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The Effect of Problem Based Learning Model with Teaching at the Right Level Approach to Improve Critical Thinking Ability in Physics

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Abstract. In modern education, teachers act as facilitators who encourage students to learn actively and independently, in line with the demands of 21st century skills such as critical thinking.The study's objectives were to: 1) evaluate how the PBL model with the TaRL approach affected the physics students' critical thinking abilities, 2) ascertain how much the students' critical thinking abilities had improved, and 3) describe how the PBL model with the TaRL approach can improve the critical thinking abilities of physics students. A quasi-experimental design with a non-equivalent control group was used in the study. Two eleventh-grade classes made up the sample: class XI E, which was the control group and used traditional teaching techniques, and class XI D, which was the experimental group and used the PBL model with the TaRL approach. With an average posttest score of 82.68, the experimental group outperformed the control group, which had an average score of 73.26. With a t-test significance value less than 0.001, the results showed a significant difference between the two groups. With an average N-gain score of 0.60 and a Cohen's d value of 1.15, this difference is categorized as substantial with a moderate effect size.

Keywords: problem based learning, teaching at the right level, critical thinking skills.

1. Introduction

The purpose of education is to prepare people for the future. However, many educators have difficulty in implementing the new paradigm, namely changing the way of thinking and approaching the learning process [1].The Independent Curriculum supports learning that is tailored to the individual needs of students by providing flexibility in learning. To develop 21st century skills such as critical thinking, more varied learning methods need to be applied, replacing the dominance of conventional methods such as lectures, discussions, and assignments [2]. The conventional learning model itself tends to focus on the teacher as the main center in the learning process where the teacher has a dominant role in providing material to students, with more limited student involvement [3]. The PBL model applied in this curriculum supports 21st century learning objectives and has been proven effective in developing students' skills, such as critical thinking, collaboration, and communication. This approach helps students solve real problems and apply knowledge in real life [4].

The PBL model was proposed by Howard S. Barrowsin the early 1980s [5]. The PBL model helps students identify problems in real situations, collect information through independent learning strategies, determine the most appropriate solution, and then present the results. By implementing the PBL model, it is expected that students' analytical skills can be improved [6]. The aim of the PBL model is for students to be able to integrate the knowledge they have, mhone skills at a more complex level,encourage an independent attitude, and strengthen self-confidence [7]. The PBL syntax consists of five main stages, namely identifying problems that are relevant to the real-world context, organizing student learning collaboratively, guiding group investigations to find solutions, developing and presenting group work results, and evaluating the problem-solving process and the solutions produced [8].

TaRL is a concept developed by the Pratham Education Foundation in India, led by Banerji. Starting from concerns about the low basic reading skills of students, TaRL highlights the need to improve the effectiveness of the education system. Inspired by Piaget's theory, the approach adapts teaching to the level of cognitive development of students, focusing on their actual abilities rather than just curriculum targets [9]. Apart from Indonesia, several countries such as the United States, Zambia, Botswana, Ghana, Nigeria, Madagascar, Nepal, and Uganda also implement the TaRL approach, although with different terms [10]. The TaRL approach enables personalized learning that motivates students and is in line with the demands of 21st century learning that prioritizes Pancasila values and applies the principles of meaningful learning as advocated by the Understanding by Design (UbD) model [11].

The TaRL approach is implemented by adjusting learning based on student abilities. In TaRL, the main focus of learning is on the potential and learning needs of each student. The TaRL approach consists of four cycles in the learning process. Cycle 1 initial assessment aims to identify students' initial abilities through diagnostic tests and group students into three levels (low, medium, high) while conveying learning objectives. Cycle 2 grouping is carried out by grouping students based on ability levels so that they can discuss and solve problems collaboratively through LKPD. Cycle 3 basic skills pedagog) focuses on strengthening basic physics skills to ensure correct understanding of concepts. Cycle 4 mentoring and monitoring includes reflection, assistance, and monitoring during learning, as well as providing facilities that motivate students to achieve optimal learning outcomes [12].

Combination The TaRL approach and the PBL model have proven to be effective because they complement each other, TaRL ensures that students learn at a level appropriate to their abilities, while PBL presents more complex problem-solving challenges [13]. Critical thinking skills are a means to solve contextual and non-contextual problems [14]. Critical thinking involves the process of considering issues in depth, exploring different approaches and viewpoints, and not taking information from any source at face value without careful evaluation [15]. Critical thinking skills involve the main components, namely statements, problems, and arguments [16]. According to Facione [17], critical thinking involves six interrelated cognitive processes, namely the ability to understand information, analyze data, evaluate arguments, draw conclusions, explain reasons, and control one's own thinking.

The main problem faced at SMAN 6 Kota Bengkulu is the low interest of students in learning, especially due to dependence on gadgets. Based on interviews with Physics teachers, there are differences in the curriculum at this school. Grades X and XI implement the Merdeka Curriculum, while grade XII continues to follow the 2013 Curriculum. Physics learning for grade XI is carried out for 5 hours per week, with the Minimum Competency Completeness (KKM) set at 75. Although there is student interest in Physics lessons, most students are still more focused on using cellphones, so a more interesting learning approach is needed. In addition, the Physics teacher revealed that the TaRL approach has not been implemented and is not yet known at SMAN 6 Kota Bengkulu. Although the PBL model has been used and attempts to connect Physics material to everyday life, students' attitudes and learning styles are still not fully focused on developing critical thinking skills.Physics teachers often face the challenge of finding new ways to make lessons more interesting and encourage active student engagement.

The purpose of this study is to examine how the Teaching at the Right Level (TaRL) approach and the Problem-Based Learning (PBL) model affect physics students' critical thinking abilities. It is inspired by observations of students' disinterest in class and their challenges grasping physics ideas. Explaining how the PBL model and TaRL approach affect students' critical thinking abilities and determining the degree of progress are two of the study's goals. The study also looks at how these methods are used to improve students' critical thinking skills in physics classes at SMAN 6 Bengkulu City.

2. Method

Two groups were used in this study: an experimental group that received treatment and a control group that did not receive treatment. The study used a non-equivalent control group application of two groups [18], O_1 and O_3 serve as pretests to assess critical thinking skills in physics before treatment, O_2 and O_4 serve as posttests after treatment, and X indicates the implementation of the PBL model together with the TaRL approach, as shown in Table 1.

Table 1.Quasi-experimental method non-equivalent control group design.

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3		O_4

This study, which focused on all grade XI students as the population, was conducted at SMAN 6 Bengkulu City. Purposive sampling, which is selecting participants based on predetermined criteria, was used to select a total of 68 students as the research sample [19]. This study used a quasi-experimental method with two groups, namely the experimental class and the control class. The treatment in the experimental class was carried out by combining the PBL model and the TaRL approach. The treatment phases include: (1) initial assessment to group students according to ability level (low, medium, high), (2) group-based learning according to ability level using the Learner Worksheet (LKPD), (3) strengthening basic physics skills through structured discussions focused on improving critical thinking skills, and (4) support for reflection and evaluation of the learning process. The data collected were pretest and posttest scores of critical thinking skills measured using validated essay-based instruments. The essay test instrument used was tested for reliability, discriminating power, and level of difficulty on students of Class XII MIPA A.

Descriptive and inferential statistical techniques were used in the data analysis process. The normality test was used in the inferential analysis to see the distribution of the data. Furthermore, Levene's test was used in the homogeneity of variance test with SPSS software to verify that the data distribution was consistent across groups. Both the experimental and control groups' posttest normality test findings revealed a significant value of sig. count ≥ sig. reference, suggesting that the data had a normal distribution. When there are no discernible variations between the variances of the two groups as determined by the homogeneity of variance test, the homogeneity assumption is met.

Using IBM SPSS software version 30, an Independent Samples t-evaluate was used to evaluate the hypothesis [20]. While the null hypothesis (H_0) contends that there is no effect, the alternative hypothesis (H_a) asserts that the PBL model with the designated strategy enhances students' critical thinking abilities. If Sig < 0.05, H_0 is rejected and H_a is accepted; if Sig > 0.05, H_0 is accepted and H_a is rejected. According to Sugiyono [21]The Pooled Variance equation for the t-test is as in equation (1).

$$\boldsymbol{t} = \frac{\bar{x}_1 - \bar{x}_2}{S_{gab}\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \tag{1}$$

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

When the results obtained show that the PBL model with the TaRL approach has a significant effect, then the next step is to look for the effect size. The following is the equation used to measure the effect size on Cohen's d, namely:

$$Cohen's\ d = \frac{\bar{X}_1 - \bar{X}_2}{\text{Pooled SD}} \tag{3}$$

The results of the calculation of the interpreted Cohen's d value are presented in Table 2 [22].

Table 2. Effect size calculation.

Percentage	Interpretation
0% - 25 %	Very Unfeasible
26 % - 50 %	Not Eligible
51% - 75 %	Eligible
76% - 100 %	Very Viable

Next, the N-Gain calculation is carried out to evaluate the development of students' critical thinking skills after treatment, by comparing the results of the students' pretest and posttest [23]. The N-Gain score is determined by applying the following equation

$$\text{N– Gain} = \frac{Skor_{posttest} - Skor_{pretest}}{Skor_{maksimal} - Skor_{pretest}} \quad (4)$$

The normalized gain is then interpreted based on the criteria for increasing critical thinking skills in physics presented in Table 3.

Table 3. Interpretation of N-gain.

Normalized Gain Value	Interpretation
$0.70 \leq g \leq 100$	Tall
$0.30 \leq g < 0.70$	Medium
$0.00 < g < 0.30$	Low

3. Results and Discussion

3.1. *Research Result*

The two groups taking part in the quasi-experimental study are the experimental group and the control group. Examining the effects of the PBL model combined with the TaRL approach on the growth of physics critical thinking abilities at SMAN 6 Kota Bengkulu was the aim of the study. A nonequivalent control group design was employed in the investigation.

Testing the validity and reliability of the instrument was carried out at the initial stage of the research.to ensure that the questions prepared meet the standards as a valid measuring tool. Three examiners, consisting of two lecturers and a physics teacher, validated 10 questions to assess their quality. Based on the validation results, some questions received an average score of 4, which indicates the "very good" category and can be used without revision. Some other questions obtained an average score of 3 to 3.33, which falls into the "good" category but requires minor revisions. By considering the criteria for question eligibility based on an average score of ≥3.5, the five best questions were selected that were considered relevant and met the criteria for use in testing. After the instrument was deemed feasible, revisions were made according to suggestions from lecturers and physics teachers, and the questions were tested on grade XII students. The results of the analysis showed that there were 7 valid questions with an r-count value of more than 0.4, exceeding the minimum validity limit, so they were considered to have good quality. The overall reliability level of the questions was in the sufficient category, with a reliability value of 0.59. In terms of difficulty level, most of the questions were classified as easy, while some others were in the moderate category.

Of the seven validated questions, five were selected to be used as test instruments. The first question was designed to measure interpretation, which assesses students' ability to understand and explain the information provided. The second question tests evaluation, which measures students' ability to evaluate the relationship between force and acceleration based on the laws of physics. The third question measures inference, which tests students' ability to draw conclusions about the effects of collisions between balls. The fourth question measures analysis, focusing on the application of Newton's laws to everyday situations. Finally, the fifth question measures explanation, which assesses students' ability to explain the relationship between force, acceleration, and friction in the context of vehicle motion.

This selection was based on several considerations, namely the appropriate level of difficulty to cover the variety of student abilities, relevance to learning objectives and critical thinking indicators to be achieved, and practicality of implementation time. The selected questions are expected to be able to provide a more representative picture of student abilities and support the achievement of optimal learning outcomes.

Assessments of critical thinking skills with an emphasis on Newton's law dynamics were used to collect the data for this study. According to Facione's theory, the test instrument was created utilizing

indications of critical thinking ability, and the normality and homogeneity tests were used to analyze the data distribution.

According to the findings of the normality test, both groups' pre- and post-test Kolmogorov-Smirnov values exhibit a normal distribution. The experimental group's significance value for the pre-test is 0.12, while the control group's is 0.07. The post-test significant value for both groups is 0.20, and each value is higher than 0.05, suggesting that the data is roughly regularly distributed. The data variances across the two groups are consistent and satisfy the requirements for additional statistical analysis, according to the homogeneity test, which yields a Levene's Statistic value of 0.53 with a significance greater than 0.05. Table 4 shows the distribution of critical thinking ability scores for both groups based on the findings of the descriptive statistical analysis.

Table 4. Descriptive statistical analysis.

	N	Minimum	Maximum	Mean
Pretest experimental class	34	26	63	48.29
Posttest experimental class	34	68	95	82.68
Pretest control class	34	24	60	40.79
Posttest control class	34	56	90	73.26
Valid N (listwise)	34			

The experimental group's average posttest score (82.68) was greater than the control group's (73.26), according to the descriptive statistical analysis, and both the lowest and highest scores demonstrated notable gains. This illustrates how well the PBL model works in conjunction with the TaRL approach. Using SPSS version 30, an Independent Sample T-test was conducted.

Table 5. Independent sample t-test results.

t-test for Equality of Means								
							95% Confidence Interval of the Difference	
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference		Lower
Critical thinking skills	Equal variances assumed	4.745	66	< ,001	9.41	1.98	5.45	13.37
	Equal variances not assumed	4.745	64.85	< ,001	9.41	1.98	5.45	13.37

According to the t-test results in the preceding table, a significance value (Sig. 2-tailed) of 0.001 < 0.05, indicates a significant difference. As a result, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is supported, indicating that the PBL model with the TaRL method significantly improves the critical thinking abilities of physics students at SMAN 6 Kota Bengkulu. With a Cohen's d value of 1.15, the Effect Size data, which are shown in Table 2, show a high impact and demonstrate the significant development in students' critical thinking abilities. The average scores of the experimental group (82.68) and the control group (73.26), respectively, were compared to arrive at this conclusion.

Table 6. N-gain test results.

	N	***Minimum***	***Maximum***	***Mean***	***Std. Deviation***
N-Gain_Score	68	.24	.91	.60	.14
N-Gain_percent	68	24.07	90.74	60.93	14.05
Valid N (listwise)	68				

According to the N-gain computation results in Table 6, the experimental group's average N-gain value was 0.60, falling into the middle category ($0.30 \leq g < 0.7$).

Table 7. N-gain test results per experimental class indicator.

Critical Thinking Ability Indicators	Pretest	Posttest	N-Gain	Category
Interpretation	64.71	95.29	0.86	High
Analysis	59.41	82.94	0.58	Medium
Evaluation	40.35	74.71	0.57	Medium
Inference	50.29	77.06	0.53	Medium
Explanation	38.82	85.29	0.76	High
Total score obtained			0.66	Medium

The overall N-Gain value of the experimental class, as shown in Table 7, is 0.66 (moderate category). While the indicators for interpretation and explanation are in the high group, the indicators for analysis, evaluation, and inference are in the moderate category.

Table 8. N-gain test results per control class indicator.

Critical Thinking Ability Indicators	Pretest	Posttest	N-Gain	Category
Interpretation	59.41	80.00	0.50	Medium
Analysis	53.53	70.59	0.36	Medium
Evaluation	37.41	75.88	0.61	Medium
Inference	38.24	75.88	0.61	Medium
Explanation	25.29	68.47	0.57	Medium
Total score obtained			0.53	Medium

According to Table 8, the control group's overall N-Gain value is 0.53, placing it in the moderate range. The metrics for evaluation and inference show the most gains. The experimental group shows a greater improvement in critical thinking abilities than the control group, even if all of the control group's indicators stay within the moderate range.

3.2. *Discussion*

In this study, physics learning at SMAN 6 Kota Bengkulu, using the PBL model in the TaRL approach was applied to develop students' critical thinking skills. Before the implementation of these two approaches, conventional learning was still dominant, through lectures and questions and answers as the main way to deliver the material. This learning model is less effective in training students to think critically due to the lack of active involvement. Conventional learning, where teachers deliver up to giving assignments. Students tend to be passive, only receiving information without much active involvement. This approach emphasizes more on theoretical understanding and memorization, and is less supportive of the development of critical thinking skills or the application of knowledge ineveryday context [2].In contrast, PBL invites students to be directly involved in solving relevant problems, working together in groups, and applying physics concepts used in everyday life. Through TaRL, learning is tailored to the level of student ability, providing the right challenges for each group of students. These two approaches support each other to create an optimal learning experience.

The learning process using the TaRL approach begins with an initial assessment to identify students' level of understanding. Based on the assessment results, students are grouped into three categories: groups that need guidance, groups that are quite proficient, and groups that are very proficient. The material is then adjusted to the ability level of each group, with the aim of providing reinforcement for students who need guidance, additional challenges for students who are quite proficient, and more in-depth material for students who are already very proficient. This approach allows for more focused and effective learning. Meanwhile, the PBL model provides students with real problems related to the topics being studied. Students work collaboratively to find solutions, developing critical thinking skills with guidance from teachers who accompany the discussion.

Diverse results from the assessment of students' critical thinking indicators demonstrated the influence of the applied learning paradigm. Students' capacity to understand and articulate the subject was indicated by the indicators for interpretation, analysis, and explanation, indicating that they are capable of making connections between ideas and effectively communicating them. The evaluation and inference markers, on the other hand, fell into the intermediate range, suggesting that although students

are capable of evaluating information, they still need more assistance when it comes to making inferences and critically assessing data. These results demonstrate the effectiveness of the PBL paradigm, which encourages group problem-solving and involves students in lively debates to understand and make sense of difficult ideas. Although more reinforcement in the domains of assessment and inference is required to improve comprehension, the TaRL approach also provides content appropriate for students' level of knowledge.

The study by Nadziroh et al. demonstrates how well the PBL paradigm and the TaRL approach work together to enhance students' critical thinking abilities [24]. PBL develops students' abilities in analysis, interpretation, evaluation, inference, and explanation while allowing them to take part in the solution of actual problems. In the meantime, TaRL adapts instruction to each student's level of proficiency, which helps to significantly raise posttest results and student performance.

According to the study's findings, after using the TaRL-based PBL approach, grade XI SMAN 6 Kota Bengkulu students' critical thinking abilities significantly improved. The t-test (Independent Sample T-test) revealed a significant difference between the experimental and control groups, with a significance value of 0.001 <0.05. With a score of 1.15, the Cohen's d test revealed a considerable impact on students' critical thinking skill development, placing them in the high category.

The experimental class's average N-gain test score was 0.60, indicating a medium-range increase in critical thinking abilities. The findings were superior to those of the control group utilizing traditional methods when the PBL model was used with the TaRL approach. These findings are consistent with Mulyani et al.'s research [25], By combining the PBL model with the TaRL approach, the study also showed that students' critical thinking abilities improved.

4. Conclusion

With a significance value of 0.001 < 0.05, the research findings indicate that students' critical thinking skills at SMAN 6 Bengkulu City were significantly better when the PBL model and TaRL approach were used together. The Cohen's d value of 1.15 further supports the magnitude of this effect and classifies it as significant. The significant improvement in critical thinking skills is also indicated by the N-gain value of 0.60, which is in the medium range.

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