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The Effect of Project-Based Learning With Liveworksheet for Improving Students' Critical Thinking Skills

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Abstract

This study aims to check how the PjBL approach in the e-LKPD method improve students' critical thingking skills at SMA N 1 Batang Kapas. The research used a one-group pretest-posttest design within a quasi-experimental framework. The population consisted of all Grade XI Phase F students at SMA N 1 Batang Kapas who took physics classes. The students' were divided into two experimental groups, selected using purposive sampling, comprising two classes with 60 students in total. Data analysis used descriptive statistics including normality tests, t-tests with a significance threshold of 0.05. Research data was collected through essay tests administered in the form of pretests and posttests. Data analysis examined the KKTP scores, followed by the N-gain test, the normality test, and the hypothesis test. The analysis results showed that the KKTP comparison resulted in an increase in student learning outcomes of 93.33 percent. The n-gain test results of 0.69 and 0.64 were in the moderate category. The normality test results indicated that students' critical thinking skills were normally distributed. Based on the hypothesis test, there was a significant difference between the average pretest and posttest scores of students. Therefore, it can be concluded that the Project-Based Learning-Based e-LKPD is effective in improving students' critical thinking skills.

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1. Introduction

21st century education aims to develop individuals' knowledge, skills, and attitudes through the learning process. In this context, learning focuses on mastering skills relevant to future challenges, often referred to as 21st century skills [1]. There are three components of 21st century skills needed by students, one of which is learning and innovation skills [2]. These skills help students adapt to constantly changing environments, making them successful and competitive in the future. One of these learning and innovation skills is critical thinking. Critical thinking is considered essential to develop in students, as it involves the ability to make trustworthy and responsible decisions [3].

Critical thinking is rational (logical) and reflective thinking that focuses on beliefs and decisions to be made. It is a process that involves applying all knowledge and skills to address new problems, make decisions, evaluate underlying assumptions, and carry out investigations or research using existing data and information to generate the intended conclusions or insights [4]. Critical thinking skills consist of six sub-skills: interpretation, analysis, inference, evaluation, explanation, and self-regulation [5]. Modern education must cultivate students' critical thinking abilities to help them meet the challenges and demands of daily life. These skills can be taught to students during classroom learning.

One of the persistent problems faced by physics teachers in secondary schools is the low students' critical thinking skill level. These abilities are assessed using essay-type test instruments validated and designed based on critical thinking indicators according to [5]. The test was given to 60 students, and their average critical thinking score was in the "sufficient" category, with a mean of 43.4%. Previous studies, particularly in the Pesisir Selatan region, also found students' low levels of critical thinking skills Research [6] showed that students' critical thinking at SMA N 1 Painan remained low, with an average of 55.4%, where students struggled with indicators of building basic skills. Critical thinking skills at SMAN 1 Koto XI Tarusan were also still in the low category [7].

The experiment experience highlighted that the teaching aids provided did not foster active student participation. The worksheets (LKPD) used in schools contained only a few pictures or just text and could not include animations or videos relevant to the learning material that would help students better understand the topic. The teaching materials used by physics teachers have not facilitated students' critical thinking skills. As many as 88% of students want more interesting teaching materials by utilizing technological assistance such as the development of e-LKPD [6], and using of LKPD both in terms of appearance, it is necessary to transform printed LKPD into digital/ electronic LKPD [8]. Interviews with the physics teacher at SMAN 1 Batang Kapas also revealed that the teaching model most often used was the conventional model, in which the teacher explained the material while students simply listened. This is probably one of the reasons for students' low critical thinking skills. This is consistent with the claim that teaching using only lecture methods cannot train students to think critically, resulting in low levels of student critical thinking [9].

Considering the gap between the ideal condition and the reality, the solution is needed to tackle the issue of students' low critical thinking skills. One such solution is implementation of e-LKPD in the teaching process. Transforming LKPD into electronic form changes students' perspective on learning, making it more effective and interactive. e-LKPD is packaged in a practical and engaging way to foster students' interest in physics learning. LKPD also encourages to actively engage in solving everyday problems and develops their critical thinking skills through a variety of activities [10]. Another solution is integrated the learning model that can improve students' critical thinking skills by developing learning models like PjBL. PjBL is an instructional approach that centers on students producing a project as the culmination of their learning experience [11]. PjBL has the potential to enhance students' critical thinking abilities [12]. Applying PjBL can boost students' academic performance and make the learning process more effective [13].

Based on the explanation, one approach to address the problem is using the e-LKPD based of PjBL to aimed at enhancing students critical thinking skills. Implementing the PjBL approach supported by e-LKPD can substantially boost students learning outcomes [14]. A previous research by development of physics e-LKPD based on PjBL has already been carried out [15]. In this study found a validity test score of 0.87 (valid category) and a practicality score of 87.9% (very practical category). Based on the description, the authors will conduct research with the theme of research an effectiveness of project-based learning-based e-lkpd assisted by liveworksheet for developing students' enhancing critical thingking skills in fluid mechanics in senior high schools. This study should help create new and better ways to teach that will help students handle the problems they might face later on.

2. Methods

This research is a type of experimental study. The experimental method is a type of quantitative research that looks at how changes in one factor affect another factor in a controlled environment [16]. This study used a quantitative approach grounded in positivist philosophy. It focuses on specific group or samples, collects data using tools, analyzes the data with numbers or statistics, and tries to prove or disprove certain ideas [17]. The study used a pre-experimental design with a one-group pretest-posttest setup.

The research subjects were 60 11th grade of students' on SMA Negeri 1 Batang Kapas in the 2024/2025 academic year. A pretest-posttest design was used, with the same subjects before and after the treatment. The assessment administered was a written test consisting of essay questions. The essay items were based on indicators developed by [5], The items underwent validation tests, reliability tests, difficulty level analysis, and discrimination index analysis to ensure their appropriateness for use. Initially, a normality test was performed to assess whether the data followed a normal distribution [18]. Second, the Minimum Mastery Criteria (KKTP) were determined. Critical thinking skills were considered effective if at least 80% of students in a class met the KKTP set by the school, which was a score of 80 [19] [20]. Normalized gain (n-gain) Score Test was done. N-gain helps find the difference between the results of a pre-test and post-test, showing how much students learning improved in the class. The N-gain formula was used to measure how much students critical thingking skills improved [21]. Finally, a hypothesis test was conducted. The hypothesis was tested using a *t-test*, which compares the mean scores from the pre-test and post-test [17].

3. Results and Discussion

This study collected data by evaluating students critical thingking abilities using the minimum mastery criteria (KKTP) scores from both sample groups. The comparison between the KKTP results and the students' critical thinking skills is show in Table 1.

Table 1. Comparison of KKTP and Students' Critical Thinking Skills

Student Learning Outcomes in Critical Thinking Skills	*Experiment 1*				*Experiment 2*			
	Pretest		*Posttest*		*Pretest*		*Posttest*	
	Count	%	Count	%	Count	%	Count	%
Completed (≥80)	1	3,33%	28	93,33%	2	6,67%	28	93,33%
Not yet completed (<80)	29	96,67%	2	6,67%	28	93,33%	2	6,67%
Count	30	100%	30	100%	30	100%	30	100%

Table 1 shows that in experimental groups 1 and 2, ≥ 80% of students achieved mastery, meeting the school's KKTP score requirement of 80, with completion rates of 93.33% and 96.67%, respectively. A class is said to have reached mastery (classical mastery) when at least ≥ 75% of its students meet the KKTP score that the school has set. Critical thinking skills were assessed using the N-gain score. Pretest and posttest essay scores for both experimental classes are shown in Table 2.

Table 2. Results of the N-gain Score Test of Critical Thinking Skills

Class	*N-Gain*	Classification
Experiment 1	0,69	Moderately
Experiment 2	0,64	Moderately

According to Table 2, the n-gain test results showed moderate improvement in students' scores that students' scores (n-gain = 0.69 and 0.64). A normality test was performed to check if the sample is came from a normally distributed population. The test results, showing L_o and Ltable values at the 0.05 significance level, are presented in Table 3.

Table 3. Results of the Normality Test of Critical Thinking Skills

	Class	α	N	L_0	L_t	Distribution
Critical Thinking Results	*Pre-Test* (Experiment 1)	0,05	30	0,159	0,1617	Ordinary
	Post-Test (Experiment 1)		30	0,1609	0,1617	Ordinary
	Pre-Test (Experiment 2)		30	0,159	0,1617	Ordinary
	Post-Test (Experiment 2)		30	0,1583	0,1617	Ordinary

Based on Table 3 it shows that students' critical thinking skills are normally distributed. It is shown that the second class sample has $L_o < L_{table}$ at a significance level of 0.05, namely experimental class 1 (0.1609 < 0.1617) and experimental class 2 (0.1583 < 0.1617). The normality test results indicate both samples are normally distributed. Thus, we can proceed with a statistical test, specifically a *t-test*, to compare the critical thinking skills of both sample classes, as show in Table 4.

Table 4. Results of the Hypothesis Test for Second Class Critical Thinking Skills

Class	N	α	t_h	t_t	Information
Experiment 1	30	0.05	22.64	1.98	A significant difference exists
Experiment 2	30		21.15	1.98	A significant difference exists

Based on Table 4, it shows that the experimental class 1 t_{count} values is 22.64 and t_{table} = 1.98, and for experimental class 2 t_{count} values is 21.15 and t_{table} is 1.98, from the two data above the criteria for accepting H_1if ($t_{count} > t_{table}$) in this study t_{count} is greater than t_{table} namely (22.64 > 1.98) and (21.15 > 1.98), from the pretest and posttest hypothesis values if the t_{count} values > t_{table} then H_0 is rejected & H_1 is accepted. The *t-test* analysis show that $t_{count} > t_{table}$, indicating a significant difference between students' pretest and posttest scores. At the conclusion of the learning process, critical thinking skills were evaluated using six indicators: interpretation (K1), analysis (K2), inference (K3), evaluation (K4), explanation (K5), and self-regulation (K6). To see the impact of using PjBL-Based E-LKPD on students' critical thingking skills, refer to Figure 1.

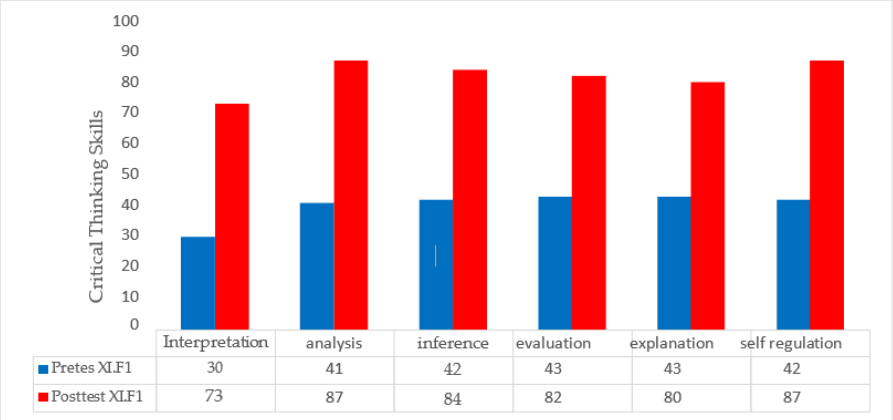

Figure 1. Average Critical Thinking Scores for XI.F1

According to Figure 1, the mean scores of critical thinking for XI.F1 in the pretest showed that evaluation and explanation were the highest indicators, while interpretation was the lowest. In the posttest data, analysis and self-regulation were the highest indicators, and interpretation remained thelowest. Based on Figure 2, in XI.F2's pretest, analysis was the highest-scoring indicator, while interpretation was the lowest. In the posttest, self-regulation was the highest, and interpretation remained the lowest. Based on the data analysis in Figure 1 and Figure 2, the average scores for students' critical thinking skills per indicator can be described. The interpretation indicator for both classes scored 73% and 74%, respectively, with average scores in the critical category. For this K1 question, students' are required to understand and express the meaning of a problem. Second, the analysis indicator scored 87% and 85%, both in the critical category.

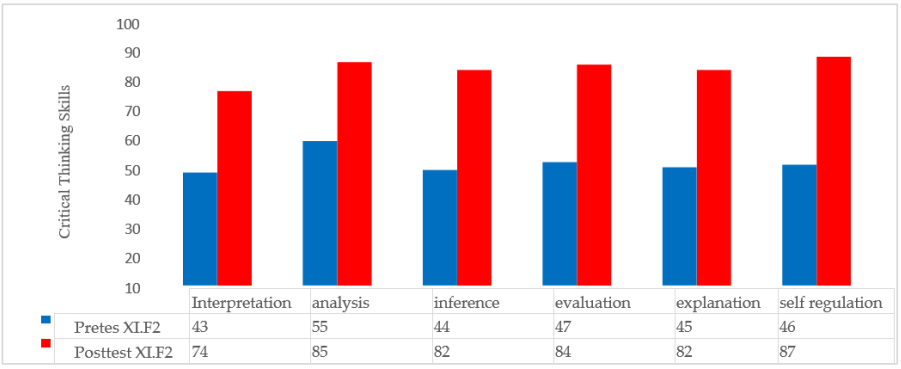

Figure 2. Average Critical Thinking Scores for XI.F2

Students' are required to have the ability to analyze statements, questions, and concepts. Third, the inference indicator scored 84% and 82%, both in the critical category. In K3, students are required to be able to infer and draw conclusions. Fourth, the evaluation indicator scored 82% and 84%, respectively. In K4, students were able to assess the quality of arguments. Fifth, the explanation indicator scored 80% and 82%, respectively. In K5, students were able to state the results of their reasoning. Finally, the regulation indicator scored 87% and 85%, respectively, with the same score. In K6, students were able to control their own cognitive activity. The average scores per indicator for experimental classes 1 and 2, show and improvement in students' critical thingking skills from pretest to posttest, with posttest scores exceeding pretest scores.

The first syntax of PjBL is defining a driving question. Learning begins with an essential question that assigns tasks to students [22]. At this stage, students identify problems related to Pascal's law, such as events involving goods in Lazada's warehouse and natural disasters like landslides. Students identify statements and questions in the e-LKPD about what they understand from the video. This question is shown in Figure 3 below.

Figure 3. Average Critical Thinking Questions

Based on Figure 3, students' answers were appropriate in understanding the video. They explained that they understood it as showing how to move goods in Lazada's storage warehouse. This response contributed to the enhancement of students' critical thinking skills. This stage trains students in the interpretation aspect of critical thinking by helping them categorize problems into clear, meaningful concepts [23]. Directly working on and discovering concepts themselves leads to better understanding and longer retention [24].

The second syntax is project design based on the issues identified in the first step. At this stage, students plan a project related to Pascal's law. The teacher ensures that each group member selects and understands the project creation process. [25]. The critical thinking indicator developed in this stage is inference (drawing conclusions). In groups, students discuss and decide on the tools and materials they will use to build a simple device applying Pascal's law. This is shown in Figure 4**.**

Figure 4. Explanation of the Second Syntax, Third Syntax, and Four Syntax

The answers given by students were consistent with Pascal's law: they designed a simple hydraulic pump. Its operation involved pressing small and large syringes alternately to feel the pressure differences. From their responses, students were able to draw conclusions about the simple tool to be made. This process of concluding supports the development of critical thinking. Critical thinkers can select and test solutions, think openly, recognize and evaluate assumptions, and communicate effectively with others to solve complex problems [26]. The third syntax is scheduling.

Teachers and students collaborate to establish a project completion timeline [27]. Students implement their project plan as assigned, working within the agreed timeframe. Their answers are shown in Figure 4. Students could determine the steps and schedule to complete the project. After setting deadlines, they planned steps and scheduled their implementation. At this stage, students had to think critically about how to plan the appropriate stages to finish the project on time. Critical thinking involves making rational decisions about what is believed [28]. The fourth syntax is monitoring project progress, which is done by facilitating students at each stage [29]. Students filled out an activity monitoring table during the project and answered e-LKPD questions such as "*What difficulties did you experience during this project?*" The teacher acted as a mentor throughout these activities. Students' answers are shown in Figure 4.

The students' responses showed improved critical thinking skills, as they tried to evaluate their project by explaining that they had gathered information about Pascal's principle and its application in a simple hydraulic system. Critical thinking involves analyzing and evaluating information to determine whether it can be used to draw valid conclusions [30]. The fifth syntax is testing results. Students were asked randomly to present their answers in front of the class. When students work in teams, they develop a range of skills [31], This step promotes critical thinking as non-presenting groups ask questions of those presenting. Students' answers are shown in Figure 5.

Figure 5. Explanation of the Fifth and Sixth Syntax

In this stage, students were asked to write a project report. Their answers aligned with Pascal's law concepts they created a report on the simple hydraulic pump project. This stage trains students' evaluation abilities as they present the results of their investigation. The product of their inquiry is then shared [32]. Students can evaluate peers' statements, suggest alternative answers, and assess information sources during discussion. The feedback from presentations allows students improve their ability to think critically about evaluation aspects [33].

The sixth syntax is evaluating experience. Reflecting on learning experiences encourages students to share what they learned and gauge their understanding of the project [34]. Together with the teacher, students evaluate the project results and summarize the topic on Pascal's law. This stage can enhance critical thinking skills because the questions cover critical thinking aspects such as analysis. Students were asked to compare the cross sectional areas of plunger 1 and plunger 2. Their answers are shown in Figure 5. The answers aligned with Pascal's law concepts. In answering the analysis question, students demonstrated an understanding that improves their critical thinking skills. This reflection stage includes teacher clarification to help students solidify their understanding and develop their critical thinking abilities.

PjBL promotes critical thinking and skill development, including analysis, evaluating, and synthesizing information. In PjBL, students engage in projects grounded in real world problems, requiring them to analyze various information sources to find appropriate solutions. This approach also increases student participation in learning, motivating them to think critically and I mprove their skills. Consistent with this view, PjBL develops not only students' cognitive skills but also their affective and psychomotor skills through problem-solving and collaborative group work [35]. The constructivist and inquiry processes inherent in PjBL are inseparable from students' perspectives and thinking [36].

Thus, Project-Based Learning can improve students' critical thinking and collaborative abilities, as it depends on students' skills in working together to achieve planned goals [37].

Based on the analysis results above, it can be said that PjBL has shown to help students develop their critical thinking abilities. This is evident through the stages of defining driving questions, designing projects, scheduling, Tracking project progress, assessing outcomes, and reflecting on experiences are integral parts of the PjBL-based E-LKPD. Project-Based Learning significantly enhances students' creativity and academic achievements [38]. Incorporating Project Based Learning into the educational setting is crucial for helping students build important thinking skills and encouraging them to want to learn more [39].

4. Conclusion

The results showed a signifivant increase in students' critical thingking skills after using PjBL e-LKPD. The KKTP, comparison revealed a 93.33% increase in learning outcomes. The N-gain test indicated a moderate improvement 0.69 and 0.64. The data was normally distributed, and hypothesis testing confirmed a significant difference between pretest and posttest scores. So, can conclude that using e-LKPD with project based learning really helps tudents think more critically.

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