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The Problem Solving Ability in Vector Addition by Using Grid and Parallelogram

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Abstract

This study aims to analyze the problem-solving ability of vector addition using the grid and parallelograms. The subjects of this study consisted of 26 students and 4 respondents were selected by giving tests. The selection of respondents was carried out in the form of a multiple choice test then grouped and categorized, and 2 respondents were selected each representing high and low. The data were obtained by giving tests to selected respondents and direct interviews with respondents. The test consists of four question numbers on vector material where two question numbers consist of vectors using a grid and two question numbers on vectors without a grid and after that, an interview is conducted. The research data were analyzed through the Polya stage score. The results showed that students were still less able to solve the problem of vector addition using the grid. Students have a lot of difficulty at the stage of implementing the plan and checking back. This is because students make technical errors which include the inability of students to perform mathematical/calculation operations.

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Introduction

One of the materials that students must master in learning physics is vectors. Research Rusli et al. (2016), shows that conceptual understanding is very meaningful and important as a way to organize or organize knowledge and is the basis for building thinking toward a higher level. The concept of vector is the most fundamental and essential concept in physics. It is said to be a very basic and essential concept because the vector concept becomes the basis for higher education levels. The concept of vector is a concept that is widely associated with almost all physical materials. Most of the concepts in physics are vector quantities, such as velocity, acceleration, force, momentum, impulse, electric field, and magnetic field. Vectors are widely used in solving problems in physics. In learning Physics in high school, vector material is a prerequisite for teaching kinematics and motion dynamics. The errors experienced by students regarding vectors will affect their mastery of other materials. These students are required to have the ability to think, be scientific, work, and solve a problem so students are expected to have the ability to represent information in many ways (Etkina, 2006).

Vector has an important role in many branches of physics (Bollen et al., (2017). Many mistakes are made by students in vector addition. Like the research conducted by Susiharti & Ismet (2017), found students difficult to do triangular vector addition which caused students to incorrectly place the starting point of the vector so that it was wrong to determine the resultant vector. He also mentioned that students found it difficult to describe the resultant vector, which resulted in errors in determining the magnitude and direction of the resultant vector.

According to Barniol & Zapala (2014), a complete understanding of several physics concepts requires a good foundation of the basic concepts of vectors. If understanding the vector students already find it difficult, it is likely that they will experience difficulties in understanding the next concept. Momentum, force, and other physical quantities are vector quantities that require an understanding of the concept of vector analysis in their application. Therefore, understanding the concept of vectors is very important for students to be able to solve problems in vector material.

The results of Knight's (2008) study revealed that the inability of students to solve given questions was due to a lack of mastery of vector concepts. Mastery of concepts in learning physics is very important. Rusli et al. (2016) state that conceptual understanding is very meaningful and important as a way to organize or organize knowledge and is the basis for building thinking toward a higher level. Rahayu (2016), stated that students' mistakes in solving problems can be caused by 3 things, namely; concept errors, principle errors, and operating errors. Information about errors in solving problems is very important because it can be used to improve and improve the quality of learning (Widodo, 2013).

Jazuri's (2009) shows that the understanding of vector symbols from the data analysis that has been obtained proves that not many students experience difficulties and their level of mastery is also in a good category. Meanwhile, in the analysis of understanding vector images, students experienced many difficulties in understanding vector images, which were located in vector painting using the triangular, parallelogram, and polygon methods, and the mastery of the said students was in a low category.

Netriwati (2016) defines problem-solving as an effort to find a way out of a difficulty in order to achieve a goal that is not easily attainable. Based on the description above, the researcher argues that problem-solving ability means the ability to apply knowledge concepts to solve new problems at hand.

According to Gagne (1985) states that "Problem-solving is a type of learning that has the highest level and complexity compared to other types of learning." In learning, problem-solving can be in the form of non-routine questions or story problems, namely questions for correct procedures that require deeper thinking. Therefore, problem-solving can improve critical, logical, and systematic thinking skills. Problem-solving has a positive impact, namely increasing problem-solving skills and increasing students' thinking levels (Ersoy & Guner, 2015).

There are three factors that influence a person's problem-solving ability: (1) experience factors, both environmental and personal, such as age, the content of knowledge (knowledge), knowledge of solving strategies, knowledge of the context of the problem, and the content of the problem. (2) effective factors, such as interest, motivation, anxiety pressure, tolerance for ambiguity, resilience, and patience. (3) cognitive factors, such as reading skills, spatial abilities, analytical skills, numeracy skills and so on (De Cock, 2012).

Research by Flores & Kanim (2015) their research in the context of physics adding vectors to find the net force, only about 50% of students can answer questions correctly. They also found that students were significantly less able to answer qualitative questions involving vector subtraction in a physics context (acceleration).

Based on the research results described above, there is a difference between research that has been done before and research that will be conducted by researchers. Where the previous research did not examine what if the vector is drawn using a grid, between a vector using a grid and a parallelogram vector without using a grid. For this reason, researchers are interested in conducting research by looking at the problem-solving ability of vector addition using a grid and parallelograms. Thus, this paper's research has presented the problem-solving ability in vector addition using a grid and parallelograms".

Materials and Method

This research is qualitative research where all data is collected based on facts obtained in the field. Descriptive-qualitative research looks more at the characteristics, quality, and relationships between activities. As expressed by Sukmadinata (2010) that descriptive research is research that does not provide action, manipulation, or make changes to independent variables, but describes the actual situation.

This research was conducted at SMA Negeri 8 Sigi to be precise on students who had taken physics subject matter vector material.

This research was conducted in the odd semester of 2020. Starting with the making of research instruments to validating instruments for guardian lecturers

The subjects of this study were students of class XI IPA at SMA Negeri 8 Sigi in the academic year 2020/2021. Research respondents who became the source of qualitative data were 6 people with 2 high ability, 2 medium ability, and 2 low ability people based on the results of the Respondent Selection Test (TSR). Two people from each ability

level were selected for data variation that includes the possibilities that occur in the field.

Before analyzing problem-solving abilities in solving problems, of course the researcher looks for respondents first. In this study, a multiple choice question was used because it can measure students' abilities according to the desired domain and according to the level of difficulty.

All students and students in one class were chosen to be research subjects. Then the questions were distributed in multiple-choice form. After the test-giving process is complete, the researcher checks the results of the test answers given. Of the students who were given the multiple choice test, as many as 6 people were selected with 2 high, medium, and low ability students each to be given essay questions again.

Respondent collection techniques

To select the six respondents, the following formula is used: To calculate the average score of students in standard deviation, the following formula is used (Sudjana, 1996).

Research instruments

1. Test

The research instrument was a test consisting of 30 multiple-choice questions on the vector addition and subtraction material given to students in one class to select research respondents. Furthermore, 6 people were selected to be respondents and then given a test in the form of description questions to measure the problem-solving ability based on the Polya stages as many as 4 numbers.

2. Interview

The purpose of conducting interviews in this study is to confirm the respondent's statement on the test answer or to strengthen in analyzing the students' problem-solving skills in vector assignment using grids and parallelograms.

Results and Discussion

Before analyzing the problem-solving abilities of students with vector addition, of course the researcher must first find the respondent. In this study, a multiple choice question was used because it can measure students' abilities according to their level of difficulty. At this stage the multiple choice questions were given to all students of class XI IPA 2 SMA Negeri 8 Sigi. The material tested in this study is vector addition.

There were 26 students selected to be research subjects. Then the multiple-choice questions were distributed. After the test-giving process is complete, the researcher checks the results of the test answers given. Of the 26 students who were given the multiple choice test, 6 were selected to be respondents representing the medium, high, and low categories. Determination of medium, high, and low categories is done by first calculating the average value and standard deviation. Result data regarding the total score and percentage of the subject's answers in this study are presented in Table 1.

Table 1. Scores and categories of the finding respondent test

NO	Respondents-Initials	Score	Value-(Xi)	Category
1	R-05	23	76.66	High
2	R-08	22	73.33	High
3	R-03	21	70.00	High
4	R-15	21	70.00	High
5	R-01	20	66.66	High
6	R-10	19	63.33	High
7	R-20	19	63.33	High
8	R-25	18	60.00	High
9	R-02	18	60.00	High
10	R-04	18	60.00	High
11	R-26	17	56.66	High
12	R-18	17	56.66	High
13	R-23	16	53.33	High
14	R-07	14	46.66	Low
15	R-13	14	46.66	Low
16	R-24	14	46.66	Low
17	R-22	13	43.33	Low
18	R-12	13	43.33	Low
19	R-16	11	36.66	Low
20	R-19	10	33.33	Low
21	R-06	10	33.33	Low
22	R-14	9	30.00	Low
23	R-17	8	26.66	Low
24	R-21	8	26.66	Low
25	R-09	7	23.33	Low
26	R-11	5	16.66	Low

Table 2. Selected respondents

Respondents Initials	Category
R-05	High
R-08	High
R-09	Low
R-11	Low

Categorizing students based on the results of the given test scores, there are five students with the respondent code R-05, R-08, R-3, R-15, R-01 who can work on the high category respondent selection test questions for the overall score. Prospective respondents who can work on the middle category respondent selection test questions are seventeen students with codes R-10, R-20, R-25, R-02, R-04, R-26, R-18, R-23, R-07, R-13, R-15, R-22, R-12, R-16, R-19, R-06. Prospective respondents who can do the respondent selection test questions in the low category are five students with codes R-14, R-17, R-21, R-09, and R-11.

The result of problem-solving ability test by respondents

In the vector addition problem, the respondent is required to work on a question of four numbers where of the four question numbers, two of them are vectors using a grid and the other two using a parallelogram. The results of the research were students' problem-solving behavior which was expressed based on the steps of the pattern, namely understanding the problem, compiling a problem-solving plan, implementing the problem-solving plan, and checking the results of the problem-solving that had been made

Table 3. Results of the problem-solving ability test

No. Question	Type of Question / Category of Respondent			
	Grid		Parallelogram	
	Low	High	Low	High
1	-	-	R-09 and R-11	R-05 and R-08
2	-	R-05	-	-
3	-	-	R-09	R-08
4	R-11	R-05	-	-

Table 4. Results of stages of problem solving ability parallelograms

Respondents	Numberof Question/Polya Stage							
	Question Number 1				Question Number 3			
	Understanding the problem	Developing a Plan	Finalizing the Plan	Re-checking	Understanding the problem	Developing a Plan	Implementing the Plan	Re-checking
R-05	√	√	√	√	-	-	-	-
R-08	√	√	√	√	√	√	√	-
R-09	√	√	√	√	√	√	√	-
R-11	√	√	√	√	-	-	-	-

Table 5. Results of stages of problem-solving ability grid

Respondents	Number of Question/Polya Stage							
	Question Number 2				Question Number 4			
	Understanding the problem	Developing a Plan	Finalizing the Plan	Re-checking	Understanding the problem	Developing a Plan	Implementing the Plan	Re-checking
R-05	√	√	√	-	√	√	√	-
R-08	-	-	-	-	√	-	-	-
R-09	√	-	-	-	√	-	-	-
R-11	-	-	-	-	√	√	√	√

The ability of students to solve problems on vector addition using the grid and parallelogram shows the four indicators, students experience the highest difficulty at the stage of implementing the plan. One of the reasons is the students' lack of mastery of mathematics and lack of thoroughness in completing mathematical operations. This is not much different from the research conducted by Sari et al. (2015) that in a row the types of errors made by students in solving questions were not understanding concepts, calculation errors, lack of understanding of question commands, and errors in doing math calculations.

The next difficulty lies in the stage of checking the answers again. This is because in learning activities students are not trained to double-check answers using several ways, for example evaluating the suitability of the unit, evaluating the suitability of the concept, and completing using different methods. So far, the one who plays a role in checking student answers is the teacher. In carrying out the assessment of learning, the teacher uses more assessment processes and learning outcomes than assessment as a learning process. Meanwhile, for the stage of understanding and planning, students experienced almost the same difficulties. This is due to the low mastery of the material, the inability of students to connect unknown variables with known variables, and the inability of students to identify variables using symbols. Which states that based on the stages of problem-solving according to his policy, students experience the greatest difficulty at the review stage. The percentage of student difficulties at the review stage was 77.18%. Meanwhile, the lowest difficulty percentage was at the understanding stage of the problem, which was 25.00%.

Based on the results of the research described above, it can be said that the inability of students to solve vector addition problems is more than those using the grid. This is because students are less able to understand the concepts in the questions. Students have difficulty writing formulas and solving these problems. The inability of students to work on vector questions using the grid is due to a lack of understanding of the concept, not understanding the working principles of the questions, and the inability to perform mathematical operations obtained from the results of the respondents' tests. There are also other factors such as a lack of student interest or a lack of practice in doing the questions, but this effect tends to be subjective because during the study there was no valid instrument used to measure the extent of students' interest in working on vector addition questions. Supporting information is only obtained from interviews with selected respondents. To improve students' abilities in solving questions, students must be able to master the concepts of a material and must also be accustomed to practicing solving questions and understanding question instructions.

Research conducted by Andrew & Thomas (2015) proved that various student difficulties in solving vector addition problems were caused by not understanding vectors and anti-vectors. Research by Knight (2008) reveals that the inability of students to solve given questions is due to a lack of mastery of vector concepts and Rahayu's (2016) research states that students' mistakes in solving problems are caused by three things, namely misconceptions, error in principle, and operator error. If it is related to previous research as described above, there are differences and similarities between the research and previous researchers.

Conclusions

Students still have a low ability to solve the problem of vector addition using the grid and parallelograms. Students experience a lot of difficulties at the stage of executing the plan and re-checking. This is because students make technical errors which include the inability of students to perform mathematical / calculation operations. Students are better able to do vector addition problems in the form of a parallelogram than those using a grid. This is because students do not understand the concept of vector addition using a grid and also the inability of students to perform mathematical / calculation operations.

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