ISSN 2715-7458
E-ISSN 2715-7466

Journal of Mathematical Pedagogy
Volume 3, No. 1, December 2021, pp. 22-32

Metaphorical Thinking Profile of Middle School Students in Solving Mathematical Problems in terms of Students' Mathematical Ability

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Abstract

Metaphorical thinking is a thinking process that can be used to get a more optimal understanding of a concept by involving some appropriate metaphors. This research is a descriptive study with a qualitative approach that aims to describe the thinking profile of junior high school students in solving mathematical problems. The subjects of this study were three students with high (ST), medium (SS), and low (SR) math abilities. Data was collected by presenting students' mathematical ability tests, problem-solving tasks, and semi-structured interviews. In general, the results in this study are the three subjects with high, medium, and low abilities in the stages of relating, exploring, analyzing, and transforming. but what makes the difference is that at the connected stage, high mathematics (ST) subjects have connected the two ideas they have, but moderate (SS) and low (SR) mathematics subjects have not been able to. And at the experience stage, ST and SS have made conclusions from the final results of the problems presented and can solve the problems faced by SR not yet able, junior high school students with high mathematical ability category have better metaphorical thinking processes than students with medium and low mathematics categories. Middle school students in the category of moderate mathematical ability have better metaphorical thinking processes than students with low ability categories.
Keywords: *Metaphorical Thinking; Math Problems; Students' Mathematical Abilities; Problem-solving*

Abstrak

Berpikir metaforis merupakan proses berfikir yang dapat digunakan untuk mendapatkan pemahaman suatu konsep yang lebih optimal dengan melibatkan beberapa metapora yang tepat. Penelitian ini merupakan penelitian deskriptif dengan pendekatan kualitatif yang bertujuan untuk mendeskripsikan profil berpikir metaporis siswa smp dalam memecahkan masalah matematika. Subjek penelitian ini adalah tiga siswa yang berkemampuan matematika tinggi (ST), sedang(SS) dan rendah(SR). Pengumpulan data dilakukan dengan pemberian tes kemampuan matematika siswa, tugas pemecahan masalah dan wawancara semi terstruktur. Secara umum, Hasil pada penelitian ini yaitu Ketiga subjek dengan kemampuan tinggi, sedang dan rendah mampu dalam tahap relate, Explore, analyze , dan transform. namun yang membedakan yaitu Pada tahap *connect*, subjek kemampuan matematika tinggi (ST) telah menghubungkan kedua ide yang ia miliki, namun subjek kemampuan matematika sedang (SS) dan rendah(SR) belum mampu. Dan Pada tahap *experience*, ST dan SS telah mampu membuat kesimpulan dari hasil akhir permasalahan yang disajikan dan mampu menyelesaikan masalah yang dihadapi sedangkan SR belum mampu, siswa SMP dengan kategori kemampuan matematika tinggi mempunyai proses berfikir metaforis yang lebih baik daripada siswa dengan kategori kemampuan matematika sedang dan rendah. Siswa SMP dengan kategori kemampuan matematika sedang mempunyai proses berfikir metaforis yang lebih baik dari pada siswa dengan kategori kemampuan rendah.
Kata kunci: *Berfikir metaforis; Masalah matematika; kemampuan matematika siswa;pemecahan masalah*

How to Cite: Makrufah & Fiangga (2021). Metaphorical Thinking Profile of Middle School Students in Solving Mathematical Problems in terms of Students' Mathematical Ability. Journal of Mathematical Pedagogy, 3 (1), 22-32.

Introduction

Mathematics plays a very important role in everyday life, various kinds of our daily activities involve a lot of mathematical concepts, one of which is in the field of education (Hartono, 2020). According to Sulistiani & Masrukan (2016), mathematics has an important role in shaping and developing thinking skills, including reasoning, logical, systematic, and critical thinking. to improve students' thinking skills can be done by providing problem-solving.

Mathematics learning is an activity that uses mathematics to achieve educational goals and as an advance in science and technology. In mathematics, the ability to process information is called thinking. With mathematics lessons, students can be trained to have thinking skills and relate mathematical problems to everyday problems. According to Purbaningrum (2017) on thinking activities, the levels of the thinking process are divided into two, namely low-level thinking and higher-order thinking, where higher-order thinking places thinking activities at a higher level which is used to synthesize, generalize, explain, interpret and draw some conclusions in new solutions to new problems. Each individual has different mathematical thinking skills, which can be seen from the individual's mastery of mathematical concepts. This is in line with the opinion that each individual has different abilities in mastering mathematical concepts, so it greatly influences the ability to solve mathematical problems (Isroil, Budayasa, & Masriyah 2017). This means that the ability to solve problems is one of the benchmarks for students' ability to understand the concepts that exist in Mathematics.

However, the reality in the field is that students' ability to solve math problems is still low, this can be seen from the results of PISA several years earlier which showed results that were still relatively low where Indonesia's ranking position decreased especially for math scores, the math score in 2018 was 379 from the average score of 463.4, while the math score in 2015 was 386 out of an average score of 458.3 (OECD, 2019). In learning mathematics, some students have difficulty in solving math problems, especially problems related to the material of flat side space, causing errors in solving problems. And from the results of research by Tomo & Yusmin (2016) which shows the results of students' mathematical abilities in understanding the problem of building flat sides are classified as moderate with 31.6%; the ability of students to solve the problem of building a flat side space according to the plan is low with a percentage of 18.2%; and students' mathematical abilities in re-examining procedures and problem-solving results are low with a percentage of 16.4%, from 4 aspects the three show that the results of students' mathematical abilities in the form of flat-sided wake-up material are still low. In line with Hendriana, et al.(2018) said that to measure student achievement students can see how students practice and students' understanding in solving the given problem, meaning that students' understanding in solving flat-sided geometrical problems still has to be trained to minimize difficulties in understanding mathematical concepts. to achieve good learning achievement.

The results of the TIMSS research (Rahmawati, 2017) reveal that Indonesian students need to strengthen the ability to integrate information, draw conclusions, and generalize their knowledge to other things and this can be seen in the difficulty of students proving mathematics clearly because they do not understand mathematical concepts and rules (Bernard, Nurmala, Mariam, & Rustyani, 2018; Pansa, Caswita, & Suharsono, 2017; Rasnawati, Rahmawati, Akbar, & Putra, 2019). Indonesian students still need to be further developed for high-level mathematical abilities. Metaphorical thinking is included in higher-order thinking because it takes the ability to generate many ideas which are then interconnected in solving a problem (Walfurqon, 2020). According to Afrilianto (2012), metaphorical thinking is a thinking process that uses several metaphors to understand a concept. To determine success in learning mathematics, students can use metaphorical thinking which is closely related to metaphors that can conceptualize abstract concepts into concrete and more familiar concepts (Rafita et al., 2020). Meanwhile, according to Arni (2019), metaphorical thinking is a thought process in illustrating a concept by using appropriate metaphors to optimize understanding of a concept. From some of the opinions above, the researcher concludes that metaphorical thinking is a thinking process that can be used to get a more optimal understanding of a concept by involving some appropriate metaphors.

Because each student has different mathematical abilities so that higher-order thinking processes in solving mathematical problems are thought to be different, metaphorical thinking has an important role in the problem-solving process, this is in line with the opinion of Rafita et al., (2020) understanding students' mathematical concepts using a metaphorical thinking approach is better than understanding students' mathematical concepts who use a deductive approach and is supported by the opinion of Setiawan (2016) that not all individuals can think maximally. The researcher suspects that this metaphorical thinking skill can also be caused by the different mathematical abilities of students so the researcher hopes to provide an overview/profile of students' metaphorical thinking with high, medium, and low abilities in solving the problem of geometrical shapes. Thus, this can make it easier for teachers to explain to students about problem-solving using appropriate metaphors. Students also find it easier to understand problem-solving steps, because metaphors link the problems they face with things that are more familiar. Based on the description above, the purpose of this study is to describe the metaphorical thinking of junior high school students in solving measurement problems in terms of students' mathematical abilities,

Method

This type of research is descriptive research with a qualitative approach. Based on this type of research, this study aims to describe the profile of students' metaphorical thinking in solving the problem of geometrical geometry in terms of mathematical ability. This research data was obtained from the results of student work and semi-structured interviews to dig up information about what the research subjects thought and did when solving the problem of building a flat side space.

The subjects of this study were students of class VIII MTS Darut Taqwa Pasuruan. The selection of research subjects was carried out by giving a mathematical ability test. This mathematical ability test aims to determine one subject of high ability, one subject of moderate ability, one subject of low ability.

The main instrument in this research is the researcher himself. The supporting instruments in this study were the Mathematical Ability Test, Problem Solving Tasks (TPM), and Interview Guidelines. The mathematical ability test instrument used in this study was the adoption of the mathematical ability questions developed by Lesmana. **Table 1** shows the indicators in administering the TPM Test on the flat-sided geometric material.

Table 1. Indicators of metaphorical thinking in solving mathematical problems (TPM).

Process	Indicator
Connect	Students can connect two different ideas, topics, or mathematical material.
Relate	Students can connect different ideas with the knowledge that is more familiar to students.
Explore	Students can make models of the problems presented and draw models of these problems.
Analyze	Students can describe the similarities between the two ideas. Peel back the steps that have been done previously.
Transform	Students can describe and conclude information based on what has been done.
Experience	Students can apply the results obtained to the problems at hand.

The results of the interviews were analyzed using three stages, namely data reduction, data presentation, and concluding. Analysis of the data in this study using analysis techniques according to Miles and Huberman (2014) which consists of:

1. Data reduction is done by categorizing students into low, medium, and high mathematical abilities. Then the giving of mathematical problem-solving tests was continued by analyzing the results of mathematical problem-solving tests and conducting interviews to describe the profile of students' metaphorical thinking in solving the problem of building a flat side space.
2. Data display (data presentation) is carried out by presenting data on the results of students' mathematical abilities, subjects that have been classified based on low, medium, and high levels, presenting the results of math problem-solving tests that are used as interview materials, and combining the results of math problem-solving tests with the results of the interview in the form of a description, and
3. Conclusion drawing/verification is carried out by concluding the results of students' mathematical problem-solving tests which are strengthened by the results of interviews so that it can be concluded that it is related to the metaphorical thinking profile of students with low, medium, and high mathematical abilities in solving flat side space problem.

Results and Discussion

The research activity began with giving a math ability test to the superior class eighth-grade students of MTS Darut Taqwa for the 2020/2021 academic year. Giving the instrument has the aim of determining the research subject including the level of high, medium, or low mathematical ability. The results of the TKM are 11 students have high mathematical abilities, 7 students have moderate mathematical abilities, and 2 students have low mathematical abilities. After obtaining one research subject in each category, the researcher conducted a problem-solving test on the flat-sided geometry material, and then the researcher interviewed the subject after the TPM was done. Interviews were conducted based on the subject's work to explore more in-depth information that might not be seen in the results of the TPM work provided by the researcher. The interview was recorded using a voice recorder and the researcher recorded all the subject's activities during the interview. The following are the results of the student TPM:

- ***Profile of Metaphorical Thinking of Middle School Students with High Mathematical Ability in Solving Problems with Flat Sided Spaces***

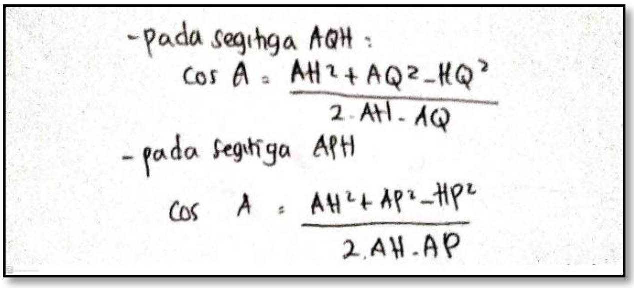


Figure 1. Idea 1 test of metaphorical thinking Subject High math ability

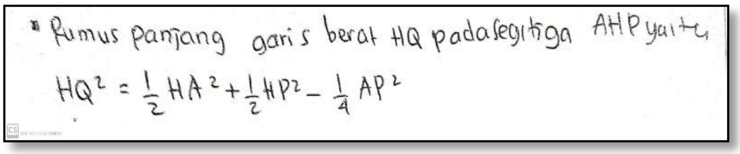
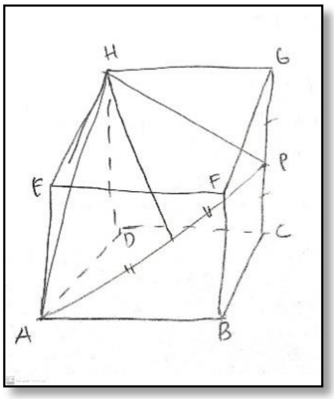


Figure 2. Idea 1 test of metaphorical thinking Subject High math ability

The results of the analysis of the profile of metaphorical thinking in solving mathematical problems of flat-sided geometrical materials show that at the connect stage, students with high mathematical abilities can connect two different ideas, topics, or mathematical material. For example, in the first question, students have two ideas. The first idea is that the subject uses the concept of the cosine rule to compare triangle AQH and triangle APH after determining the lengths of several sides of the cube. The idea of both subjects uses the concept of line length, weight after determining the length of several sides of the cube **(Figures 1, 2).** At the *relate* stage, students with high metaphorical abilities can connect different ideas with the knowledge that students are more familiar with. as in the first question students connect other ideas, namely the topic of Pythagoras, and algebra. ST stated that he had encountered a problem in the material that was solved using the Pythagorean and algebraic fraction comparisons. So on that basis, the subject uses the concept of the cosine rule by comparing two triangles to determine the distance between two points.



Figures 3. Student Work

In the *explore* stage, the subject can make a model of the problems presented and draw a model of the problem. the subject describes a cube in which there is a triangle with a size that corresponds to the sol in the metaphorical thinking ability test (**Figure 3**). The subject also determines the midpoint of the line and connects it with other points appropriately. In the *analyze* stage, students can describe the similarities between the two ideas. Peel back the steps that have been done previously. For example, the subject re-explains how he described the cube by assuming the right size as stated or known in the problem. The subject also explained in detail how he determined the length of several sides of the cube, then the subject also explained how to find the distance between two points using the cosine rule. The subject also re-described the similarities between the two ideas that he found as well as in the *explore* stage above so that the subject finally chose how to use the cosine rule. In the *transform* stage, students can describe and conclude information based on what has been done. For example, the subject concludes the distance between the two points after determining the lengths of the sides of the cube and the lengths of the sides of two triangles using the cosine rule.

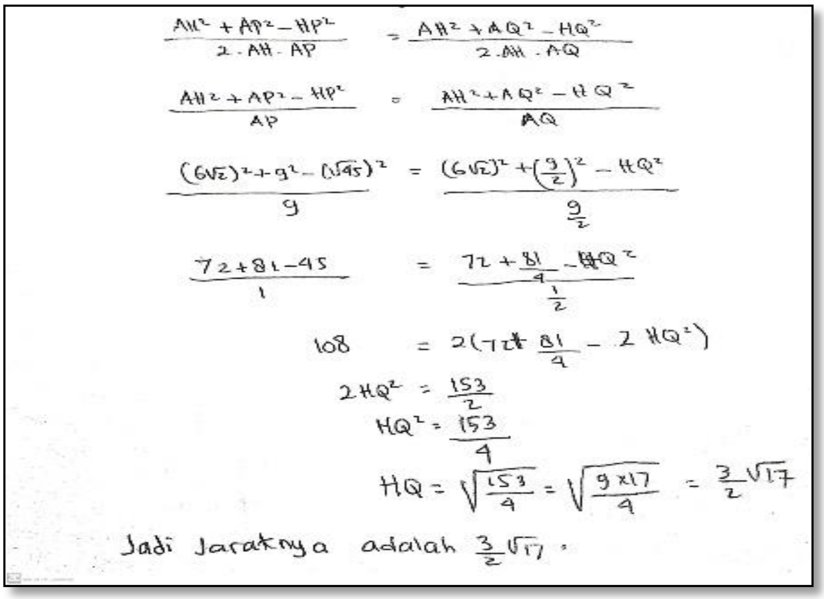


Figure 4. Student Work

At the *experience* stage, the subject has applied the results he got by solving the problems he faces, for example, the subject determines in advance the length of several sides, namely the length of AH, length of HP, length of AP, and length of AQ. And determine *cos A* with the cosine rule, then compare the cosine of the triangle AQH and triangle APH so that the distance between the two points or the distance HQ is obtained (**Figure 4**). it's just that in some questions the subject is less precise in terms of calculations so that the end is not right into the correct answer.

Profile of Metaphorical Thinking of Middle School Students with Mathematics Ability in Solving Problems of Flat Sided Space

The results of the analysis of the profile of metaphorical thinking in solving mathematical problems with flat-sided geometry show that at the *connect* stage students with moderate mathematical abilities cannot connect two different ideas, topics, or mathematical material in solving the problem. For example, in the first question, students only have an idea to solve the problem with the concept of a weighted line. At the *relate* stage, students with moderate metaphorical abilities can connect advanced ideas with the knowledge that students know better. as in the first problem students use the concept of Pythagoras, and the concept of diagonal space to find the sides of the cube AP, AH, and HP. SR stated that he had never encountered a problem with the material, he had asked questions about the cube but never had any deep questions related to the sides of the cube. students just try to find each length of the sides of the triangle AHP with Pythagoras. And students also understand the concept of weight line. So on that basis, the subject uses the Pythagorean concept and the weight line on the AHP triangle to find the length of HQ.

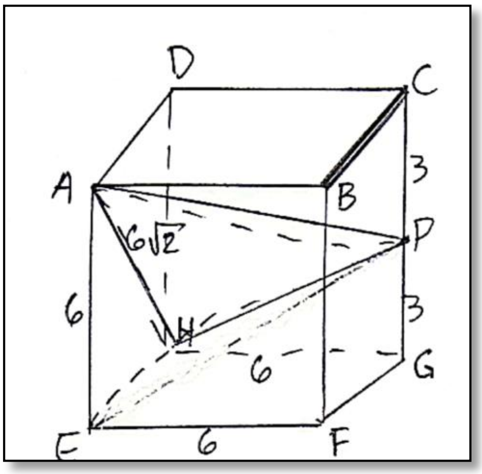


Figure 5. Student Work

In the *explore* stage, the subject can make a model of the problems presented and draw a model of the problem. the subject describes a cube in which there is a triangle with a size that corresponds to the questions in the metaphorical thinking ability test **(Figure 5)**. However, the student's picture does not describe the location of Q. At the *analyze* stage, students can describe their idea. Peel back the steps that have been done previously. For example, the subject re-explains how he describes the cube by assuming that the correct size is listed or known in the problem, and what has been calculated is also included in the picture. The subject also explained how he determined the length of several sides of the cube, but in finding HQ the students did not know the concept of a line of weight. However, SR still uses the line weight formula to find HQ. At the *transform* stage, students can conclude to find the distance H and Q based on what has been done. For example, the subject concludes that the distance between the two points is calculated by the formula for the weight line after determining the length of the sides of the cube with the Pythagorean concept in several triangles..

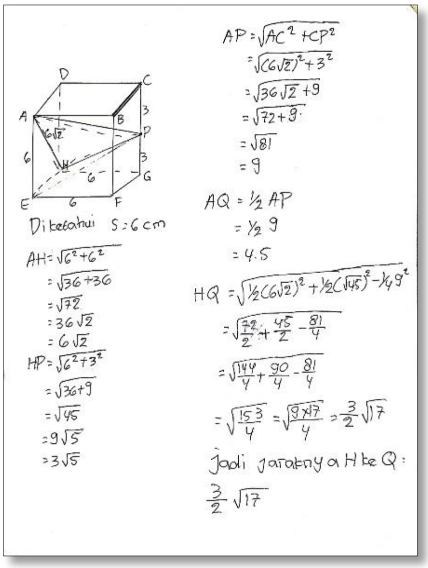


Figure 6. Student Work

At the *experience* stage, the subject has applied the results he got by solving the problems he faces, for example, the subject determines in advance the length of several sides, namely the length of AH, length of HP, length of AP, and length of AQ. And determine the length of HQ by involving the lengths of AH, HP, AP with the formula for the length of the line of weight, **(Figure 6).** In the implementation of this SR, there is a misconception about the concept of multiplication of roots $72 = 36\sqrt{2}$, but the final answer is correct.

Profile of Metaphorical Thinking of Middle School Students with Low Mathematical Ability in Solving Problems with Flat Sided Spaces

The results of the analysis of the profile of metaphorical thinking in solving mathematical problems with flat-sided geometrical materials show that at the *connect* stage, students with low mathematical abilities cannot connect two different ideas, topics, or mathematical material in solving the problem. For example, in this first problem, students only have the idea of solving the problem with the concept of the area of a square but students cannot solve it. At the *relate* stage, students with low metaphorical abilities can connect advanced ideas with the knowledge that students know better even though they do not understand the concept. as in the first problem students use the Pythagorean concept to find only the sides of AP and HP. SR stated that he had never encountered a problem with the material, he had asked questions about the cube but never had any deep questions related to the sides of the cube. students only try to find each length of the sides of the AHP triangle with Pythagoras but the SR calculation in finding the AP has not been done because they still do not understand the Pythagorean concept. So on that basis, the subject uses the Pythagorean concept to calculate the area of AHP in determining the length of HQ.

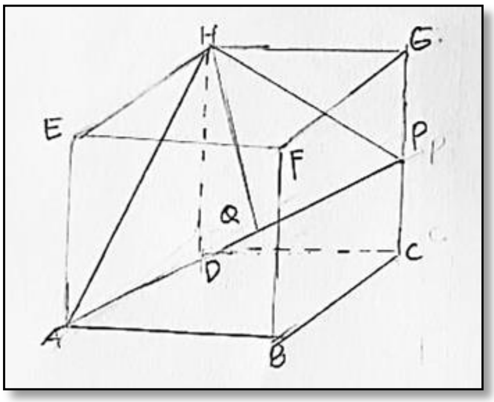


Figure 7. Student Work

In the *explore* stage, the subject can make a model of the problems presented and draw a model of the problem. the subject describes a cube in which there is a triangle by the test questions of metaphorical thinking skills, although there are shortcomings related to the description of the length of the side of the cube, the length of the side divided by the midpoint. **(Figure 7)**. At the *analyze* stage, students can describe their ideas. Peel back the steps that have been done previously. For example, the subject re-explains how he described the cube by assuming the right size as stated or known in the problem. The subject also explained how he determined the length of several sides of the cube with the Pythagorean concept which was at the *relate* stage, however. However, SR was not finished solving the problem until the end because SR was confused about what formula to use in the next step. At the *transform* stage, students can conclude to find the distance H and Q. For example, the subject looks for the HQ by dividing the area into two, then from the area divided by two the side lengths are searched. although in the end SR still did not understand the mathematical formula used to solve the problem.

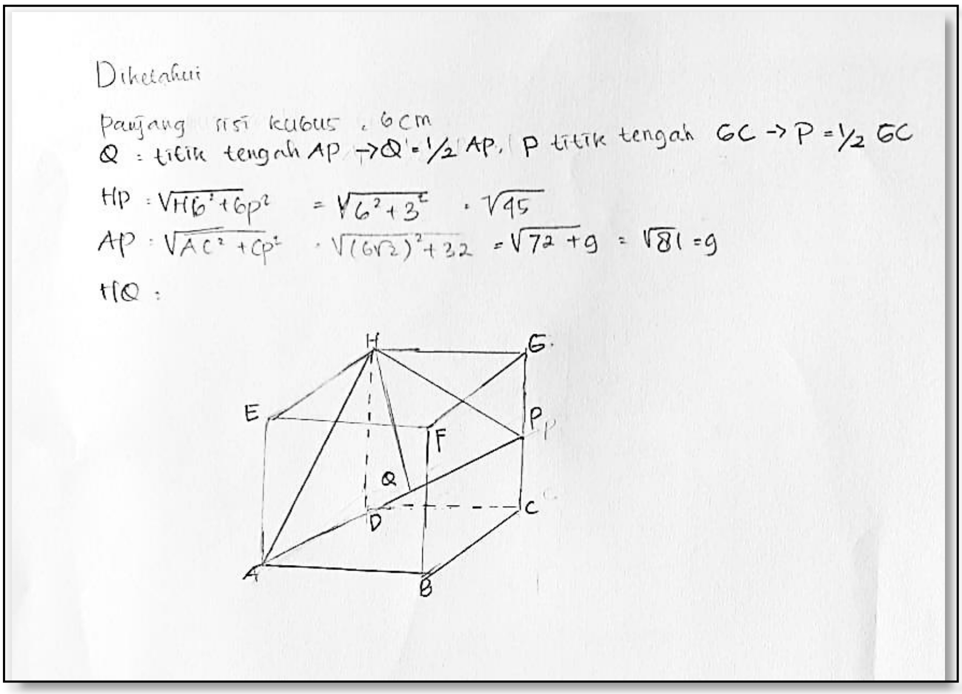


Figure 8. Student Work

At the *experience* stage, the SR subject has not been able to apply the results he got by solving the problems he faces, for example, the subject determines in advance the length of several sides, namely the length of the HP, the length of the AP, the SR subject has not been able to calculate the length of the AH, the area of the triangle AHP **(Figure 8)**.

Based on the research data, metaphorical thinking is characterized by connecting abstract ideas to more tangible objects.Metaphorical thinking connects models and interpretations, allowing students to explore their knowledge while learning mathematics. Students' learning processes become more relevant because they can perceive the connections between concepts they are learning and concepts they are already familiar with (Komang &Febriyanti, 2020).Therefore, metaphorical thinking becomes vital in learning mathematics because mathematical concepts are abstract.

Conclusion

The results of this study indicate that metaphorical thinking in terms of students' mathematical abilities is junior high school students with high mathematical ability category having metaphorical thinking aspects at the *Connect, Relate, Explore, Analyze, Transform, Experience stage,* junior high school students with moderate mathematical ability category have aspects of metaphorical thinking in *Relate stage, Explore, Analyze, Transform, Experience,* and junior high school students with low math ability category have metaphorical thinking aspects in the *Relate, Explore, Analyze, Transform stage*. Junior high school students with high mathematical ability categories have better metaphorical thinking processes than students with medium and low mathematical ability categories. Junior high school students with moderate mathematical ability category have better metaphorical thinking processes than students with low ability category. Therefore, the results of this study should be used as views or considerations for teachers to be able to train and hone students' mathematical abilities related to students' metaphorical thinking in solving a mathematical problem with more attention to students' mathematical abilities.

In this study, there was no in-depth study of the relationship between metaphorical thinking and students' mathematical abilities. Thus, it is hoped that further research will be carried out on the influence or relationship between metaphorical thinking and mathematical ability, especially in the section on determining research instruments and selecting research materials to obtain more accurate results.

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