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Analysis of Students' Difficulties in Solving Physics Problems Using Polya's Theory

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Abstract: The ability of students in solving physics problems used Polya's theory is still at a low level, in general students have difficulty in solving physics problems at the stages of planning and implementing problem solving. This study aims to determine the level of difficulty of students in solving physics problems used Polya's theory and find out what are the difficulties of students in solving physics problems used Polya's theory. The research approach used is mixed method, with the explanatory sequential design. Data collection techniques used tests and interviews. The results of data analysis show that the very high level of difficulty of students in solving equilibrium problems of rigid bodies is at the stage of seeing / checking back, but the difficulties experienced by students at this stage are very dependent on the other three stages of Polya, namely understanding the problem, planning problem solving and implementing problem solving. Students' difficulties in solving physics problems used Polya's theory, among others, students had difficulty in translating or changing the problem in physics symbols, students had difficulty in making plans because they did not know the formula that should be used, students had difficulty in completing mathematical operations and students did not re-examine the solution steps and answers that had been obtained so that some answers were still not correct.

Keywords: Physics problem; Polya's theory; Students' difficulties

Introduction

Schools as formal educational institutions accommodate a variety of learners with different personality backgrounds. Teachers are often faced with a number of diverse characteristics of learners. Charli et al. (2019) stated that "Some learners can follow learning activities well and some have difficulty in learning". Learning difficulties are problems or obstacles experienced by students in understanding or mastering certain materials or skills. Mulyono (2012) stated that "learning difficulties are generally classified into two groups, namely (1) learning difficulties related to development, where these difficulties include disorders in attention, memory, motor skills and perception, language and thinking; (2) academic learning difficulties, including difficulties in reading, writing, counting or math".

The phenomenon of student learning difficulties is usually evident from the decline in academic performance or learning achievement. If students experience learning difficulties, it is necessary to pay attention to the factors that cause these difficulties. Student learning difficulty factors consist of internal factors which include intelligence, attention, interest, talent, motivation, maturity and readiness, while external factors include family factors, school factors and infrastructure (Slameto, 2010).

Learning outcomes have an important role for teachers to determine the success of student learning. The process of assessing learning outcomes and evaluation can provide information about the progress

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of students and efforts to achieve learning goals through learning activities (Suarga, 2019). Anggraeni et al. (2021) stated that, "Evaluation activities are a process of measuring the success of learning, whether learning can be continued, improved or repeated the material that has been delivered in order to get the desired results". Evaluation will usually be given by educators in the form of test questions. These evaluation questions can also be interpreted as a test tool for students' ability to solve problems (Bekti, 2014). Physics is a subject whose material contains abstract concepts and complex problem solving. For most students, physics is a subject that is quite difficult and complicated to understand, therefore it is important for a physics teacher to be able to manage learning methods well. But in addition to the teacher's ability to manage learning methods, the seriousness of students in learning also plays an important role. Students who are serious in learning physics will find it easier to achieve a better understanding and succeed in mastering the physics concepts given (Anggraeni et al., 2021).

Solving a problem not only applies known knowledge, but must try hypotheses, think and if successful will produce new knowledge. In a learning process, students often experience obstacles, one of the obstacles experienced by students is that they tend to find it difficult to solve problems so that they experience errors in solving physics problems (Priyadi et al., 2019). The low ability to solve problems is influenced by several factors, including errors in determining units and quantities (Darsa et al., 2020), difficulty when given problems in microscopic representations (Priyadi et al., 2019). Errors in solving problems occur when students have difficulty understanding the problem (Azam et al., 2022). Students' difficulties in solving physics problems are also influenced by the level of depth of the material studied, learning activities in class and the teacher's teaching style (Azizah et al., 2017).

Based on the results of interviews conducted by researchers with teachers at MAN 4 Aceh Besar, it shows that students in class XI IPA have used Polya's theory in solving physics problems, but there are still many students who experience errors in solving physics problems, especially at the stages of planning and implementing problem solving, thus causing student learning outcomes to still be at a low level of 60 from the provisions of the minimum completeness criteria which is 75. The results of interviews with several students show that students have difficulty in solving problems because they do not understand the meaning of the given problem, students also do not understand how to correctly derive formulas, students often have difficulty performing mathematical operations, students are less able to write unit conversions, and students do not remember physics symbols.

Mariati et al. (2023) stated that "Problem solving difficulties are caused by a weak understanding of the principles and rules of physics, lack of understanding of the problem, and insufficient motivation from students". The learning difficulties of students, especially in problem solving, will have an impact on learning achievement because to obtain good achievement can be obtained from the treatment of learning at school and outside school and on the provisions and efforts of students in learning, therefore this learning difficulty must be solved properly. Solving physics problems requires systematic steps to keep the solution process simple and directed. Sugiarto et al. (2016) stated that, "Problem solving is an important part that can be used to apply physics concepts". Many experts have studied problem solving with different views and ways to solve it, one of which is George Polya. Problem solving steps using Polya's stages apply problem-solving steps more systematically and present problem-solving techniques that are not only interesting, but also convince previously learned physics concepts (Djudin, 2020; El Bedewy et al., 2021; Jiwanto et al., 2012).

Problem solving as an effort to find a way out of a goal that is not so easy to achieve immediately (Almulla et al., 2023; Purba et al., 2021; Santos-Trigo et al., 2021; Szabo et al., 2020). Problem solving is an attempt to find a way out of a difficulty or non-routine problem so that the problem is no longer a problem (Barana et al., 2022; Chacón-Castro et al., 2023; Kohen et al., 2022). Through Polya's theory it will be easier to find out the level of difficulty of students in solving physics problems, because Polya's theory applies the steps of solving problems systematically, namely understanding the problem in the problem, planning a solution, carrying out problem solving, and seeing/re-examining the problem that has been solved (Anggraeni et al., 2021; Jamilah et al., 2022; Sampanis, 2020; Soebagyo et al., 2021). Therefore, this study aims to determine the level of difficulty of students in solving physics problems using Polya's theory and find out what are the difficulties of students in solving physics problems using Polya's theory.

Method

This research uses mixed methods with the explanatory sequential design. This research design is used because in the first stage researchers collect and analyze data quantitatively to answer the first problem formulation. Then followed by qualitative data collection using the interview method in order to answer the second problem formulation in the research This research was conducted at a high school in Aceh Besar, the population in this study was class XI IPA. Many

samples used in this study were taken 30% of the population. The sampling technique used simple random sampling. While the research subjects to be used for interviews were selected based on the test results and categorized into high, medium and low groups based on the criteria in table 1 then 6 students were selected to be interviewed.

Table 1. Score Grouping Criteria

Student Score	Level
Score ≥ Mean +SD	High
Score – SD ≤ Score < Mean + SD	Medium
Score < Mean – SD	Low

The research instrument used a test with the material of equilibrium of a firm object to determine the level of difficulty of students and interviews to find out what difficulties students experience in solving physics problems at each stage of Polya. The results of the test on the equilibrium of a firm object were analyzed using descriptive statistical analysis with the aim of knowing the level of difficulty of students in solving physics problems using Polya's theory. The test results will be analyzed quantitatively and given a score, according to table 2.

Table 2. Guidelines for Scoring Students' Problem Solving Ability Score

Aspects assessed	Description	Score
Understanding the problem	Did not write known and asked at all	0
	Mentioned what is known without mentioning what is asked or vice versa	1
	Writing known and questioned but still incomplete	2
	Known and questioned are written completely and correctly	3
Planning problem solving	Did not plan the solution at all	0
	Planned a solution but the plan was wrong	1
	Planned the solution but less precise	2
	Planned the solution correctly	3
Implementing problem solving	Did not write the answer at all	0
	Implemented the plan and also made an answer, but the answer was wrong	1
	Implemented the plan and also made the answer correctly, but incomplete	2
	Implemented the plan and also made the answer correctly and completely	3
Looking/Back Checking	Did not write the conclusion	0
	Wrote a conclusion, but the conclusion is wrong	1
	Wrote a conclusion, but the conclusion was not correct	2
	Wrote the conclusion correctly	3

Furthermore, the researchers calculated the percentage of the level of difficulty of students in solving the equilibrium problem of a firm object based on criteria (Sudijono, 2010). The calculated percentage is the percentage per indicator of Polya's theory on each question/each cognitive domain given during the test. The percentage level of student difficulty according to Sudijono is as follows:

$$P = \frac{f}{N} x100\% \quad (1)$$

Description:
P = Percentage number
f = Frequency of students who make mistake
N = Number of individuals / students

The percentage results that have been obtained will then be averaged and grouped based on the level / level of student difficulty according to Heng et al. (2014) found in table 3.

Table 3. Student Difficulty Levels

Level of Difficulty (%)	Criteria
$80 \leq P < 100$	Very High
$60 \leq P < 79$	High
$40 \leq P < 59$	Medium
$20 \leq P < 39$	Low
$0 \leq P < 19$	Very Low

Furthermore, to analyze the results of the interview, source triangulation was carried out to obtain data validity and to obtain a pure picture regarding certain information, in this case the researcher compared the data obtained from research informants with other research informants.

Result and Discussion

Results

The results of the level of difficulty of students using Polya's theory in each cognitive domain are presented as follows:

Analysis of Level of Difficulty in C3 Cognitive Domain

The level of difficulty of students in solving problems on the equilibrium material of rigid bodies in the C3 cognitive domain (applying) is presented in table 4. The level of difficulty of students in solving problems in the cognitive domain C3 (applying), which shows that at the stage of understanding the problem is categorized as very low, namely 10%, the stage of planning problem solving is categorized as low, namely 35%, the stage of implementing problem solving is categorized as moderate, namely 40% and the stage of seeing/ checking back is categorized as very high, namely 83%.

Table 4. Students' Level of Difficulty Using Polya's Theory at C3 Cognitive Domain

Cognitive Domain	Stages of Polya's Theory	Percentage Difficulty of Each Problem		Average Percentage Difficulty	Category
		1	2		
C3	Understanding the Problem	6 %	13 %	10%	Very Low
	Planning Problem Solving	35%	35%	35%	Low
	Carrying out the plan	35 %	45 %	40%	Medium
	Looking/Back Checking	81%	84%	83%	Very High

Analysis of the Level of Difficulty in the C4 Cognitive Domain

The level of difficulty of students in solving problems on the equilibrium material of rigid bodies in the C4 cognitive domain (analyzing) is presented in table 5. The level of difficulty of students in solving problems in the C4 cognitive domain (analyzing), which shows that at the stage of understanding the problem is categorized as moderate, namely 52%, the stage of planning problem solving is categorized as moderate, namely 50%, the stage of implementing problem solving is categorized as moderate, namely 50% and the stage of seeing/checking back is categorized as high, namely 60%.

Table 5. Students' Level of Difficulty Using Polya's Theory at C4 Cognitive Domain

Cognitive Domain	Stages of Polya's Theory	Percentage Difficulty of Each Problem		Average Percentage Difficulty	Category
		3	4		
C4	Understanding the Problem	52 %	52 %	52%	Medium
	Planning Problem Solving	35%	65%	50%	Medium
	Carrying out the plan	23%	77 %	50%	Medium
	Looking/Back Checking	29%	90%	60%	High

Analysis of the Level of Difficulty in the C5 Cognitive Domain

The level of difficulty of students in solving problems on the equilibrium material of rigid bodies in the cognitive domain C5 (synthesis) is presented in table 6. The level of difficulty of students in solving problems in the cognitive domain C5 (synthesis), which shows that the stages of understanding the problem are categorized as moderate, namely 55%, the stages of planning problem solving are categorized as very high, namely 81%, the stages of implementing problem solving are categorized as very high, namely 94% and the stages of seeing/checking back are categorized as very high, namely 97%.

Table 6. Students' Level of Difficulty Using Polya's Theory at C5 Cognitive Domain

Cognitive Domain	Stages of Polya's Theory	Percentage Difficulty of Each Problem	Category
		5	
C5	Understanding the Problem	55 %	Medium
	Planning Problem Solving	81%	Very High
	Carrying out the plan	94%	Very High
	Looking/Back Checking	97%	Very High

Based on the analysis data obtained above, it can be concluded that the highest level of difficulty of the problem is in question number 5 with cognitive domain C5 (synthesis) which shows that almost all stages of problem solving using Polya's theory at a very high percentage. Based on the explanation and data obtained regarding the difficulty of students in solving problems using Polya's theory above, it can be concluded that the highest level of difficulty is at the stage of seeing/checking back, but the difficulties experienced by students at this stage are highly dependent on the other three Polya stages, namely understanding the problem, planning problem solving and implementing problem solving as shown in tables 4, 5 and 6. The percentage of difficulty at the stage of seeing/checking back will be high if students have difficulty in the previous stages. As the results of Susanto (2011), the suitability of answers in the solution process is seen

starting from the beginning of the process carried out to the final answer that has been obtained, such as describing the problem, using formulas, preparing the solution steps and the final result or answer is appropriate.

Triangulation through Student Interviews

The results of interviews from 6 students who became research subjects at each Polya stage showed that at the stage of understanding the problem, including students having difficulty in translating or changing the problem in physics symbols, students did not understand the meaning of the problem so they could not write what was known and asked in the question. At the stage of planning problem solving (devising a plan), students have difficulty in making plans because they do not know the formula that must be used, students do not complete writing a solution plan so that they have difficulty when implementing problem solving.

The stage of carrying out the plan, the difficulties experienced by students at this stage include difficulties in performing mathematical operations such as not being able to reduce numbers in fractions and multiply numbers in decimal form so that the results obtained are not correct, difficulty in understanding the image and direction of motion of the rope tension of the system of rigid bodies, and difficulty in determining the value of the angle. At the looking back stage, students generally do not re-examine the steps of completion and the answers that have been obtained so that some answers are still not correct and students forget to write the conclusions of the answers that have been done.

Discussion

Understanding the problem is the first stage in problem solving where students must be able to understand the conditions of the problem or the problem in the problem. This step includes, among others, determining what data or information is known and asked from the problem, what is the core problem of the problem that requires solving, are there important conditions that need to be considered in the problem (Purba et al., 2021). Based on the data analysis of the answers, the level of difficulty of students at C3 is categorized as very low, at C4 is categorized as moderate and at C5 is categorized as moderate.

Based on the interview data, it is found that the difficulties experienced by students at this stage include difficulties in translating or changing the problem in physics symbols, and students do not understand the meaning of the problem so they cannot write what is known and asked in the question. This is in accordance with the results of research Lestari et al. (2016) which states that without an appropriate understanding of the problems given, students will not be able to solve problems properly and there are several factors that affect students' problem solving abilities, namely learning interests, learning habits, social conditions, social climate in the classroom, learning characteristics, intelligence levels, perceptions of teachers and so on.

Planning problem solving defined by applying equations or formulas that must be used to solve physics problems accordingly (Purba et al., 2021). Based on the data analysis of the answers, the level of difficulty of students at C3 is categorized as low, at C4 is categorized as medium and at C5 is categorized as very high. Based on the interview data, it is found that the difficulties experienced by students at this stage include difficulties in making plans because they do not know the formula that must be used to solve the problem. So it can be said that there are still some students who do not know the physics formula used in answering questions. The ability to use physics formulas is inseparable from understanding the concept of solving the problems given. This is in line with the results of research Ulya (2015) which states that, problem solving can be done well if you have adequate understanding and knowledge in each aspect and have a variety of strategies or ways that can be chosen when facing the problem at hand or the problem at hand.

Carrying out the plan this stage emphasizes the implementation of the solution plan, students are ready to carry out calculations with all kinds of necessary data including appropriate concepts and formulas or equations (Purba et al., 2021). Based on the data analysis of the answers, the level of difficulty of students at C3 is categorized as moderate, at C4 is categorized as very high and at C5 is categorized as very high. Based on the interview data, it is found that the difficulties experienced by students at this stage include difficulties in performing mathematical operations such as not being able to reduce numbers in fractions and multiply numbers in decimal form so that the results obtained are incorrect, difficulty in understanding the image and direction of motion of the rope tension of the rigid body system, and difficulty in determining the angle value. This is in accordance with research conducted by Tari (2022), which states that, most students are still wrong in using equations to answer problems, so that the operation of mathematical procedures performed is not correct and results in every step for problem solving is also wrong.

Looking back, this stage is done by checking the correctness of the answer, what is expected of students' skills in solving problems for this stage is that students must try to double-check the answers that have been done and make conclusions at the end of solving the problem (Purba et al., 2021). Based on the data analysis of the answers, the level of difficulty of students at C3 is

categorized as very high, at C4 is categorized as high and at C5 is categorized as very high.

Based on the interview data, it is found that the difficulties experienced by students at this stage include not checking the solution steps and answers that have been obtained so that some of the answers are still not correct, students forget to write the conclusion of the answers that have been done. Isnaini et al. (2021) stated that, "In solving problem solving problems with the Polya stages, students often forget the checking back stage so that no students answer completely according to the 4 stages of Polya in all problem numbers". This is also in accordance with the statement put forward Setyawan (2020), at the stage of checking back answers sometimes not carried out by students, causing final result errors, procedural errors, and conceptual errors, where the process of checking back in solving problems is a person's steps to check the answer or planning results or understanding results to prove the procedure used is correct or the resulting answer has answered the problem.

Conclusion

The very high level of student difficulty in solving the equilibrium problem of a firm object is at the stage of seeing/checking back, but the difficulties experienced by students at this stage are very dependent on the other three Polya stages, namely understanding the problem, planning problem solving and carrying out problem solving. Students' difficulties in solving physics problems using Polya's theory include students' difficulties in translating or changing problems in physics symbols, students' difficulties in making plans because they do not know the formula that must be used, students' difficulties in completing mathematical operations and students' failure to re-examine the solution steps and answers that have been obtained so that some answers are still not correct.

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Haital Miza conceptualized the research idea, methodological, design, data analysis, funding acquisition, writing-original draft, software, management and coordination for the research activity planning and execution. Evendi, Mawarni Saputri, and Abdul Hamid guided, directed, helped the process of processing and analyzing data, provided ideas and suggestions in writing research.

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