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ANALYSIS OF STUDENTS' INITIAL PROBLEM-SOLVING SKILLS IN VECTOR TOPICS AT SMAN 1 DUA KOTO

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ABSTRACT

Problem-solving skills are essential in physics education, and vectors serve as a prerequisite concept for many subsequent physics topics. This study aims to describe the initial level of students' problem-solving skills regarding vector material at State High School 1 Dua Koto before the implementation of an instructional intervention. The study employed a quantitative descriptive approach with the subjects being all 59 students in the 11th-grade Phase F physics track class, selected through total sampling. Data were collected using a seven-item essay test scored based on five indicators proposed by Docktor and Heller: understanding the problem, describing the problem in terms of physics concepts, planning a solution, implementing the solution, and evaluating the solution. The data were then analyzed descriptively based on achievement percentages. The results showed that students' problem-solving ability was 38%, falling into the low category. The indicators for planning a solution (47%), describing the problem (45%), and implementing the solution (44%) fell into the moderate category, while understanding the problem (32%) and evaluating the solution (26%) fell into the low category. These two main weaknesses indicate that students are more proficient at the procedural stage than at the representation and reflection stages. Consequently, physics instruction on vector material should encourage students to sketch and represent problems before performing calculations and to check the direction, units, and plausibility of their results.

Keywords :problem-solving skills; vectors; Docktor and Heller indicators; initial conditions; physics education

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I. INTRODUCTION

Learning physics requires students not only to understand concepts and master mathematical equations, but also to be able to solve problems systematically. These skills include identifying relevant information, relating that information to physical principles, determining a solution strategy, and verifying the results obtained. Problem-solving is a higher-order thinking skill required in 21st-century learning [1]. Since students' thought processes can only be observed and assessed when solutions are developed step-by-step, assessments that focus solely on the final answer are insufficient for evaluating students' abilities [2].

Problem-solving is an effort to find a way out of a difficulty in order to achieve a goal that cannot be reached directly, as well as a process of overcoming problems that cannot be solved using routine procedures [3]. One of the key competencies that needs to be developed in students is problem-solving skills. These skills are essential for students to be able to face various problems that arise in the learning process as well as in daily life. Through problem-solving skills, students can learn to understand a problem, analyze available information, and find appropriate solutions. In addition, problem-solving activities can also help students build new knowledge and develop more systematic, logical, and critical ways of thinking. Therefore, problem-solving skills are an important aspect that must be considered and developed in the learning process [4].

Problem-solving ability is a comprehensive process for students in physics education; this is because problems in physics are related to real-life contexts. Problem-solving ability is one of the most important skills students need to develop in physics education[5]. In physics, this skill is particularly important because the

subject requires not only an understanding of abstract concepts but also the ability to apply them to solve complex, context-specific problems [6]. Problem-solving skills involve a person's thought process in solving problems, beginning with the stage of gathering facts, analyzing information, and selecting the appropriate solution to resolve the problem. Problem-solving skills must be practiced and require an understanding of the concepts and principles involved in solving them [2].

The assessment of the step-by-step problem-solving process can be conducted using Docktor and Heller's five indicators: understanding the problem (visualize the problem), describing the problem in physics terms (describe the problem in physics terms), planning a solution (plan a solution), executing the solution (execute the plan), and evaluating the solution (check and evaluate) [7][8]. These five indicators were selected because they follow the sequence of students' thinking when solving problems, allowing each indicator to be assessed separately from the written answer sheet. The underlying rubric has been tested on introductory physics problems and is designed to be applied by different raters [2]. Thus, these indicators not only show the level of students' abilities but also identify the stages where students encounter difficulties, and allow the results to be compared with previous studies using the same framework [9].

Several studies indicate that high school students' physics problem-solving abilities are not yet optimal and are uneven across each stage. A study of 47 11th-grade students found that the majority fell into the moderate category, with the "executing a plan" and "reviewing results" stages being the weakest [6]. In the linear motion topic, the highest achievement was in the "describing the problem" stage and the lowest in the "evaluating the solution" stage [10], whereas in the parabolic motion topic, the lowest stage was "applying variables to physics concepts" [11]. Average scores in the moderate category were also reported for static fluids, and most students remained at the beginner level [12]. The differences in the weakest stages across these studies indicate that problem-solving ability profiles are influenced by subject matter, grade level, and assessment methods; therefore, a specific analysis is needed for each subject.

Vectors hold a special place because they serve as a representational tool in nearly all topics of mechanics, such as kinematics, dynamics, and work and energy. Solving vector problems requires several skills simultaneously: depicting the direction and position of a vector, decomposing a vector into components, adding like components, and interpreting the resultant as a quantity with both magnitude and direction. Inadequate understanding of vectors has been reported among students; specifically, only about one-third of engineering students reported being familiar with determining the magnitude and components of vectors [13], and more than one-quarter of students at the start of the second semester of calculus-based physics were still unable to add two-dimensional vectors [14]. Graphical vector addition and subtraction are also among the most difficult concepts for science and engineering students [13].

Similar difficulties were found among high school students. Approximately 25% of the 32 twelfth-grade students still demonstrated a low level of understanding in solving plane vector problems [15], while for tenth-grade students, the initial score on vector problem-solving skills was only 21.80 out of 100 before instruction was provided [16]. Another study of 12th-grade students at a madrasah aliyah reported that their understanding of plane and spatial vector concepts was considered adequate [17]. These results indicate that students' proficiency with vector material varies, and mastery of concepts must be accompanied by the skills to represent and solve problems in a systematic manner.

A research gap exists in two areas. First, studies on vectors among students generally assess conceptual understanding or final problem-solving outcomes, while details of achievement at each stage of problem-solving have not been widely reported. Second, research based on Heller's indicators has been conducted on other topics, such as the equilibrium of rigid bodies [18] and fluid dynamics [19], but has not focused on vector material. The novelty of this study lies in its depiction of the initial conditions for solving vector problems, specifically for each of Docktor and Heller's indicators, among students at State Senior High School 1 Dua Koto—a finding that has not been previously reported. This information is necessary to ensure that improvement efforts do not stop at the general conclusion that students' abilities are low.

Mapping these initial conditions is also essential before implementing any instructional model. Problem-Based Learning (PBL) has been shown to influence physics problem-solving skills based on meta-analyses [20][21], and a deep learning approach grounded in the principles of mindfulness, meaningfulness, and enjoyment can enrich PBL by emphasizing conceptual understanding and reflection [22]. For such learning to be effective, the weakest stage of problem-solving must first be identified. Furthermore, changes in students' abilities following the new intervention can only be interpreted if their initial conditions have been clearly documented.

Based on this discussion, this study aims to describe the initial state of problem-solving skills among 11th-grade students at SMA Negeri 1 Dua Koto in the topic of vectors, based on the five indicators proposed by Docktor and Heller. The description is provided both overall and for each individual indicator. The results are expected to serve as an empirical basis for teachers in determining which stages require reinforcement. These results are also expected to serve as a benchmark for future research testing instructional models designed to improve problem-solving skills.

II. METHOD

Research Design, Subjects, and Location

This study employed a quantitative descriptive approach in the form of a preliminary study, which aimed to describe the initial level of students' problem-solving skills in vector-related material without applying any intervention to the research subjects[23]. This approach was chosen because the purpose of the study was solely to describe existing achievements, not to test the effect of an intervention. The study was conducted at SMA Negeri 1 Dua Koto, Pasaman Regency, in August 2026. Data collection was carried out once via a written test completed individually by the students.

Sampling employed total sampling, in which the entire population was included as the study sample [23]. The research subjects were all 59 students in the 11th-grade Phase F physics track, consisting of 30 students from Class XI F3 and 29 students from Class XI F4. This technique was chosen because the population size was small, allowing all students to be included without the need for random selection. Thus, the research results reflect the status of all physics track students in that phase at this school.

Research Instrument

The research instrument consisted of a seven-item essay test on vector material developed by Chayrani in a previous study. The questions were designed so that each item included five problem-solving indicators identified by Docktor and Heller, allowing a student's single response to be evaluated against all five indicators. All seven items were found to be valid, reliable, possess good discriminant power, and be of moderate difficulty. Based on these results, the questions meet the criteria as a research instrument suitable for measuring students' problem-solving abilities.

The indicators assessed in each question are described as follows. Understanding the problem involves describing the problem situation, identifying known and unknown information, and recognizing relevant concepts. Describing the problem in terms of physics concepts means writing the known and unknown quantities using physics symbols and units. Planning a solution involves transforming physics concepts and principles into systematically formulated equations, while implementing the solution consists of substituting the values of the quantities into the equations and performing the calculations. Evaluating the solution involves checking the completeness, correctness, and reasonableness of the answer

The scoring guidelines are based on Huffman's problem-solving indicators because these indicators are structured according to systematic problem-solving stages and are relevant to the characteristics of physics learning [24]. The maximum score for each item is 2 for understanding the problem, 3 for describing the problem in terms of physics concepts, 2 for planning the solution, 4 for implementing the solution, and 4 for evaluating the solution; thus, the maximum score for a single item is 15. Scores for each indicator are assigned based on the completeness and accuracy of the components written by the students according to the answer key, with higher scores given for more complete and accurate answers. The maximum score for the seven items is therefore 14 for understanding the problem, 21 for describing the problem, 14 for planning a solution, 28 for implementing the solution, and 28 for evaluating the solution, for a total of 105.

Procedures and Data Analysis

The research procedures were conducted in three stages. First, the researcher obtained permission from the school and set a test schedule in collaboration with the physics teachers. Second, a written test was administered to all students in classes XI F3 and XI F4 with identical instructions, and the students completed the test independently without assistance. Third, the answer sheets were collected, checked, and scored for each indicator of each test item based on the scoring guidelines. The scores obtained were then analyzed by calculating the percentage of problem-solving ability achievement. This percentage was obtained by comparing the raw scores with the ideal maximum score and then multiplying by 100%, following the equation below [25]:

$$N_P = \frac{R}{SM} \times 100\% \quad (1)$$

where N_P is the achievement percentage, R is the raw score obtained, and SM is the ideal maximum score. The achievement for each indicator is calculated as the ratio of the students' average score on that indicator to its maximum score, both for each individual item and for all seven items combined. Overall achievement is calculated as the ratio of the total score across all indicators to the total maximum score, which is 105. The calculation results are rounded to whole numbers before being grouped into categories so that every figure in the table and text can be interpreted in the same way.

To determine students' problem-solving ability levels, a five-level categorization system is used based on the percentages obtained by students. Achievement percentages are grouped into five categories, as presented in the following table [26]:

Table 1. Problem-Solving Ability Categories

Achievement Percentage (%)	Problem-Solving Ability Level
80<AP≤100	Very High
60<AP≤80	High
40<AP≤60	Moderate
20<AP≤40	Low
0<AP≤20	Very Low

A five-interval scale with 20-point intervals was chosen because it is simple, can be applied to all indicators with different maximum scores, and makes it easier for readers to compare achievement levels across indicators. These categories are used for overall achievement, achievement on each indicator, and achievement on each test item. The analysis is descriptive in nature; therefore, no tests for differences between groups were conducted.

III. RESULT AND DISCUSSION

Results on Problem-Solving Skills

The study was conducted on 59 eleventh-grade students at SMA Negeri 1 Dua Koto. The students' problem-solving skills in vector-related material achieved an overall score of 38%, with an average score of 40.08 out of a maximum of 105, which falls into the low category. This achievement is at the upper end of the low category, just slightly below the threshold for the moderate category. The distribution of students reinforces this picture: 43 students were in the low or very low category, 12 students were in the moderate category, and 4 students were in the high category, while no students were in the very high category. Thus, the low achievement was not caused by a small number of students but was experienced by the majority of students. The data on the overall problem-solving ability of the students can be seen in Figure 1.

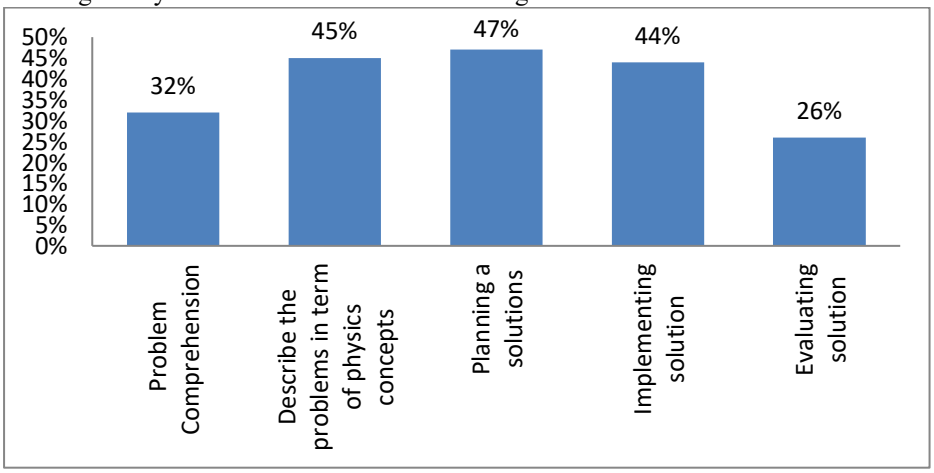


Figure 1. Data on Problem-Solving Skills Achievement

The achievement levels for each indicator and the details for each test item are presented in Tables 1 through 5. The "planning a solution" indicator achieved the highest score (47%), followed by "describing the problem" (45%) and "implementing a solution" (44%), all of which fall into the moderate category. The indicators "understanding the problem" (32%) and "evaluating solutions" (26%) fall into the low category. The

difference between the highest and lowest indicators is 21 percentage points, indicating that students' weaknesses are concentrated at the beginning and end of the problem-solving process.

Achievement on Each Problem-Solving Indicator

The "understanding the problem" indicator achieved a score of 32% and fell into the low category, with an average score of 4.54 out of a maximum score of 14 (Table 2). A total of 47 out of 59 students were in the low or very low categories, while only seven students reached the high or very high categories. This indicator relates to students' ability to describe the problem situation, identify known and unknown information, and recognize relevant concepts. In the vector material, this stage involves determining the direction and magnitude of vectors so that the problem is represented accurately.

Table 2. Proficiency in Problem Comprehension

Question	Achievement	Category
Question 1	41 %	Moderate
Question 2	39 %	Low
Question 3	38 %	Low
Question 4	31 %	Low
Question 5	36 %	Low
Question 6	31 %	Low
Question 7	10 %	Very low
Overall	**32 %**	**Low**

The level of problem comprehension for each test item ranged from 10% to 41%. Only Item 1 fell into the "moderate" category; Items 2 through 6 were in the "low" category; and Item 7 was in the "very low" category. This pattern indicates that difficulty in understanding the problem was not limited to a single item but occurred in nearly all items and was most pronounced in the final item. Students rarely wrote out a complete representation of the problem, especially as the questions became more complex-for example, by sketching vectors along with their directions and angles.

Difficulties in understanding vector representations, particularly graphically, have also been reported among science and engineering students [12]. These results are lower than those of other 11th-grade students, most of whom were in the moderate category for the problem-understanding stage [6]. This difference is likely related to the specific requirement for visualizing direction and magnitude in vector material, as students must translate the problem statement into a diagram before they can perform calculations. Thus, the problem-understanding stage needs to be reinforced from the very beginning of vector instruction.

The low achievement on this indicator suggests that students have not yet made visualization their first step in solving vector problems. Ideally, students should be able to translate the problem's narrative into a vector sketch that includes direction, magnitude, and angle before performing calculations. This issue can be addressed by encouraging students to draw vector diagrams in every exercise, for example, through worksheets that provide a dedicated column for sketches and identifying key information. Teachers can also provide guided examples that demonstrate the process of converting problem statements into diagrams, then gradually reduce this assistance. The use of visual media or interactive vector simulations can strengthen students' understanding of the relationship between direction, magnitude, and vector components.

The indicator describing the ability to frame problems in terms of physics concepts achieved a score of 45% and fell into the moderate category, with an average score of 9.46 out of a maximum of 21 (Table 3). A total of 27 students were in the moderate category, 24 students in the low or very low category, and eight students in the high or very high category. This indicator relates to students' ability to express known, unknown, and asked-for information using symbols and physical quantities. This distribution indicates that students' abilities at this stage are quite varied.

Table 3. Achievement in the ability to describe problems in terms of physics concepts

Question	Achievement	Category
Question 1	56 %	Moderate
Question 2	58 %	Moderate
Question 3	53 %	Moderate
Question 4	39 %	Low
Question 5	61 %	High
Question 6	15 %	Very low
Question 7	34 %	Low
Overall	**45 %**	Moderate

The achievement rates for describing the problem in each item ranged from 15% to 61%. Item 5 achieved the highest rate (high category); items 1, 2, and 3 were in the moderate category; items 4 and 7 were in the low category; and item 6 was in the very low category. This wide range across items indicates that the ability to describe problems depends on the question format; thus, students who perform well on one item may not necessarily do so on another. A similar shortcoming was reported in the topic of equilibrium of rigid bodies, where students often wrote the names of physical quantities without using physics symbols [16], and in the topic of linear motion, where this issue was actually the most prevalent [7]. This suggests that writing physical quantities using symbols is relatively easier than representing problems visually, but it still requires practice to ensure consistency.

Performance on this indicator shows that students have an adequate foundation in writing physical quantities, but this ability is not yet stable when the question format changes. Ideally, students should consistently convert problem information into the correct symbols, physical quantities, and units regardless of the question format. One approach is to implement a standardized writing format consisting of "given," "asked," and the relationships between quantities in every problem solution. Practice with a variety of problem contexts is also necessary so that students become accustomed to recognizing the same quantities in different situations. Teacher feedback on the accuracy of symbols and units will help students break the habit of writing quantities without physical notation.

The "planning a solution" indicator achieved a score of 47% and was the highest among the five indicators, falling into the "moderate" category with an average score of 6.59 out of a maximum of 14 (Table 4). A total of 28 students were in the moderate category, 20 students in the low or very low category, and 11 students in the high or very high category—the largest number in that category among the five indicators. At this stage, students identify appropriate physics concepts and principles and organize them into solution equations. In the vector material, this stage involves determining the appropriate method for adding or decomposing vectors based on the problem data.

Table 4. Proficiency in Planning Solutions

Question	Achievement	Category
Question 1	64 %	High
Question 2	54 %	Moderate
Question 3	58 %	Moderate
Question 4	35 %	Low
Question 5	59 %	Moderate
Question 6	30 %	Low
Question 7	29 %	Low
Overall	**47 %**	**Moderate**

Performance on planning solutions ranged from 29% to 64%. Question 1 fell into the high category, questions 2, 3, and 5 were in the moderate category, and questions 4, 6, and 7 were in the low category. This average performance was uneven because students were quite capable of formulating plans for questions involving familiar procedures, but their performance declined for questions that required adapting procedures. The procedures for decomposing and adding vector components are relatively standardized; thus, the ease of this stage is likely related to the nature of vector material and differs from research on other 11th-grade students, which identified planning as a problematic stage [6]. Nevertheless, the moderate achievement indicates that the ability to select strategies appropriate to the problem conditions is not yet optimal, even though the accuracy of the strategy influences subsequent calculation steps.

The highest achievement on this indicator reflects that students are sufficiently familiar with the procedures for adding and decomposing vectors, but their strategy selection still involves merely imitating examples. Ideally, students should be able to weigh several possible solution methods and then choose the strategy that best fits the data and the objective of the problem. This can be developed by providing non-routine problems that require adapting procedures, accompanied by discussions about the rationale for choosing a particular method. The use of flowcharts or step-by-step solution maps can help students formulate a logical plan before executing it. In this way, students are encouraged to understand the logic behind the procedures, rather than merely memorizing the sequence of steps.

The "Implementing Solutions" indicator achieved a score of 44% and fell into the moderate category, with an average score of 12.22 out of a maximum of 28 (Table 5). A total of 29 students were in the low or very low category, 20 students in the moderate category, and 10 students in the high or very high category. This indicator relates to students' ability to apply equations, substitute values, and carry out calculation procedures systematically. Although the average achievement fell into the moderate category, nearly half of the students were still in the low or very low categories.

Table 5. Proficiency in implementing solutions

Question	Achievement	Category
Question 1	45 %	Moderate
Question 2	46 %	Moderate
Question 3	42 %	Moderate
Question 4	34 %	Low
Question 5	61 %	High
Question 6	43 %	Moderate
Question 7	33 %	Low
Overall	**44 %**	Moderate

Performance on the solutions ranged from 33% to 61%. Question 5 had the highest performance (high category), questions 1, 2, 3, and 6 fell into the moderate category, and questions 4 and 7 fell into the low category. Because the maximum score for each item on this indicator is quite high—4—losing points on a single step in the calculation significantly affects performance. In the vector material, calculations involve component decomposition, trigonometry, square roots, and direction signs; thus, basic mathematical skills also determine student success, and errors made during the planning stage can carry over to this stage. This finding is consistent with research that identifies the "executing the plan" stage as a barrier for students [6].

Student achievement on this indicator shows that the application of calculation procedures is already quite good, but precision and mastery of supporting mathematical skills are not yet consistent. Ideally, students should be able to perform substitutions, trigonometric operations, and determine direction signs accurately and systematically across all levels of problem complexity. Strengthening mathematical prerequisites—particularly trigonometry and algebraic operations—is necessary before or concurrently with vector instruction. Students also need to be encouraged to write out their calculation steps sequentially, including units, so that errors can be easily traced. Repeated practice with gradually increasing difficulty levels will help build procedural fluency and reduce errors carried over from previous stages.

The indicator assessing solution evaluation achieved a score of 26% and was the indicator with the lowest achievement, falling into the low category with an average score of 7.27 out of a maximum of 28 (Table 6). A total of 54 out of 59 students were in the low or very low categories, including 15 students in the very low category, and only one student reached the high category. This indicator relates to students' ability to check the completeness of their solution steps, the correctness of their answers, and the reasonableness of their results. Thus, nearly all students have not yet developed the habit of double-checking their solutions.

Table 6. Proficiency in Evaluating Solutions

Question	Capaian	Kategori
Question 1	33 %	Low
Question 2	30 %	Low
Question 3	31 %	Low
Question 4	21 %	Low
Question 5	24 %	Low
Question 6	19 %	Very Low
Question 7	23 %	Low
Overall	**26 %**	**Low**

All test items fell into the low or very low categories, with achievement rates ranging from 19% to 33%. Not a single item reached the moderate category; thus, the low achievement on this indicator was not caused by any specific item but rather by the habit of checking answers. These results are consistent with a study on linear motion, which found evaluation to be the lowest stage [7]; a study of 11th-grade students, which reported that most students were in the low category at the review stage [6]; and a study on fluid dynamics, which found that the evaluation stage was still inadequate [17]. Different results were reported for parabolic motion, where the evaluation stage had the highest achievement [8], suggesting that performance at this stage appears to be influenced by the subject matter and the assessment method.

Consistently low achievement on this indicator indicates that rechecking has not yet become an ingrained part of students' problem-solving habits. Ideally, students should independently check the completeness of steps, the accuracy of calculations, and the reasonableness of results-for example, by comparing the direction and magnitude of the resultant force against the initial sketch. This habit can be fostered by providing an evaluation checklist on the worksheet and explicitly incorporating evaluation components into the grading rubric. Peer assessment activities-in which students check and correct their classmates' work—can also help develop

sensitivity to errors. If peer assessment is counted toward the final score, students will view this stage as an essential part of problem-solving, rather than as an extra step.

Reasons for Low Achievement in Understanding Problems and Evaluating Solutions

Low achievement on these two indicators can be explained by the nature of these stages in the problem-solving process. Understanding problems and evaluating solutions do not directly yield a final score, so students who are answer-oriented tend to skip them. In vector problems, understanding the problem requires students to visualize the direction and position of vectors before calculating, while evaluating solutions requires students to assess whether the magnitude and direction of the resultant vector make sense in relation to the diagram. These two requirements differ from students' usual practice of immediately writing down formulas and performing calculations.These two stages also serve as the entry and exit points of the problem-solving process. Inaccurate representations in the early stages influence the selection of equations during the planning stage, and incorrect equations result in wrong calculations even if the substitution procedure is correct. Without evaluation, these errors go undetected and are accepted as the final answer. Therefore, weaknesses in these two stages can lower the quality of the entire process even if the intermediate stages are sufficiently sound.

The achievement patterns of the five indicators, when read sequentially, form a "down-up-down" pattern: low in the initial stage, increasing in the description and planning stages, decreasing slightly in the execution stage, and then dropping sharply in the evaluation stage. This pattern suggests that some students are able to proceed to the procedural stage without a strong initial representation of the problem, and once they obtain a result, they rarely go back to check its accuracy. In other words, students tend to treat problem-solving as the application of a formula rather than as a holistic process. Among the test items, the lowest achievement scores for each indicator were consistently found on items 6 or 7, indicating that the items at the end of the test were more difficult for students at nearly every stage; this may be due to the complexity of the items or time constraints.

Implications for Physics Instruction

The research results indicate that students' problem-solving skills in vector-related material remain in the low category, with the main weaknesses lying in the stages of understanding the problem and evaluating solutions. These findings highlight the need for instruction that not only emphasizes the use of formulas and calculations but also trains students' thinking processes-from understanding the problem to verifying the results. During the problem-understanding stage, students can be encouraged to sketch vectors, including their directions and angles, before writing down equations. During the solution-evaluation stage, students can be encouraged to check the units, direction, and reasonableness of the magnitude of the resultant vector, as well as to write a conclusion for their answer.

For physics teachers, these findings can serve as a basis for designing a sequence of learning activities on vector topics. The initial stage of instruction can include problems that require students to draw and label vectors before performing calculations, so that the representation of the problem becomes part of the assessment. In the final stage, students can be asked to write a single verification statement, such as whether the direction of the resultant aligns with the sketch and whether its magnitude is reasonable compared to the magnitudes of its component vectors. Simple activities like this do not add to the course load but provide space for the two lowest-scoring indicators to improve.

The implementation of PBL can be considered as an alternative because this model gives students the opportunity to tackle problems, discuss them, and develop solution strategies, and its impact on physics problem-solving skills is supported by meta-analyses [18,19]. A deep learning approach can complement this by encouraging students to understand concepts meaningfully and reflect on the problem-solving process [20]. Conceptually, the problem-oriented approach and process evaluation in PBL are related to the two weakest indicators; however, this connection needs to be proven through research that tests its impact on each indicator. The achievement levels for each indicator in this study can serve as a benchmark when students' abilities are reassessed after the learning intervention is implemented.

Study Limitations

This study has several limitations. First, the analysis is based solely on the percentage achievement for each indicator; therefore, the types of errors students made at each step of the problem-solving process cannot yet be fully explained. Second, the data came from two classes at a single school; therefore, the results are not intended to be generalized. Third, the five categories used differ from those in some previous studies; thus, comparisons

with those studies provide only a general overview. Therefore, future research could examine students' thought processes and the types of errors they make in greater depth.

IV. CONCLUSION

The problem-solving skills of 11th-grade students at SMA Negeri 1 Dua Koto in the topic of vectors fall into the low category, with an overall achievement rate of 38% and the majority of students falling into the low or very low categories. The indicators for planning solutions, describing problems, and implementing solutions fall into the moderate category. Two major weaknesses were found in the indicators "understanding the problem" and "evaluating solutions," both of which were in the low category, with the lowest achievement found in "evaluating solutions." These two weaknesses indicate that students are not yet accustomed to beginning the problem-solving process with a representation of the problem and concluding it by checking the results.

These findings suggest that students are more capable at procedural stages than at stages requiring representation and reflection. Vector instruction should encourage students to sketch and write down problem representations before calculating, as well as to check the direction, units, and reasonableness of the results before drawing conclusions. Such instruction can improve these two weak stages without increasing the workload. These results can serve as a basis for teachers in determining priorities for reinforcement and as preliminary data for further research examining the effect of instructional models on each problem-solving indicator..

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