Analysis of Students' Metacognition Skills in Solving Static Fluid Problems

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Abstract: Students' errors in solving problems are caused by a lack of accuracy and calculation as well as the use of strategies in problem solving. So, to improve academic achievement, students need metacognitive skills so they can manage their cognition and find weaknesses so they can be corrected. This research aims to describe students' metacognitive skills in solving static fluid physics problems. The type of research used is quantitative descriptive research. Participants in this research were class XI science students at SMA Negeri 12 Ambon, a total of 26 students. The sample was selected using a purposive sampling technique. The instruments used are tests and non-tests in the form of essay test questions and the MAI metacognitive skills questionnaire. Based on the research results, it can be concluded that with a total of 26 students with metacognitive skills in planning and monitoring indicators in solving test questions, it can be seen that 21 students (80.8%) and 18 students (69.2%) have very good qualifications. Meanwhile, in the evaluation category, only 9 students (34.6%) qualified as very good. In this way, MAI can be used by teachers in solving students' physics problems. Therefore, students are expected to be more active and study hard, especially practicing solving physics problems with different problems in order to achieve good metacognitive skills.

Keywords: Metacognition Skills; Physics Student; Static Fluids

Introduction

Progress in thought patterns can foster and facilitate the resolution of various problems that are always faced in life. This is to prepare students to have the ability to think logically, analytically, systematically, critically, and creatively, as well as have the ability to work together (Ayal et al., 2016). Students' thinking abilities are one indicator to determine the quality of the learning and education process (Changwong et al., 2018). Students' thinking abilities have an impact on solving a problem through problem-solving steps (Haavold & Sriraman, 2022). The steps used by students in solving problems are influenced by students' awareness and control of cognitive activities (Güner & Erbay, 2021). Awareness and control of cognitive activities is known as the metacognition (Perry et al., 2019).

Metacognition is the ability to know and monitor someone's thinking activities so that each person's metacognition process will differ according to their abilities (Leasa et al., 2023). Students who have a high level of metacognition will demonstrate good metacognitive skills, such as planning their thinking processes, monitoring their thinking processes, and evaluating their thinking processes and results (Stanton et al., 2021). Bryce & Whitebread (2012) stated that based on various research results, metacognitive skills appear around the age of 8-10 years and are preceded by other cognitive abilities such as cognitive development in Theory of Mind (TOM). The importance of metacognition was also stated by Koriat et al. (2006) who stated that metacognitive monitoring and metacognitive control can be thought of as a quality control system that functions to ensure that only accurate and appropriate output is produced.

According to Baran et al. (2018) In learning physics, student activity is very necessary. Activeness in learning physics lies in two aspects, namely active in acting (hands activity) and active thinking. Physics

learning has objectives including developing students' knowledge, understanding, and analytical skills regarding the environment and surroundings. In physics learning, students are expected not only to master concepts but also to apply the concepts they understand in solving physics problems (Batlolona et al., 2020). However, classroom learning tends to emphasize mastery of concepts and ignores students' physics problem-solving abilities (Batlolona et al., 2022). In fact, one of the goals of learning physics is to create people who can solve complex problems by applying their knowledge and understanding to everyday situations (Sutopo, 2016). Basically, students' mistakes in solving problems are caused by a lack of accuracy and calculation as well as the use of strategies in solving problems. So, to improve their academic achievement, students need metacognitive skills so they can manage their cognition and find weaknesses that will be corrected (Safari & Meskini, 2016).

Apart from teaching science in physics content, teachers are also faced with teaching that teaches students how to become successful learners (Batlolona et al., 2019). Therefore, schools can help students become learners who are able to adapt to new environments, integrate knowledge from various sources, and continue learning throughout their lives (McDowell, 2019). One important aspect of students' success in learning physics at the basic to advanced physics level is their ability to organize and solve physics problems correctly (Taasoobshirazi et al., 2015). Many cognitive processes, such as metacognition, used in physics problem-solving are similar to those used in other science fields (Lebuda & Benedek, 2023).

Metacognition is proven and very important in contributing to students' physics learning. However, there is still little research examining the impact of metacognition on students' abilities to solve physics problems (Winarti et al., 2022). Most of the existing research involves verbal interviews developed by researchers. Students whose metacognition is deeper during physics problem-solving are more likely to solve the problem correctly (Rozencwajg, 2003; Versteeg et al., 2021). The results of studies in Thailand provide information that the majority of students consider physics to be a difficult subject. It's hard to understand because it's full of calculations. Then, most students don't like it (Pimvichai et al., 2015). Apart from that, the concepts that students have based on their experience are still limited so there are still conceptual errors in static fluid material (Jamaludin & Batlolona, 2021; Irma et al., 2023).

The research results showed that the average student's problem-solving ability was 59.60 (medium category). The percentage of students who fall into the novice category is 86.0% (hydrostatic pressure), 88.4%

(Pascal's law), and 55.8% (Archimedes' law) (Estianinur, 2020). Students still experience difficulties in applying strategies so they cannot solve problems well. Students' errors in solving physics problems are caused by a lack of accuracy, calculation, and application of problem-solving strategies in solving the problems contained in the questions. So, to improve students' academic achievement, students' metacognitive skills are needed so they can manage their cognition well (Zepeda et al., 2015); (Halmo et al., 2022).

Based on the background description above, it is necessary to conduct research on students' metacognitive skills, to analyze students' metacognitive skills in solving physics problems related to static fluids. Therefore, this research aims to describe students' metacognitive skills in planning, monitoring and evaluation indicators in solving static fluid physics problems.

Method

Research Type

This research is classified as a quantitative descriptive research type, because it aims to analyze students' metacognitive skills in solving static fluid physics test questions in class XI students at SMA Negeri 12 Ambon.

Research population and sample

The population in this study were all students in class XI Science at SMA Negeri 12 Ambon, totaling 78 people spread across 2 classes. Research Sample. The sample in this research was class XI IPA 1 students, totaling 26 students. The sample in this research was taken using a purposive sampling technique. Determination of the sample was based on the determination of class XI IPA 1 as a sample to analyze students' metacognitive skills in solving physics problems on static fluid material.

Research Instrument

Consists of essay test questions with a total of 10 questions. The test questions were created by teachers who provide physics lessons in class XI and researchers. The purpose of creating test questions together with the teacher is because the teacher knows more about the learning process and the level of understanding of students in class compared to researchers who do not carry out the learning process in class, especially static fluid material. Then the aim of giving test questions to students is to trace the process of students' metacognitive skills on planning, monitoring and evaluation indicators in solving static fluid material physics test questions. The MAI Questionnaire Sheet (metacognitive awareness inventory) which was

modified from Schraw & Dennison (1994) and has been translated into Indonesian contains 35 statements, these statements are used to obtain information directly from the research object related to the research problem under study, namely knowing students' metacognitive skills (Schraw & Dennison, 1994).

Data Analysis Technique

The data obtained from this research was then processed using descriptive analysis. Descriptive analysis is used to describe students' metacognitive skills on planning, monitoring and evaluating indicators in solving physics problems.

Result and Discussion

In solving static fluid physics questions based on work results in the form of student answer sheets, researchers analyzed the data obtained based on metacognitive skill indicators which were assessed based on a predetermined assessment rubric. The metacognitive skills test results of qualifying participants' metacognitive skills achievement scores on the indicators can be seen in Table 1.

Table 1. Description of qualifying participants' metacognitive skills. Scores of students' metacognitive skills achievement on the indicators

Intervals Score Achievement	Planning		Monitoring		Evaluation		Qualification
	F	%	F	%	F	%	Excellent
85-100	21	80.8	18	69.2	9	34.6	Good
75-84	4	15.4	4	15.4	11	42.3	Sufficient
55-74	1	3.8	4	15.4	4	15.4	Less
41-54	-	-	-	-	2	7.7	Much less
0-40	-	-	-	-	-	-	Excellent

MAI metacognitive skills questionnaire (metacognitive awareness inventory). The responses obtained from each student after completing the test questions can be seen in Appendix 8, while the average results of the students' metacognitive skills questionnaire can be seen in Table 2.

Table 2. Metacognitive skills questionnaire results

Achievement Score Interval	Frequency	(%)	Qualification
85-100	10	38.46	Excellent
75-84	12	46.15	Good
55-74	4	15.38	Sufficient
41-54	-	-	Less
0-40	-	-	Much less

Description of students' metacognitive skills using planning indicators in solving static fluid physics problems

Based on the results of research with a total of 26 students for metacognitive skills in planning and monitoring indicators in solving test questions, it can be seen that 21 students (80.8%) and 18 students (69.2%) had very good qualifications. Meanwhile, in the evaluation category, only 9 students (34.6%) qualified as very good. This shows that students use metacognitive knowledge when solving test questions. It can be seen from the completion of the questions on the answer sheet that students understand the problem in the question and understand important information in the question. It can be seen from the answer sheet that students can write down what they know and are asked in the problem and can determine the equation to be used and use physics symbols and physical units

correctly when solving the problem. Apart from that, several learning models and strategies used so far include problem-based learning, inquiry, and project-based learning which support improving MAI. With these various learning models, teachers must also implement an assessment process that supports increasing student metacognition. To achieve this target, teachers must have a correct understanding of what, why, and how metacognition-based learning is applied (Hindun et al., 2020). The Figure 1 is an example of a student's answer to the planning indicators section with excellent qualifications.

In Figure 1 it can be seen that students with excellent qualifications are able to process the information found in the questions well, as seen from the answers of students who can write down what they know and are asked in questions 1-10 well and can determine the correct formula and prepare a good plan to solve the problems in the questions given, so that students can solve questions no. 1-10 well and fulfill the planning indicators with excellent qualifications. For students with sufficient qualifications (3.8%) the planning indicator shows that students can write down what is known and asked in the problem but have not been able to determine the correct concept/formula or the opposite to be used in solving physics problems so that the score obtained is 2 or 3 out of a maximum score of 4, and also for some questions students have not been able to answer the questions given or have not answered because the students have not understood the problems contained in the questions. The following is an example

of a student's answer (question no. 8) in the planning indicators section with sufficient qualifications.
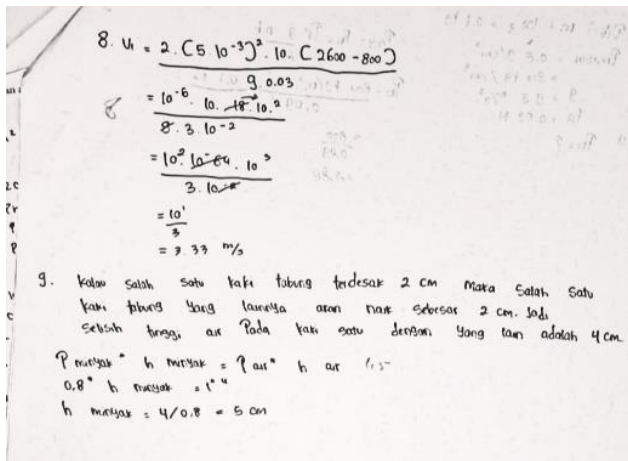

Figure 1. Students' answers to planning indicators with very good qualifications.
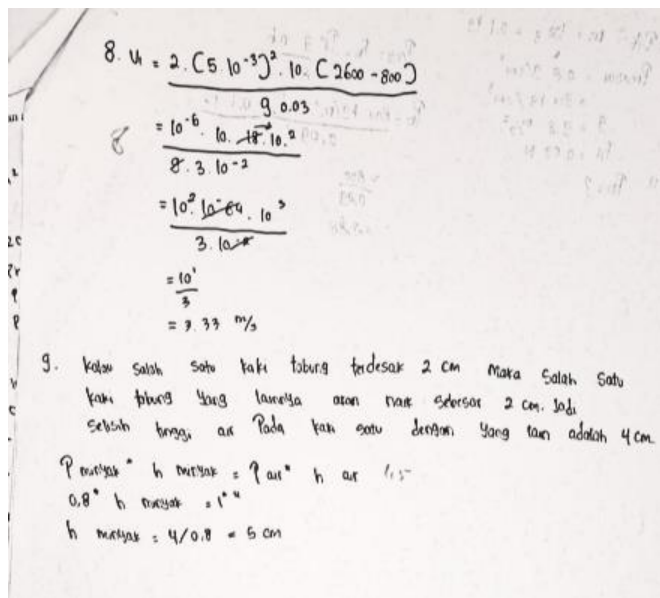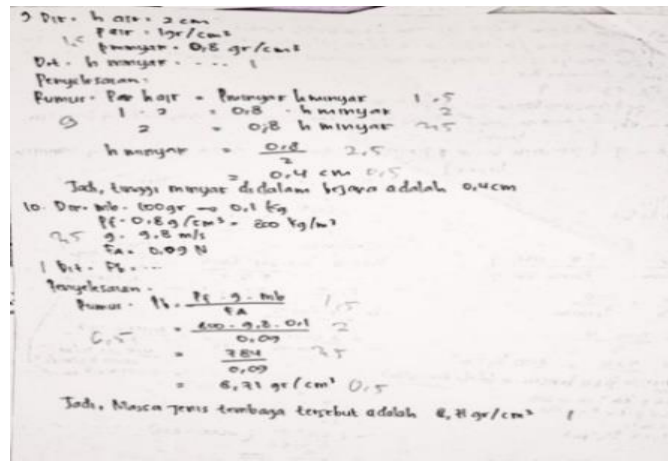

Figure 2. Answers of planning indicator students with sufficient qualifications

In Figure 2 it can be seen that students with sufficient qualifications have not been able to process the information obtained well, as can be seen from the students' answers to numbers 8 and 9, students cannot write down what they know and are asked in the questions, and also students do not write plans. good solution to solve the questions, of the ten questions given, 2 of them students have not used metacognitive skills in planning indicators well, because students cannot process information regarding viscosity and hydrostatic engineering material well so students do not know how to make plans plan to solve the problem. Subjects who do not have good planning have difficulty solving questions so they do not know how to draft a plan to answer questions. When solving subject

questions, you also don't estimate the time needed to work on the questions. Therefore, students who have good metacognitive knowledge will carry out the problem-solving process well. Metacognition has been suggested as an important factor in physics problem-solving. Increasing metacognitive awareness can facilitate problem-solving (Dulger & Feral, 2018).

Some metacognitive skills (planning, monitoring, and evaluation) should be incorporated into problem-solving instruction to further refine students' problem-solving skills. By implementing MAI you can promote cognitive processes that build structured knowledge develop thinking habits and guide students through the stages of cognitive development (Gok, 2010). Previous findings analyzed the relationship between metacognitive skills and gender in high school students at a private school in the city of Bogotá, Colombia. The findings show that there are no significant differences between men and women (Garzón et al., 2020). Other data also provides information that women have better metacognitive skills than men (Erhan, 2016). On the other hand, there is research that concludes that there are no differences in metacognitive activity between men and women (Demirel et al., 2015).

Description of Students' Metacognitive Skills Using Monitoring Indicators in Solving Physics Problems on Static Fluid Materials

The research results showed that the monitoring indicators for 18 students had an average achievement score of 69.2 with good qualifications. Students carry out the steps to solve the problem well, can understand the information used and the suitability of the plan made with its implementation in solving the problem well, and students understand the concept of formulas/equations related to questions in a static fluid

material, because by understanding the concept It is good that students can remember and apply the formulas used correctly. This statement is supported by the research results of Jamaludin et al., (2022) which state that a good understanding of concepts will make it easier for students to remember and determine the formulas to be applied. For students with sufficient qualifications (15.4%) on the answer sheets it was found that in solving questions, the plans made were inconsistent with their implementation, and students had not been able to reflect on the problem-solving process properly so in the calculation process they got inaccurate results. So, the score obtained is 2 or 3 out of a maximum score of 4 for several questions worked on. The following are examples of student answers in the monitoring indicators section with the qualifications excellent, good, and sufficient.
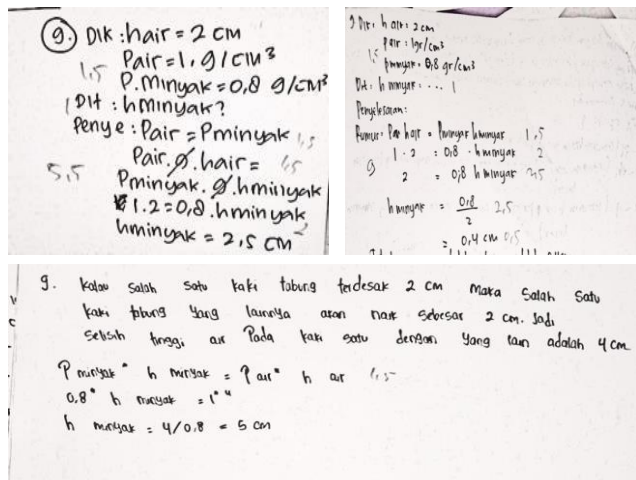

Figure 3. Student answers to indicators of mentoring with very good qualifications

In Figure 3, it can be seen that students with excellent, good, and sufficient qualifications on the monitoring indicators have different ways of solving problems as seen in solving problem number 9 to determine the level of oil in a vessel. In this question, students with excellent qualifications write a problem-solving strategy in the form of a description of the hydrostatic pressure formula, which already includes the density of water, the height of the water in the vessel, and the acceleration due to gravity. The process for getting the value of the height of the oil in the vessel is also correct in entering the value in the formula and calculating it correctly.

Based on the results of the analysis of the students' answers above, they carry out a solution process in solving problems and monitoring activities in metacognitive activities which include writing appropriate problem-solving procedures, the procedures used are correct, and the results obtained are

also correct. Meanwhile, for students who have good qualifications, it is found that when solving the problem of determining how high the oil is in the vessel, there are still errors in the calculation process. The problem-solving step is good, but when calculating or entering the value, it is still wrong, so the results obtained are wrong. students with sufficient qualifications, it was found that in solving problems students were not able to write down problem-solving strategies well, and students did not carry out monitoring activities as seen from the use of formulas that were still wrong and the values entered were still wrong, so that in the calculations to get high marks the oil in the vessel is wrong.

Description of Students' Metacognitive Skills Using Evaluation Indicators in Solving Physics Problems in Static Fluid Material

Evaluation is the ability to assess the final results of the tasks and concepts used, this can include re-evaluating the strategies used in the learning management process (Schleicher et al., 2019). The research results showed that 9 (34.6%) students had very good qualifications, 11 (42.3%) students had good qualifications, 4 (15.4%) had sufficient qualifications and 2 (7, 7%) are less qualified. The average achievement score of students on the evaluation indicators is 77.50, which is a good qualification. This shows that when solving the test questions, students were found to write down the final answer, were confident in the correct final answer, and reviewed what had been done, but it was found that there were several students who did not explain the final answer obtained in the form of a conclusion about whether the results obtained were correct. appropriate and in accordance with the objectives, this is because students are confident in the final answer they get because they have carried out the steps to solve the problem well and correctly. Students only check the results of the answers but do not carry out evaluations so that they find wrong or inappropriate answers, students are confident in the answers that have been presented so they do not realize that there are wrong answers and students do not look for other information. Students also do not realize that there are other steps that can be used to work on questions. From these results it can be said that there is a lack of ability to re-examine or review the steps taken to see whether they are in accordance with the information known about the problem. So, the score obtained by students for those with adequate and poor qualifications is 2 or 3 out of a maximum score of 4. The following are examples of student answers in the monitoring indicators section with very good and sufficient qualifications.
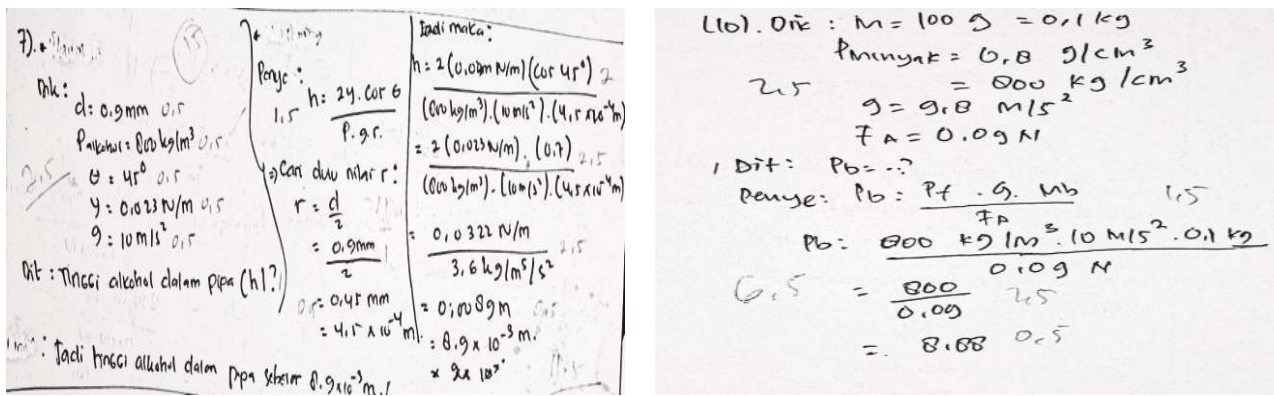
Figure 4. Student answers to evaluation indicators with very good and sufficient qualifications

In Figure 4 it can be seen that students with very good qualifications have the word writing so at the end of their answer. This shows that students with good qualifications carry out an evaluation process in solving questions and evaluation activities in their metacognitive activities. Based on written data, it was found that students understood the problem correctly, planned problem-solving steps and solved the problem correctly, and carried out evaluations during the problem-solving process, so that the final result obtained to determine the density of copper was correct, namely 8.71 $gr/cm3$. Meanwhile, students with sufficient qualifications do not carry out solution processes in solving problems and metacognitive activities which include not writing down problem solving procedures appropriately, as can be seen in the section explaining the formula for determining the value of the density of copper (ρb). And it is also seen that students do not solve the problem completely and do not provide conclusions at the end of their answers. This shows that students with sufficient qualifications do not carry out evaluation processes in solving problems and evaluation activities in their metacognitive activities.

Students' Readiness and Strategies in the Learning Process and Solving Questions

The questionnaire used is the MAI questionnaire, the questionnaire is distributed after students complete the test questions. The purpose of this questionnaire is to determine the metacognitive skills that students have or the readiness and strategies that students use in the learning process and solving problems. In the data obtained, it was found that the average achievement score on the questionnaire was 77.77 with good qualifications, this means that students have metacognitive skills in readiness and the strategies used in the learning process and solving questions are good, but the research data shows that It was found that there were students who had sufficient qualifications (15.38%) because the students did not have a good strategy or readiness when solving test questions or the learning

process as seen from the questionnaires filled out by the students on the metacognitive skills questionnaire instrument. Previous research has shown students who demonstrate higher metacognitive awareness are better equipped to apply self-regulated learning and they also tend to learn better (Young and Fry 2008).

Students who have high metacognitive confidence use knowledge and concepts involved in regulatory decision-making. In addition, students who have high metacognitive confidence know what they should do in the task and consider the task easier and more meaningful, meaning that students' metacognitive awareness is an important aspect in organizing their learning (Çini et al., 2023). In learning students will be involved in groups. This can encourage collaboration among students with different academic abilities. Collaborative learning in the form of group discussions can stimulate students to think critically and encourage them indirectly to understand their assignments (Kallio et al., 2021). Apart from that, with collaborative learning students can complete assignments more efficiently. Metacognitive awareness is one form of providing support for group members in a collaborative learning environment (Järvelä et al., 2015).

Conclusion

Based on the findings, it can be concluded that metacognitive skills in planning and monitoring indicators in solving test questions show that 21 students (80.8%) and 18 students (69.2%) have very good qualifications. Meanwhile, in the evaluation category, only 9 students (34.6%) qualified as very good. This means that students understand the problem in the question and understand the important information in the question. It can be seen from the answer sheet that students can write down what they know and are asked about in the question and can determine the equation that will be used and use physics symbols and physical units correctly when solving problems. In this way, MAI

can be used by teachers in solving students' physics problems.

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