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# Analysis of Students' Mathematical Connection Skills in Solving High-Order Thinking Skills Problems if Flat- Sided Space Building

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**Abstract**

Mathematical connection skills are essential for solving Higher-Order Thinking Skills (HOTS) problem, yet Indonesian students struggle to link concepts across contexts. This study investigates how junior high school students apply these skilss in flat-sided space geometry, addressing gaps in contextual and interdisciplinary problem solving. A descriptive qualitative approach was employed with 18 Class VIII students at MTs Daarun Nahdhah Bangkinang. Data were collected through a validated essay text (expert judgment: k=0.82) measuring three indicators: (1) inter-mathematical concept connection, (2) mathematics to other fields applications, and (3) real world problem solving. Responses were scored using a rubric (0-4 scale) and analyzed thematically by ability level(high/medium/low). Only 28% of students excelled in connecting mathematical concept (indicator 1), while 22% performed well in interdisciplinary applications (indocator 2). Real world problem solving (indicator 3) showed the lowest mastery (11%). High ability students demonstrated coherent relational understanding, whereas medium/low ability students relied on rote memorization or made calculation error. The finding highlight critical gaps in students ability to contextualize mathematics, emphasizing the need for scaffolding in curriculum design. Implications suggest integrating real world examples and interdisciplinary tasks to strengthen HOTS based connection.

Keywords: Flat-Sided Space Geometry; HOTS; Mathematical Connection Skills

## 1. Introduction

Almost all learning theories place understanding as the main goal of the learningprocess. As mentioned in Permendikbud No. 70 of 2013, one of the core competencies that learners must have is understanding, applying, and analyzing knowledge (2013). Knowledge gained through understanding will be the basis fordeveloping new knowledge and is useful insolving unusual problems. When learners have gained conceptual understanding in mathematics, they will see connections between concepts and procedures and be able to argue why some facts are consequences of other facts. The more they understand, the better their ability to connect mathematical concepts. They become more confident, so they are able to learn higherconcepts. This is called mathematical connection ability (Suhandri et al. 2017). Mathematical connection skills are very important for every learner to have from an early age, because through this context, they can develop understanding based on prior knowledge.

The *National Council of teachers of Mathematics* (NCTM) states that there are fiveprocess standards in learning mathematics,namely, (1) *problem solving*, (2) *reasoning and proof*, (3) *communication, (*4) *connection,* and (5) *representation*, and one of the standards of the mathematics learning process according to NCTM is mathematical connection ability. (Ningrum et al. 2019). This statement is in line with one of the objectives of mathematicslearning quoted from Depdiknas (2019), the first point states that students must understand mathematical concepts, explain relationshipsbetween concepts, and apply concepts or algorithms with flexibility, accuracy, efficiency,and accuracy in solving problems. This shows thatthe initial abilities that students need to master is the ability to connect concepts mathematically (Anita, 2014). In mathematics, the ability to connectconcepts is referred to as connection ability. Students who have good connection skills will be able to build good mathematical understanding.Therefore, mathematical connection ability is one of the main objectives of learning mathematics at school, which in turn becomes a requirement for students to master higher abilities. Connection is arelationship or linkage.

In mathematics, connection from an internal perspective refers to the relationship between mathematical ideas or concepts within the field of mathematics itself. In contrast, from an external perspective, this relationship involves the linking of mathematical ideas or concepts with various other disciplines and their application in everyday life. (Husna & Sukoriyanto, 2024) in line with this (Nurafni & Pujiastuti, 2019) states that mathematicalconnection is the relationship between various mathematical ideas, both between mathematics and other fields of science and real life. From this thought, it can be concluded that mathematicalconnection is a high-level thinking ability that connects mathematical material and ideas internally, namely between mathematics and other fields of science and everyday life.

Mathematical connections help studentsform perceptions by seeing math as integrated from the real world and understanding its benefits in and out of school. When students can connect mathematical ideas, their understanding becomes deeper and longer lasting. Without mathematical connections, students have to learn and remember many mathematical concepts and procedures separately. Mathematical connection ability is an important part that needs to be emphasized at every level of education, and is a process skill thatmust be owned, mastered, and developed by students through mathematics learning. Learning mathematics is not enough to memorize and use formulas. All concepts in math are interrelated. The ability to connect these mathematical concepts is called connectionability. Students must have connection skills. (Retnawati, 2019) Behind the fact that mathematicalconnection skills are important for students, the situation that occurs actually shows different indications.

Various data show that mathematics education in Indonesia is not yet good. Because math still has aless pleasant image for many students at school. Mathematics is considered a difficult field of study, disliked by students. The learning processat school is still dominated by teacher-centeredteaching methods. As a result, students rarely use their connection skills, because they only receive information from the teacher and are not accustomed to connecting new concepts with

previously learned concepts. This is also supported by research conducted by (Elisahaya & Imami 2020). This study uses mathematical connection indicators which include the correlation between mathematics and itsapplication in everyday life.

The results showed that the mathematical connection skills of junior high school students were still very low. This is inline with the findings (Aspuri, 2019) which show that students' mathematical connection skills insolving story problems are still low. This is due to the inability of students to use all information from the problem and make the right mathematical model, so that the answers obtained are irrelevant. International surveys reveal that Indonesian students' math learning achievement is still low. In the 2018 PISA survey, Indonesia was ranked 72 out of 78 participating countries (OECD, 2019). One of the aspects measured by PISA is mathematical connection, where students are asked to connect mathematical ideas with integrated information to solve given problems.

The low learning outcomes of students in Indonesia are caused by their lack of ability to relate mathematical material that has been learned and lack of familiarity in finding solutions to problems related to problem solving. (Risdayati et al. 2022) This also happened at MTs Daarun Nahdhah Thawalib Bangkinang. The condition of students' mathematical connection skills varies. Based on the results of interviews with severalmathematics teachers at MTs, in general, students lack practice in linking the material being studied with other materials, so that if given a problem that is different from what is taught, students cannot answer it. Some students are also not familiar with problems related to other subjects,so they have difficulty answering questions that are different from those taught. During the learning process, only a few students actively asked about mathematical connections with everyday life.

The teacher also revealed that students are less trained in solving *HOTS* (*Higher order Thinking skills) questions* so they are not used to and have difficulty in answering them. An educator is expected to design mathematics learning that is in accordance with the needs of students in developing mathematical concept connections in a directed and planned manner.This will help students develop their higher order thinking skills known as *HOTS*. This higher order thinking allows students to use logic inunderstanding mathematical concepts and solving complex problems (Abosalem, 2016). The ability to think at a high level in mathematics in Indonesia can be said to be still low. This is evident from the results of research (Junaidi et al. 2020) that students' higher order thinking skills at MTs Al- Huda are still relatively low.

This is due to thelack of student practice in working on *HOTS* high-level thinking skills questions and the absence of special questions designed to train students' thinking skills that can be used by teachers is the main cause. Based on this explanation, it is necessary to investigate the extent to which students master mathematical connection skills.This study aims t o describe the mathematical connection skills of junior high school students onthe material of flat-sided spaces. Flat-sided space building is the material taught in class VIII ofjunior high school in even semester. This material includes cubes, beams, prisms and pyramids. This study has similarities with previous studies in terms of analyzing mathematical connection skills. The difference lies in the material discussed, namely flat-sided space, theindicators used, the aspects of connection ability analyzed, and the categorization of the level of students' mathematical connection ability based on each indicator. The purpose of this research is to find out the extent of students' mathematical connection ability and analyze their errors in answering questions related to the mathematical connection ability.

## 2. Method

This research is a qualitative descriptive research, the researcher analyzes the mathematical connection ability of students in solving hots problems on flat-sided space building material. The subjects of this study were students of class VIII F MTs Daarun Nahdhah Thawalib Bangkinang consisting of 18 students. The data from this study are in the form of facts that are presented in accordance with the facts that occurin the study. Data collection in this study used mathematical

connection ability test instruments. Written tests were used to obtain data on students' mathematical connection skills in solving problems (*HOTS*). The test used in this study was in the form of a description test based on indicators of mathematical connection ability. The mathematical connection ability test is a test question that has been validated by two experts, namely a lecturer and a mathematics teacher. Bothvalidators stated that the connection ability testwas suitable for use with some revisions related tolanguage.

The criteria for scoring guidelines for mathematical connection skills are as follows:

a. For score 4, on the criteria of answers and reasons that show understanding of the concept and mathematical processof the problem, using the right terms and notation, implementing the algorithm correctly and completely.

b. For score 3, the answer and reasoning criteria show a good understanding of the concepts and mathematicalprocesses of the problem, using almost correct terms and notation, carrying out the algorithm completely and generally correct calculations, but there are still errors.

c. For score 2, with the criteria of answers and reasons that almost understand the concept and mathematical process of the problem, identify erroneous elements, make some calculation errors.

d. For score 1, with the criteria for answers and reasons that partially understand the concepts and mathematical processes of the problem, use inappropriate tools and solution strategies and are not appropriate. made many errors in calculations.

e. Score 0 for students who do not providean explanation of their answer.

(Suhandri et al. 2017)

At the data analysis stage, researchers analyzed the data after the research process was completed and the data was collected using qualitative descriptive analysis. Written data analysis is carried out by checking the suitability of the answers given by students to the mathematical connection ability test questions,using the completion instructions and answerkeys that have been prepared by the researcher. researcher. After that, conclusions were drawn from the collected data and verified to ensure the truth. After getting the score from the mathematical connection ability test, score categorization is carried out to determine the level of students' mathematical connection ability based on indicators classified into high, medium, or low, according to the category of mathematical connection ability. Guidelines for assessing students' mathematical connectionskills according to (Angelina & Effendi 2021), namely as follows

**Table 1.** Categories Mathematical Connection Ability

| Value Criteria | Indicator |
|---|---|
| $\mathbf{x > \bar{x} + s}$ | High/capable |
| $\mathbf{\bar{x} - s \leq x \leq \bar{x} + s}$ | Moderate/quite capable |
| $\mathbf{x < \bar{x} - s}$ | Low/less capable |

## 3. Results and Discussion

The students' test answers related to mathematical connection ability questions given to 18 students of class VIII F MTs Daarun Nahdhah Bangkinang consisting of 3 questions. Analysis is carried out at each step of the student's answer process according to the three indicators of students' mathematical connection skills. The description of students' mathematical abilities is described in the following indicators:

a) Students' ability to understand and use relationships between topics in mathematics (connections between mathematical concepts) is measured through test question number 1.

b) Students' ability to apply mathematics to other fields (math connections with other disciplines) wasmeasured through test question number 2.

c) Students' ability to apply mathematics in everyday life (math connection with the real world) ismeasured through test question number 3.

After students complete the test questions, their answers will be assessed based on predeterminedindicators then the mathematical connection ability score will be calculated for each research subject.According to (Isnaeni et al. 2019), the research subject's connection ability score is obtained from a test thatis assessed based on the criteria for mathematical connection ability. From the tabulation results, the level of mathematical connection ability of each research subject will be known. The guidelines for the category of mathematical connection ability test results in this study were modified from the grouping of test scores proposed by Arikunto (Suhandri et al. 2017). From the results of data analysis, the results of mathematical connection scoring on flat-sided spacebuilding material can be seen in the following table.

**Table 2.** Scoring Results of Students Mathematical Connection Skills

| **Number of** | **Question Indicator** | | |
|---|---|---|---|
| | Problem 1 | Problem 2 | Problem 3 |
| 4 | 5 | 4 | 2 |
| 3 | 5 | 5 | 4 |
| 2 | 6 | 7 | 6 |
| 1 | 2 | 2 | 6 |
| 0 | 0 | 0 | 0 |

Based on this table, it can be seen that in indicator 1, 5 people scored 4, 5 people scored 3, 6 people scored 2, 2 people scored 1. In indicator 2, 4 people scored 1. people who scored 4, 5 people with score 3, 7 people with score 2, 2 people with score 1.

It can be seen that students have a low mathematical connection ability. It can be seen in the aspect of understanding and using connections between topics in mathematics (connections between mathematical concepts). In question number 1 only 5 out of 18 students (28%) were able to answer perfectly. In terms of applying mathematics in the context of other fields (math connections with other sciences), only 4 out of 18 students (22%) were able to provide correct and complete answers. In the ability to apply mathematics in everyday life (mathematical connections with the real world), shows a very low category, only 2 out of 18 students (11%) who have successfully understood mathematical concepts relevant to real life.

It can be seen that the lowest mathematical connection ability of students in class VIII F MTs DaarunNahdhah Bangkinang is in the indicator of mathematical connection to real life. This is in line with others research findings which show that students have difficulty in connecting mathematical conceptswith everyday life (Tata & Haerudin, 2022). For more details, the following is presented the distribution of students' mathematical connection ability test scores grouped by ability level with reference to themathematical connection ability category in table

**Table 3.** Distribution of Students' Mathematical Connection Ability Test Scores

| Ability level | Student score | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| High | 4 | 1 | 3 | 2 |
| | 3 | 2 | 0 | 1 |
| | 2 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 |
| Medium | 4 | 3 | 0 | 0 |
| | 3 | 5 | 1 | 2 |
| | 2 | 1 | 6 | 4 |
| | 1 | 1 | 2 | 3 |
| | 0 | 0 | 0 | 0 |
| Low | 4 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| | 1 | 1 | 2 | 5 |
| | 0 | 0 | 0 | 0 |

Each step in the process of students' answers was analyzed according to the three indicators of students' mathematical connection skills. One person representing each category was taken to analyze their mathematical connection ability for each indicator. Based on the table, the following explanation is presented.

## A. Analysis of High Ability Students

### 1) Indicator 1

This assessment evaluates student's ability to recognize and use relationships between mathematical ideas. Among three high ability students, all could identify known information, understand problem requirements, and use symbols or diagrams for clarity. They determined correct problem solving approaches and connected mathmematical concept, though two made calculation error. Despite these mistakes, they provided logically structured answers, demonstrating their ability to apply mathematical relationships effectively. The following shows the answer of one of the high ability students on indicator 1.

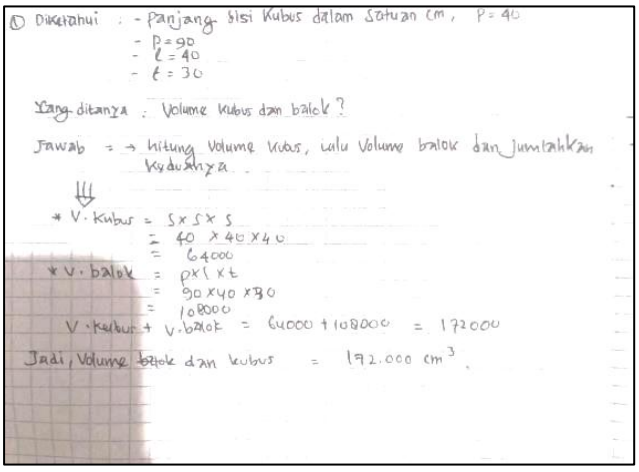


**Figure 1**. Answers of High Category Students on Indicator 1

### 2) Indicator 2

In this second indicator, students with high ability have been able to apply mathematics in other fields, students have been able to determine the known things and the purpose of solving the problem, students can write a way to calculate the volume of a cube from the density formula bydoing calculations by connecting mathematical and physical concepts and procedures and can answer questions using appropriate sentences. The right steps are very important to solve problems in the indicators of the application of mathematics other fields. The following is the answer of one of the high ability students on indicator 2

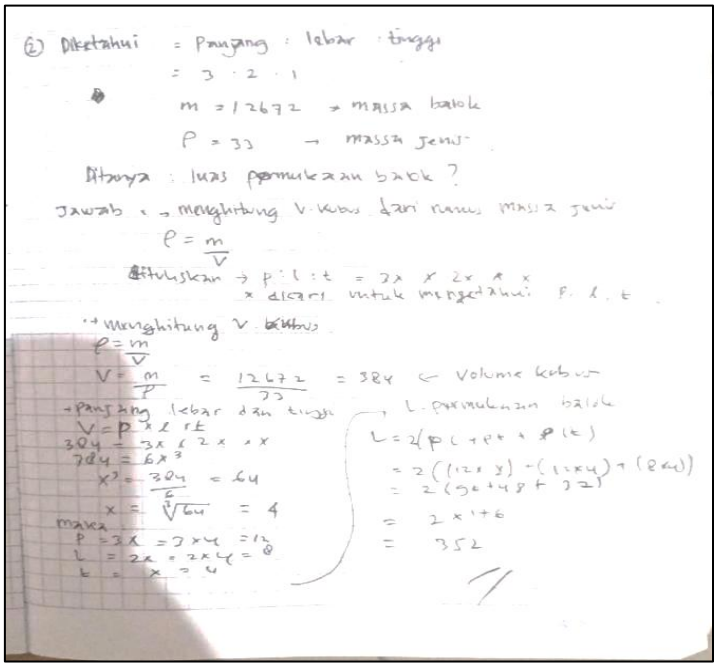

**Figure 2.** Answers of High Category Students on Indicator 2

### 3) Indicator 3

The third indicator of students' mathematical connection ability is recognizing and applying mathematics related to everyday life. This high ability student has been able to calculate and concludethe information in the problem well, students have been able to perform calculations and connect mathematical concepts and procedures and have answered questions with appropriate statement sentences. However, 1 of the 3 high ability students made a mistake in the summation of the final result, but students with high abilities have been able to recognize and apply mathematics in the context of everyday life. The following is the answer of one of the high ability students on indicator 3.

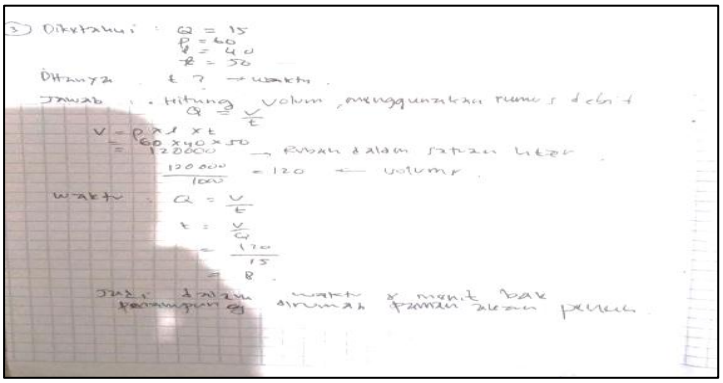

**Figure 3.** Answers of High Category Students on Indicator 3

## B. Analysis of medium ability students

### 1) Indicator 1

Based on one of the answers of students who have moderate mathematical connection ability,it can be concluded that from the results of student answers it can be seen that students with moderate ability have been able to understand the problem well, students can write down what is known and asked, but students make mistakes in connecting mathematical concepts and procedures. Students almost understand the mathematical concepts and processes in the problem, are able to identify important elements, but there are some wrong ideas and some calculation errors. Of the 9 students in the moderate category, only 3 students were able to answer the question correctly in its entirety in thisindicator 1. 5 students who already had a good understanding of the concepts and mathematical processes of the problem, had used almost correct terms and notation but there were still errors in the addition process. 2 students have almost understood the concept and mathematical process of the problem, have been able to identify important elements, but there are still wrong ideas and also make some mistakes in calculations. And in this moderate category there is 1 student who has partially understood the concept and mathematical process of the problem but did not use the right tools and solution strategies and made many mistakes in calculations. Here is one of the answers of medium ability students. Medium category students' answers on Indicator 1

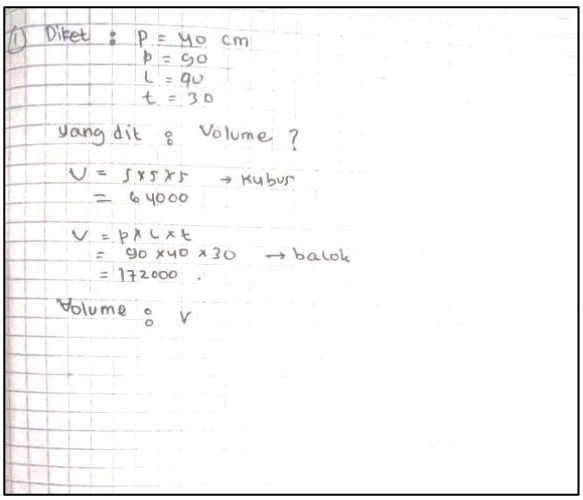


**Figure 4.** Answers of Medium Category Students on Indicator 1

### 2) Indicator 2

Based on the answers of medium ability students in indicator 2, no students were correct overall. 1 student already had a good understanding of the mathematical concepts and processes in theproblem, as well as using almost correct terms and notations. But in performing calculations by connecting mathematical and physical concepts and procedures students still experience errors. 6 out of 9 students with moderate ability almost understood the mathematical concepts and processes in the problem and were able to identify important elements, but there were many wrong ideas and some calculation errors. And there were 2 students who partially understood the concepts and mathematical processes in the problem, but used inappropriate tools and solution strategies and made many calculation errors. However, overall, moderate ability students in indicator 2 have been able to apply mathematics to other fields, but the biggest mistake is that most students in this category make mistakes in the calculation process. The following shows one of the answers of moderate ability students on indicator 2.

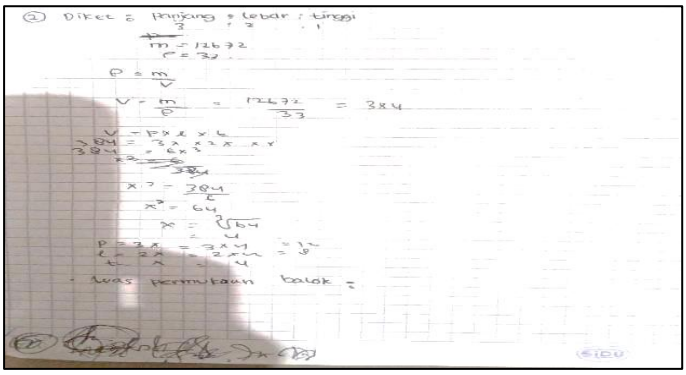

**Figure 5.** Medium Category Students' Answers on Indicator 2

### 3) Indicator 3

Based on the answers of students who are categorized as medium in this third indicator in terms of the answer process, students have been able to find a formula for solving the problem, noneof these medium ability students are correct overall, 2 students have been able to understand the mathematical concepts and processes in the problem, have used the right terms and notation, the calculations are generally correct but there are still some errors, some students have been able to mathematical concepts and procedures, but there are many wrong ideas and some errors in calculations. The following is the answer of one of the medium ability students on indicator 3.

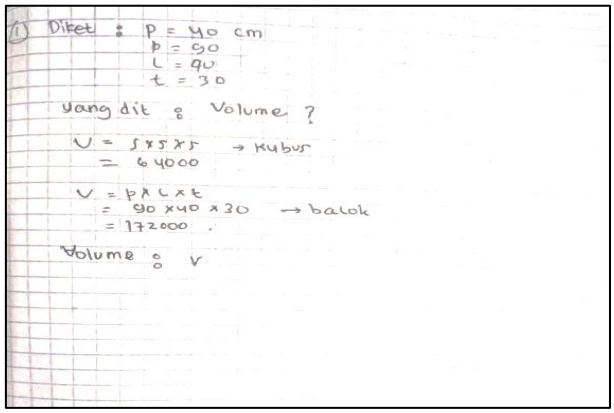


**Figure 6 .** Medium Category Students' Answers on Indicator 3

## C. Analysis of Low ability students

### 1) Indicator 1

The test results showed that students with low ability did not record the things known and asked in the problem, this shows students' incomprehension of the problems given. Students cannot imagine and understand the problem. 5 out of 6 students who almost understand the mathematical concepts and processes but are mistaken in some errors in calculations and students still cannot connect mathematical concepts and procedures well. The following is the result of one of the low ability students' answers on indicator1.

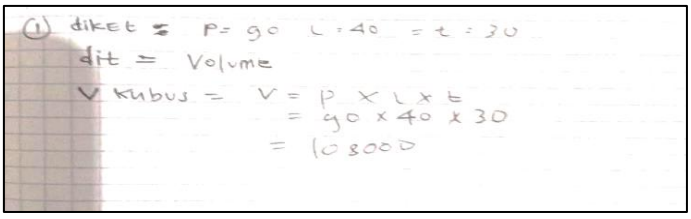


**Figure 7.** Low Category Students' Answers on Indicator 1

### 2) Indicator 2

The results of students' answers to the mathematical connection ability test indicator 3 show that students' mathematical connection ability in indicator 3 is still low. 4 out of 6 students havealmost understood the mathematical concepts and processes in the problem but there are still many mistakes and errors in calculations. Overall in this category students still cannot apply mathematics to other fields. The following shows one of the results of low category student answers on indicator 2

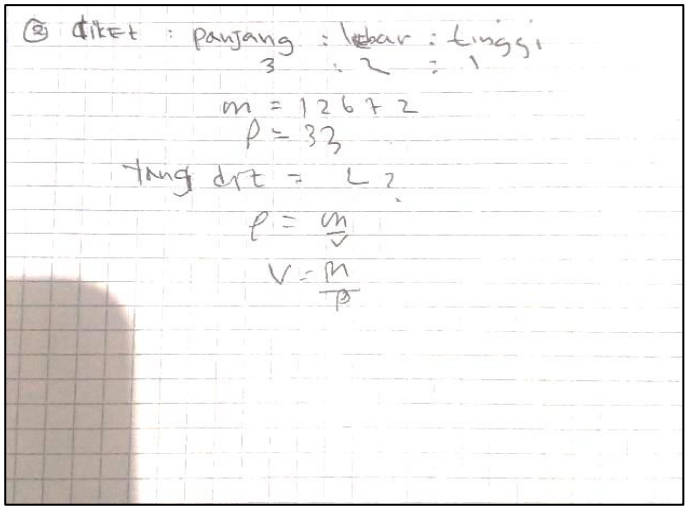


**Figure 8.** Low Category Students' Answers on Indicator 2

### 3) Indicator 3

In this indicator, low ability students have understood the symbols used in writing mathematical formulas, but they have not been able to conclude the steps to be taken in solving the problem. So it can be concluded that students have not been able to recognize and apply mathematics in the context of everyday life. The following is the answer of one of the low ability students on indicator 3.

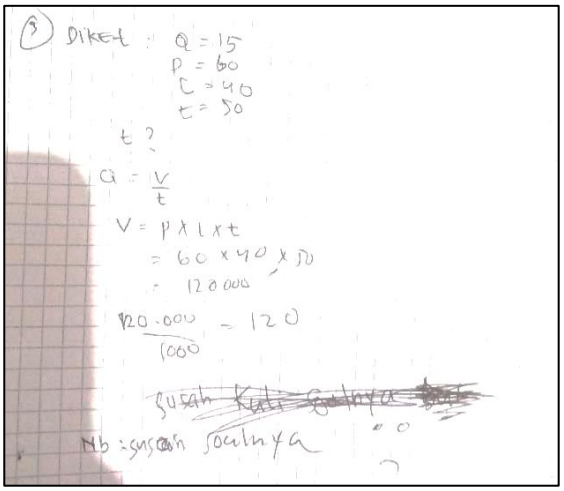


**Figure 9.** Low Category Students' Answers on Indicator 3

## 4. Conclusion

Overall, the mathematical connection ability of students in class VIII F MTs Daarun Nahdhah Bangkinang is still relatively low, among the 18 students who took the test there were 3 students with high ability, 9 people with medium ability, and 6 people with low ability. Students who have high mathematical connection skills can master well the important aspects of this ability. They can identify and use relationshipsbetween mathematical concepts, understand how these

concepts are interrelated and support each other to form a coherent whole, and can apply their understanding in contexts outside the field of mathematics, namely in other fields and in everyday life.

The findings align with previous research (Sholekah & Waluyo, 2017), which indicates that high ability students face no difficulty in applying connections between mathematical topics. Meanwhile, students with moderate mathematical connection skills demonstrate partial mastery they can recognize and use relationships between mathematical ideas (first indicator) but struggle to see how these ideas interconnect and support one another. Although some recognize the applicability of mathematics in real world context (third indicator), they fail to apply it effectively.

A key issue among moderate ability students is their reliance on rote memorization of formulas without deep conceptual understanding, leading to errors in problem solving. This corroborates the findings og (Hadin, 2018), who observed that missing steps in solutions often result in innacurate answers.

For low ability students, the challenges are more pronounced. They cannot identify or utilize relationships between mathematical ideas, particularly in geometry. Additionally, they struggle to connect mathematical concepts to real world situations, as noted by Nari & Musfika (2017) and Zainuddin & Utami (2021). This gap highlights the importance of structured problem solving approaches to achieve accurate results.

To address these issues, the following ateps are recommended:

1. Focus on conceptual understanding – move beyond memorization by explaining the reasoning behind formulas and using concept maps to show connections.
2. Link math to real life – use applied problems and project based tasks to helps students see math relevance.
3. Differentiate instruction – provide advanced challenges for high ability students and targeted reinforcement for struggling learners.
4. Teacher training – equip educators with strategies to teach mathematical connections and address misconceptions effectively.

These steps can help students grasp math as in interconnected subject and apply it confidently.

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