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ANALYSIS OF THE MATHEMATICAL REASONING ABILITY OF JUNIOR HIGH SCHOOL STUDENTS IN THE SET MATERIAL

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Abstract

Mathematical reasoning skills are an important aspect of mathematics learning that needs to be developed from an early age. This study aims to analyze the mathematical reasoning ability of grade VII junior high school students in set materials with a qualitative descriptive approach. The research subjects were selected purposively based on varying levels of mathematical ability (high, medium, and low). Data was collected through mathematical reasoning tests and semi-structured interviews to dig into students' thought processes. The test instruments are arranged based on mathematical reasoning indicators. The results showed that 43.75% of students were in the good category, 43.75% in the fair category, and 12.5% in the low category. These findings indicate that most students have been able to display adequate mathematical reasoning, although there are still weaknesses in drawing conclusions and making mathematical guesses. The implications of this study emphasize the importance of designing adaptive and contextual learning strategies, as well as the need for the integration of cognitive and affective approaches to improve the quality of students' reasoning in mathematics learning.
Keywords: mathematical reasoning, sets, junior high school students, qualitative approach

INTRODUCTION

Mathematics has a significant role in the world of education because it forms a logical, critical, and structured way of thinking for students (Permatasari, 2021). One of the crucial competencies to be developed in the mathematics learning process is mathematical reasoning skills. (Safitri et al., 2024). This ability is not only useful in understanding and solving mathematical problems, but also plays an important role in improving analytical thinking skills, compiling generalizations, and drawing conclusions based on available patterns and data.

The topic of the set is a very important basic material for junior high school students to master (Ahmad & Asmaidah, 2017). Mastery of this material becomes the foundation for learning advanced mathematical concepts and practicing the ability to classify, identify, and present mathematical objects systematically (Iani Rahmadani Putri, 2024). A good understanding of set concepts also supports students in representing information through Venn diagrams (Stuart, Stuart and Stuart 2025).

perform mathematical manipulations, as well as draw conclusions and make generalizations of observed patterns.

However, the results of observations in the field show that students' reasoning skills in the topic of the set are still relatively low (Physical 2022). One of the reasons is the lack of practice questions that hone high-level thinking skills and the lack of variety of learning strategies applied (Saraswati & Agustika, 2020). Therefore, a more in-depth analysis is needed to find out the extent of students' mathematical reasoning levels and to design more effective learning interventions. With the right understanding of these conditions, teachers and related parties can design more effective and innovative learning strategies, so that the teaching and learning process can run more optimally and be able to improve the quality of students' understanding and thinking skills as a whole (Haeruman et al., 2017).

External factors such as learning methods, cognitive styles, and learning environments also affect students' mathematical thinking skills (Susanti, 2024). Previous research has shown that reflective and impulsive cognitive styles contribute to the way students solve math problems; Reflective students tend to be cautious and meticulous, while impulsive students tend to be quick but less careful (Sholihah et al., 2024). In addition, the application of innovative approaches such as problem-based learning and open-ended questions has been proven to support the improvement of reasoning skills.

The motivation factor for learning is also an important element that should not be overlooked. Strong motivation, especially related to task scores and orientation to mastery goals, has been shown to have a positive influence on students' mathematical reasoning skills. In addition, critical thinking skills act as a bridge that strengthens the relationship between motivation and mathematical reasoning skills (Setiowati et al., 2024). Therefore, improving mathematical reasoning skills must prioritize cognitive aspects, as well as pay attention to affective factors and students' motivation (Angraini et al., 2023).

Considering the diverse range of factors that affect mathematical reasoning abilities, it is important for educators and teachers to design a thorough and flexible lesson plan. This plan needs to be able to adapt to a variety of student characteristics, including early abilities, anxiety levels, confidence, and learning styles (Sutomo & Aini, 2024). In addition, teachers must provide adequate guidance so that students can develop high confidence and motivation to learn, so as to optimize their mathematical reasoning skills (Novianty et al., 2023).

From the explanation above, research related to the mathematical reasoning ability of junior high school students in set materials is very important (Ma'ruf 2024).

The results of the study are expected to provide a comprehensive understanding of the profile of students' mathematical reasoning abilities, influential factors, and recommendations for effective learning strategies to improve these abilities. With this method, the goal of learning mathematics that focuses on improving critical thinking skills can be achieved well (Winarti et al., 2022).

Although many studies have discussed students' mathematical reasoning skills, most of them emphasize quantitative analysis that only shows the final result of the problem, not the students' thought process (Marasabessy, 2021). This approach is not enough to show the extent to which the understanding of mathematical concepts is built through the student's reasoning process. In addition, the use of analytical frameworks such as SOLO taxonomy in assessing the depth of mathematical reasoning is still limited, so there are shortcomings that need to be filled. The SOLO taxonomy has the advantage of categorizing the quality of answers based on the structure of student understanding in stages (Biggs & Collis, 1982). Therefore, this study aims to fill this gap by exploring the mathematical reasoning ability of junior high school students on set materials qualitatively and in-depth, using reasoning indicators and support from the SOLO taxonomy.

METHOD

The mathematical reasoning ability of junior high school students in the set material was researched using a qualitative descriptive approach. This approach was chosen to gain a deeper understanding of students' thinking processes and reasoning abilities in solving problems related to the set. The research was carried out on grade VII junior high school students who had studied the association material.

The research subjects consisted of junior high school grade VII students who were selected purposively based on variations in mathematical ability, namely high, medium, and low. The selection of this subject aims to obtain varied data related to mathematical reasoning skills at various levels of students' abilities.

The main instruments used in this study were mathematical reasoning tests and interview guides. The mathematical reasoning test is based on the indicators of the reasoning, and this test includes two main problems related to the set material. The interview guide is also structured based on aspects of mathematical reasoning ability. In this study, some of the indicators of mathematical reasoning will be shown in the table below.

Table 1. Presents the Indicators Used to Assess Mathematical Reasoning Skills

No.	Indicators of Mathematical Reasoning Ability
1.	Describe mathematical statements with writing supported by diagrams or illustrations.
2.	Apply calculation procedures with appropriate and relevant principles.
3.	Deduce appropriately based on mathematical concepts or steps.
4.	Developing a guess
5.	Summing up the overall results

Details about the assessment guide used to assess the results of the mathematical reasoning ability test are presented below.

Table 2. Mathematical Reasoning Ability Assessment Guidelines

Score	Guidelines
0	The response given has not indicated a reasoning procedure or no answer has been found.
1	The answers given do not include a complete solution, but show the existence of an argument or procedure that is in accordance with the principles of mathematical reasoning.
2	The correct answer is generally correct, although there are some important errors.
3	In addition, answers were also found that contained one significant error or omission.
4	Complete and error-free answers

Furthermore, the data analysis in this study was carried out based on a scale of 100, with calculations described through the following formula:

$$Nilai\ siswa = \frac{Total\ skor\ yang\ didapat}{Skor\ maksimum\ yang\ bisa\ dicapai} \times 100$$

After assessing students' grades, the next step is to group them according to the assessment criteria listed in Table 3.

Table 3. Guidelines for Mathematical Reasoning Ability Test Results

Guidelines	Score
Excellent	$80 < N \leq 100$
Good	$60 < N \leq 80$
Enough	$40 < N \leq 60$
Low	$20 < N \leq 40$
Very Low	$0 < N \leq 20$

Modification (Emilya, 2010)

In addition to using tests, semi-structured interviews are conducted to better understand the students' thinking process when solving questions, reasons for choosing strategies, and obstacles faced.

Data collection is carried out through several stages:

a. Students complete a validated mathematical reasoning test.
b. The results of the students' work were analyzed to determine the type of reasoning applied (imitative or creative) and the level of achievement of mathematical reasoning indicators.
c. Interviews were conducted with several selected students (based on test results) to explore the thinking process and completion strategies used.
d. The test and interview results data were analyzed descriptively to obtain an overview of students' mathematical reasoning abilities in the set material.

Data analysis is carried out qualitatively with the following steps:

- Grouping students' answers based on mathematical reasoning indicators,
- Determine the type of reasoning (imitative or creative) used by students,
- Analyze interview transcripts to understand students' thought processes,
- Draw conclusions about students' mathematical abilities in terms of reasoning in general.

To ensure the validity of the data, triangulation was carried out between test results, interviews, and validation by experts. The formula used to calculate the percentage is as follows:

$$p = \frac{f}{N} \times 100\%$$

Information:

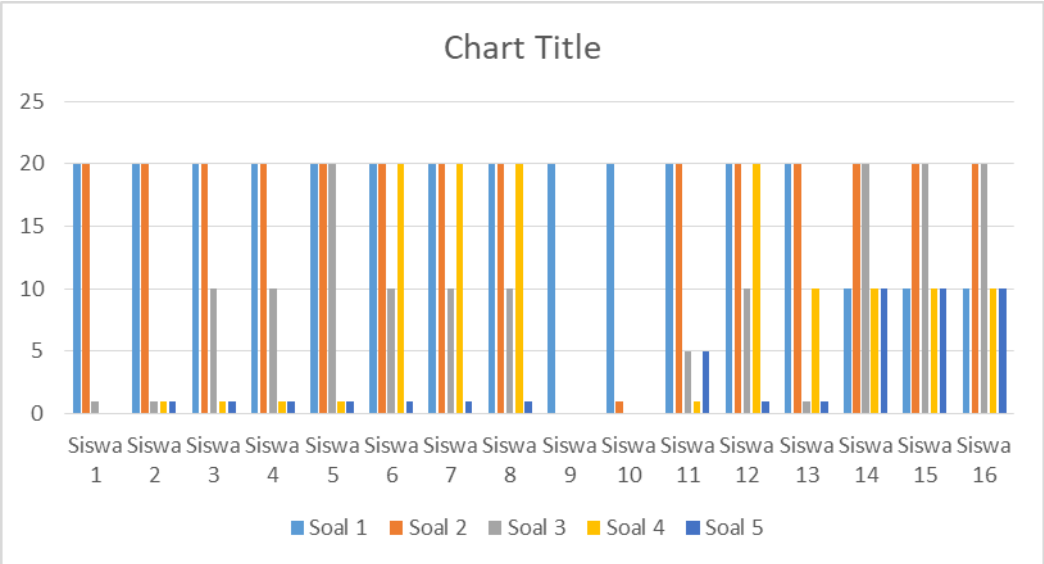
P : percentage of students' mathematical reasoning

f : number of students in a certain category

N : total number of students

Mathematical reasoning test instruments are tested for validity and reliability before use. Validity is tested through expert judgment as well as empirical testing, while reliability is measured using reliability coefficients (e.g. Alpha Cronbach) to ensure consistency of measurement results. The tools used are considered valid and reliable if they meet the established statistical criteria.

RESULTS AND DISCUSSION



For indicator 1, almost all students got the maximum score (20) on this question, except for Student 16 (10). This shows that the majority of students are able to explain mathematical statements well through writing and/or diagrams. The basic ability to understand and state mathematical problems has been mastered well by most students. Similar to question 1, the majority of students got the maximum score (20), except for Student 9 (0) and Student 10 (10). This shows that students are generally able to apply calculation procedures correctly, showing mastery of algorithms and calculation rules. Student 9 needs special attention because he totally failed in this aspect. For indicator 3, the score on this indicator varies greatly, from 0 to 20. This indicator requires conceptual and logical thinking skills. Many students have difficulty in drawing accurate conclusions from the steps taken. Strengthening the ability to make generalizations from mathematical processes is needed. For indicator 4, the average score tends to be low, although some get a score of 10, most students only get 1 or 0 points. This shows that the ability to think or make predictions has not developed optimally. Explorative or open-ended activities in learning need to be improved. For indicator 5, the distribution of scores is also uneven. Many students scored 1 or 0, indicating weakness in concluding the overall final results. This aspect shows that the reflective ability of the entire problem-solving process is still uneven.

After a mathematical reasoning test and interviews with grade VII junior high school students related to the completion of problems in the set material, results were obtained that were classified into three categories: good, adequate, and low. The overall data breakdown is shown in the following Table 4:

Table 4. Results of the Mathematical Reasoning Ability Test

Category	Number of Students	Percentage (%)
Good	7	43,75%
Enough	7	43,75%
Low	2	12,5%

The analysis of the answers and explanations contained in Table 4 which shows students' mathematical reasoning skills, will be discussed further below.

Good Category

By referring to the results of the mathematical reasoning test focusing on the set material, there were 7 students who were in the good category group. If calculated in percentages, this number is equal to 43.75%.

The following is an example of the work of one of the students who is included in the good category.

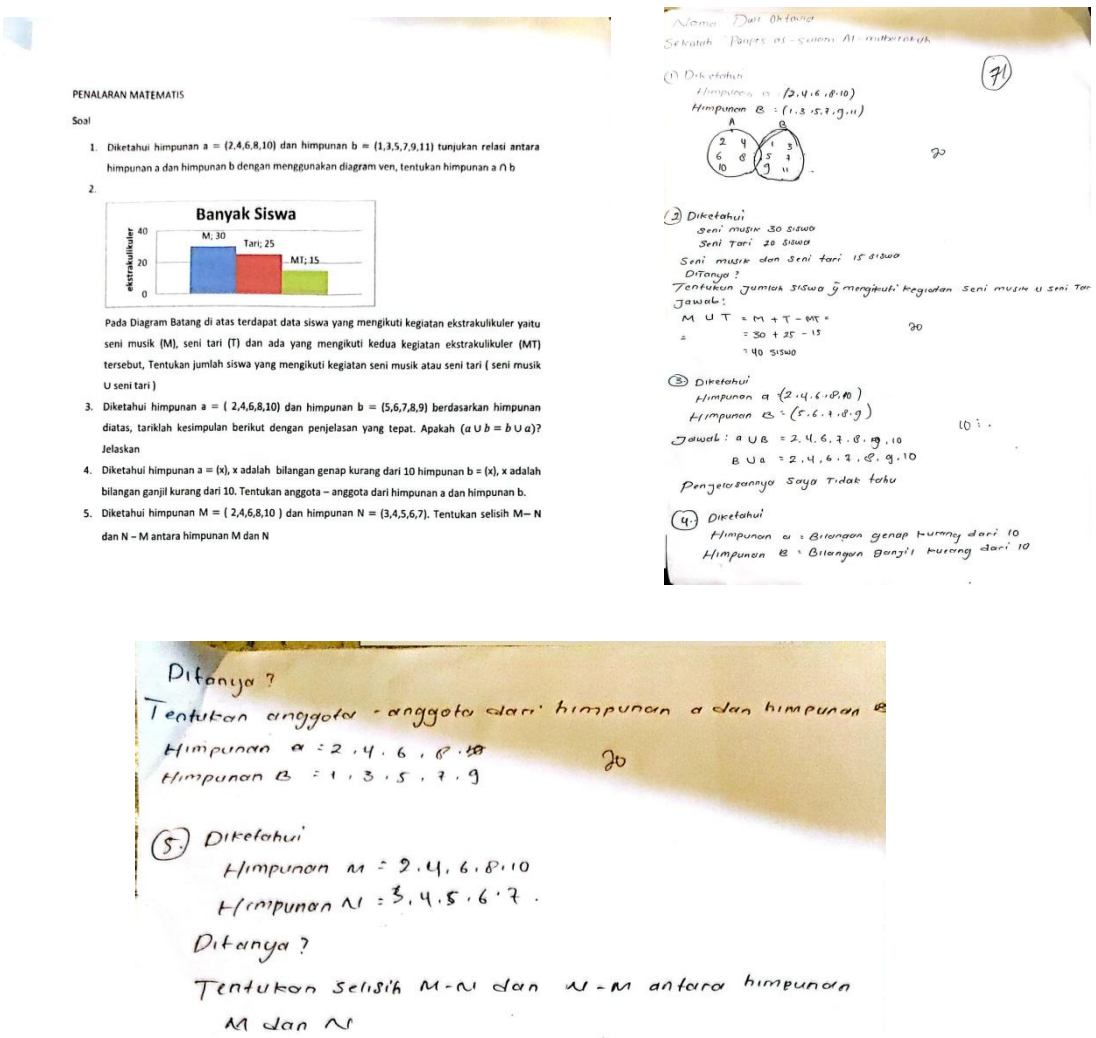


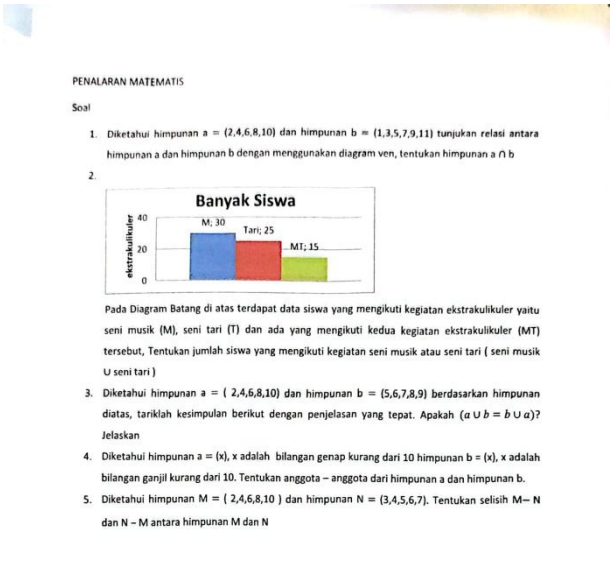
Figure 1. Example of the Completion of the Good Student Category

A total of seven students (43.75%) are included in this category. Based on the test results, students are able to explain mathematical statements both in writing and through diagrams. They are also able to apply calculation procedures accurately, draw conclusions according to concepts, and develop logical conjectures and correctly infer the overall results.

From the interviews, it is known that students in this category understand the problem clearly and are able to design a systematic solution strategy. The maximum score achieved on several indicators shows that their reasoning skills are sufficiently mature. The number of students in this category has met the grade criteria $60 < n < 80$.

Sufficient Category

For the second category, the results of the mathematical reasoning ability test regarding the set material showed that there were 7 students who were in the Sufficient category. In percentage, the number of students in this category is also 43.75%. The following is an example of the performance of a student who is in the sufficient category.

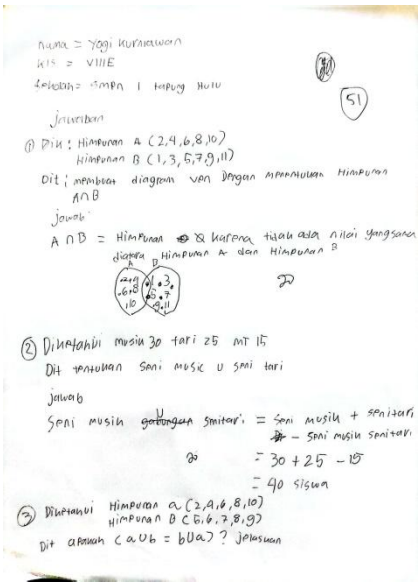


PENALARAN MATEMATIS

Soal

1. Diketahui himpunan a = {2,4,6,8,10} dan himpunan b = {1,3,5,7,9,11} tunjukan relasi antara himpunan a dan himpunan b dengan menggunakan diagram ven, tentukan himpunan a ∩ b
2.

Pada Diagram Batang di atas terdapat data siswa yang mengikuti kegiatan ekstrakulikuler yaitu seni musik (M), seni tari (T) dan ada yang mengikuti kedua kegiatan ekstrakulikuler (MT) tersebut, Tentukan jumlah siswa yang mengikuti kegiatan seni musik atau seni tari (seni musik U seni tari)
3. Diketahui himpunan a = (2,4,6,8,10) dan himpunan b = (5,6,7,8,9) berdasarkan himpunan diatas, tariklah kesimpulan berikut dengan penjelasan yang tepat. Apakah $(a \cup b = b \cup a)$? Jelaskan
4. Diketahui himpunan a = (x), x adalah bilangan genap kurang dari 10 himpunan b = (x), x adalah bilangan ganjil kurang dari 10. Tentukan anggota – anggota dari himpunan a dan himpunan b.
5. Diketahui himpunan M = (2,4,6,8,10) dan himpunan N = (3,4,5,6,7). Tentukan selisih M– N dan N – M antara himpunan M dan N



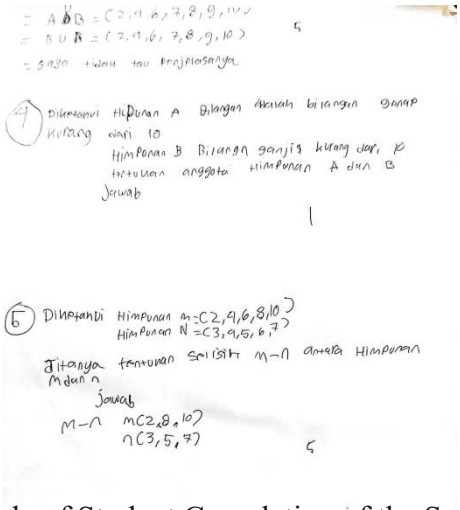


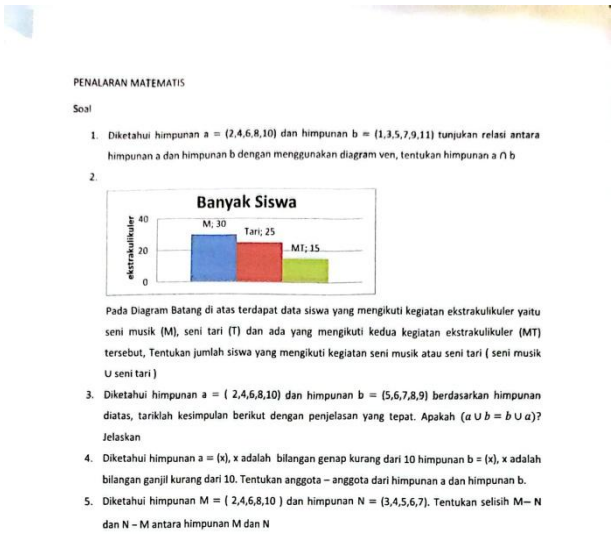
Figure 2. Example of Student Completion of the Sufficient Category

A total of seven students (43.75%) were also in this category. In general, they can write mathematical statements and include illustrations, although they are not yet complete. The calculations were done correctly, but the conclusions drawn did not reflect the overall understanding of the concept. Some students also still experience mistakes in the development of conjectures and final conclusions.

Interviews revealed that some students in this category understood the problem, but often missed an important step in solving. This causes their grades to not reach the good category, even though the potential to grow is quite large. In sufficient categories, students meet the grade criteria that $40 < N < 60$.

Low Category

Based on the results of the evaluation of students' mathematical reasoning skills about data and diagrams, there are two students who fall into the low category. If calculated in percentages, this figure reaches 12.5%. The following is an example of a question worked on by one of the students who is in the low category.



PENALARAN MATEMATIS

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1. Diketahui himpunan a = {2,4,6,8,10} dan himpunan b = {1,3,5,7,9,11} tunjukan relasi antara himpunan a dan himpunan b dengan menggunakan diagram ven, tentukan himpunan a ∩ b
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Pada Diagram Batang di atas terdapat data siswa yang mengikuti kegiatan ekstrakulikuler yaitu seni musik (M), seni tari (T) dan ada yang mengikuti kedua kegiatan ekstrakulikuler (MT) tersebut, Tentukan jumlah siswa yang mengikuti kegiatan seni musik atau seni tari (seni musik U seni tari)
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5. Diketahui himpunan M = { 2,4,6,8,10 } dan himpunan N = {3,4,5,6,7}. Tentukan selisih M– N dan N – M antara himpunan M dan N

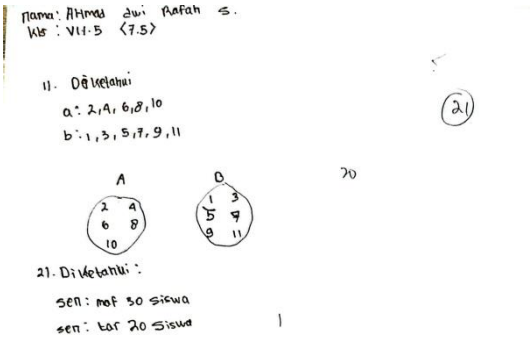

Figure 3. Examples of Student Completion of the Low Category

A total of two students (12.5%) are included in this category. They showed difficulty in writing mathematical statements sequentially and rarely used supporting diagrams. Calculations are not carried out according to the rules, and the conclusions drawn tend to be irrelevant or not in accordance with the concept in question. The allegations made are also inaccurate or do not appear at all.

The interviews reinforce these findings, showing that students in this category have problems in understanding the problem and are unable to formulate the solution steps properly. Mastery of basic materials and confidence in answering questions is also still low. This problem results in scores and grades obtained by students that are not optimal, so their grades are still below average. In the low category, students who have $20 < N \leq 40$.

Based on the results of the classification of students' mathematical reasoning skills, it can be seen that the proportion of students who are in the good and sufficient category is 43.75%, while those in the low category are 12.5%. This shows that most students have shown sufficient to good reasoning skills, although there are still a number of students who need special attention.

These results are in line with the findings (Wahyuni et al., 2019) which states that the mathematical reasoning ability of high school students is generally in the medium category, with a small percentage in the high and low categories. These findings reinforce that reasoning skills are not formed instantly, but through a continuous and directed learning process.

One of the causes of low reasoning skills is the lack of optimal understanding of basic concepts and lack of mastery of problem-solving strategies (Marlinda & Budiman, 2025). In addition, affective factors such as self-confidence also play a role in influencing student performance in solving math problems. This is consistent with

previous research that states that motivation, confidence, and critical thinking skills contribute to improving mathematical reasoning skills (Apriani & Sudiansyah, 2024).

Thus, a learning approach is needed that not only focuses on the cognitive aspect, but also pays attention to the affective aspect of students. Teachers need to create a learning environment that encourages students to think critically, present arguments, and develop problem-solving strategies independently. Approaches such as problem-based learning and open-ended questions can be effective alternatives to improve the overall quality of students' mathematical reasoning.

CONCLUSION

Based on the analysis, the material given to grade VII students can be used to draw conclusions regarding their abilities, most of which are in the intermediate category. This conclusion is taken from the scores obtained by each student. The results of the mathematical reasoning ability test showed that 43.75% of students (7 people) were in the good category, 43.75% (7 students) were in the sufficient category, and 12.5% (2 students) were in the low category.

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