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AN ANALYSIS OF ADAPTIVE REASONING ABILITY IN MIDDLE SCHOOL STUDENTS MATHEMATICS LEARNING

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ABSTRACT

Mathematics is one of the subjects taught in formal educational institutions, which is an important part of efforts to improve the quality of education. Students' adaptive reasoning ability in mathematics is reflected through their critical, logical, and systematic thinking, and their objective, honest, and disciplined nature in solving problems, whether in mathematics, other subjects, or daily life. This study aims to evaluate the adaptive reasoning ability in mathematics of middle school students. This research employs a qualitative approach with a descriptive method. The subjects of this study were 14 students from SMPIT Al-Irsyad Al-Islamiyyah Karawang, grouped into five levels: very high, high, medium, low, and very low. Data were collected from the tests on adaptive reasoning ability in mathematics to understand the students' reasoning abilities. Scores were given to students who answered each question based on the indicators achieved. The highest percentage was obtained on the indicator of forming conjectures, at 48.21%, while the lowest rate was 3.57% on the indicator of finding patterns in a mathematical phenomenon. Overall, the average results for each indicator were: Indicator 1 - 48.21%, Indicator 2 - 26.79%, Indicator 3 - 35.71%, Indicator 4 - 8.93%, and Indicator 5 - 3.57%. Therefore, the average percentage of student achievement in answering the adaptive reasoning ability test in mathematics was 24.64%. It can be concluded that middle school students' mastery of adaptive reasoning ability in mathematics is categorized as low.

Keywords: Adaptive Reasoning, Learning Ability, Mathematical Reasoning

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INTRODUCTION

Mathematics is one of the subjects taught in formal educational institutions, which is an important part of efforts to improve the quality of education (Novitasari, 2016). Mathematics lessons involve various interrelated concepts. These concepts are forms of abstract ideas that have the potential to categorize objects into examples and non-examples. The interrelationship between concepts in mathematics indicates the importance of understanding existing mathematical concepts. Therefore, understanding a mathematics topic becomes difficult if students are not able to comprehend the previous material or the prerequisite material that forms its basis.

Students often experience difficulties in understanding mathematics material or studies. This is explained by Russefendi (Cited in Novitasari, 2016) that 'many children, after learning

simple parts of mathematics, fail to understand them and many concepts are misunderstood. Mathematics is considered a difficult and deceptive science.' Mathematics is an inseparable part of human life. Unconsciously, mathematics becomes an essential component needed in various situations and conditions, making it vital. However, in the process of learning mathematics, there are still challenges that can lead to students' failure to understand the subject.

According to the Regulation of the Minister of National Education of the Republic of Indonesia Number 22 of 2006, one of the objectives of learning mathematics is for students to master mathematical concepts, describe relationships between concepts, and use these algorithms or concepts flexibly, accurately, and efficiently in problem-solving. From the elaboration of these objectives, it is clear that reasoning ability in learning mathematics becomes one of the key competencies that students must possess. This is due to the complexity of mathematics, which consists of various interrelated reasoning abilities, which are then used gradually in learning.

According to Rohman et al., (Cited in Suendang, 2017) reasoning is a series of human activities to conclude one or more known decisions. According to Wade and Ravris (Cited in Suendang, 2017), students' reasoning ability is reflected in their critical, logical, and systematic thinking, and their objective, honest, and disciplined nature in solving problems, whether in mathematics, other subjects, or daily life. In line with Ball, Lewis, and Thamel's opinion (Cited in Widjaya, 2010), "*mathematical reasoning is the foundation for the construction of mathematical knowledge*".

Mathematics plays an important role in the academic development of middle school students because it has broad relevance in various aspects of learning. Mathematics serves as the foundation for reasoning ability, which is crucial in science. The logical, analytical, and critical thinking skills developed through mathematics learning can help students solve problems effectively, both within and beyond mathematical contexts. Additionally, mathematics introduces students to essential skills such as modeling, abstraction, and problem-solving, which are vital competencies in education. Kusumawardani et al., (2018) state that students are not only required to have arithmetic skills but also need to possess logical and critical reasoning abilities to solve problems. Solving problems is not only about answering questions but also about applying this ability in daily life.

Mathematics learning involves several skills necessary for students as a form of their mastery of the subject. According to the National Research Council, reasoning ability that combines both inductive and deductive methods is known as adaptive reasoning. According to Kilpatrick et al., (2006) in their work Adding It Up (2001), state that adaptive reasoning is not limited to deductive reasoning based on formal proof but also includes intuitive and inductive reasoning using patterns, analogies, and metaphors as the basis for concluding.

Adaptive reasoning is the human cognitive ability to adjust their thinking and behavior according to changing environments or situations. It involves the capacity to learn from experience, process new information, and adapt thinking strategies and actions based on ever-changing conditions. For example, in situations where individuals are faced with tasks they have never encountered before, adaptive reasoning allows them to identify patterns, make appropriate decisions, and adjust their approach dynamically based on received information. Thus, adaptive reasoning plays a crucial role in helping individuals navigate the complexities of a rapidly changing world. Adaptive reasoning emphasizes not only problem-solving but also logical thinking, which is reasonable and uses correct reasoning. This is based on previously known facts and genuinely considers that the solution procedure is indeed by applicable rules (Putra, (2016).

Additionally, adaptive reasoning can be seen in the context of learning and personal development. When individuals face challenges or difficulties in achieving their goals,

adaptive reasoning allows them to evaluate the strategies they use, identify alternative solutions, and adjust their approaches to achieve the desired outcomes. This process includes the use of metacognition, the ability to monitor and regulate one's thinking, and reflection on past mistakes or failures. In this way, adaptive reasoning not only helps individuals overcome obstacles but also facilitates personal growth and the development of adaptive skills necessary to face future challenges.

Adaptive reasoning skills refer to students' ability to prove a statement by combining two methods of proof, namely inductive and deductive reasoning. Heinze et al., (2009) (Cited in Fikriya, 2018) emphasize that adaptive reasoning skills are an important aspect of students' mathematical abilities that need attention in educational development. They explain that when students solve mathematical problems, especially word problems, they must be able to formulate arguments and strengthen them through representation, thus being able to apply and prove them in problem-solving.

Mathematics learning requires problem-solving that involves critical thinking, creativity, reasoning, and the ability to make connections between concepts. Through this process, students gain improvements in various cognitive aspects such as understanding, memory, and higher-order thinking skills. Furthermore, adaptive reasoning often involves structured and methodical thinking processes, which in turn strengthen students' abilities to face academic challenges across various subjects. Therefore, mathematics is not only a central subject in the curriculum but also plays a crucial role in forming the foundation of intelligence and learning abilities for middle school students.

According to Wahyudin (Ramdan & Roesdiana, 2022), students' success in understanding mathematics material is often closely related to their adaptive mathematical reasoning abilities. Wahyudin highlights that a lack of understanding and proper application of reasoning by students is often a primary factor in their failure to grasp mathematical concepts. Based on this background, this study aims to evaluate the adaptive reasoning abilities in mathematics among middle school students. The assessment of these reasoning abilities uses several indicators, including students' ability to generalize to predict answers and devise solution processes, perform mathematical manipulations, identify patterns and relationships to analyze mathematical situations and draw conclusions from the analysis results. This research is significant in measuring the extent to which students' mathematical reasoning abilities have developed. Therefore, this study aims to provide a better understanding of students' reasoning abilities in solving various types of mathematical problems and to describe the overall level of mathematical reasoning abilities.

METHOD

This research employs a qualitative study with a descriptive method. The subjects of this study are 14 middle school students from SMPIT Al-Irsyad Al-Islamiyyah Karawang, categorized into five levels: very high, high, medium, low, and very low based on their average scores and standard deviations, as outlined by (Arikunto, 2010). Data collection techniques involve using essay tests tailored to five indicators: formulating hypotheses, providing reasons or evidence for the truth of a statement, drawing conclusions from a statement, verifying the validity of an argument, and identifying patterns in mathematical phenomena. Subsequently, students' responses will serve as answers and outcomes from which conclusions will be drawn.

RESULTS AND DISCUSSION

The research involves collecting data from test results on students' adaptive reasoning in mathematics to understand their adaptive reasoning abilities. Scores are given to students who have answered each item based on the achieved indicators. The total score from each

indicator is then calculated based on the indicator to be achieved. To determine the average and percentage of students' mathematical adaptive reasoning abilities for each indicator, student responses are analyzed by calculating the percentage of the average scores obtained, and the results are interpreted based on predefined categories of mathematical adaptive reasoning abilities. The study utilizes mathematical adaptive reasoning indicators as outlined by Widjajanti (2011), which can be seen in Table 1.

Table 1. Adaptive Reasoning Ability Indicators

No.	Category
1	Formulating hypotheses
2	Providing reasons or evidence for the truth of a statement
3	Concluding a statement
4	Verifying the validity of an argument
5	Identifying patterns in mathematical phenomena

Furthermore, the adaptive reasoning indicators developed by Wibowo (2016) are shown in Table 2.

Table 2. Adaptive Reasoning Assessment Indicators

No.	Adaptive Reasoning Indicator
1	Ability to propose conjectures or hypotheses
2	Ability to provide reasons for the given answers
3	Ability to conclude a statement
4	Ability to examine an argument
5	Ability to identify patterns in a mathematical problem

Based on the interpretation criteria of students' adaptive reasoning abilities, the range categories of the adaptive reasoning assessment scores in this study can be seen in Table 3.

Table 3. Range Categories of Adaptive Reasoning Assessment Scores

High (M+1SD <= X)	$66 \leq X$	0	0%
Medium (M-1SD<=X<M+1SD)	$23 \leq X < 66$	4	33%
Low (X<M-1SD)	$X < 23$	10	67%

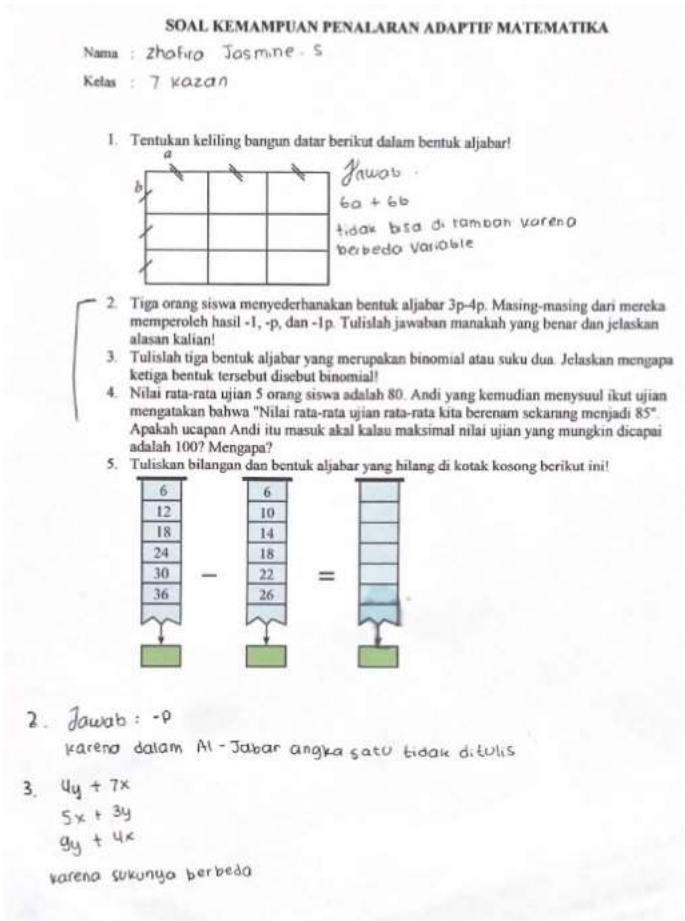
The proficiency test conducted on November 22, 2023, utilized mathematical adaptive reasoning assessment indicators. The results of the mathematical adaptive reasoning test are shown in Table 4.

Table 4. Results of the Mathematical Adaptive Reasoning Test

No.	Assessment Indicator	Number of Correct Answers	Percentage of Correct Answers	Average
1	Formulating hypotheses	27	48.21%	2
2	Providing reasons or evidence for the truth of a statement	15	26.79%	1
3	Concluding a statement	20	35.71%	1
4	Verifying the validity of an argument	5	8.93%	0
5	Identifying patterns in mathematical phenomena	2	3.57%	0
	Average		24.64%	Low

Based on the data analysis presented in Table 5, it can be concluded that there are three criteria across the five tested indicators. These criteria are moderate, low, and very low. One indicator falls under the moderate criterion, while two indicators fall under the low criterion, and the remaining two indicators fall under the very low criterion. The highest percentage of correct answers in this study is 48.21%, obtained in the indicator of forming hypotheses. Meanwhile, the lowest percentage of correct answers is 3.57%, observed in the indicator of identifying patterns in mathematical phenomena. Additionally, the indicator of providing reasons or evidence for the truth of a statement has a correct answer percentage of 26.79%, the indicator of concluding a statement has a correct answer percentage of 35.71%, and the indicator of evaluating the validity of an argument has a correct answer percentage of 8.93%.

These results are consistent with the adaptive reasoning test administered to 14 tested students. From this study, it can be concluded that the majority of students encountered difficulty in the mathematical adaptive reasoning indicator of identifying patterns in mathematical phenomena. This condition led to nearly all students being unable to provide answers, resulting in the lowest percentage for the indicator of identifying patterns in mathematical phenomena. Examples of student responses can be found in Figure 1.



SOAL KEMAMPUAN PENALARAN ADAPTIF MATEMATIKA

Nama : Zhafira Jasmine S

Kelas : 7 kazan

1. Tentukan keliling bangun datar berikut dalam bentuk aljabar!

Jawab :
6a + 6b
tidak bisa di tambah karena berbeda variable

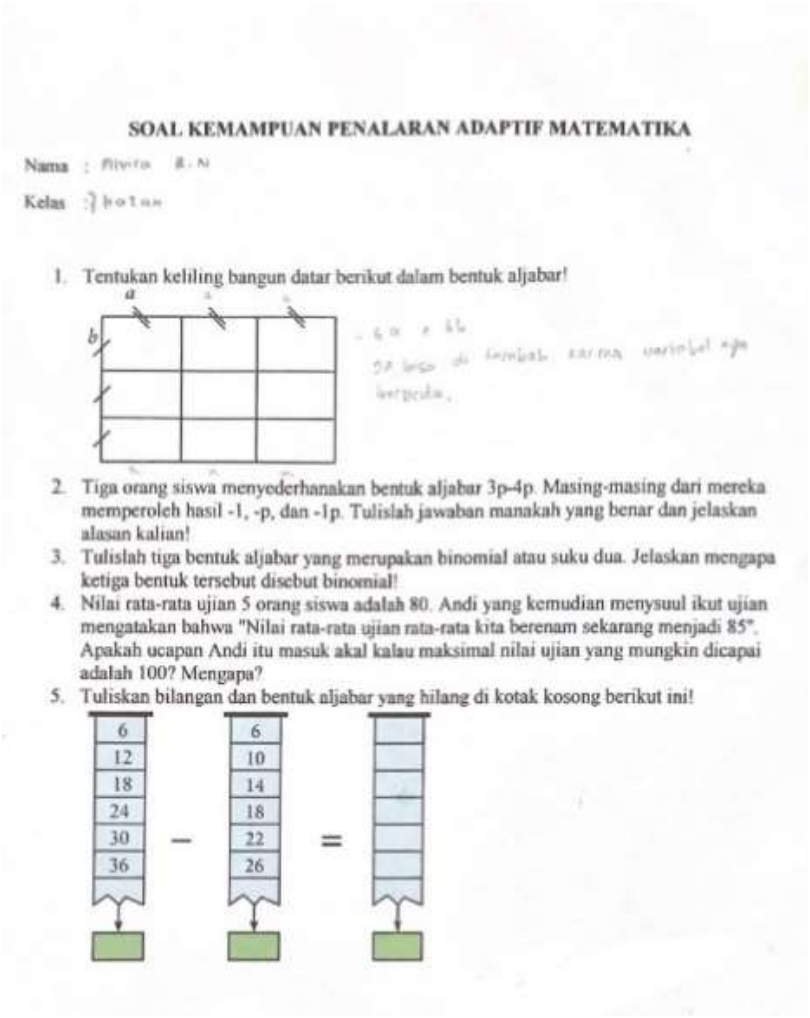
2. Tiga orang siswa menyederhanakan bentuk aljabar 3p-4p. Masing-masing dari mereka memperoleh hasil -1, -p, dan -1p. Tulislah jawaban manakah yang benar dan jelaskan alasan kalian!
3. Tulislah tiga bentuk aljabar yang merupakan binomial atau suku dua. Jelaskan mengapa ketiga bentuk tersebut disebut binomial!
4. Nilai rata-rata ujian 5 orang siswa adalah 80. Andi yang kemudian menyusul ikut ujian mengatakan bahwa "Nilai rata-rata ujian rata-rata kita berenam sekarang menjadi 85". Apakah ucapan Andi itu masuk akal kalau maksimal nilai ujian yang mungkin dicapai adalah 100? Mengapa?
5. Tuliskan bilangan dan bentuk aljabar yang hilang di kotak kosong berikut ini!

6	6	
12	10	
18	14	
24	18	
30	22	
36	26	

2. Jawab : -p
karena dalam Al-Jabar angka satu tidak ditulis

3. $4y + 7x$
$5x + 3y$
$9y + 4x$
karena sukunya berbeda

Figure 1. Student 1's Response Results to the Question Figure



SOAL KEMAMPUAN PENALARAN ADAPTIF MATEMATIKA

Nama : Rivera R. N

Kelas : 7 Intan

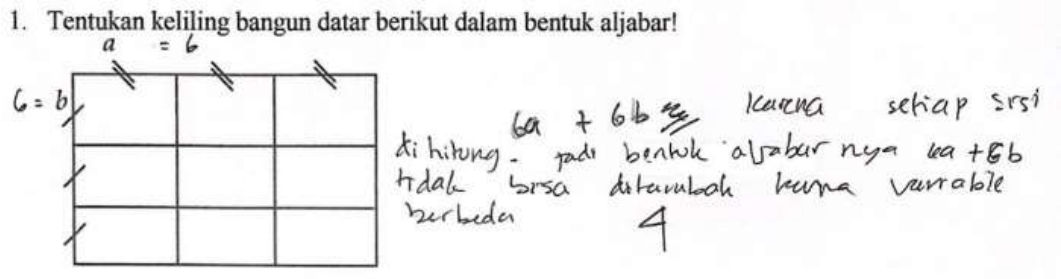
1. Tentukan keliling bangun datar berikut dalam bentuk aljabar!

2. Tiga orang siswa menyederhanakan bentuk aljabar 3p-4p. Masing-masing dari mereka memperoleh hasil -1, -p, dan -1p. Tulislah jawaban manakah yang benar dan jelaskan alasan kalian!
3. Tulislah tiga bentuk aljabar yang merupakan binomial atau suku dua. Jelaskan mengapa ketiga bentuk tersebut disebut binomial!
4. Nilai rata-rata ujian 5 orang siswa adalah 80. Andi yang kemudian menyusul ikut ujian mengatakan bahwa "Nilai rata-rata ujian rata-rata kita berenam sekarang menjadi 85". Apakah ucapan Andi itu masuk akal kalau maksimal nilai ujian yang mungkin dicapai adalah 100? Mengapa?
5. Tuliskan bilangan dan bentuk aljabar yang hilang di kotak kosong berikut ini!

6		6			
12		10			
18		14			
24		18			
30	−	22	=		
36		26			

Figure 2. Student 2's Response to the Question Figure

From Figure 1, it can be observed that the student was able to answer all the questions effectively. However, upon closer examination of each item, it becomes evident that the student employed varied problem-solving methods. This finding aligns with Sulistiawati's research (Lestari et al., 2018) which suggests that a significant portion of student errors in answering questions stems from difficulties in determining the appropriate steps during problem-solving. This issue often arises due to students' lack of familiarity with reasoning tasks.



1. Tentukan keliling bangun datar berikut dalam bentuk aljabar!

6a + 6b karena setiap sisi di hitung. jadi bentuk aljabar nya 6a + 6b tidak bisa ditambah karna variable berbeda

4

Figure 3. Student 1's Response Results to Question Number 1

The sample in Figure 3 represents the student's response, which is a form of statement that represents the indicator of forming hypotheses. This indicator yielded the highest percentage in the results. Therefore, it can be determined that Question Number 1 is the easiest task based on students' adaptive mathematical reasoning. This finding aligns with Mugianto et

al., (2021), indicating that students' ability in adaptive reasoning, specifically in hypothesizing, is moderate.

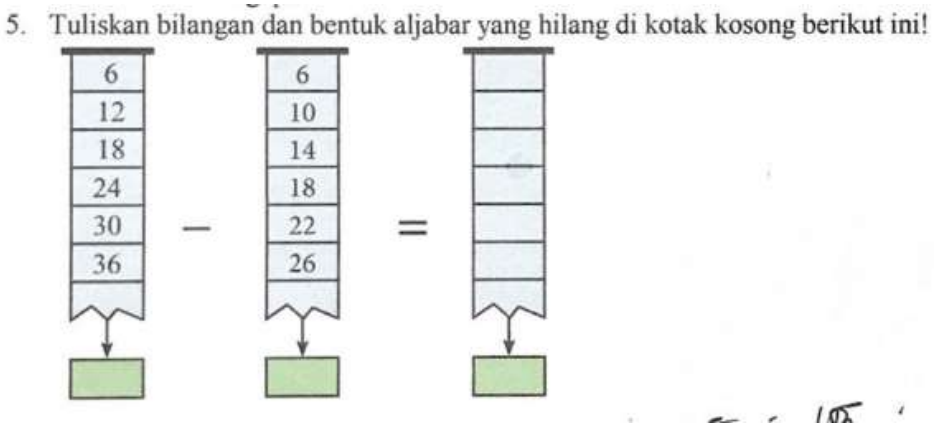


Figure 4. Student 2's Response Results to Question Number 2

In Figure 4, the sample answer represents Question Number 5, which corresponds to the indicator with the lowest percentage, specifically the indicator of identifying patterns in mathematical phenomena. Upon reviewing the student's response, it is evident that the student struggled to identify the pattern needed to estimate the answer and to devise a solution process for the mathematical phenomenon presented in the question. The task required the student to write the missing number and algebraic form in the blank box. This illustrates that the student has not yet mastered the indicator of identifying patterns in mathematical phenomena. This finding is consistent with Permana et al.'s research (2020), which concluded, based on test results and interviews with students, that students with high, moderate, and low abilities have difficulty identifying patterns in mathematical phenomena.

Based on the data, it is apparent that students' adaptive reasoning abilities are categorized as low. The importance of improving students' adaptive reasoning skills is crucial, considering its significant impact on their mathematical abilities. Windayana (2016) asserts that reasoning is a critical aspect that must develop as students learn mathematics, alongside other skills. Reasoning is considered the most fundamental aspect of mathematics and should be optimally developed by students. Students need to be equipped with problem-solving skills because learning is not solely about memorizing information but also about the process of solving problems involving reasoning (Amaliyah, Pujianti, & Fauziah, 2022).

The relationship between specific factors and students' adaptive reasoning abilities is a crucial area of research for understanding the dynamics of mathematics learning. These factors may include the teaching methods employed, the learning environment, and individual motivation. For instance, teaching methods that emphasize active problem-solving and the use of flexible thinking strategies tend to enhance students' adaptive reasoning abilities. Learning environments that facilitate discussion and collaboration among students can also strengthen adaptive reasoning by allowing students to consider various perspectives and problem-solving strategies. According to the findings discussed by Indriani et al. (2017), regarding each indicator of adaptive reasoning abilities, a common cause affecting students' adaptive reasoning abilities in problem-solving is errors in understanding the problem conditions or issues presented, leading to the use of inappropriate problem-solving strategies.

Moreover, individual motivation plays significant role in students' adaptive reasoning abilities. Students with high intrinsic motivation towards mathematics tend to be more active in seeking a deep understanding of mathematical concepts, thereby strengthening their adaptive reasoning abilities. Conversely, students who are less motivated or feel pressured

by academic stress may encounter obstacles in developing adaptive reasoning skills. By understanding the relationship between these factors, educators can design more effective learning strategies to enhance students' adaptive reasoning abilities within the context of mathematics education.

CONCLUSION AND SUGGESTIONS

Based on the results and discussion from the conducted research, the highest percentage was obtained in the indicator of forming hypotheses at 48.21%, while the lowest percentage was 3.57% in the indicator of identifying patterns in mathematical phenomena. Overall, the average percentage score for students' achievement in the adaptive mathematical reasoning test was 24.64%. It can be concluded that middle school students' mastery of adaptive mathematical reasoning skills falls into the low category.

Recommendations for future research include creating creative learning models and enhancing students' understanding of adaptive mathematical reasoning skills. Given the low adaptive mathematical reasoning skills among students, appropriate teaching strategies are essential to improve their proficiency in this area.

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