramid. students who do not meet the indicators do not select the answers correctly and can relate the analogy (similarity) used between the source problem and the target problem. Confirmed through interviews as follows.

Researcher : What made you not do the problem?

Subject : I don't memorize the pyramid formula

Researcher :Do you see the similarities in picture 1 and picture 2 to answer the question?

Subject : No.

Based on interviews students did not answer because students did not memorize the pyramid formula and also students had not been able to see the analogy to the source problem and target problem so students also could not answer questions using the formula obtained from the analogy. Agree with statement that the students' difficulties lie in the strategy of making wrong calculations and some students do not memorize the formula (Hakim & Daniati, 2014 ; Tuti et al., 2018). In analogy known as the source problem and the target problem. The source problem is information for students in terms of linking and comparing it with the target problem so that the structure of the source problem can be applied to the target problem. meaning that the source problem can help students in solving the target problem. The advice that can be given is to accustom students to learning

mathematics by associating it with other problems (analogy) that have the same structure to facilitate problem solving.

CONCLUSION

From the results and discussion it can be concluded that the mathematical analogy reasoning abilities of class VIII junior high school students in the material of pyramids based on the indicators put forward by Stenberg. Obtained that the indicator most students mastered was the indicator of solving source problems (inferring). Meanwhile, the indicators that were the least mastered by students were looking for relationships and making conclusions (mapping). In the analogy, the mapping indicator is an indicator that can train students' mathematical analogy abilities. Furthermore, there were only two students who mastered the four indicators of analogical reasoning ability and there were six students who did not master any indicators at all. It can be concluded from this study that the ability of analogical reasoning based on the indicators put forward by Stenberg is still low.

Based on the strengths and weaknesses of the mathematical analogy reasoning abilities possessed, the advice that can be given is to accustom students to learning mathematics by associating it with other problems (analogy) that have the same structure to facilitate problem solving and further research to find solutions to address student barriers. by using analogical reasoning.

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