Analysis of Students' Metacognition Skills in Problem Solving on Thermochemical Materials

Ramayanti N. Manaa[1], Astin Lukum[1*], Julhim S. Tangio[1], Masrid Pikoli[1], La Alio[1], Mangara Sihaloho[1], Vivi Dia Afrianti Sangkota[1]

[1]Universitas Negeri Gorontalo, Gorontalo 96554, Indonesia

Article Info

Abstract

This research is a descriptive quantitative research that aims to find out in depth the metacognition skills of students in problem solving on thermochemical material. In this study, the instrument used was a description test consisting of 5 numbers of problem solving questions, which were specifically designed to measure students' metacognition skills. The subjects of this study were 34 students of class XI at SMA Negeri 1 Tapa. To analyze the data, a quntitative descriptive analysis technique was used, which includes the stages of data reduction, data presentation, data analysis, and conclusion drawing. The results showed that from the indicators of the questions given, students obtained an average value of metacognition skills in each indicator, namely the planning indicator of 67.8%, the monitoring indicator of 48.2%, and the evaluation indicator of 21.2%. From these average results, it can be concluded that the ability of students' metacognition skills in planning indicators is high, monitoring indicators are moderate, and evaluation indicators are low. This research provides new insights into students' metacognition abilities in thermochemical problem solving, which can be the basis for further research in developing more effective learning strategies and curriculum.

1. INTRODUCTION

Permendikbud Number 103 Year 2014 on Learning in Primary Education and Secondary Education in society and the state contributes to the welfare of human life. Learning is the process of developing the potential and character of each student through the synergy between school, family and community education (Wahono et al., 2021). This process provides opportunities for students to develop their potential into increased abilities in attitudes (spiritual and social), knowledge and skills needed by life (Misnatun & Ummah, 2023).

The phenomenon that often occurs in schools is that many students have difficulty in understanding complex chemical concepts, such as thermochemical reactions, which is often caused by the lack of adequate metacognition skills. Research by Teichert et al., (2017) showed that students' engagement in a thinking process involving the construction of molecular models consistent with experimental evidence, accurate metacognitive monitoring, and the use of evidence to justify model refinement was strongly associated with their success in applying knowledge in new contexts. This suggests that the development of metacognition skills can assist students in overcoming the difficulties they face in science learning, particularly in understanding and applying thermochemical concepts. Another study conducted by Setiawan & Supiandi, (2019) showed that metacognition skills play a significant role in improving students' problem solving ability, as expressed by, who found a positive relationship between metacognition skills and reasoning skills on students' problem solving ability in a problem-based learning (PBL) model. Therefore, metacognition

skills are very important in the problem-solving process, especially in the context of thermochemical learning.

Metacognition is awareness of the learning process, including planning, strategy selection, monitoring the learning process, self-improvement, self-evaluation, and methods and adjustments to personal learning strategies (Balashov et al., 2020). In the learning process, misconceptions often occur, both experienced by students and by teachers (Suprapto, 2020). However, metacognition can help monitor the stages of students' thinking, so that they are able to explain their way of thinking and thinking The concept of metacognition consists of metacognitive knowledge, metacognitive skills, and metacognitive experiences (Sengul & Katranci, 2012).

Furthermore Dori et al., (2018) explained that metacognition is a skill to weave important messages with previously acquired knowledge. According to Hassan & Rahman, (2017), metacognition is very important in improving students' skills because it is closely related to planning, monitoring, and evaluation in problem solving. The development of metacognition is considered important because it is the key to achieving meaningful and lasting understanding of the material (Frazier et al., 2021). In addition Rahmat & Chanunan, (2018) found that students who have metacognitive skills are able to manage and control their learning process. Each individual has the ability to develop self-control at every stage of learning (Oriol et al., 2017). Meanwhile, learning must produce a final value that can be used to measure understanding of the material.

Problem solving is a planned process that needs to be carried out in order to obtain a certain solution to a problem that may not be obtained immediately Muhaimin et al., (2023) there are four stages of problem solving, namely: (1) understanding the problem (2) planning problem solving (3) implementing the problem solving plan (4) re-examining problem solving. Problem solving has been defined as a high-level cognitive process that requires modulation and control over routine and basic skills (Sabora et al., 2022).

This study provides a new contribution in understanding students' metacognition in thermochemistry material through a more focused and measurable approach. This research is very important theoretically and practically because it can deepen the understanding of metacognitive skills in problem solving, especially in thermochemical materials. Theoretically, this study contributes to the development of metacognition theory and learning theory, by revealing the relationship between metacognitive skills and learning outcomes in science. The results showed that respondents from the upper group involved metacognition consistently in every problem, whether difficult, medium, or easy problems, while respondents from the middle group only optimally involved their metacognition in easy and medium problems (Mansyuroh., 2020). Practically, the results of this study can help educators design more effective teaching methods, improve students' critical thinking skills, and integrate problem-based learning approaches. In addition, this research contributes to curriculum development that is more focused on learning higher order thinking skills, as well as opening up further research opportunities in science and STEM education.

Different from previous general studies, this study uses a descriptive test instrument with five problem-solving questions to measure metacognition skills, including indicators of planning, monitoring, and evaluation (Ilma et al., 2022). The subjects of the study were grade XI students at SMA Negeri 1 Tapa, providing a different local context from previous studies at higher education levels. By highlighting metacognition in the context of thermochemistry, this study aims to provide insight into the management of students' thinking processes, which can help teachers design more effective learning strategies.

2. METHOD
Type of Research
This research is a descriptive quantitative approach. Descriptive research is a study that explains / describes a symptom or event, an event that is happening now (Arikunto, 2010).

Time and Place of Research
This research was conducted at SMA Negeri 1 Tapa which is located in Bone Bolango Regency, Gorontalo Province.

Target/Subject of Research
This study involved 34 respondents of class XI IPA students of SMA Negeri 1 Tapa.

Data, Instruments, and Data Collection Techniques
This research is intended to see and know how students answer the questions given, from the answers produced we can see how their metacognitive skills in

solving the problems in the problem. The data collection techniques used are through observation, essay test instruments, and documentation. The test instrument used in this study is a description test. The characteristic of this description test is that the answer to the question is not provided by the question compiler, but must be compiled by the test participants themselves. Before using the test to collect data, first test the validity of the instrument.

According to Arikunto (2010) validity is a measuring tool that can show the level of effectiveness or effectiveness of the tool. If an instrument can reveal the variable data being studied, it is considered effective.

Data Analysis Technique

The formula for the validity of an instrument is given by:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}} \quad (1)$$

Information:

r_{xy} = Question validity

$\sum X$ = Total item score

$\sum X^2$ = Square of the total score of each item

$\sum Y$ = Total score of respondents

$\sum Y^2$ = The square of the respondent's total score

$\sum XY$ = Correlation of the score with the total score of each item

N = Number of respondents

Metacognitive Skills Assessment

To find the metacognitive value of students, the following formula is used:

$$\text{Student Score} = \frac{\text{the students metacognitive score}}{\text{total maximum score}} \times 100\% \quad (2)$$

To determine the average value of students' problem-solving and metacognitive skills for each activity, the mean value is calculated using:

$$\text{Mean value} = \frac{\text{number of student metacognitive scores}}{\text{total number of students}} \quad (3)$$

3. RESULT AND DISCUSSION
3.1. Result

This research is a quantitative research conducted in Gorontalo, precisely at SMA Negeri 1 Tapa which consists of 2 classes, namely class XI IPA 1 and class XI IPA 2 with the number of samples obtained as many as 34 respondents. This study aims to determine students' metacognitive skills in solving thermochemical material problems.

The results of this study are the percentage of students' metacognitive skills in answering thermochemical questions. The results of the percentage of metacognitive skills of each question indicator in this study are in Table 1.

Table 1. Percentage results of metacognitive skills for each question indicator.

No	Question Indicators	Metacognitive Skills		
		Planing	Monitoring	Evaluation
1.	Identify reactions that require heat and reactions that release heat.	21%	38%	12%
2.	Identify the enthalpy of dissolution of LiOH in water.	76%	10%	0%
3.	Analyse the amount of heat released in the change of enthalpy of reaction, namely the enthalpy of vaporisation of H_2O.	93%	79%	29%
4.	Analyse some compounds for the temperature rise of a calorimeter.	68%	38%	0%
5.	Determine the enthalpy of combustion (ΔHc) of one of the fuels.	81%	76%	65%
	Percentage of metacognitive skill indicators	67,8%	48,2%	21,2%

Table 1 shows that students have different metacognitive skills abilities in each question indicator. The ability of students' metacognitive skills on thermochemical material using problem solving strategies

ranging from planning, monitoring, and evaluation shows differences in 5 problem indicators. The results of the calculation of the percentage of students' metacognitive skills on 5 question indicators can be seen in Figure 1.
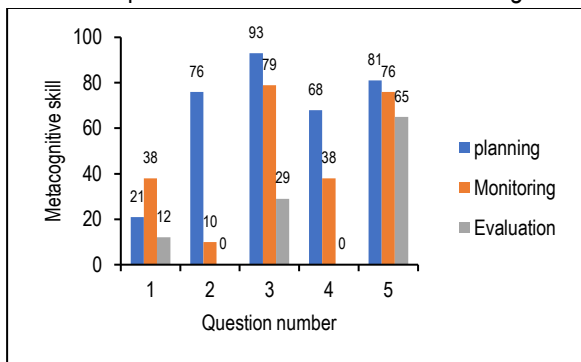

Figure 1. Graph of the percentage of results of metacognitive skill indicators on 5 question indicators.

Figure 1 shows that the ability of students metacognitive skills is higher in the percentage results on the planning indicator compared to the other 2 indicators of metacognitive skills. The graph above also shows that in question indicators number 1-4 the difference between planning, monitoring, and evaluation indicators has a large percentage difference in value, but it is different from the question indicator in number 5 which has the results of the percentage of metacognitive skills whose difference is not much different in value.

Analysis of students' metacognitive skills on question number 1

In item number 1 with the indicator of identifying reactions that require heat and reactions that release heat. For the percentage results of metacognitive skills on item number 1 can be seen from Figure 2.
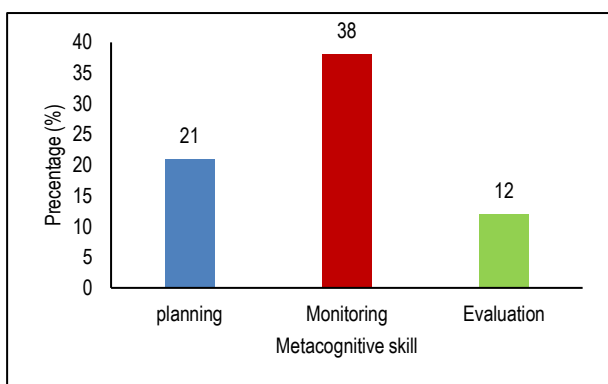

Figure 2. Graph of the percentage results of metacognitive skills on question number 1.

Figure 2 shows that from the percentage results there are 3 indicators of metacognitive skills that have different values ranging from planning, monitoring and evaluation indicators.

Analysis of students' metacognitive skills on question number 2

In question item number 2 with the question indicator, identify the enthalpy of dissolution of LiOH in water. For the percentage results on item number 2, it can be seen from Figure 3.
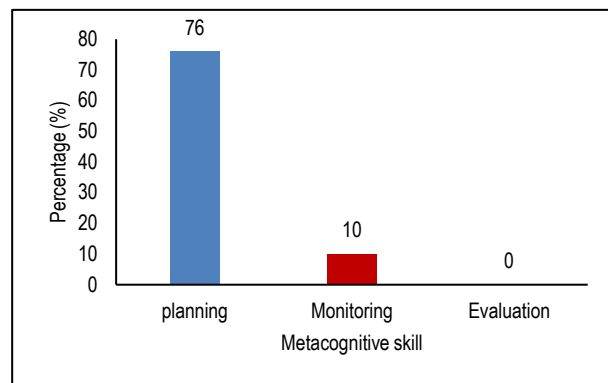

Figure 3. Graph of the percentage results of students' metacognitive skills on question number 2.

Figure 3 shows that in question number 2, only two indicators have a percentage value, namely the planning and monitoring indicators, while the evaluation indicator has no percentage value.

Analysis of students' metacognitive skills on question number 3

In item number 3 with the question indicator, analyse the amount of heat released in the change in enthalpy of the reaction, namely the enthalpy of vaporisation in H_2O. The percentage results on item number 3 can be seen from Figure 4.
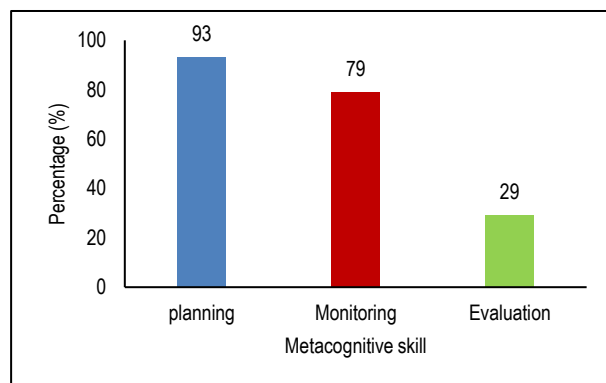

Figure 4. Graph of the percentage results of students' metacognitive skills on question number 3.

From the percentage results in Figure 4, it can be seen that the score in question number 3 has increased from planning, monitoring, and evaluation compared to the previous 2 numbers.

Analysis of students' metacognitive skills on question number 4

In item number 4 with the question indicator, analyse several compounds to increase the temperature of the calorimeter. For the percentage results on item number 4, it can be seen from Figure 5.
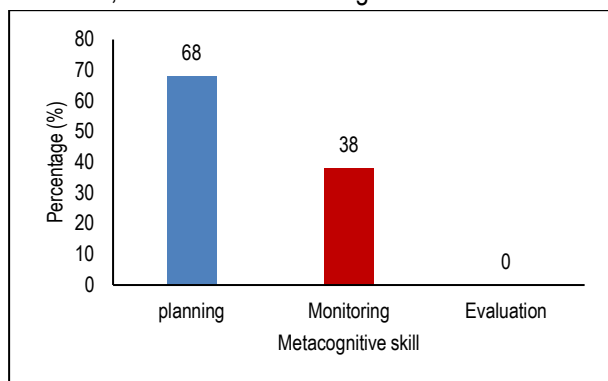

Figure 5. Graph of the percentage results of students' metacognitive skills on question number 4.

From Figure 5 it is clear that the percentage value that exists is only the planning indicator and the monitoring indicator while the evaluation indicator does not have a percentage value, which means that the ability of metacognitive skills of some students only reaches the monitoring indicator.

Analysis of students' metacognitive skills on question number 5

In question item number 5 with the question indicator, determine the enthalpy of combustion (ΔHc) of one of the fuels. For the percentage results on item number 5 can be seen from Figure 6.
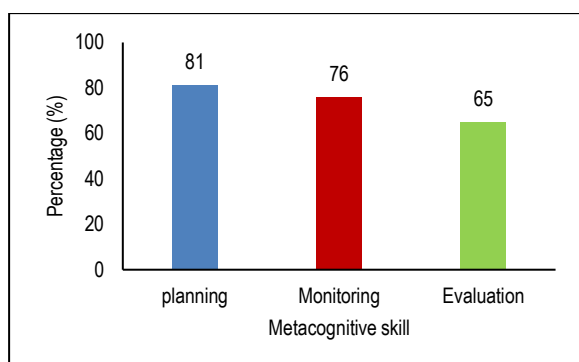

Figure 6. Graph of the percentage results of students' metacognitive skills on question number 5.

Figure 6 shows that the percentage results of these 3 indicators of metacognitive skills have different values ranging from planning, monitoring and evaluation indicators. However, of the three percentage indicators of metacognitive skills in question number 5, it shows the best results in terms of the percentage results. This is because the percentage value of these 3 indicators has a small difference and the average percentage in number 5 is above 50%.

4. Discussion

In this study, there were 5 items of description of thermochemical material tested by analyzing the ability of metacognitive skills which included 3 indicators, namely: (1) planning, monitoring, and evaluation on problem solving questions. These elements are crucial to encourage effective learning strategies among students, especially in complex subjects such as thermochemistry. Antika et al., (2022) highlighted that students often lack encouragement to develop metacognitive skills, leading to passive participation in the learning process. By focusing on planning, students can set clear goals and strategies for their learning tasks. Monitoring allows students to assess their understanding and progress in real-time, so they can make necessary adjustments. Finally, evaluation encourages students to reflect on their performance and the effectiveness of their strategies, thus promoting a deeper understanding of the material. This study aims to determine students' metacognitive skills in problem solving on thermochemical material at SMA Negeri 1 Tapa.

Analysis of planning indicators in problem number 1

In this planning indicator, students should be able to understand the problem given by collecting known and questionable data and students have thought of a concept or formulation that will be used to solve the problem. In this case students should write what reaction equations are known and what is the enthalpy of each reaction equation and students write the enthalpy of what equation will be asked in the problem. However, in question item number 1, most of the answers given by students did not choose strategic planning or write down the known, asked and formula to be used, so the percentage obtained from 34 respondents was only 21%.

Analysis of monitoring indicators in question number 1

Furthermore, the percentage results show that the monitoring indicator has the highest value of the other two indicators. In this monitoring indicator, students have been able to answer questions with the right steps because they see the plans that have been designed previously starting from known, asked and the formula to be used. Furthermore, to answer question number 1 in order to get the right and accurate answer, students must solve the problem according to the planning formula. However, from the answers given by students, the percentage of results obtained was 38% of 34 respondents. This is because there are several types of answers from students, the first is that there are only a few students who answer the problem by using appropriate steps and strategies such as writing known, asked, and the formula to be used then continuing the answer by using the previously defined strategy to solve the problem solving problem in item number 1 until it is finished so as to get the right answer. This is done by students who have high metacognitive skills. However, it is different from most of the students' answers who do not have planning at the beginning but directly solve the problem. In this case students are included in the ability of low metacognitive skills because students have not monitored their understanding and prefer to ask their friends for ways to solve the problem (Afdal et al., 2023). The answers given by students do not write planning indicators such as known, asked and formulas to be used but directly on monitoring indicators, namely strategies and steps for solving problems and the results obtained are correct and accurate (Bialangi et al., 2023).

In question number 1, the evaluation indicator obtained a percentage result of 12%. This is because students do not recheck the answers after they finish working on problem number 1. The evaluation activity carried out by students is by writing in detail and clearly the final results obtained. From this evaluation indicator has several levels. First, high metacognitive skills have carried out evaluation activities because during the process of working students have examined and understood well the faithfulness of the steps written down so that students are confident in the answers obtained (Amien & Hidayatullah, 2023). Second, moderate metacognitive skills perform rechecking by recalculating according to students' thinking abilities (Azzahra &

Mariani, 2022). Third, low metacognitive skills, almost all students do not evaluate which can be seen on the answer sheet that is not filled in (Ramadhanti & Yanda, 2021).

Analysis of planning indicators in question number 2

The planning indicator in problem number 2 has the highest percentage value. In the analysis of problem number 2, most of the students' answers have used planning indicators where students have understood the questions given and written down strategies such as known, asked and formulas that students will set to solve existing problem solving problems. And only a small percentage of student answers did not write down the planning strategy and initial determination to solve the problem in problem number 2. This is what makes the percentage value of the results of metacognitive skills on planning indicators high. So in question number 2, the level of students' metacognitive skills has reached a good category in the planning indicator.

Analysis of monitoring indicators in question number 2

Unlike the monitoring indicator, in this question indicator the percentage obtained in the monitoring indicator is only 10%. This shows that only a small proportion of students can answer questions correctly which includes monitoring indicators. In this case, only a small number of students can monitor the process of solving the problem that has been arranged in the previous planning strategy to get the right final result. There are also students who write answers and predictions for solving problems correctly but for the final results given by students are still not correct. So that based on some of the answers given for the ability of metacognitive skills, especially in monitoring indicators, it is still relatively low.

Analysis of evaluation indicators in question number 2

The evaluation indicator in question number 2 does not have a percentage value. This is because all students did not provide answers or did not write evaluation indicators on their answer sheets. So for the abilities that exist in question number 2, it only reaches the indicator of monitoring or solving problems based on the steps that have been planned before, but students do not carry out rechecking activities for the answers given. This is because students do not understand what is being done and answered. So for the ability of metacognitive

skills in question number 2, it does not reach the evaluation indicator.

Analysis of evaluation indicators in problem number 2

From Figure 4, it can be seen that the percentage of planning obtained is 93%, the value is very high and seen from the answers of the average student writing the activities of planning indicators such as known, asked, and the formula to be used. Therefore, students are considered to have understood and understood the questions given and have determined the strategies that will be taken to solve the existing problem solving problems. This shows that almost all students have used their metacognitive skills (Winarti et al., 2022). However, in this section because the problems given are fairly easy, it can be seen from the results of student work which varies greatly depending on the difficulty level of the problem. In general, when students are faced with easy problems, they immediately use the formulas they are used to when facing similar problems. Meanwhile, in difficult problems, students generally use help to change the question sentence into simple language that is easy to understand.

The evaluation indicator in question number 2 does not have a percentage value. This is because all students did not provide answers or did not write evaluation indicators on their answer sheets. So for the abilities that exist in question number 2, it only reaches the indicator of monitoring or solving problems based on the steps that have been planned before, but students do not carry out rechecking activities for the answers given. This is because students do not understand what is being done and answered. So for the ability of metacognitive skills in question number 2, it does not reach the evaluation indicator.

Analysis of student monitoring indicators in question number 3

The monitoring indicator shows that the percentage result obtained is 79%. Judging from the answers given, most students are in accordance with the steps and strategies for working on problem solving problems. However, there are student answers that the stages of work are appropriate but the final result is not correct. This is because students are not careful in working on problems. So this is what is meant in the concept of metacognitive skills, especially in monitoring indicators, namely being able to monitor every step and

answer during the process of working in order to get correct and precise results.

Analysis of student evaluation indicators in question number 3

While in this evaluation indicator from the percentage results of Figure 4 shows a value of 29%. From the results of the percentage, it is still relatively small, because the answers given by some students do not recheck, in this case not writing the answer to the final result which is included in the evaluation indicator. However, there are also some who do recheck the answers that students give. However, the answers students give are less precise or different from the final results on the monitoring indicator. This is because students are not careful in answering questions. So the conclusion is that some students have metacognitive skills abilities that have reached the evaluation indicator stage and some have only reached the monitoring stage.

Analysis of student planning indicators on question number 4

Figure 5 shows that the planning indicator has a percentage value of 68%. The student answers given in question number 4 are that some students have understood the problem and have designed strategies to be able to solve existing problems such as students have written the question, known and formula to be used. There are also some students who answer the questions on this indicator according to the desired steps, it's just that the data or information known and collected is still incomplete, so the value given to the student's answer score is also reduced. This is due to students' lack of understanding.

Analysis of student monitoring indicators in question number 4

In this monitoring indicator, it can be seen that the percentage obtained is 38%. The results of this percentage are the same as the percentage in the previous question number 1. The answers given by students in number 4 are some of the students have understood the meaning of the questions given so that students solve the questions by monitoring the answers made by the students themselves so as to get the correct and correct results. There are also students who complete the answer with the right steps and strategies but the results of the answer are still not correct. This is because students are not careful in answering the questions. While not a few of the students do not

understand question number 4 so that the answers given by students are not correct. In this case it can be seen that students' metacognitive abilities are still fairly low.

Analysis of student evaluation indicators on question number 4

Figure 5 shows that the percentage results of this evaluation indicator do not exist or only amount to 0%. From all the answers given by students, students did not write answers to this evaluation indicator, it can be concluded that in question number 4 students did not check back after finishing answering the question. So the ability of metacognitive skills in question number 4 does not reach the evaluation indicator.

Analysis of student planning indicators in question number 5

In Figure 6 the planning indicator gets a high percentage result of 81%, this is because in question number 5 most of the students already understand and understand the problem given. So that students have planned strategies and concepts before solving the problem. From these students' answers, most of them have written the correct planning steps such as known, asked and the formula to be used. So the ability of students' metacognitive skills on planning indicators in question number 5 is said to be good.

Analysis of student monitoring indicators in question number 5

The monitoring indicator shows that the percentage result is 76%. Most students have given the right answer to question number 5 because the steps and strategies given by students are in accordance with the desired answer. This is caused by students who have used the ability of metacognitive skills so that every step made to solve the problem at hand runs based on the correct and appropriate strategy (Lisnawati et al., 2023). Although there are still some students who have used the steps to solve the problem, the answers given are still not correct. So in question number 5, the ability of metacognitive skills specifically on monitoring indicators is good.

Analysis of student evaluation indicators in question number 5

The evaluation indicator shows that the percentage result is 65%. From the answers given by students in problem number 5, most of them have written the final result or drawn the final conclusion for the results of problem number 5, it can be seen from the student's

process of planning to solving the problem. then in this evaluation indicator the student's answer has drawn conclusions from the final results obtained. There are also some answers given by the results with different final conclusions because students are less careful in answering the questions. The answers given by students and from the three indicators of the percentage results of the ability of metacognitive skills are classified as very good.

5. CONCLUSION

Based on the research conducted, it can be concluded that the metacognitive skills of SMA Negeri 1 Tapa students vary in each indicator. The planning indicator, the average student score reached 67.8%, indicating a fairly good ability to design problem solving strategies. However, the monitoring indicator only reached 48.2%, indicating that students still need to improve their ability to monitor and evaluate the problem solving process. Meanwhile, the evaluation indicator obtained the lowest score, which was 21.2%, indicating students' difficulties in reflecting and evaluating the strategies used. Although students were able to plan problem-solving strategies well, they still faced difficulties in the monitoring and evaluation stages, indicating a lack of understanding of the importance of self-reflection in the process. This indicates the need for more practice to improve students' ability to monitor and evaluate their thinking process. For this reason, classroom learning needs to be more focused on developing metacognitive skills as a whole, with an emphasis on improving evaluation skills. Future research is recommended to design learning programs that include more diverse instruments to practice evaluation, so that students can more effectively reflect on and improve their strategies, which in turn can improve overall learning outcomes.

6. ACKNOWLEDGEMENTS

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