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The Influence of STEM-PBL to Improve Students' Critical Thinking Skills in Straight Line Kinematics Material

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Abstract. The independent curriculum emphasizes developing critical thinking skills and solving scientific, analytical, and practical problems. Schools need to facilitate learning that enhances these skills, and teachers must create appropriate strategies. Interviews with physics teachers at SMAN 11 Kota Bengkulu reveal that the independent curriculum is implemented, but assessment data and daily exams show that 50-60% of grade XI students struggle with solving physics problems. Students tend to be passive, memorizing formulas without understanding the concepts deeply. This indicates a lack of critical thinking skills such as analyzing, synthesizing, solving problems, concluding, and evaluating material, especially in linear motion kinematics. Additionally, students' interest in learning is low, and they find physics difficult. To address this, a STEM-based Problem Based Learning (PBL) model was applied. This study aims to determine the effect of STEM-based PBL on improving students' critical thinking skills and the extent of improvement in linear motion kinematics. The study used a quasi-experiment with a non-equivalent control group design, with XI C as the control class and XI B as the experimental class. Hypothesis test results show a significant t-test value (α = 0.05) with Sig. (2-tailed) value of 0.000 <0.05. Cohen's d effect size is 2.07, categorized as large, with a big interpretation. The N-gain score is 0.57, with a moderate interpretation. In conclusion, STEM-based PBL effectively improves critical thinking skills at SMAN 11 Bengkulu City, enhancing the quality of learning.

Keywords: Problem Based Learning, STEM, critical thinking skills.

1. Introduction

21st-century learning is no longer focused on educators (teacher-centered learning) but rather on developing skills through a student-centered learning process. In this skill, students are required to develop life skills and soft skills. The goal is to develop critical thinking and learning skills relevant to this era. These skills are called "4C Skills" (Communication, Collaboration, Critical Thinking, and Creative and Innovative), which are formulated by the 21st Century Skills Framework Partnership, which are very much needed following the demands of the current independent curriculum [1].

Critical thinking skills are one of the demands of the current independent curriculum [2]. The independent curriculum emphasizes developing critical thinking skills and solving scientific, analytical, and practical problems effectively [3]. Therefore, schools need to facilitate learning that can improve critical thinking skills; teachers must evaluate and create appropriate strategies to improve critical thinking skills [4]. The low ability of students to think critically is a serious problem that must be solved immediately, it is feared that students will not be able to analyze and solve real problems that they experience in everyday life and will have difficulty in making decisions quickly and accurately [5].

According to [6], students' thinking skills are still relatively low because students only have the ability to understand theories and concepts obtained from the material, so that students are still unable to apply problem solving. Many students do not participate in teaching and learning activities properly, so that when asked to summarize the material they have learned, students cannot conclude. In addition,

when students are given practice questions related to the subject matter, many are unable to work on the questions. This activity proves that there are learning barriers that result in low critical thinking skills in students [7].

Based on the International Trends in International Mathematical and Scientific Research (TIMSS), stating that students are weak in solving problems related to contextual reasoning, demanding reasoning and directing students towards critical thinking is very important. This condition is also evidenced by the low achievement of students in Indonesia in facing the demands of the 21st century. PISA (Program for International Student Assessment) is an international study that assesses the quality of the education system by measuring learning outcomes essential for success in the 21st century. The results of the PISA 2022 study were recently announced on December 5, 2023. The ranking of Indonesian students' learning outcomes for literacy rose 5 to 6 positions compared to PISA 2018. Indonesia is ranked 68th with the PISA score in Indonesia showing an overall decline compared to 2018. The 2022 results in reading scores (359), mathematics (366), Science (383), this is among the lowest ever measured by PISA in the three subjects [8].

The science, technology, engineering, and mathematics (STEM) approach is one approach to answering the challenges of 21st century learning [9]. The STEM approach is very suitable to be applied when learning physics. Because it can train students to solve problems, create innovative solutions, be independent, think logically, and have technological skills [10]. The advantage of combining science and mathematics which is packaged from the combination of technology and engineering so that it can develop students' critical thinking processes and improve the quality of physics learning [11]. The STEM approach can be associated with a problem-solving model, PBL (Problem Based Larning). This learning model uses problems that occur in everyday life as a benchmark for learning and in terms of solving problems, students need a new experience as a solution [11]. According to [13] the results of the implementation of the STEM-based Problem Based Learning (PBL) learning model show an influence on improving students' critical thinking skills. The implementation of the STEM-based PBL model emphasizes several aspects in the learning process, including: (1) asking questions and defining problems; (2) developing and using models; (3) planning and conducting investigations; (4) analyzing and interpreting data; (5) using mathematics; information and computer technology; and computational thinking; (6) constructing explanations (science) and designing solutions (engineering) [13].

Based on the results of interviews with physics teachers at SMAN 11 Bengkulu City, information was obtained that independent curriculum learning had been carried out at the school. In grades X and XI since the 2023/2024 school year. Physics learning hours are set at 5 JP × 40 minutes in one week and learning using textbooks available in the library, the teacher admitted that in teaching he still uses conventional methods such as lectures in class, using media such as whiteboards to explain the material, and using learning models such as contextual learning models, generative models, discovery learning models. However, in chapter 2 of the kinematics of straight motion material using the discovery learning model. However, in chapter 2 the kinematics of straight motion material uses the discovery learning model. This is in line with Setyono's research in [14] it was concluded that students still experience difficulties in the kinematics of straight motion material on several indicators. The profile of student difficulties is based on the achievement of KKM, initial knowledge, material profile, misconceptions, and problem solving. Initial knowledge or prerequisites are very important in problem solving activities because initial knowledge is a provision for being able to learn new knowledge. In addition, He admitted that in teaching he did not pay attention to the model and approach in the learning process, especially the STEM approach sounded foreign to his ears. Information was obtained that the minimum physics competency score (KKM) was 75. then, from the assessment data and daily exam results conducted by teachers, around 50-60% of students in grade XI still had difficulty in determining what steps they should take to solve physics questions and problems given by the teacher. Students tend to be passive and they only memorize formulas, enter numbers, and solve mathematical equations without understanding the concept of physics orientation. This shows that in learning physics students have difficulty in thinking critically in indicators such as the ability to analyze, synthesize, problem-solving skills, conclude and evaluate the material taught, especially the material of straight motion kinematics. In addition, students still have weaknesses in learning interest and consider physics difficult to

understand, critical thinking skills and identifying problems based on basic physics concepts and understanding in formulating problems so that they can be solved properly.

Based on the problems described above, the researcher is interested in conducting an experimental study with the aim of this study being to determine the Effect of STEM-Based Problem Based Learning (PBL) on Improving Students' Critical Thinking Skills on Straight Motion Kinematics Material, and to determine how much influence STEM-Based Problem Based Learning (PBL) has on Improving Students' Critical Thinking Skills on Straight Motion Kinematics Material and improving students' critical thinking skills on STEM-based problem based learning (PBL) on straight motion kinematics material.

2. Method

The quantitative approach is the approach used in this study with the Quasi Experimental method. The target location of this study was SMA Negeri 11 Bengkulu City in the 2024/2025 academic year. The population in this study were all class XI students at one of SMA Negeri 11 Bengkulu City. Sampling in the study was carried out using the Simple Random Sampling technique, by analyzing students' daily test scores and then conducting a random draw. As a result, two class XI were taken with class XI B as the experimental class and class XI C as the control class. The time of implementation of this research was carried out in the odd semester of the 2024/2025 academic year. The method used in this study is the quantitative descriptive method. The design form in this study uses the Nonequivalent Control Group Design as follows [14].

Table 1. Nonequivalent control group design.

Experimental Class	O_1	×	O_2
Control Class	O_3	–	O_4

The technique used is a test technique to collect data on the level of critical thinking skills of students in the cognitive domain. The test was conducted twice, namely a pretest at the first meeting and a posttest at the last meeting. The test instrument to measure the level of critical thinking skills of students that will be used was first validated by experts by lecturers and school teachers, after which it was consulted with the supervising lecturer and revised before being given to respondents for testing. The pretest and posttest question instruments in this study were made in the form of essay questions. Then, the results of the trial of the instrument that had been given to respondents were then tested for the validity of the questions, reliability of the questions, the difficulty level of the questions, and the discriminatory power of the questions, which would then be tested on the research sample. The essay test questions given to students in this study will be assessed based on the stages of students' critical thinking skills. The stages of students' critical thinking skills used in this study are adapted from the stages of critical thinking skills put forward by Ennis [15]. Ennis et al. outline the development of critical thinking skills in five stages. The first stage focuses on basic understanding by introducing key terms such as “argument” and “evidence.” The second stage builds on the foundation by having students identify assumptions, evaluate evidence, and draw conclusions. The third stage encourages students to apply these skills to making decisions and drawing conclusions. The fourth stage digs deeper by teaching source evaluation, identifying logical fallacies, and considering multiple perspectives. The fifth stage integrates all of these skills into everyday life through the development of personal critical thinking strategies. It is important to remember that this process is dynamic, and students may move between stages as the complexity of the problem at hand dictates. Flexibility in the learning approach allows students to develop comprehensive and ongoing critical thinking skills.

The data analysis techniques used in this study are descriptive and inferential statistical analysis. The inferential statistical analysis used in this study consists of a normality test, to see whether the data is normally distributed or not and a homogeneity test to see information that the data of each group comes from a population that is not much different in diversity with the Levene test using SPSS Software. After the normality and homogeneity tests are carried out, the next step is to test the hypothesis, where in this study the parametric statistical analysis is used. After the data is tested for normality and homogeneity

using the Kolomogorv-Smirnov test and the results of the posttest normality test for the experimental and control classes are obtained, the sig.count value ≥ sig. reference then it is normally distributed and the homogeneity test value sig.count ≥ sig. reference then both data groups have the same data variance, therefore, it can be concluded that the data is homogeneous. Furthermore, parametric statistical analysis is carried out to test the hypothesis using the t-test.

The null hypothesis or $H0$ proposed in this study is that there is no influence of STEM-based Problem Based Learning (PBL) to improve students' critical thinking skills at SMAN 11 Bengkulu City, while the alternative hypothesis or Ha is that there is an influence of STEM-based Problem Based Learning (PBL) to improve students' critical thinking skills at SMAN 11 Bengkulu City. The testing of this research hypothesis was carried out using the Independent Sample t-Test using the Pooled Varian equation. Where the basis for decision making is if the Sig value <0.05 then $H0$ is rejected and Ha is accepted. Meanwhile, if the Sig value> 0.05 then $H0$ is accepted and Ha is rejected. According to Sugiyono [14] the Pooled Varian equation for the t test is as in equation (3)

$$\mathbf{t} = \frac{\bar{x}_1 - \bar{x}_2}{S_{gab}\sqrt{(\frac{1}{n_1} + \frac{1}{n_2})}}, \quad (1)$$

$$S_{gab} = \sqrt{\frac{(n_1-1)S_1^2 + (n_1-1)S_2^2}{n_1+n_2+2}}, \quad (2)$$

When the results obtained show that the STEM-based Problem Based Learning (PBL) model has a significant influence on improving students' critical thinking skills, the next step is to look for the effect size. The following is the equation used to measure the effect size in Cohen's as follows [16]:

$$Cohen's\ d = \frac{\bar{X}_a - \bar{X}_b}{Pooled\ SD}. \quad (3)$$

The results of the Effect Size calculation are interpreted in Table 2.

Table 2. Effect size calculation.

Effect Size	Interpretation
0,8 ≤ Cd ≤ 2,0	Large
0,5 ≤ Cd < 0,8	Medium
0,2 ≤ Cd < 0,5	Small

Then an N-gain calculation is carried out to determine the extent of the increase in students' critical thinking abilities, which can be calculated using the following equation [17]

$$Ngain = \frac{Skor_{Posttest} - Skor_{Pretest}}{Skor_{Ideal} - Skor_{Pretest}}. \quad (4)$$

The interpretation of N-gain can be seen in Table 3.

Table 3. The interpretation of N-gain.

Normalized Gain Value	Interpretation
(< g >) ≥ 0,7	High
0,7 > (< g >) ≥ 0,3	Medium
(< g >) < 0,3	Low

3. Results and Discussion

3.1. *Research Results*

This study is based on the results of observations conducted in class XI at SMA Negeri 11 in Bengkulu City. This study involved two classes that received different teaching treatments: the experimental group

was taught using the STEM-based Problem Based Learning (PBL) model, while the control group used the discovery learning method. Prior to implementation, the assessment instrument was validated by a panel of experts, consisting of two university lecturers and one school teacher, to ensure its suitability for the study. This validation process aims to increase the reliability of the instrument before being administered to the sample population. Data for this study were collected using a critical thinking ability assessment given to the study sample, which consisted of a descriptive test consisting of 10 questions focused on kinematics topics related to linear motion. The findings of the descriptive statistical analysis are presented in Table 4.

Table 4. Results of descriptive statistical analysis.

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Experimental Class Pretest	30	17	86	43.20	15.858	251.467
Experimental Class Posttest	30	56	97	75.73	12.242	149.857
Control Class Pretest	30	10	60	38.03	14.421	207.964
Control Class Posttest	30	20	73	53.83	13.170	173.454
Valid N (listwise)	30					

Based on table 4, the output of the descriptive statistical analysis test using SPSS 25 software shows that in the pretest results of the experimental class, the minimum value obtained is 17 while the maximum value is 86, the average pretest of the experimental class is 43.20 with a standard deviation of 15.858 and a variance of 251.467. Then the posttest results of the experimental class, the minimum value obtained is 56 while the maximum value is 97, the average posttest of the experimental class is 75.73 with a standard deviation of 12.242 and a variance of 149.857. Furthermore, in the pretest results of the control class, the minimum value obtained is 10 while the maximum value is 60, the average pretest of the control class is 38.03 with a standard deviation of 14.421 and a variance of 207.964. Then the results of the control class posttest, the minimum value obtained was 20 while the maximum value was 73, the average posttest of the control class was 53.83 with a standard deviation of 13.170 and a variance of 173.454. After conducting a prerequisite test to determine normality, the normality test used was the Kolmogorov-Smirnov test where this test was used because the sample in this study was more than 50 samples. As stated by [17] if the number of samples in the study consists of more than 50 samples, the normality test used is the Kolmogorov-Smirnov test, while if the number of samples is less than 50 samples, the Shapiro-Wilk test and homogeneity of research data, for further testing the hypothesis can be done using the t-test to determine the significant difference in students' critical thinking skills between the experimental class and the control class. In this study, one of the parametric tests was used with the help of SPPS 25 software, namely using the Independent Sample T-test by comparing the average value of two groups of free or unrelated samples. Table 5 shows the results from the Independent Sample T-test of students' critical thinking abilities.

Table 5. Independent sample T-test results.

T-test for Equality of Means								
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Critical thinking skills	Equal variances assumed	6.671	58	.000	21.900	3.283	15.329	28.471
	Equal variances not assumed	6.671	57.693	.000	21.900	3.283	15.329	28.471

Based on table 5, it can be seen that the Sig. (2-tailed) value obtained is 0.000 where this value is smaller than the significance (α) = 0.05. Therefore, based on the basis of decision making for the t-test if the sig. <0.05 then it can be concluded that $H0$ is rejected and Ha is accepted. Thus it can be said that there is an influence of STEM-based Problem Based Learning (PBL) to improve students' critical thinking skills at SMAN 11 Bengkulu City. When the results are obtained that the STEM-based Problem

Based Learning (PBL) model has a significant influence on improving students' critical thinking skills, the next step is to look for the size of its influence (effect size). The results of the hypothesis test can be seen in table 6.

Table 6. Effect size test result data.

	N	*Xa*	*Xb*	*Effect size*	*Interpretasi*
Cohen's d	30	75.73	53.83	2.07	Besar

Table 6 above shows the average and standard deviation of each class so that Cohen's d is 2.07, categorized as large with $\alpha = 5\%$. So Ho is rejected because t count ≥ t table (2.07 ≥ 0.05) and Ha is accepted, it can be concluded that the magnitude of the influence of STEM-based Problem-Based Learning (PBL) to improve critical thinking skills at SMAN 11 Bengkulu City is 2.07 with a large interpretation. Furthermore, the N-gain calculation is carried out using the pretest and posttest values of the Experimental class. The N-gain test to see how much the students' critical thinking skills in the experimental class have increased, using the N-gain equation, which can be seen in equation (5). The results of the N-gain test for the experimental class can be seen in Table 8. Based on Table 6, it can be seen that in the experimental class, the average N-gain score for the experimental class is 0.57. Then for the N-gain percent, an average of 0.5734 is obtained. Where for this N-gain score when viewed based on the N-gain interpretation table (table 2) the N-gain results for this experimental class are at a value of $0.7 > (< g >) \geq 0.3$ then the value is 0.57 with a moderate interpretation. The following is Table 7 of the following N-gain test results.

Table 7. N-gain test results.

	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Ngain_Score	30	.07	.94	.5734	.20612
Ngain_Persen	30	6.98	94.34	57.3421.08	20.61215
Valid N (listwise)	30				

3.2. *Discussions*

In this study, the learning model applied by the teacher in the classroom has a very important role in the learning process. The application of a learning model that is in accordance with the subject matter that is adjusted to the needs and characteristics of students will significantly improve their critical thinking skills. In this study, the researcher applied the STEM-based Problem Based Learning (PBL) model to identify differences in learning between the control class using the discovery learning model. The results of using STEM-based Problem Based Learning (PBL) showed a significant influence on improving students' critical thinking skills. The success of improving critical thinking skills can be seen from the learning strategies applied by paying attention to the indicators of critical thinking skills used.

The first activity is to orient students to the problem and focus on questions (STEM aspect: science). This activity aims to stimulate students' curiosity. Students are expected to ask scientific questions based on phenomena. This process hones students' thinking skills. This process trains students to associate prior knowledge with new information obtained, thus creating cognitive conflict and triggering critical questions. In addition, the teacher also guides students in providing predictions or temporary answers. The next step is to organize students to learn, where students are directed to explore information related to the topic of the material to be taught.

The next step is to plan, carry out investigations, and draw conclusions (STEM aspects; science, technology, engineering, mathematics) In this stage, students conduct investigations to collect data and information from various sources. The information obtained is then analyzed collectively (STEM aspects: science, mathematics). This activity directly trains students in analyzing patterns and relationships based on the information obtained. Thus, students have undergone cognitive and thinking processes. Critical thinking skills are related to decision making, strategic planning, scientific methods, and problem solving to obtain solutions. In the phase of formulating solutions to problems (STEM aspects; science, technology, engineering, mathematics), the last activity is to present ideas and conduct evaluations. At this stage, students will present the results of the designs that have been prepared. Students are trained to analyze and convey arguments related to the problems given, which can hone

critical thinking skills. The success of improving critical thinking skills is significantly influenced by the application of the Problem-Based Learning approach. The STEM approach integrated at every stage of the learning process also contributes to the success of improving critical thinking skills. This is shown based on the results of descriptive statistical analysis showing that students' critical thinking skills in class XI B, as an experimental class before the implementation of STEM-based Problem Based Learning (PBL), had an average pretest of 43.20. Furthermore, there was an increase after the implementation of STEM-based Problem Based Learning (PBL), with an average student posttest result reaching 75.73. Class XI C functions as a control group that receives conventional learning through the discovery learning model, with an average student pretest result of 38.03 and an average student posttest result of 53.83.

In this study, the indicators of critical thinking skills according to Ennis et al. are used, namely providing simple explanations, building basic skills, concluding, providing further explanations and arranging strategies and tactics. Each indicator uses 2 essay questions with a total of 10 essay questions used. Figure 1 shows the average value of the control and experimental groups with the results of students' critical thinking skills on each indicator according to Ennis et al.

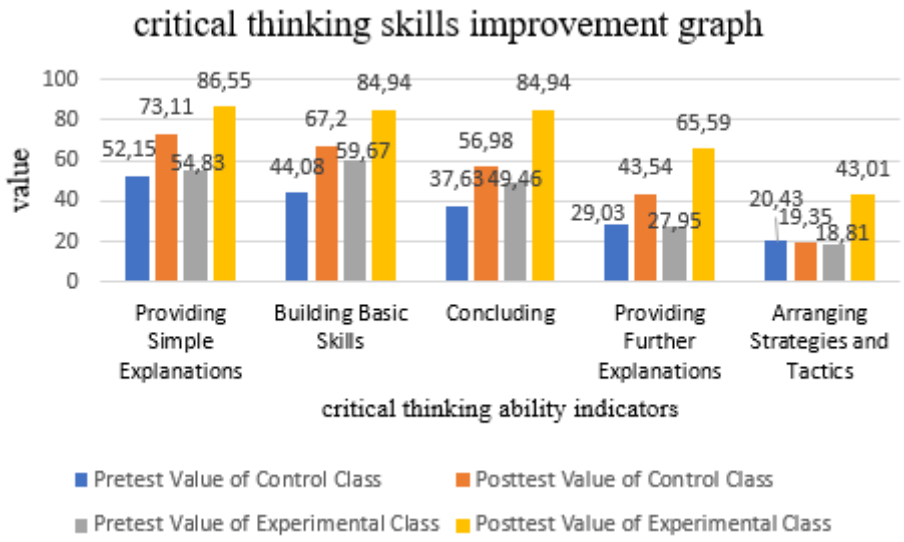

Figure 1. Graph of students' critical thinking skills improvement.

The results of the graph of the increase in students' critical thinking skills in Figure 1 show that in the control class, the average pretest and posttest scores for indicators 1) providing simple explanations were 52.15 and 73.11. 2) building basic skills were 44.08 and 67.2. 3) concluding were 37.63 and 56.98. 4) providing further explanations were 29.03 and 43.54 and 5) arranging strategies and tactics were 20.43 and 19.35. Meanwhile, in the experimental class, the pretest and posttest scores for indicators 1) providing simple explanations were 54.83 and 86.55. 2) building basic skills were 59.67 and 84.94. 3) concluding were 49.46 and 84.94. 4) providing further explanations of 27.95 and 65.59 and 5) arranging strategies and tactics of 8.81 and 43.01. From these data we can conclude that there is a significant influence when using STEM-based Problem Based Learning (PBL) in learning if it is seen that the critical thinking indicators used have reached a minimum completion value (KKM) of 75 with details of indicators providing simple explanations, building basic skills, concluding. However, the other 2 indicators, namely providing further explanations and arranging strategies and tactics, students at SMAN 11 Bengkulu City have not reached the expected minimum completion value.

The difference in critical thinking skills between the experimental and control classes can be influenced by several factors, including the use of different instructional models. In the experimental class that implemented the STEM-based Problem Based Learning model, students became more active during the learning process. Because students are directed to real-world problems as a learning context,

they develop critical thinking skills and acquire new knowledge through their own way of solving problems, both individually and in groups. The findings of this study are in line with the research by Wijaya [18] which shows that the problem-based learning model encourages students to be more active, critical, and responsible in the learning process, so that they are trained to produce new ideas. All of this is related to student learning activities. In addition, the positive impact of implementing this problem-based learning model is that students must become independent learners who are able to solve problems independently based on the experiments carried out. Therefore, students participate directly in the problem-solving process, which facilitates their understanding. In addition, with the help of supporting media, namely power points and projectors, students become more enthusiastic in the learning process, because learning becomes more interactive and interesting and makes it easier for students and teachers during the learning process. In addition, the experimental class also uses a simple project technique to create demonstration tools for linear motion kinematics material to increase students' mastery of the material by creating and working on simple project-based worksheets on linear motion kinematics material.

Hypothesis testing in this study was carried out using parametric statistical analysis. Hypothesis testing was carried out using the t-test to determine whether there was an effect of STEM-based Problem Based Learning (PBL) on students' critical thinking skills. According to the results of the t-test listed in table 5, the Sig. (2-tailed) value was obtained at 0.000, which is smaller than the significance level (α) = 0.05. Based on the t-test decision-making criteria, if the significance value is less than 0.05, then there is a difference between the control class and the experimental class. This is in line with research according to [19] stating that the independent sample test (t-test) is one of the parametric tests that functions to see whether or not there is a relationship or an influence from two independent samples. So that the null hypothesis ($H0$) is rejected and the alternative hypothesis (Ha) is accepted. Therefore, it can be concluded that there is an influence of STEM-based Problem Based Learning (PBL) on improving students' critical thinking skills at SMAN 11 Bengkulu City. The findings of this study are in line with previous research by Nurazmi & Hartono Bancong, which showed significant differences in students' critical thinking skills taught using the integrated STEM-PBL approach and have an important role compared to conventional teaching methods.

When the results have been obtained that STEM-based Problem-Based Learning (PBL) significantly improves students' critical thinking skills, the next step is to determine the size of its influence (Effect size). This Effect Size test uses a formula that calculates the average and standard deviation of the experimental class and the control class. The results of the hypothesis test can be found in Table 6 which shows the average and standard deviation of each class, producing a Cohen's d value of 1.04 which is relatively large with $\alpha = 5\%$. Ho is rejected because t count $\geq$ t table ($2.07 \geq 0.05$) and Ha is accepted, so it can be concluded that the effect of STEM-based Problem Based Learning (PBL) on improving critical thinking skills at SMAN 11 Bengkulu City is 2.07 with a large interpretation.

Based on the results of the N-gain test, the N-gain score reached 0.57, which based on the interpretation of the N-gain value, is in the range of $0.7 > (< g >) \geq 0.3$, with a moderate interpretation, indicating a significant increase in students' critical thinking skills. These results suggest that critical thinking skills in the experimental class that implemented STEM-based Problem-Based Learning (PBL) experienced a more significant increase compared to the control class that used conventional learning through the discovery learning model. This aligns with previous research [20] showing that students' critical thinking skills implementing PBL-STEM are higher than those in classes using conventional learning models.

This study has several limitations. First, the research sample was limited to grade XI students of SMA Negeri 11 Kota Bengkulu, so the research results must be generalized carefully. Second, the instrument used to measure critical thinking skills only focused on the cognitive domain. Third, the time available for the study was relatively short, so the intensity of the implementation of STEM-based PBL learning may not have been optimal. Fourth, the material used in this study was only linear motion kinematics material. Therefore, further research is needed with larger samples and materials, more complete instruments, and longer time to confirm the results of this study.

4. Conclusion

Based on the results of the research and data analysis that have been carried out, it can be concluded as follows 1). There is an influence of STEM-based Problem Based Learning (PBL) to improve students' critical thinking skills at SMAN 11 Bengkulu City. This shows a significant influence of 0.000 where this value is smaller than the significance (α) = 0.05. 2). The magnitude of the influence of STEM-based Problem Based Learning (PBL) to improve students' critical thinking skills at SMAN 11 Bengkulu City was obtained by Cohen's d of 2.07 which is categorized as large with α = 5%. So Ho is rejected because t count ≥ t table (2.07 ≥ 0.05) and Ha is accepted, it can be concluded that the magnitude of the influence of STEM-based Problem Based Learning (PBL) to improve critical thinking skills at SMAN 11 Bengkulu City is 1.04 with a large interpretation. 3) Improving students' critical thinking skills in STEM-based Problem Based Learning (PBL) at SMAN 11 Bengkulu City based on the results of the N-gain test, the N-gain score was 0.57 which when viewed based on the interpretation of the N-gain value was at 0.7> (<g>) ≥ 0.3 with a moderate interpretation meaning that there was a moderate increase in students' critical thinking skills. These results indicate that critical thinking skills in the experimental class using STEM-based Problem Based Learning (PBL) have a higher increase compared to the control class using conventional learning using the discovery learning model.

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