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Analysis of Students' Metacognition in Solving Arithmetic Sequence and Series Problems Reviewed from the Mathematical Ability of SMA Negeri 1 Ngabang

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Abstract

This study aims to analyze students' metacognitive processes in solving arithmetic sequence and series problems based on their mathematical ability. This study employed a qualitative approach with a descriptive research design. the research subjects consisted of three eleventh grade students of high, medium, and low mathematical ability. Data were collected through problem solving tests on arithmetic sequence and series material structured interiews to explore students' thingking processes in greater depth. Data were analyzed using qualitative analysis techniques consistng of data reduction data presentatio, and conclucion drawing with verification. The results showed that students with high mathematical ability were able ti plan solution strategies, monitor the problem solving process, and evaluate the results effectively. students processes, although they still experienced difficulties in moitoring the soling process and determining solution strategies in some problems. meanwhile, students with low mathematical ability experienced difficulties in understanding the problem, determining solution strategies, and evaluating the results of their solutions. The study consludes that mathematical prolem. Therefore, teachers are recommended to develop learing strategies that can train students' metacognitive awareness i order to improve their mathematical problem solving abilities.

Keywords: metakognition. mathematical ability, problem solving, arithmetic sequence, arithmatic series.

INTRODUCTION

Mathematics is a crucial subject for developing logical, analytical, and systematic thinking skills. In the 21st-century educational era, these skills are a key asset for students facing life's challenges and rapid technological advances. At the senior high school (SMA) level, mathematics instruction significantly contributes to the development of higher-order thinking skills, particularly problem-solving. One of the curriculum's key focuses is the ability to solve mathematical problems. In solving mathematical problems, metacognitive skills and learning creativity are essential and crucial for students to successfully solve various mathematical problems (Oktaviani et al., 2023) .

However, students often face difficulties in understanding concepts and applying problem-solving strategies in mathematics learning, especially in the material of arithmetic sequences and series. This material requires a strong understanding of number patterns, the nth term, the sum of n terms, and the ability to identify and use the concept of arithmetic sequences correctly.

According to (Safari et all, 2025) arithmetic sequences and series are one of the important topics in mathematics that have many applications in various disciplines, such as science, economics, and engineering. One of the main characteristics of an arithmetic sequence is the constant difference in value between each term, while an arithmetic series refers to the sum of all terms in the sequence. Student errors usually occur in identifying whether a sequence is arithmetic, determining the difference (d), using the nth formula, calculating the sum of n terms, and relating the concept to its application in the context of everyday life. In addition, arithmetic sequences and series are also an important foundation for understanding advanced concepts such as linear growth, pattern analysis, and other contextual problems.

Students' difficulties are not only caused by a weak understanding of concepts, but also a lack of awareness of the thought processes they engage in when solving problems. This is where metacognition plays a major role. The role of metacognition in mathematics learning is very significant, especially in the context of problem- solving. Metacognition was introduced by John Flavell, defined as thinking about thinking or a person 's knowledge of their thought processes (Aprilia et al., 2021) . According to (N. Erni Susiani, 2021) , metacognition is the awareness and knowledge of a person's thinking in developing thinking strategies to solve problems. Therefore, the involvement of metacognition is necessary to reduce student difficulties in problem-solving (Rosali, 2024) . In line with previous research, students with high metacognition showed better problem-solving performance than students with low metacognition.

Developing metacognition in mathematics learning is crucial for students to become more independent, critical, and reflective learners. Through metacognition, students can understand what they think, what they know, and what they have learned to build stronger new understandings, thus optimizing the problem-solving process. Furthermore, according to Aprilia et al. (2021) , through metacognitive development, students are expected to become accustomed to monitoring, controlling, and evaluating their actions. Furthermore, a person needs to manage their thoughts effectively by utilizing existing knowledge, controlling, and reflecting on their own thought processes and outcomes, which can aid in problem-solving. Through metacognitive skills, students are encouraged to understand what they think, what they have, and what they need to acquire, so that their mathematics learning experiences can generate new, more complex knowledge and improve mathematical problem-solving.

In addition to metacognition, mathematical ability is also an important factor influencing students' success in solving arithmetic sequences and series. According to (Suciati & Mailili, 2022) , mathematical ability is the ability or skill possessed by students in facing and solving mathematical problems, consisting of communication reasoning, problem solving, connections, conceptual understanding, and critical and creative thinking, among others. (Anisa et al., 2021) stated that students with moderate and high mathematical understanding abilities tend to be able to apply formulas and perform calculations correctly.

Meanwhile, students with low mathematical understanding abilities are not yet able to apply formulas and perform calculations correctly (Inductive Understanding). This difference in mathematical ability directly affects the quality of students' metacognition, because the better a person's mathematical ability, the more focused the planning, monitoring, and evaluation processes carried out when solving problems. Therefore, reviewing metacognition based on mathematical ability is important to understand how students think and organize strategies when facing problems with arithmetic sequences and series.

Several previous studies have explained the relationship between metacognition and mathematics learning outcomes. However, not many have studied in depth the metacognitive process of students in solving arithmetic sequence and series problems in terms of mathematical ability, especially in the context of grade XI high school. Therefore, this study is important to analyze the metacognitive process of students in solving arithmetic sequence and series problems in terms of mathematical ability. The results of this study are expected to provide an in-depth picture of the differences in students' thinking processes based on their mathematical abilities and become a reference for teachers in developing learning strategies that can increase students' metacognitive awareness in the material of arithmetic sequences and series.

METHODS

This study uses a qualitative approach with a descriptive research type. (Safarudin et al., 2023) Qualitative Research is a humanistic research model, where humans in this study are placed as the main subjects in a social event. According to (Adhimah, 2020) , research subjects are data sources that can provide information related to the research problems being studied. The subjects of this study were grade XI students of SMA Negeri 1 Ngabang who became sources of information regarding the metacognitive process in solving arithmetic sequence and series problems. The research subjects were selected by purposive sampling, purposive sampling is one of the non-random sampling techniques in which researchers determine sampling by determining special characteristics that are in accordance with the research objectives so that they are expected to answer the research problems (Peldi et al., 2024) . Determination of subjects is based on the category of mathematical ability, namely high, medium and low. One student from each category will be taken as the main subject of the study so that the total subjects are three students .

The research data consists of two data sources: primary data and secondary data. Primary data is the primary source of information collected directly by researchers during the research process. This data is obtained from original sources, namely respondents or informants related to the research variables. Primary data can be in the form of observations, interviews, or data collection through questionnaires (Undari and Mohamad, 2024) . The primary data in this study were obtained through a test on arithmetic sequences and series and interviews. The test consisted of three descriptive questions that had been validated by the Mathematics Study Program Lecturer and Mathematics Teacher of SMA Negeri 1 Ngabang. Interviews were conducted in a structured

manner to deepen understanding of students' thought processes that were not fully reflected in written answers.

Secondary data sources are data collected by researchers to support primary data obtained from primary sources. In other words, secondary data is not primary data, but it can serve to supplement or provide additional information relevant to the research (Haifa et al., 2025) . Secondary data is obtained from supporting documents such as daily test scores or student academic data as the basis for grouping mathematical abilities.

According to (M. Fathun Niam et all, 2024) in qualitative research researchers collect data in the form of text, images, sound or other forms of non-numeric data, to then be analyzed using an inductive approach. The data analysis technique uses the Miles and Huberman qualitative analysis model which includes 3 stages, namely:

(1) data reduction, (2) data presentation and (3) drawing conclusions and verification. According to (lanny et all, 2022) Data reduction is part of the data analysis activities used during data collection. Data reduction is carried out by selecting, grouping and coding data based on metacognitive indicators. Data presentation is a crucial stage in the qualitative data analysis process which aims to organize information systematically and meaningfully (Qomaruddin, 2024) . The data presentation process is carried out in the form of descriptive descriptions to display students' metacognitive patterns in each category of mathematical ability .

drawn continuously through a verification and triangulation process between test data, interviews, and documentation to ensure the validity of research findings. According to (Anjarima et al., 2023), drawing conclusions, or verification, is the final stage in analyzing data using the Miles and Huberman model. Conclusions lead to the research questions previously posed. Conclusions in qualitative research include a description of all subcategorizations of the themes listed, accompanied by verbatim quotes from interviews. After being described, the research results need to be explained to answer the research questions based on the aspects, components, factors, and dimensions of the research.

RESULTS AND DISCUSSION

The mathematical ability of each subject was used as a reference for selecting the subjects, resulting in three subjects in total. These three subjects were determined based on the scores from the mathematics test results conducted on Tuesday, January 27, 2026, which consisted of three mathematics questions on arithmetic sequences and series. The researcher's method for coding each subject was that AN was a subject with high mathematical ability, AH was a subject with moderate mathematical ability, and WD was a subject with low mathematical ability.

To determine the mathematical abilities of each student, the researchers conducted an in-depth analysis by analyzing the results of the written tests

administered and then analyzing the results of interviews with each subject selected to represent high-, medium-, and low-ability student groups. Table 1 presents the research subjects and their metacognition:

Table 1
Research Subjects and Subject Metacognition

Code Nam	Test Score	Mathematical Ability Level	Question	Metacognition Indicators					
				P1	P2	M1	M2	E1	E2
AN	100	Tall	1	✓	✓	✓	✓	✓	-
			2	✓	✓	✓	✓	✓	-
			3	✓	✓	✓	✓	✓	-
AH	83.33	Sedang	1	-	✓	✓	✓	✓	-
			2	-	✓	✓	✓	✓	-
			3	-	✓	✓	✓	✓	-
WD	11,11	Rendah	1	✓	✓	-	✓	-	-
			2	-	-	-	-	-	-
			3	-	-	-	-	-	-

Information:

P1 : Ability to identify known and asked information

P2 : Ability to determine appropriate strategies, formulas and approaches M1 : Ability to check the correctness of steps during the process

M2 : Ability to adjust strategy if errors are found

E1 : Ability to check the suitability of the final result with the objective of the question and ensure the correctness of the answer

E2 : Ability to compare final results with previous steps

✓ : do

\- : do not do

Based on Table 1, the research subject with the code name AN scored 100 on the math test, categorizing his mathematical ability as high. The subject with the code name AH scored 83.33, categorizing his mathematical ability as moderate. Meanwhile, the subject with the code name WD scored 11.11, categorizing his mathematical ability as low.

After administering a math test to the subjects, the next step was to analyze the written answers and interviews with each subject. The following is a breakdown of the written answers from the three subjects:

High Category Student Metacognition (AN)

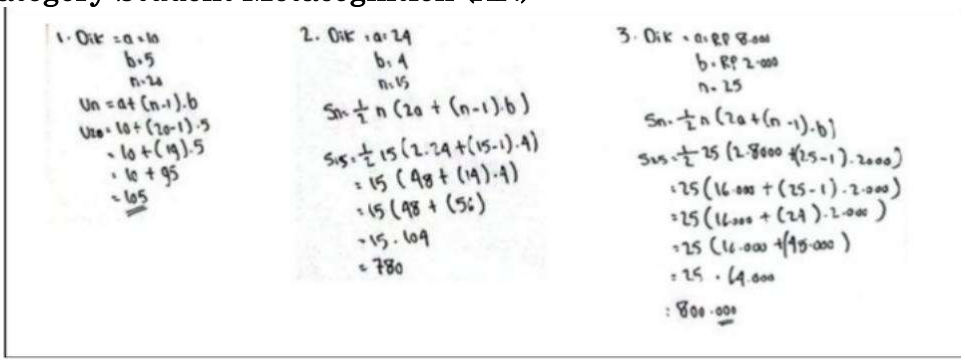


Figure 1. AN Written Answer

Based on the results of the AN written answers, it can be seen that subjects with the high mathematical ability (AN) category can identify known and asked information quite well. The subject is said to be quite good at identifying the information because the subject can write down the known information from the questions well, but for the things asked in the three questions the subject cannot write on the written answer sheet. In the aspect of the planning indicator: determining the appropriate strategy, formula, approach, the subject did it well. Based on the written answers from AN, in all three questions the strategy or formula or approach was written appropriately to formulate problem solving. This is supported by the subject's statement that the most important thing in the question is the formula and the steps to work on it. Although the subject stated that he must be more careful in determining the formula and steps to work on the question, the subject made an error in identifying the things asked in the three test questions. From the results of the written answers and interviews on both aspects of the planning indicator: identifying known and asked information, & determining the appropriate strategy, formula, approach, it can be concluded that the subject's metacognitive ability is quite good. This is shown through the subject's ability to plan appropriate solution strategies, although limitations are still found in explicitly identifying the information asked for in the questions.

In the first aspect of the monitoring indicator, namely checking the correctness of the steps during the process, subjects with high ability performed very well. This is evident in the AN written answers, which indicate that the problem-solving steps are written systematically and without procedural errors. The good written answers are also supported by the interview results, where the subject stated that the subject understood the problem-solving process and rechecked the steps and the answers obtained. In the second aspect, adjusting strategies if errors are found, the subject's answers never changed on the three questions because the subject ensured that the use of the formula and solution steps were carried out properly and correctly. Based on the interview results, the subject also stated that the subject rechecked the formula, steps and answers to ensure that the problem-solving steps and answers were correct.

For the evaluation indicator (evaluating) aspect of checking the conformity of the final results with the objectives of the questions and ensuring the correctness of the answers, the subject stated that the subject confirmed the answers to the three questions so that the final results could be ensured in accordance with the

objectives of the questions. In the aspect of comparing the final results with the previous step, the subject with a high level of mathematical ability did not carry out this aspect. This is indicated by the results of the subject's written answers, which did not explicitly write down the final results of the three test questions. Furthermore, based on the results of the interview, the subject stated that the subject ensured the correctness of the answers obtained without writing or reaffirming the final results of the solutions carried out.

Metacognition of Students in the Medium Category (AH)

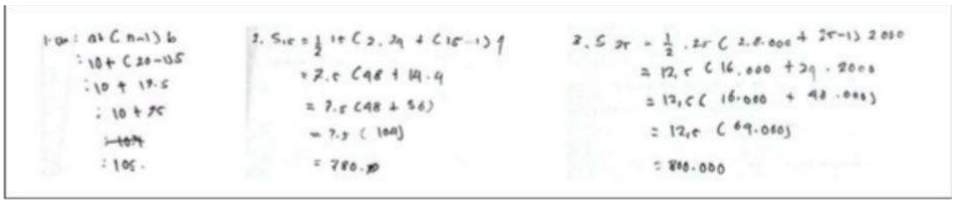


Figure 2. AH's Written Answer

Based on AH's written answers, in the first aspect of the planning indicator, the ability to identify known and asked information, the subject with the medium mathematical ability category (AH) did not demonstrate this ability in the three test questions. Meanwhile, in the second aspect of the planning indicator, the ability to determine the appropriate strategy, formula, and approach, the subject was able to choose a strategy to solve the problem correctly even though when first reading the test question he had difficulty determining the solution formula. Another statement from the subject explaining how the subject planned the strategy used to solve the test question was by reading the test question, choosing the formula and completing the steps. According to the subject, the important thing in the question section is the formula and its solution, so that the information aspects of the test question (what is known) and the question (what is asked) are not included in the subject's written answers. This indicates that the elaboration of the question information (what is known and what is asked) is not necessary to determine the appropriate strategy, formula, or approach for problem solving.

In the monitoring stage, the aspect of checking the correctness of the steps during the process, the subject adjusted the problem-solving process from the previously planned strategy and ensured that the problem-solving steps were correct by selecting the appropriate formula from the three test questions. However, during the problem-solving process, the subject did not recheck the calculations because the subject was more focused on solving the problem, so that he ended up changing the strategy or formula after experiencing confusion and being realized by the teacher that the formula used in question number two was the wrong formula. In addition, there was an error in calculating the results of the problem-solving so the subject rewrote the correct result. This indicates that subjects with moderate mathematical abilities have the ability to adjust strategies if they find errors (monitoring indicator of the second aspect).

In the first aspect of the evaluation indicator, the ability to check the final conformity with the objectives of the question and ensure the correctness of the answer, the subject ensures that the results of the problem-solving process have been carried out correctly by re-checking the problem-solving answers for each test question. Then the subject stated that there was a question that could be done better, namely question number one, which means the subject had confirmed the correct answer. Although, the subject had confirmed all the answers to the three questions were answered correctly, the subject was not good at carrying out the metacognitive evaluation indicator in the second aspect (the ability to compare the final result with the previous step). This is shown from the subject's written answer which did not write down the entire final result of the question answer.

Low Category Students' Metacognition (WD)

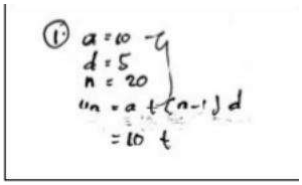


Figure 3. WD's Written Answer

Based on WD's written answers, subjects with low mathematical abilities were able to identify some of the information from the test questions, namely what was known, although there were errors in identifying the information. Meanwhile, for other information, namely what was asked by the test questions, the subjects were unable to explain in the breadth of their answers. This indicates that the subjects were able to carry out the first aspect of the metacognitive planning indicator, namely identifying the information that was known and asked. The second aspect of the planning indicator, determining the appropriate strategy, formula, and approach, the subjects were able to determine the strategy and write it down even though there were errors in writing the appropriate formula or approach to solve the problem. This is supported by the subject's statement that stated they had difficulty in understanding the information and formulas used in the test questions, which were classified as quite difficult and not yet understood by the subjects.

In the metacognitive stage, the monitoring indicator for the first aspect, which checks the correctness of the steps during the process, ensures that the subject has found and understood the formula and the solution method. However, the subject ultimately failed to complete the problem-solving process on the written answer sheet. During the problem-solving process, the subject did not recheck the calculations due to limited understanding and time, despite changing the solution strategy several times. This indicates that subjects with low mathematical ability demonstrated the ability to perform the second aspect of the monitoring indicator, namely adjusting strategies if errors are encountered.

Based on the test and interview results, the subject demonstrated an inability to perform the evaluation indicators, both in terms of checking the final result's conformity to the question's objectives and ensuring the answer's accuracy, and in terms of comparing the final result with the previous step. The written answer sheet (WD) illustrated that the subject's ability to answer the test questions was not complete, thus failing to perform both aspects of the evaluation indicators. The subject also stated that he was unable to complete all three test questions satisfactorily.

Discussion

Metacognition of Students with High Mathematical Ability in Solving Arithmetic Sequence and Series Problems

In this study, subjects with high mathematical ability (AN) after being analyzed based on metacognition and problem-solving indicators have fulfilled the metacognition planning indicator in solving arithmetic sequence and series problems by Polya, which means that students (AN) understand the meaning of the problem well so they are able to describe what is known correctly, even though the subject does not write what is asked in the problem. The results of this study are in line with research conducted by (Patmah et al., 2025) where subjects with high metacognition abilities are able to identify problem information well and fulfill all problem-solving steps. Subjects with high mathematical abilities are able to determine strategies, formulas, and appropriate approaches to problem-solving well and correctly, even though there are limitations in explicitly identifying the information asked in the problem .

The subject also checked the correctness of the steps during the process according to the correct formula determined by the subject. During the problem-solving process, subjects with high mathematical abilities rechecked the formulas, work steps, and answers that had been done to ensure their accuracy. The subject had precision in working on test questions and understood the formulas and steps for working on the questions, so that the final answer results were obtained from steps that were in accordance with the concept. Adjustments to the strategy if errors were found in the problem-solving process were carried out well with a sufficient understanding of the concept of sequences and arithmetic series so that the problem did not become a problem for the subject in solving the problem. Comparable to research conducted by (Fajrin & Liberna, 2020) where students' problem-solving abilities in the indicator of planning a solution or developing a solution strategy were very high because students were able to complete the indicator well.

In the evaluation indicator, subjects with high mathematical ability category This was done to align the final results with the objectives of the question and the correctness of the three answers can be ensured. Subjects with high mathematical ability category were aware that they could solve the problem using a better method, but an indication of error in the problem work was that the subject did not explicitly write down the final results of the three test questions.

Metacognition of Students with Moderate Mathematical Ability in Solving Arithmetic Sequence and Series Problems

The results of the study on subjects with moderate mathematical ability (AH) have quite good metacognition in solving problems. This is shown by the subject's ability to identify information without systematic writing, or in other words, the subject does not include what is known and what is asked in the test questions. The results of this study are in line with research conducted by (Patmah et al., 2025) where subjects with moderate metacognitive abilities have unfulfilled problem- solving steps. Subjects with moderate mathematical abilities have difficulty in determining appropriate strategies, formulas, and approaches to solving problems, but even so, the problem-solving strategy used by the subject, namely determining the solution formula, is appropriate.

In the metacognitive monitoring (evaluating) stage by subjects with moderate mathematical abilities, in the middle of the problem-solving process, the subject ensures that the solution steps are correct, namely the formula used is appropriate and precise in solving the problem. During the problem-solving process, the subject does not re-check the correctness of the calculation of the answer to the question because it is more focused on solving the problem. The subject does not re-check causing the subject to confusion in solving the problem, and is evidenced by the use of an incorrect formula so that the subject must use a new strategy in solving the problem. This means that the metacognitive monitoring indicator (monitoring) aspect of adjusting strategies if errors are found in subjects with moderate mathematical abilities is well fulfilled.

The metacognitive evaluation stage (evaluating), subjects with moderate mathematical abilities are fulfilled quite well where after completing the three questions, the subject checks the suitability of the final results with the objectives of the questions and ensures that the answers written are correct and precise, but the subject does not explicitly write the final results of the three test questions. Research conducted by Permata, Solehudin, Nuraida and Sugilar (2023) provides the same explanation as this study where the subject has solved the problem correctly, but errors in applying the questions to the answers still occur.

Metacognition of Students with Low Mathematical Ability in Solving Arithmetic Sequence and Series Problems

In the metacognitive planning stage of problem solving, subject WD, who is a subject with low mathematical ability, experienced difficulty in identifying information from the three test questions. Errors in writing known things in the questions indicate that the subject does not have an understanding of the basic concepts of sequences and arithmetic series. The subject considered that the problem being worked on was quite difficult for him to solve. The results of this study are in line with research conducted by (Patmah et al., 2025) , subjects with low metacognitive abilities only fulfilled the step of planning problem solving, namely planning the appropriate formula, but the other steps were not fulfilled. The aspect of determining the appropriate strategy, formula, or approach was carried out by the subject poorly because the formula used by the subject was not

appropriate. Thus, subjects with low mathematical abilities did not fulfill metacognition in planning, monitoring, and evaluating.

Based on problem-solving monitoring indicators, subjects with low mathematical abilities ensured they understood the formulas and problem-solving methods needed for problem-solving. Due to their limited understanding of arithmetic sequences and series, subjects spent a significant amount of time searching for strategies, including appropriate formulas, to process the problem-solving process.

The metacognitive evaluation indicator cannot be fulfilled properly by subjects with low mathematical abilities because they do not complete problem solving. The results of this study have similarities with the results of research conducted by (Patmah et al., 2025) , subjects with low mathematical abilities can write less precise solution plans because the concept of work carried out by the subject is wrong and not understood correctly, so that the metacognitive indicator in the stage of re- examining the results of problem solving has not been fulfilled.

CONCLUSION

Based on the research discussion that has been conducted, it can be concluded that: (1) Subject AN is a research subject with a high mathematical ability category. Subjects with high mathematical abilities tend to have a good understanding of the concept of arithmetic sequences and series so that the subject can identify information from test questions. Then the AN subject can also determine appropriate strategies, formulas, approaches to problem solving, and evaluate the final results of problem solving . This research is in line with research (Hanief et all, 2021) which states that students with high abilities rewrite the questions given, are able to state what information is given in the questions, relate problems to the material on sequences and series, and are able to solve problems with good procedures.

(2) Meanwhile, subject AH is a research subject with a medium mathematical ability category. Subjects with medium mathematical ability tend to be able to understand questions without writing down the information contained in the test questions. Subjects can solve problems well, even though they have experienced errors in determining problem-solving strategies. This research is in line with research conducted by (Fahrul et al., 2024) that subjects with medium ability are able to state what is known and what is asked well and correctly in their own language. However, when answering problems, the subjects get less precise final results, this occurs because the subjects have poor metacognitive processes. (3) The last subject, namely WD, is a research subject with a low mathematical ability category. Subjects with low mathematical ability tend to use their metacognitive activities inappropriately, both planning, monitoring, and evaluating. This research is in line with research (Patmah et al., 2025) that students with low metacognitive abilities can understand problems that are marked, known and asked, and solve problems according to plan which is not fulfilled because the final answer is not correct.

Based on the research that has been conducted, the researcher can provide several suggestions as follows: (1) For students, it is hoped that they can improve

their metacognitive abilities in learning and solving mathematical problems. (2) For educators, it is hoped that they can know and train students' metacognition so that they are more aware and able to solve mathematical problems. (3) For further research, it is hoped that further research can be carried out on students' metacognition using other mathematical subjects and materials.

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