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Identification of Students' Metacognitive Levels in Physics Learning Viewed from the Problem-Solving Ability

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Abstract. This study aimed to look at the level of physics problem-solving ability achieved by students and identify the level of metacognition based on the ability to solve physics problems at each level. The research method used was a mixed method with a sequential explanatory strategy. The populations in this study were all eleventh-grade science students of Kebumen Islamic High School, Tanggamus District. The sampling technique used was a balanced sample with a participant selection model. The instruments used in this study were the physics tests, interviews, and documentation. The data analysis process included two stages of analysis, namely quantitative data analysis and qualitative data analysis. The results of this study indicated that 12.12% of students belong to the high problem-solving group, 66.67% of students belong to the moderate problem-solving group, and 21.21% of students belong to the low problem-solving group. The high problem-solving group had a high level of metacognition, namely Semi-reflective use with a percentage of 10% and Strategic use with a percentage of 10%. The moderate problem-solving group had Semi-strategic use level with a percentage of 40% and Aware use with a percentage of 20%. The low problem-solving group had the lowest metacognition level, namely Tacit use with a percentage of 20% of the total sample taken. so, the levels of metacognition ability of students in learning physics identified in this study were: tacit use, aware use, semi strategic use, strategic use, and semi-reflective use.

1. Introduction

Physics is one of the most basic sciences [1, 2]. The scope of education encompasses all forms of the environment that take place in a variety of forms, patterns, institutions, and at any time by carrying out the goals that encompass all life goals. Education has an important role in determining the quality of a nation and this is related to the quality of human resources of a nation. Human resources are capable in managing natural resources and artificial resources and provide great opportunities for development in the country [3]. Educational practitioners are people who are involved in the learning atmosphere. So, a country that has good quality human resources (HR), has a good quality of education [4]. Education is a conscious effort and important factor in investment in human resources [5, 6]. Education is often associated with school institutions, not because schools are the only place where education takes place, but because schools are institutions that aim to educate educational practitioners to achieve educational success. Education that occurs in the school environment is characterized by a teaching-learning process that involves teachers and students by relying on a curriculum determined by the educational unit [7]. Learning is an activity that involves all aspects of human personality [8]. In this case, learning can be said to be successful if it can make its component to learn.

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The aim of national education integrated into schools is to develop potential students to become human beings who have faith and are devoted to God the Almighty, noble, healthy, knowledgeable, capable, creative, independent, democratic, and responsible citizens. Although students already know, if the results of learning are not supported by the value of Islamic law, the education that it supports can be categorized as failed [9]. Therefore, Islam has provided the true concept of educational goals which is to form humans as human beings who are noble in the world and the hereafter. This implies that the result of education not only creates smart people in one type of intelligence but includes all types ranging from intellectual, spiritual, emotional and political which are all listed in the objectives of Islamic education [9]. Of course this is in line with what educational institutions want to achieve. Where, the success of education in schools depends on the success of the learning process that takes place at school. One of the characteristics of a successful learning process is the students' ability in solving problems that are relevant to what they have learned during the teaching-learning process. Meanwhile, the learning process undertaken by each student produces diverse learning outcomes [4]. The ability to solve the problem is also different. The ability to process knowledge is referred to as metacognition [10]. Several factors of students' low physics problem-solving are influenced by students' low motivation to learn, their lack of fondness for learning physics, the material they learn, the learning activities experienced by students, and the teacher's teaching style, as well as the rarity of students doing problem-solving exercises independently [11], In general, students have difficulty developing their thought processes. Learners will be able to solve simple calculation problems but find it difficult to solve the improved version of the previous problems [12].

Based on the results of the pre-research questionnaire filled out by science students in Kebumen Islamic High School, Tanggamus Regency, the researchers found some problems, they are: the low motivation of students to learn, the low preference of students towards physics subjects, students rarely do problem-solving exercises independently, and students often feel difficulty in completing the questions given by the teacher. The physics teacher at Kebumen Islamic High School said that the learning outcome of physics was fairly low. The lack of study hours at school makes the physics teacher less optimal in addressing the subject matter so that the students who do not pay attention to the lesson will have difficulty in solving problems. Students who have difficulty solving problems, of course, have an impact on the low learning outcomes they get. In connection with these problems, metacognition is considered important in determining learning outcomes and student achievement [10, 11]. As carried out by the education curriculum in Indonesia where one of the standards for graduating education that takes place at school is to have good metacognition knowledge [15].Based on the results of interviews with the teachers, they only recognize metacognition as a term and do not understand deeply what and how metacognition is for students and their role in controlling the learning process which is reflected in the success of students in solving given problems. This is, of course, worth worrying about given that metacognition is one of the graduation standards set by the government in the Education Unit Level Curriculum of 2013 [16]. Things like this could only be one of the many similar cases, where the lack of awareness of education providers about the importance of metacognition. In general, the teachers consider students with low problem-solving abilities as low achieving students, but basically, students who are classified as having low problem-solving abilities are only students with a low level of metacognition, and high and low levels of metacognition that owned by students can be seen based on their ability to solve problems.

Previous studies have categorized that the high level of metacognition is the Reflective Use, the moderate level of metacognition is Strategic Use, and the low level of metacognition is Aware Use [17]. The classification used by fitaria is a classification developed by Swart and Perkins which includes Tacit Use, Aware Use, Strategic Use, and Reflective Use. However, because there are students who do not belong to any of those categories, then the improved, valid and reliable formulation was used with the tendency of the level characteristics presented to be more subtle and specific [18]. The classification used by researchers in this study is a formulation formulated by Theresia and this is what distinguishes this research with the previous one. Besides, what makes this study different from previous research is the method used to obtain data and sampling techniques to represent the existing population, hoping to be able to provide more valid and reliable results based on actual conditions. Apart from classifying these ability levels, with the right learning strategy, the level of students' metacognition can be increased. To increase the level of metacognition abilities of students in learning physics, a physics teacher needs to see the extent of the level of metacognition ability of students, so that later can provide appropriate treatment by the expected educational goals. Therefore, researchers intend to provide an overview related to the identification of the levels of metacognition abilities of students in learning physics in terms of the ability to solve problems, to see the extent to which students' abilities in solving physical problems are then reflected in the levels of metacognition abilities.

2. Method

The research method used was a mixed method with an explanatory sequential strategy[19]. The method used in this research is presented in the following chart:

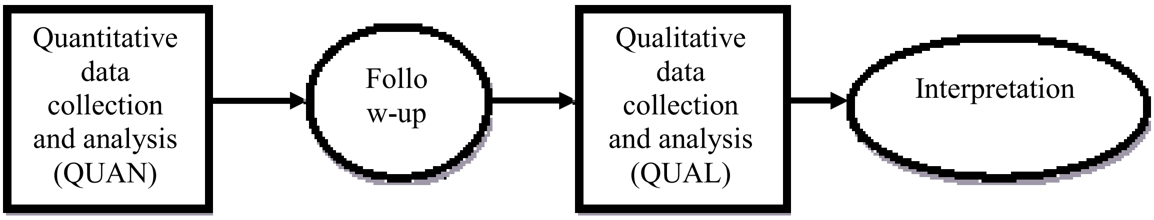
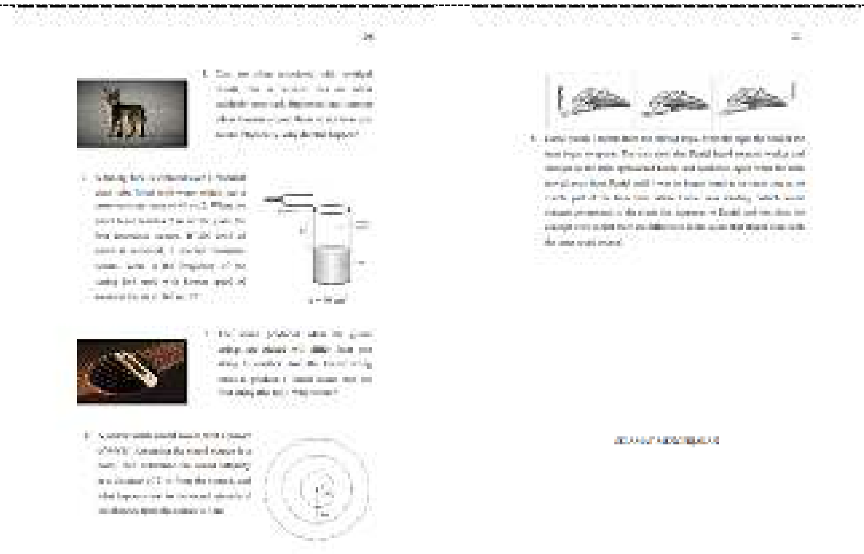


Figure 1. The design of the explanatory sequential mixture method. Data collection takes place in two different phases with careful quantitative sampling in the first phase and certain sampling in the second phase. Where, quantitative results are used to plan qualitative follow-up.

The data obtained in this research consisted of two types of data namely quantitative data and qualitative data so that the required analysis also included both quantitative and qualitative data analysis. Quantitative data in this research, aims to provide an overview related to students' problem-solving abilities. As well as determining the follow-up to be carried out in the next research phase. The next stage, which is qualitative, aims to identify the level of metacognition abilities of each problem-solving group whose data have been obtained at an early stage.

This research was conducted in Kebumen Islamic High School, Tanggamus Regency. This research was conducted in the first semester of the 2019/2020 academic year. The population in this research were all students of class XI MIA Kebumen Islamic High School, Tanggamus Regency. Where class XI was chosen with consideration that class XI already had data on physics learning outcomes, so that, it is accurate in gathering data needed in qualitative methods in this research. The sampling technique used was a balanced sample with the participant selection model. To determine the sample, the size of the subject is determined by the ideal percentage of the sample from the existing population and the intended participant selection model, namely the existence of sample cone at each level of research conducted. The ideal percentage used by researchers is 27% of the total 101 population [20]. The number of samples in the initial stages of the research, is equal to 33 respondents distributed in all existing XI MIA classes. Then, in the second stage of the research again 27% of samples were taken from each group of physics problem solving obtained from the data of problem-solving results.

The data collection techniques used in this research were tests, interviews, and documentation. There were 5 problems provided to see the level of students' physics problem-solving abilities that previously had been tested for validity, reliability, discrimination index, and the level of difficulty as prerequisite tests. The test material given is sound wave material, this was decided by considering that the sound wave material is physics material that has been studied by students and is one of the physics methods that is considered not too difficult by students, so that the data obtained is really relevant to the actual situation, where the material is chosen is not only understood by a small number of students. The indicators of the questions used were derived from the indicators of achievement of competencies developed by physics teachers at Kebumen Islamic High School [21]. Another instrument used was the interview guideline sheet to identify the level of metacognition of the problem-solving groups that have been classified. The research instruments used are presented in the following figure 2(a) and figure 2(b):



(a) (b)

Figure 2 (a) and (b), is a test item used to identify students' physics problem solving abilities on sound wave material.

The results of respondents' answers were analyzed based on indicators of the ability of metacognition in solving problems [22], as follows:

Table 1. scoring problem-solving skills

Indicators of Metacognition in Solving Problems	Assessment Options	A score of each Item
Planning • Known and asked	➢ Do not write down the points known and asked.	0
	➢ Write down the points known and asked but not exact and incomplete.	1
	➢ Write down the points known and asked completely but not exactly.	2
	➢ Write down the points known and asked precisely but not yet complete.	3
	➢ Write down the points known and asked precisely and completely.	4
Monitoring • Answered	➢ Not answering questions, answers do not indicate efforts in answering questions such as "I don't know, I haven't learned" and words that indicate that the respondent is merely answering.	0
	➢ The answer is written is too far from the theoretical concept of the matter and sound wave material.	1

	➢ The written answer contains one of the important points contained in the answer key (If the problem is not included as a counting problem). ➢ The answer is not right but it is still related to theoretical and mathematical concepts of the test problem and sound wave material (if the problem is a matter of counting).	2
	➢ The written answer contains more than one important point contained in the alternative answers (If the problem is not included as a counting problem). ➢ The answer is not right or incomplete but has used the right equation (if the problem is a matter of counting). ➢ Equipped with pictures (if any).	3
	➢ The written answer contains more than two important points contained in the alternative answers; The written answer contains the theoretical and mathematical concepts of sound wave problems and matter; The written answer is equipped with an equation or picture that is by the concept of the matter and sound wave material (If the problem is not included as a counting problem). ➢ The answer has been right, has used the right equation, the workmanship has been precise and systematic (if the problem is a matter of counting).	4
Evaluating • Evaluation of completion results.	➢ No evaluation was carried out because it did not write down the answers or the answers written too far from the concept of the matter and sound wave material (only from answering).	0
	➢ There is no visible improvement in the written answers so that the answers are left incorrect or incomplete.	1
	➢ Visible stains for correction materials such as streaks and type x, labels, erasers, etc. indicate an attempt to improve the answers they write; But the answer is still not right, or incomplete;The equation used is not right. ➢ The written answer contains only one important point in the alternative answers (If the problem is not included as a counting problem).	2
	➢ There is a stain on the correction material which indicates that an improvement has been made to the answer he wrote; The equation used is correct; There was an error in the calculation or the answer was not done until the end. ➢ The answer is correct or has contained more than one important point in the alternative answers (If the problem is not included as a counting problem).	3
	➢ There are no stains on the correction material but the answers are correct and complete; Use the right equation; The steps are systematically arranged; Equipped with pictures (if any). ➢ The words written are interrelated (If the problem is not included as a counting problem).	4

The level of problem-solving ability is classified based on the problem-solving ability category [23] as follows:

Table 2. Problem-Solving Ability Category

Interval	Categories
$x \geq (M_x + 1SD)$	High
$(M_x - 1SD) \leq x \leq (M_x + 1SD)$	Medium
$x < (M_x - 1SD)$	Low

The percentage of the distribution of problem-solving groups and metacognition levels of each problem-solving group is calculated using the following percentage formula: [22]

$$\% = \frac{n}{N} x\ 100\%$$

The level of categories of the metacognition involved [16] can be seen in Table 3 below:

Table.3. Metacognition Ability Level Classification

Indicators of Problem Solving	Metacognition Level
Planning	Tacit Use
1.1. Determine what is known from the given problem.	
1.2. Determine what is asked from the given problem.	Aware Use
1.3. Determine the stage of completion that will be used.	
Monitoring	Semi-Strategic Use
2.1. Explain the right answers.	
2.2. Use the right equation.	Strategic Use
2.3. Use your language.	
Evaluating	Semi-Reflective Use
3.1. Check the answers.	
3.2. Check the accuracy of the equation used.	Reflective Use
3.3. Check the accuracy of the words used.	
3.4. Have a strong argument for the written answers.	

3. Results and Discussion

Based on the test results, 33 students were distributed into three problem-solving groups as follows:

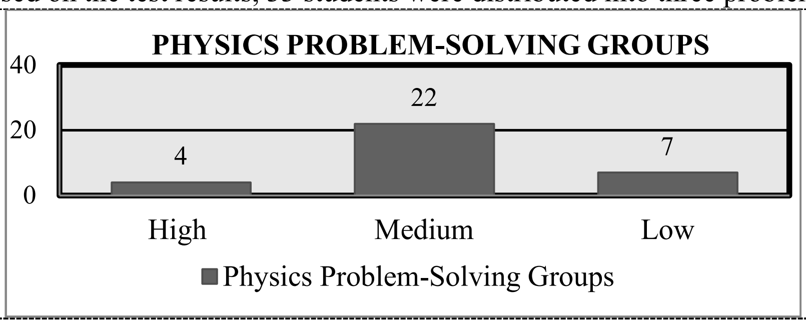


Figure 3. Classification Charts of Physics Problem-Solving Groups

The next step was an interview. It was aimed to see the ability of respondents that cannot be seen through the results of the answer sheets. Each group was re-sampled by 27% [23] as follows:

Table 4. Results of Problem Solving-Ability Analysis

Problem-Solving Group	Number of Respondents	The Percentage of the Problem-Solving Group	Samples (27%)	Respondent Code	Score
High	4	12.12%	2	HF	41
				FH	26
				FRH	22
				DRY	22
Medium	22	66.67%	6	ARA	20
				RM	19
				DP	12
				NA	12
Low	7	21.21%	2	RAT	5
				PS	5

Table 4 shows that the respondents are identified into three problem-solving groups. There are 12.12 % belong to the high problem-solving group, 66.67% belong to the medium problem-solving group, and 21.21% belong to the low problem-solving group. Furthermore, after an analysis of the results was done, each sample of respondents in each group was interviewed to determine the metacognition classification level in solving physics problems. The details are presented in table 5 and 6:

Table 5. The Recapitulation of Interview Data on the Identification of Metacognition Level

Problem Solving Group	Respondent Code	Metacognition Indicators in SolvingProblems	Trend Indicator of eachLevel	Level
High	HF	Planning 1.1. Initial knowledge of the information in the given problem.	1.1. Semi Reflective Use 1.1. Semi Reflective Use 2.1. Reflective Use 2.2. Semi Reflective Use 3.1. Semi Reflective Use 3.2. Reflective Use	Semi Reflective Use
	FH	1.2. Understanding the problems and planning strategies. Monitoring	1.1. Semi Reflective Use 1.1. Strategic Use 2.1. Strategic Use 2.2. Strategic Use 3.1. Strategic Use 3.2. Strategic Use	Strategic Use
Medium	DP	2.1. Resolving problems based on planned	1.1. Aware Use 1.1. Aware Use 2.1. Tacit Use 2.2. Aware Use	Aware Use

		strategies.	3.1. Aware Use 3.2. Aware Use	
	FRH	2.2. Rechecking the strategy used. Evaluating 3.1. Rechecking the formulated answers. 3.2. Correcting the errors.	1.1. Semi Strategic Use 1.1. Aware Use 2.1. Strategic Use 2.2. Strategic Use 3.1. Semi Strategic Use 3.2. Semi Strategic Use	Semi Strategic Use
	RM		1.1. Semi Strategic Use 1.1. Semi Strategic Use 2.1. Semi Strategic Use 2.2. Strategic Use 3.1. Semi Strategic Use 3.2 Semi Reflective Use	Semi Strategic Use
	ARA		1.1. Semi Strategic Use 1.1. Aware Use 2.1. Semi Strategic Use 2.2. Semi Strategic Use 3.1. Aware Use 3.2. Semi Strategic Use	Semi Strategic Use
	DRY		1.1. Semi Strategic Use 1.1. Semi Strategic Use 2.1. Semi Strategic Use 2.2. Semi Strategic Use 3.1. Semi Strategic Use 3.2. Semi Strategic Use	Semi Strategic Use
	NA		1.1. Aware Use 1.1. Tacit Use 2.1. Aware Use 2.2. Aware Use 3.1. Aware Use 3.2. Aware Use	Aware Use
Low	RAT		1.1. Tacit Use 1.1. Tacit Use 2.1. Tacit Use 2.2. Tacit Use 3.1. Tacit Use 3.2. Tacit Use	Tacit Use
	PS		1.1. Tacit Use 1.2. Tacit Use 2.1. Tacit Use 2.2. Tacit Use 3.1. Tacit Use 3.2. Tacit Use	Tacit Use

Table 6. Classification of Metacognition Levels

Problem Solving Groups	Number of Samples	Metacognition Levels	Percentage Level
High	2	Semi Reflective Use	10%
		Strategic Use	10%
Medium	6	Semi Strategic Use	40%
		Aware Use	20%
Low	2	Tacit Use	20%

Based on tables 5 and 6, the high problem-solving group has a fairly high level of metacognition, namely Semi Reflective Use with a percentage of 10% and Strategic Use with a percentage of 10%. The medium problem-solving group with metacognition level of Semi-Strategic Use with a percentage of 40% and Aware Use with a percentage of 20%. Furthermore, the low problem solving-group has the lowest metacognition level, namely Tacit Use with a percentage of 20%. The data shows that the school where the research was conducted has students whohave medium problem-solving abilities with the Semi Strategic Use level.

Overall, high problem-solving groups tend to have high levels of metacognition and are classified as high achieving students. This has been proven whereby having good metacognition abilities, the learning outcomes are also good [10, 11, 21, 22], and the ability to think is also high, both higher-order thinking [14] and critical-thinking [26]. By having good metacognition skills, students will be able to solve problems well [27], be able to understand the subject matter well, and have good learning achievements [28] because to develop a critical mindset requires metacognition abilities [29]. In other words, it can be said that metacognition has a positive relationship with academic success [27, 28]. Then, students in the medium problem-solving group can understand the problem quite well, tend to experience confusion and doubt about the steps chosen, just understand the basic physics material, and have knowledge of the theoretical and mathematical concepts of the problem but don't know what steps to take. Students with low problem-solving abilities will have a low level of metacognition ability too. Students with low problem-solving abilities tend to have difficulty in understanding subject matter, have problems in learning, difficulty capturing important information contained in test questions, difficulty finding the right solution, and just answer recklessly.

Based on the research results, respondents with a Semi Reflective Use metacognitionlevel, meet all indicators of problem-solving ability. Respondents at this level are able to apply various strategies to improve the accuracy of their thinking, know their strengths so that they are calm in solving problems, always act carefully by reflecting the process of finding answers, able to solve problems thoroughly, re-examine the answers, and can prove their ability to master the concept of the material. Respondents with a Strategic Use metacognition level are able to meet all indicators of the ability of metacognition in problem-solving, but only on the number of questions they worked on, able to demonstrate their ability to maintain arguments that support the accuracy of their thinking, re-checking or comparing their answers with other information from various relevant sources, and believe in what they are doing. Students in the high problem-solving group can understand the problem well, could immediately find the right solution, have alternative answers, and have a strong argument for the results of his thinking. Students who are classified into the high problem-solving groups can explain the steps of their work and understand the subject matter being tested so that they can explain theoretically and mathematically. This group tends to have high accuracy so that they can evaluate well and know what improvements must be made to produce the right answer.

Respondents with Semi Strategic Use metacognition ability can meet a small portion of the indicators, try to check the answers but could not make improvements on the incorrect answers, and were doubtful about the information. Respondents withAware Use metacognition ability could not fully fulfill all metacognition indicators in solving problems of all the problems they worked on. Respondents at this level can explain the reasons for what they do such as weaknesses in understanding the problem, experiencing confusion in the problem-solving process, knowing what they do not know from the given problem, and only understanding the basic concepts of physics. Respondents with Tacit Use metacognition ability level cannot fulfill all indicators of metacognition ability in solving problems for all given problems. Respondents at this level tend to answer questions carelessly, cannot re-explain what they have written in the answer sheet, are unaware of their weaknesses in understanding the problem, and provide inconsistent explanations during the interview.

The difference in the level of metacognition is caused by students' internal factors in learning [32]. So, it is necessary to have an appropriate learning strategy to foster students with a low level of ability to improve their abilities. In this case, teachers are not only demanded as reliable material deliverers but are also expected to be able to imply appropriate learning media to attract learners [2], be able to teach good problem-solving strategies [33], and teachers are not only required to think what material will be taught to students, but even deeper than that, the teacher must be able to think about how to deliver the teaching material so that it can be absorbed easily by students. Thus, the goals of education stated in the curriculum can be achieved by producing students with good metacognition skills.

4. Conclusions

The results of research on the identification of the level of students' metacognition on physics learning in terms of physics problem-solving ability are concluded as follows: The distribution of physics problem-solving groups is 12.12% of the high group, 66.67% of the medium group, and 21.21% of the low group. The metacognition levels identified from the high group are Semi Reflective Use with a percentage of 10% and Strategic Use with a percentage of 10%, the medium group are Semi Strategic Use with a percentage of 40% and Aware Use with a percentage of 20%, and the low group is Tacit Use with a percentage of 20%. The solution for other researchers, it is necessary to research the factors that affect the level of metacognition and good learning strategies to increase the level, as well as the analysis of the difficulties experienced by each level of metacognition from research subjects taken.

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