



The Effect of Using Worksheets Based on the Problem-Based Learning Model on Students' Critical Thinking Skills in Vector and Kinematics for 11th Grade

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ABSTRACT

This study was motivated by the low level of critical thinking skills among students at SMAN 1 Tanjung Raya. This situation is caused by a learning process that does not fully utilize a learning model appropriate to its stages, resulting in students being passive during the learning process. Therefore, an educational innovation is needed that actively involves students and fosters critical thinking skills through the use of worksheets based on the problem-based learning model. This study aims to analyze the effect of using worksheets based on the problem-based learning model on the critical thinking skills of students at SMAN 1 Tanjung Raya. The research design used is a quasi-experiment with a posttest-only control design. The study population consists of all students in Grade 11 Phase F at SMAN 1 Tanjung Raya for the 2025/2026 academic year. The sampling technique employed is purposive sampling. The sample in this study consisted of the 11th-grade health major class, comprising 31 students as the experimental group, and the 11th-grade engineering major 2 class, comprising 32 students as the control group. Data on critical thinking skills were obtained through a test instrument in the form of essay questions. The analysis techniques used were the normality test, homogeneity test, and hypothesis testing using the independent samples T-test. The results of the study indicate that the average critical thinking skills of students in the experimental class were higher than those in the control class, specifically $60 > 45$. The results of the hypothesis test showed that the significance value obtained was 0.00, which is smaller than the significance level of 0.005. Thus, the null hypothesis " (H_0) " was rejected, and the alternative hypothesis " (H_1) " was accepted. It can be concluded that the use of worksheets based on the problem-based learning model has an effect on students' critical thinking skills in the subject matter of vectors and kinematics for 11th grade.

Keywords: LKPD, Problem-Based Learning Model, Critical Thinking Skills



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I. INTRODUCTION

Advances in science and technology (S&T) in the digital age have had a significant impact, particularly in the field of education in the 21st century[1]. To achieve educational goals that align with the needs of the times, 21st-century learning must be implemented using a *Student-Centered Learning* (SCL) approach, which focuses on developing four key skills: *Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity and Innovation*[2]. One of the essential skills required to solve problems in line with the demands of the 21st century is critical thinking. Critical thinking is vital in an era filled with challenges that require individuals to think critically, logically, rationally, and systematically[3]. Critical thinking is a reflective thinking ability focused on decision-making processes regarding what to believe, what to do, and what can be justified[4]. Critical thinking skills are higher-order thinking abilities used to identify problems, analyze

problems, evaluate, and solve problems[5] . Critical thinking skills require students to consider and evaluate every piece of information received, enabling them to draw conclusions based on rational thought to effectively solve problems[6].

Therefore, the development of critical thinking skills is a crucial aspect of 21st-century learning that must be optimally implemented across all levels of education, including in physics education. Physics is a branch of natural science that studies the properties of matter in space and time along with physical concepts; nearly every human activity is related to physics[7] . In physics lessons, students are not merely required to memorize concepts and formulas but must also be able to connect physical concepts to everyday life. Thus, physics education plays a vital role in developing students' critical thinking skills.

The five indicators of critical thinking skills used by Ennis's theory are providing simple explanations, building basic skills, drawing conclusions, formulating simple explanations, and devising strategies and tactics[4] . Students' critical thinking skills can be assessed using a critical thinking test instrument in the form of essay questions; the critical thinking skills test was administered to 11th-grade students in Phase F of the Health Department at SMAN 1 Tanjung Raya. Based on the analysis of the critical thinking skills test results, students' performance is still classified as low. The average score for critical thinking skills among 11th-grade students in Phase F of the health program was 34.08, falling into the low category. This indicates that students are not yet able to analyze and solve physics problems effectively.

Based on interviews with physics teachers at SMAN 1 Tanjung Raya, the teachers stated that critical thinking skills are an important aspect of physics education; however, during their teaching, they have not directly assessed students' critical thinking skills in physics lessons. Furthermore, in their teaching practice, the instructional materials used by teachers consist solely of printed textbooks. The methods employed by teachers in the learning process are lectures and discussions. This is what causes students' critical thinking skills to be low; for one thing, students have not been trained to be more active in problem-solving, critical reasoning, and explaining phenomena in greater detail. However, students are still not accustomed to this and tend to be passive, expecting explanations from the teacher during the physics learning process and unable to access knowledge independently, so their thinking skills do not develop—especially critical thinking skills, which are not being trained.

Based on interviews with five students, they stated that physics lessons are uninteresting; the reason students are not interested in physics is that the subject is perceived as difficult, involving too many numbers and calculations. Furthermore, students find it challenging to solve the problems given because they rely solely on existing formulas without understanding the underlying concepts. Furthermore, observations conducted directly by the researcher indicate that physics instruction at SMAN 1 Tanjung Raya has not fully integrated the *problem-based learning* model into the teaching process. Instruction remains conventional, with teachers frequently delivering material in a one-way manner without involving students in the learning process. Consequently, students tend to be passive and rely solely on the teacher's explanations, without attempting to solve problems independently. This directly impacts the low level of students' critical thinking skills in solving physics problems.

Given the issues identified above, one solution that can be implemented is to integrate the use of instructional materials in the form of worksheets based on the problem-based learning model, which can enhance students' critical thinking skills. LKPDs are printed instructional materials in the form of worksheets containing content, summaries, and instructions that students must follow based on core competencies [8]. Additionally, LKPDs are worksheets that students can use, containing laboratory instructions, experiments to conduct, discussion topics, portfolio assignments, and various practice questions. This will increase student engagement in the learning process [9]. LKPDs are an important tool that teachers can use in the learning process because they facilitate learning activities and foster effective interaction between students and teachers, thereby capturing students' attention and motivating them to learn [10]. The use of LKPDs in physics instruction will help students understand the material or concepts thoroughly through laboratory work and theory, as well as apply the concepts they have discovered [11]. This means that LKPDs play a crucial role in student-centered learning, particularly in problem-solving processes that guide students to formulate hypotheses, collect data, and draw conclusions, thereby effectively developing critical thinking skills.

One learning model that can develop students' critical thinking skills is the *problem-based learning* model. The *problem-based learning* model is a type of learning model that places students at the center of the learning process, thereby fostering creativity, critical thinking, and collaboration, while enhancing understanding and developing higher-order thinking skills[12] . *The steps in problem-based learning* activities guide students to think, analyze, investigate, and design solutions[13] . *The problem-based learning model* consists of five components aligned with Arends' theory: orientation, organization, investigation, presentation of results, and evaluation[14]. By using a *problem-based learning* model focused on problem-solving, students are guided to identify problems, collect data, analyze, and draw conclusions from the issues they encounter[15] . Through the components of the *problem-based learning* model, such as conducting group investigations and presenting

results, critical thinking skills are directly integrated into the process of solving the identified problems[16] . Therefore, this approach indirectly trains students to think critically when addressing the challenges they face. This learning model presents students with authentic and engaging problems, enabling them to discover knowledge on their own. This aligns with the objectives of *problem-based learning*, which is to train students to solve problems. Thus, the use of worksheets based on the *problem-based learning* model can serve as a tool to enhance students' critical thinking skills.

This is supported by Effendi's (2021) research, which states that through PBL-based worksheets, students' critical thinking skills in learning can be improved, and the delivery of lesson material can be facilitated using these worksheets [17]. According to the results of Diana's (2022) research, which states that the implementation of learning activities using worksheets can increase student engagement in reading and writing and encourage students to think critically about the subject matter to be taught, thereby making students more active and helping them absorb and understand the material presented in the worksheets [18].

Based on previous research, the use of LKPDs as teaching materials and the *problem-based learning* model has been extensively studied. However, there are still shortcomings and the results show little significant difference. Specifically, there has been little research that comprehensively examines the influence of using LKPDs based on the *problem-based learning* model on students' thinking skills, particularly in the context of physics learning on vector and kinematics topics. Previous studies have tended to focus on general learning outcomes and have not made critical thinking skills the primary focus. Furthermore, previous studies have not systematically integrated the stages of *the problem-based learning* model into the structure of the worksheets. Consequently, no specific study has been found that examines the effect of using worksheets based on the *problem-based learning* model on students' critical thinking skills in vector and kinematics topics.

Based on the problem description above and the actual conditions observed in the field, the research problem can be formulated as follows: "Does the use of worksheets based on *the problem-based learning* model affect students' critical thinking skills in vector and kinematics topics for 11th-grade students?"

II. METHOD

This study aims to analyze the effect of using a worksheet-based problem-solving learning model on students' critical thinking skills in the subject of vectors and kinematics for 11th-grade students. The research method used in this study is a quasi-experimental design. This method includes a control group; however, it cannot fully control external variables that influence the course of the experiment [19]. The research design used in this study is a posttest-only control design. This study employs the problem-based learning model using worksheets. After the treatment, the classes were administered a posttest to assess the critical thinking skills of students in each class. A simplified overview of the research design is presented in Table 1.

Table 1. Research Design

Group	Treatment	Posttest
Experimental	X	O
Control	-	O

(Source: Ref[19])

A population is the generalizable domain consisting of objects or subjects possessing specific qualities and characteristics defined by the researcher for study, from which conclusions are drawn[19] . Thus, it can be concluded that a population is the entire research subject group possessing specific characteristics. The population in this study is the entire 11th-grade Phase F class at SMAN 1 Tanjung Raya for the 2025/2026 academic year, consisting of 3 classes studying physics. Sampling was conducted using *purposive sampling*. The sample was determined based on specific considerations by the subject teacher, who categorized classes with nearly identical average abilities as assessed by diagnostic test results. Class XI Health was selected as the experimental class, and Class XI Engineering 2 as the control class.

A research variable is a construct defined by the researcher to be studied in order to obtain information about the subject and subsequently draw conclusions [20]. The independent variable in this study is the Student Worksheet (LKPD) based on the problem-based learning model. The dependent variable used in this study is the critical thinking ability of 11th-grade students in the first semester at SMAN 1 Tanjung Raya.

The procedures implemented comprised three stages: preparation, implementation, and completion. The researcher used a test to measure critical thinking skills and analyze the improvement that occurred following the intervention. The test used in this study was a posttest to measure students' critical thinking skills after the intervention. Instrument analysis consisted of validity testing, reliability testing, difficulty level testing, and discriminant power testing. Meanwhile, for data analysis, a normality test was conducted on the posttest data to determine whether the data were normally distributed. Next, a homogeneity test was conducted to determine

whether the two class groups had homogeneous variances. If the data were normally distributed and had homogeneous variances, a t-test was performed using the Independent t-Test.

III. RESULTS AND DISCUSSION

Data on students' critical thinking skills were obtained from the results of a written test consisting of 8 essay questions on vector and kinematics material. This test was administered to both sample classes at the end of the research sessions. Based on statistical calculations, the highest score, lowest score, mean, and standard deviation for the experimental and control classes are shown in Table 2.

Table 2. Summary of Test Results for the Experimental and Control Classes

Category	Posttest	
	Experimental	Control
Highest score	88	81
Lowest score	38	9
Average	60	45
Standard deviation	12.0	16.6

Based on the analysis of the critical thinking skills test, the results of the achievement of critical thinking skill indicators in vector and kinematics material can be seen in Table 3.

Table 3. Achievement of Critical Thinking Skill Indicators

Critical Thinking Skills Indicators	Posttest	
	Experimental	Control
Providing a simple explanation	64%	38
Building basic skills	84%	73
Drawing conclusions	42%	45%
Providing further explanation	68%	46%
Developing strategies and tactics	43%	35

Based on Table 3, it can be seen that there is a significant difference in the *posttest* results for each indicator of students' critical thinking skills in both the experimental and control classes. This indicates that the learning implemented in the experimental class was more effective than that in the control class.

Normality Test

The *Shapiro-Wilk* test was used to determine whether the samples came from a normally distributed population. The results of the normality test for both sample classes can be seen in Table 4.

Table 4. Results of the Normality Test

Class	Data			Conclusion
	N	Sig	α	
Experiment	31	0.145	0.05	$Sig > \alpha$ (Normally distributed)
Control	32	0.786		

Based on the results of the normality test in Table 4, there is a significant difference between the two sample groups, where the obtained significance value is greater than the significance level. Therefore, it can be concluded that the data from both sample groups are normally distributed.

Homogeneity Test

The homogeneity test used the *Levene's test statistic*, which is used to determine whether the sample classes have homogeneous variances or not. The results of the homogeneity test for the two sample classes can be seen in Table 5.

Table 5. Homogeneity Test Results

Class	Statistical Data			Conclusion
	N	α	Sig	
Experiment	31	0.05	0.061	$Sig > \alpha$ (homogeneous variances)
Control	32			

Based on the results of the homogeneity test in Table 5, the significance values for both sample groups are greater than the significance level; therefore, it can be concluded that the two sample groups have homogeneous variances.

Hypothesis Testing

Hypothesis testing is used to determine whether a hypothesis is accepted or rejected. The hypothesis test used in this study was the *independent samples t-test* using SPSS software. After conducting normality and homogeneity tests on the *posttest* data of both sample classes, it was found that the data in both sample classes were normally distributed and had homogeneous variances. The results of the hypothesis test for both sample classes can be seen in Table 6.

Hypothesis Test Data (Independent Samples T-Test)		Conclusion
α	Sig. (2-tailed)	Sig. (2-tailed)
0.05	0.00	Therefore, H_0 is rejected, and H_1 is accepted

Based on the hypothesis test using an *independent samples T-test* with a significance level of 5%, the *posttest* data values indicate that the *sig. (2-tailed)* value is smaller than the significance level; therefore, the hypothesis test decision is that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This indicates that there is a significant difference between the critical thinking skills of students in the experimental class and the control class. Thus, it can be concluded that the use of worksheets based on the *problem-based learning* model has a significant effect on students' critical thinking skills.

As seen in each critical thinking skill indicator, the experimental class achieved superior results compared to the control class. This occurred because the learning process using *PBL-based* worksheets involved problems that required students to identify issues, formulate hypotheses, gather facts, conduct investigations, and draw conclusions to solve the problems. Additionally, the steps in the *problem-based learning* model guide and assist students in achieving each of the indicators within critical thinking skills. The first step is student orientation to the problem, where students are presented with a problem related to the application of vector concepts in daily life. Through the given problem, the educator directs students to discuss with their respective groups to understand and formulate hypotheses on the worksheet. This demonstrates that during the problem orientation stage using the worksheet, this activity directly trains students' thinking skills from the outset of learning, particularly in the ability to understand problems and formulate tentative assumptions (hypotheses) as a foundation for the problem-solving process.



Fig. 1. Student Answers in the First Syntax

In the second syntax, which involves organizing students, students are able to predict answers to the comprehension exercises in the worksheet, thereby encouraging them to actively participate in developing critical thinking skills regarding their initial understanding. By using the worksheets, students can organize their thinking to solve problems and describe problems in terms of physics concepts, allowing them to determine solutions to the problems[21]. This demonstrates that the worksheets play an active role in fostering critical thinking skills, particularly in assessing students' initial understanding.

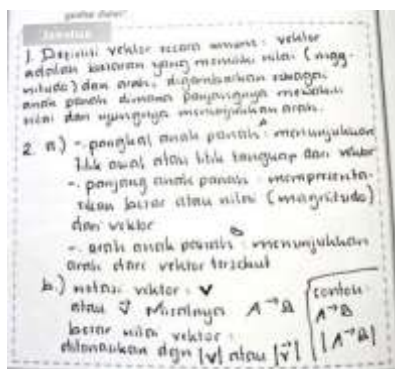


Fig. 2. Student Responses in the Second Syntax

In the third syntax, which involves guiding individual or group investigations, educators ask students to conduct investigations related to vector concepts and their properties. In the fourth syntax, which involves developing and presenting data results, students are asked to record their investigation results in a table provided in the worksheet. Through this investigative process, students can determine relevant solutions based on facts and scientific concepts[22]. This indicates that students have developed critical thinking skills, particularly in analyzing data, communicating results, and solving problems.

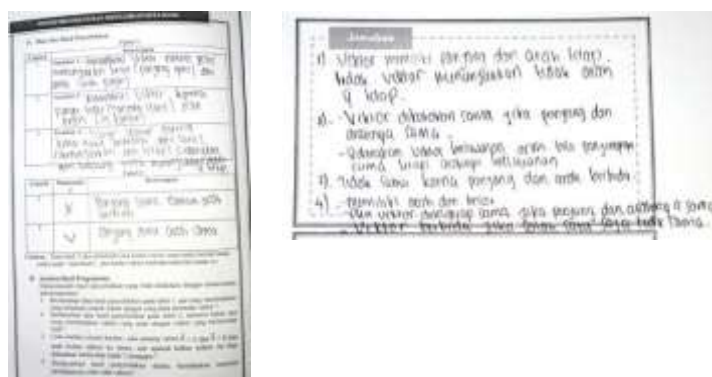


Fig. 3. Student Answers in the Fourth Syntax

The fifth step involves evaluating the problem-solving process, during which students and educators jointly assess the problem-solving process that has taken place and collectively summarize what has been learned. This stage plays a crucial role in developing students' critical thinking skills, particularly in reflecting on and evaluating their understanding of the material, especially for students who are less active in discussions.

Learning using worksheets based on the *problem-based learning* model allows students to learn independently within their respective groups and follow the learning steps in the worksheets in accordance with the *problem-based learning* model syntax. Working in groups, students will discuss and solve a problem presented in the worksheet before presenting their findings. This aligns with Astuti's (2018) theory, which states that worksheets serve as a guide for students to develop both cognitive and learning aspects through inquiry-based or problem-solving activities in accordance with the desired learning outcomes[23]. The use of worksheets based on the *problem-based learning* model () offers numerous benefits in the learning process. Furthermore, with the assistance of *these worksheets*, students' critical thinking skills can be enhanced, particularly in physics education, as they possess several advantages. One such advantage is that the worksheets make learning more engaging and enjoyable by encouraging students to interact directly with technological advancements. The use of *PBL-based* worksheets helps sharpen students' thinking abilities and engagement, thereby enhancing their critical thinking skills. This aligns with the theory of critical thinking proposed by Nafiah and Suyanto (2014), who state that critical thinking is an active process involving the manipulation and transformation of information stored in memory[24]. Based on the theory proposed by these experts, it is evident that this is related to and supported by the learning process observed during the study. During the learning process, the researcher observed students actively and competitively seeking solutions to problems presented through the worksheets within their respective groups. Students engaged in discussions, exchanged ideas, and expressed their opinions and hypotheses to resolve the issues in the worksheets, which they would subsequently present.

The results of this study align with research conducted by Effendi (2021), who stated that using worksheets based on the *problem-based learning* model can enhance students' critical thinking skills in learning and simplify the delivery of lesson material[14]. According to Diana's (2021) findings, worksheets based on the *problem-based learning* model are developed in accordance with the *problem-based learning* syntax. Through this learning model, students can be encouraged to solve problems involving collaborative work[25].

Based on the discussion above, it can be concluded that the use of worksheets based on the *problem-based learning* model can improve students' critical thinking skills, particularly regarding vector and kinematics material in 11th grade.

IV. CONCLUSION

Based on the data analysis conducted, it can be concluded that there is a significant difference in critical thinking skills between the two sample classes. This difference in ability is due to the different treatments administered. The experimental class was provided with worksheets based on the *problem-based learning model*, while the control class was only provided with the application of the *problem-based learning* model. Thus, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted, namely that there is an effect of using worksheets based on the *problem-based learning model* on students' critical thinking skills in the vector and kinematics material for 11th grade.

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