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Analysis of Students' Errors in Solving Physics Problems Based on Bloom's Cognitive Levels

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ABSTRACT
This study aimed to investigate the influence of the Science, Technology, Engineering, and Mathematics (STEM) learning approach on the physics achievement of high school students. A quasi-experimental design with a non-equivalent pretest-posttest model was employed. The study involved two Grade XI science classes from SMA Negeri 1 Sindue Tobata, with one class as the experimental group using the STEM approach and the other as the control group applying a scientific approach. Data were collected through pretests and posttests, analyzed using t-tests to determine the significance of differences in learning outcomes. Results showed that the experimental group achieved a higher mean score (15.95) compared to the control group (12.25), with a t-value of 3.00 exceeding the critical value (2.024) at a 0.05 significance level. This indicates a significant positive impact of the STEM learning approach on students' physics achievement. These findings suggest that integrating STEM can enhance cognitive engagement and improve problem-solving skills, offering a promising strategy for teaching physics effectively.

INTRODUCTION

The educational process at school is carried out in the form of teaching and learning. Learning in the sense of change and improvement of cognitive, effective, and psychomotor abilities to obtain high learning achievement. In carrying out teaching and learning activities to improve students' cognitive abilities is not an easy thing. Especially in physics learning [1].

There are several problems that are found in learning physics including students think that physics is too difficult because there are many calculations and formulas, students think that physics is a science that is difficult to understand and requires a lot of energy and time to understand it [2]. Furthermore, the results of these observations show that students often find students who do not understand the concepts well and make mistakes in working on problems,

especially when the problems given are in different forms, causing low achievement of cognitive competence.

Based on observations that have been made during the Introduction to the School Environment (PLP) program at SMP Negeri 11 Palu, there are students if they get physics problems with high levels (application, analysis), students tend to be confused about which steps to work on the problem. Students tend to only master the questions given by the teacher during practice questions and discussed in class learning. So that when given a problem with a different form, students have difficulty so that errors in working on the problem appear.

One of the big problems in the learning process, if the errors that occur are not corrected then students will face a problem, to correct errors like this it is necessary to analyze the error, the location of the error and what causes the error. Errors indicate the inability of knowledge and are closely related to imagination and creativity in new situations and are caused by inadequate mastery of facts, concepts and skills [3].

The results of previous research show that student errors in solving application ablitiylevel questions (C3) reach 70.92% or students have great difficulty answering application ability questions can be categorized as poor [4].

Based on previous research, it can be seen that students' errors in solving physics problems at the application level (C3) still do not get maximum results. Where students tend to still be confused about what steps to do. Students only master the problems given by the teacher during practice problems and discussed in class learning so that when given problems with different forms students will have difficulty [5].

METHOD

This research is a descriptive - qualitative research obtained in the field. This study describes student errors in solving physics problems at the application level (C3) in simple aircraft material. The research location was carried out at SMP Negeri 11 Palu in the 2019/2020 academic year in class VIII. The subjects in this study were all students of class VIII B at SMP Negeri 11 Palu who were registered in the 2019/2020 academic year.

The steps taken in data collection are divided into 2 stages, namely, the preparation, implementation and final stages. For the preparation stage, the first is to make observations to find out the conditions at SMP Negeri 11 Palu, then look for instruments that will be used in this study, then adapt the instruments to be used. The implementation stage, at this stage the researcher determines the respondents in this study then the researcher will give an essay test with the application level (C3) then determine the respondents based on the test results then the researcher conducts each respondent and then analyzes the results of student answers and the results of interviews that have been conducted. And the final stage, namely at this stage includes processing and analyzing data and preparing it in the form of a research report. The instruments used in this research are research itself observation, and documentation.

Qualitative Data Analysis

This research is a qualitative research used to analyze student errors in solving application level physics problems (C3). The stages of qualitative data analysis are reducing data, presenting data, and drawing conclusions. Qualitative data in this study are student errors in solving application level physics problems (C3).

Reducing data

Reducing data is a form of analysis that classifies, directs, discards unnecessary data, and organizes data in such a way that conclusions can be drawn and verified. The stage of reducing data in this study is to examine the results of student work and simplify the results of interviews

into a good arrangement.

Presentation of data

Data presentation is a set of organized information that provides the possibility of drawing conclusions and taking action. In this stage the data in the form of student work is arranged according to the order of the research object. this activity brings up and shows a collection of organized and categorized data or information that allows a conclusion or action to be drawn. The data presentation stage in this study includes: 1) Presenting the results of interviews that have been recorded through interviews from the results of presenting data in the form of student work and the results of interviews are analyzed, then concluded in the form of data findings so as to answer the problems in this study, 2) Determining the types of errors can be known where the location of student errors in various types of errors, namely types of translation errors, concept errors, strategy errors and calculation errors. Then concluded the type of error most made by students, 3) Drawing conclusions and verifying data is part of an activity from an intact configuration so that it can answer research questions. Drawing conclusions in this study by comparing the results of students' written tests with the results of interviews so that conclusions can be drawn.

Descriptive Data Analysis

Calculating Average Value and Standard Deviation

To calculate the average value of students and standard deviation, the following formula is used [6].

$$\bar{X} = \frac{\Sigma fiXi}{n}$$

$$SD = \sqrt{\frac{\Sigma(Xi-\bar{X})^2}{n}} \ldots.$$

Details:

$\bar{X}$ = Average score obtained by students

n = The number of samples

SD = Standard deviation

RESULTS AND DISCUSSIONS

Results

In this study, a written test instrument in the form of an essay was used. The test was given on January 11, 2021, class VIII B of SMP Negeri 11 Palu, which was attended by 20 students online. Then 6 students were selected who were classified into the high category, medium category and low category by first calculating the average value and standard deviation. The average value obtained was 22.6 and the standard deviation value was 9.23. Based on these categories, 2 people were selected from each of the high, medium, and low categories (HML). Then an interview was conducted based on the HML answers totaling 4 questions that were randomly selected based on the HML answers, namely in Table 1.

Table 1. Respondents by Category

No	Student Initial	Score	Category	Respondent Category Code	Description
1	R-06	40	High	RT-01	High Respondent
2	R-15	36	High	RT-02	
3	R-02	24	Medium	RS-01	Medium Respondent
4	R-08	16	Medium	RS-02	
5	R-20	8	Low	RR-01	Low Respondent
6	R-10	8	Low	RR-02	

The results of the research conducted on 6 respondents in solving physics problems at the application level (C3) on simple moment material can be seen in Table 2.

Table 2. Percentage of errors and categories of error types

Respondent Category	Respondent	Error per Item			
		T	K	S	H
High	RT-01	1	1	0	0
	RT-02	1	1	0	0
Medium	RS-01	0	1	0	0
	RS-02	1	0	0	1
Low	RT-01	0	0	0	0
	RT-02	0	0	0	1
Total		3	3	0	2
Percentage of Error		50%	50%	0%	33,3%

Discussions

This study aims to determine students' errors in solving physics problems on simple plane material, as well as to determine the types of errors made by students, namely translation, concept, strategy and calculation errors. To find out how students' errors in solving physics problems are carried out from the analysis of students' answers. Students work on 4 questions containing simple plane material. From the 4 questions, there is an analysis of students' errors in solving physics problems, each of which has a different score. From the answers and interview results of each respondent, the most difficult question is question number 2.

According to respondents, question number 2 is difficult because they do not really understand the meaning of the question, and do not understand it because there are pictures and physics symbols. This is what makes it difficult for respondents to solve question number 2 properly and correctly, besides that there are still significant errors in other question numbers.

In the first question, 2 respondents did not make any mistakes, namely R-20 and R-10, then 4 respondents made different mistakes, namely R-06, R-15, R-08 and R-02. Errors in the first question include inaccuracy in reading the data in the image and also placing the units incorrectly in solving the problem. In the second question, all respondents made different mistakes. In the second question, respondents lacked understanding and did not translate the questions in the image so that respondents had difficulty in processing the data to solve the problem. For the third question, two respondents did not make any mistakes, namely R-08 and

R-10. Four respondents made mistakes, namely R-06, R-15, R-02 and R-20. In the third question, most respondents had a misconception caused by a lack of understanding of the theory, and only followed the steps in the example so that they were given different questions, respondents had difficulty solving the questions. And in the fourth question, 2 respondents did not make mistakes, namely R-08 and R-20, 4 respondents made mistakes, namely R-06, R-02, R-10 and R-15. In the fourth question, it can be said that respondents made mistakes in operating what is known and what is asked in the question.

Based on the answers and results of interviews with each respondent, the type of error that is most often made is a translation error, students make mistakes in writing what is known and what is asked in the question with a percentage of 58.3% errors. The second most common error made by students is a conceptual error, namely a student's error in understanding the purpose of the question to determine the equation used in the solution process with a percentage of 41.6%. The third most common error is a strategy error, a strategy error is closely related to determining the steps for solving the question using the wrong data. Less thorough or even in a hurry to complete the questions with an error percentage of 20.8%. The error that is very lacking is the type of calculation error with a validity percentage of 16.6%.

From the test results of all respondents conducted, it shows that in solving physics problems on simple plane material, many still make mistakes in solving problems. These student errors result in students solving the problems given incorrectly.

Translation errors made by students include errors in writing what is known and what is asked in the problem into physics symbols, understanding the meaning of the problem, and not understanding the physics symbols of the data mentioned in the problem and being less careful in reading and understanding the meaning of the problem. In the interview results, respondents had difficulty in digesting or understanding the language and interpreting words or symbols. This finding is in line with research conducted by Kurniawan [7]. The level of errors made by students in the type of translation errors obtained from the percentage results of all students was 58.3%.

Conceptual errors are errors in perception or understanding of a concept so that the concept deviates from the opinions of experts that have been agreed upon and recorded. Conceptual errors that are commonly made by students are errors in determining the formulas and principles used to solve problems, so that students cannot solve or continue to the completion stage. In the interview results, it was found that students made conceptual errors influenced by the example questions given, so that after being given different questions, students had difficulty solving the questions. The level of errors made by students in the type of conceptual errors obtained from the results of calculating the percentage of error rates was 41.6%.

Common strategic errors are errors in using data and in determining steps to solve problems caused by students forgetting, being less careful, not practicing enough questions, being in a hurry to answer questions and lack of time [8]. This can be seen from the quote from the Respondent's answer which stated that they made mistakes in writing equations and in writing units in the process of solving problems. The strategic errors made by respondents are very clearly due to the lack of thoroughness of the respondents in solving problems. The strategic errors made by respondents are in line with research conducted by Suroso (2016) which states that the strategic errors commonly made by students are errors in solving problems caused by students being less careful or in a hurry [9]. The level of errors made by students in the type of strategic errors obtained from the results of the calculation of the percentage of error rates is 20.8%. The errors made are errors in carrying out arithmetic operations caused by students being less careful in calculating and rushing in doing it. This finding is in line with research conducted by Hastuti (2012) the cause of arithmetic errors is the lack of understanding of the

concept of students in calculating and the lack of accuracy of students in carrying out arithmetic operations. The level of errors made by students in the type of calculation errors obtained from the results of the calculation of the percentage of error rates is 16.6%.

The difficulties that many students find in solving problems do not only depend on the level of difficulty of the problem itself but also on the level of knowledge or mastery of the material. In making decisions to choose a series of actions that can lead to achieving a solution, that is also what is mastered in this case can translate the problem.

The results of this study indicate that the type of translation error is more often made by respondents than the type of concept, strategy and calculation errors. The type of translation error greatly influences the solution of the problem which results in students being unable to determine the steps in solving the problem. Where students pay less attention to the procedures for solving physics problems.

The factors causing students to make mistakes found in the study were a lack of understanding the problem well, a lack of understanding of the concepts related to the problem, incorrect interpretation of the meaning of the problem, a lack of understanding of the sequence of steps used to solve the problem. Lack of understanding of the problem and lack of cognitive ability about simple machine material. Low understanding of students in reasoning about simple machine material in everyday life.

CONCLUSION AND SUGGESTION

Based on the results of the research that has been conducted on each type of student error in solving physics problems at the application level (C3) in simple machines, it can be concluded that there are still errors made by students in solving physics problems, including: 1) Translation errors, in the form of errors in writing symbols, errors in determining what is known and asked in the problem. The percentage of error types of 58.3% is in the fairly high category, 2) Conceptual errors, in the form of errors in determining the equations used in determining the steps for solving the problem. With a percentage of error types of 41.6% in the low category, 3) Strategy errors, in the form of errors in using data and errors in determining the steps for solving the problem. With a percentage of error types of 20.8% in the very low category, 4) Arithmetic errors, in the form of errors in performing arithmetic operations. With a percentage of error types of 16.6% in the very low category.

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