

## The Effect of Problem-Based Learning Assisted by Wizer.Me e-LKPD on High School Students' Critical Thinking Skills in Renewable Energy

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### Abstract

*This study aimed to investigate the effect of Problem-Based Learning (PBL) assisted by Wizer.me e-LKPD on high school students' critical thinking skills in renewable energy learning. A quasi-experimental study employing a pretest–posttest control group design was conducted with 66 tenth-grade students selected through purposive sampling, with one class serving as the experimental group and another as the control group. Data were collected using a critical thinking skills test developed based on Ennis's critical thinking indicators and analyzed using descriptive statistics, the Mann–Whitney U test, normalized gain (N-gain), and effect size analysis. The results showed that students who learned through Wizer.me-assisted PBL achieved higher critical thinking skills than those who received conventional instruction. The experimental group obtained a higher mean posttest score (77.80) than the control group (49.02), with an N-gain of 0.71 (high category) compared to 0.32 (moderate category) in the control group. The Mann–Whitney U test revealed a significant difference between the two groups ( $p < 0.001$ ), while the effect size value of 0.66 indicated a strong effect. These findings indicate that Wizer.me-assisted PBL effectively improves students' critical thinking skills, highlighting the potential of interactive e-LKPD to foster higher-order thinking in physics learning, particularly on renewable energy topics.*

**Keywords:** Problem-Based Learning, e-LKPD Wizer.Me, Critical Thinking, Renewable Energy.

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## 1. INTRODUCTION

Modern education emphasizes the development of 21st-century skills, commonly known as the 4Cs: communication, collaboration, creativity, and critical thinking (Hidayati, 2019). Among these competencies, critical thinking is considered one of the most essential skills, particularly in physics education. Physics learning involves more than mastering scientific concepts and principles; it also requires students to engage in scientific reasoning through analyzing phenomena, interpreting data, evaluating evidence, drawing conclusions, and solving problems systematically. Such competencies are fundamental for developing deep conceptual understanding and applying physics knowledge to real-world situations (Bao & Koenig, 2019). Critical thinking is a higher-order thinking skill that enables students to analyze, evaluate, and relate information to contextual problems (Sinaga et al., 2024). According to Ennis (2011), critical thinking consists of several indicators, including providing simple explanations, building basic skills, making inferences, providing further explanations, and determining strategies and tactics. However, previous studies and international assessment results indicate that Indonesian students' critical thinking skills remain relatively low. This condition is reflected in the 2022 Programme for International Student Assessment (PISA) results, which showed that most Indonesian students performed at lower proficiency levels (OECD, 2023). Although PISA primarily measures scientific, mathematical, and reading literacy, many of its assessment tasks require students to analyze information, evaluate evidence, and solve complex problems, which are fundamental components of critical thinking. Therefore, the PISA results provide an important indication of the need to strengthen students' critical thinking skills in science and physics learning.

Additionally, low critical thinking skills have also been reported in Bengkulu. Research conducted by Nainggolan et al. (2023) revealed that students' average critical thinking achievement reached only 48%, indicating that their critical thinking skills remain underdeveloped. Furthermore, interviews with physics teachers at SMA Negeri 7 Bengkulu Selatan revealed several challenges in implementing physics learning, including variations in students' abilities, limited instructional time, and low student engagement during classroom activities. Many students still tend to be passive and rely on their peers when solving problems, resulting in difficulties in analyzing information, evaluating arguments, and drawing conclusions based on evidence. One possible factor contributing to this condition is the limited use of interactive learning resources that can effectively support students' engagement in problem-solving activities. Although Problem-Based Learning has been implemented, its effectiveness may be constrained when not supported by learning media that facilitate active participation and independent inquiry. Therefore, the integration of Wizer.me e-LKPD with Problem-Based Learning is expected to provide a more interactive learning environment that can support the development of students' critical thinking skills.

One alternative learning medium that can support the development of critical thinking skills is the Electronic Student Worksheet (e-LKPD) integrated with the Wizer.me platform. As an interactive digital learning tool, Wizer.me enables students to engage with learning materials, respond to questions, receive feedback, and collaborate in a structured online environment. This aligns with constructivist learning theory, which emphasizes that knowledge is actively constructed by learners through interaction, exploration, and reflection rather than passively received from teachers (Karwasz & Wyborska, 2023). Furthermore, digital learning environments such as Wizer.me provide opportunities for students to access learning resources, organize information, and express their ideas more actively, thereby supporting higher-order thinking processes (Susanti et al., 2025). To maximize the benefits of digital learning media, Wizer.me e-LKPD can be integrated with the Problem-Based Learning (PBL) model. PBL was selected because it is specifically designed to engage students in solving authentic problems through investigation, discussion, and reflection, which are essential processes for developing critical thinking skills. In physics learning, PBL is particularly relevant because many physics concepts require students to analyze phenomena, evaluate evidence, formulate explanations, and solve contextual problems (Agustin et al., 2026). These learning activities are closely aligned with Ennis's critical thinking indicators, including providing simple explanations, building basic skills, making inferences, providing further explanations, and determining strategies and tactics. The integration of Wizer.me e-LKPD and PBL is expected to create an interactive and student-centered learning environment that facilitates active participation, problem-solving, and scientific reasoning. Previous studies have also reported positive findings regarding both approaches. Amanda & Alfiandra (2025) found that the use of Wizer.me-based e-LKPD could improve students' critical thinking skills, while (Ardianti et al., 2021) reported that PBL effectively promotes active learning and supports students in solving real-world problems.

Previous research indicates that the use of e-LKPD and The PBL paradigm can help students become more adept at critical thinking. A study carried out by (Sari et al., 2022) demonstrates that *PBL* e-LKPD can moderately improve students' HOTS. Another study by (Riadah et al., 2024) Using PBL-based worksheets has a substantial influence on critical thinking skills students, with an N-gain score in the high range. That implies that improving students' critical thinking abilities depends critically on both the learning model and the learning medium.

Previous studies have investigated the implementation of Problem-Based Learning (PBL), Wizer.me-based e-LKPD, renewable energy learning, and students' critical thinking skills. However, these studies have generally examined these variables separately. Research on Wizer.me-based e-LKPD has primarily focused on its effectiveness as a digital learning medium, while studies on PBL have emphasized its role in promoting active learning and problem-solving skills. Few studies have integrated Wizer.me e-LKPD with the PBL model to improve students' critical thinking skills, particularly in renewable energy learning. Unlike conventional worksheets, Wizer.me-based e-LKPD provides interactive features such as multimedia integration, immediate feedback, and digital accessibility, which can increase student engagement and support active learning processes. These characteristics make Wizer.me a promising platform for facilitating critical thinking development when integrated with PBL. The novelty of this study lies in the integration of Wizer.me e-LKPD and the PBL model to enhance students' critical thinking skills in renewable energy learning based on

Ennis's critical thinking indicators. Therefore, this study aims to investigate the effect of Wizer.me-assisted Problem-Based Learning on high school students' critical thinking skills in renewable energy learning. The findings are expected to provide empirical evidence regarding the effectiveness of integrating digital learning media with PBL and serve as a reference for physics teachers in selecting innovative learning strategies that promote critical thinking skills.

## 2. METHODS

A quasi-experimental method employing a nonequivalent control group design was used in this study. This design was chosen because random assignment of students was not feasible in the school setting, as the existing classes had already been established. Therefore, intact classes were assigned as the experimental and control groups to examine the effect of the treatment under actual classroom conditions (Sugiyono, 2013 ; Nurhaedah et al., 2022). It consisted of one one control class and one experimental class. Before the intervention ( $X$ ), the experimental and control groups took the pre-test ( $O_1$  and  $O_3$ ), whereas the post-test ( $O_2$  and  $O_4$ ) was administered after the treatment ( $X$ ). The PBL model was applied to the experimental class with assistance from the Wizer.me e-LKPD ( $X_1$ ). In contrast, the control group employed the traditional Problem-Based Learning approach without the assistance of the Wizer.me e-LKPD ( $X_2$ ). Thus, both groups received PBL-based learning, but differed in the media used. This research design is shown in Table 1.

**Table 1.** Nonequivalent Control Group Design

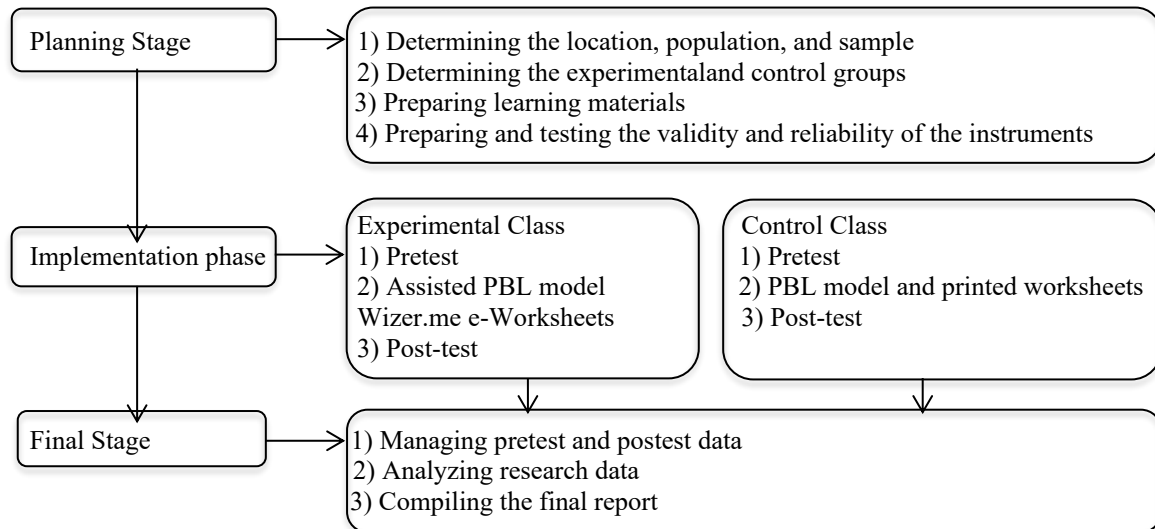
Class	Pretest	Treatment	Posttest
Experiment	$O_1$	$X_1$	$O_2$
Control	$O_3$	$X_2$	$O_4$

This study was conducted at SMA Negeri 7 Bengkulu Selatan. The school was selected as the research site because it has implemented the Merdeka Curriculum, which supports the application of student-centered learning models such as Problem-Based Learning (PBL). In addition, the school provides tablet devices that facilitate the use of digital learning media, including Wizer.me e-LKPD. The population consisted of all tenth-grade students, comprising seven classes (X A–X G) with a total of 234 students. Each class received three hours of physics instruction per week. Tenth-grade students were selected because renewable energy is included in the Grade X physics curriculum. The sample consisted of Class X A and Class X B, selected through purposive sampling based on several criteria aligned with the research objectives (Sugiyono, 2013; Ramadani et al., 2025). The selection criteria included: (1) an equal number of students in each class (33 students per class), (2) comparable learning schedules, and (3) students' readiness to participate in the learning process. The comparability of the two groups was supported by the pretest results, in which the experimental group obtained a mean score of 26.591 and the control group obtained a mean score of 25.455. The small difference between these scores indicates that students in both classes had relatively similar initial critical thinking abilities before the treatment was implemented. Following the sample selection process, Class X A was assigned as the experimental group and received PBL assisted by Wizer.me e-LKPD, while Class X B served as the control group and learned through PBL supported by printed worksheets and textbooks.

The research procedure was carried out through several systematic stages, including the planning, implementation, and final stages, as shown in Figure 1. In the planning stage, the researcher determined the location, population, and sample of the study, identified the control and experimental groups, and prepared the learning materials and research instruments. Prior to implementation, the instruments were subjected to validity testing using Pearson Product Moment correlation and reliability testing using Cronbach's Alpha through SPSS analysis to ensure their suitability for data collection.

During the implementation phase, physics instruction on renewable energy was conducted over three meetings, totaling nine class periods. Prior to the intervention, both classes were administered a pretest to assess students' initial critical thinking skills. Subsequently, instruction in the experimental class was carried out using the Problem-Based Learning (PBL) model supported by Wizer.me e-LKPD, which consisted of the following stages: problem orientation, group formation, investigation, solution

development, presentation, and reflection. Students actively worked in groups to solve problems presented through the Wizer.me e-LKPD, while the teacher acted as a facilitator throughout the learning process. Meanwhile, the control class received instruction using the same PBL model supported by school textbooks and conventional printed worksheets containing the same learning objectives and renewable energy content as those used in the experimental class. Students completed the activities manually under teacher guidance while still following the stages of the PBL model, but without the support of interactive digital features provided by the Wizer.me e-LKPD.



**Figure 1.** Research Procedure

After the learning intervention was completed, both classes were administered a posttest to measure the improvement in students' critical thinking skills. In the final stage, the pretest and posttest data were processed and analyzed. The results of the analysis were then compiled into a research report as the final outcome of the study.

Ten items on a critical thinking essay exam based on Ennis's five indicators—giving a brief explanation, developing fundamental abilities, drawing conclusions, offering more explanations, and formulating plans and tactics—were used as the research tool. Each indicator was represented by two essay questions with contextual stimuli related to renewable energy, so that every dimension of critical thinking was explicitly measured. For example, one item asked students to explain contrasting arguments about PLTU and solar panels (simple explanation), another required analysis of energy transformation in a small-scale hydropower observation report (basic skills), while other items guided students to conclude causes of electricity blackouts (conclusion), evaluate arguments on fossil vs renewable energy (further explanation), and design alternative energy solutions for a village (strategy and tactics). Three specialists confirmed the instrument's content (two physics education lecturers and one physics teacher). Revisions were made in response to the validators' comments, particularly to the presentation of the stimuli to better align with the research context. Subsequently, the instrument was pilot-tested on 30 students who had studied renewable energy material, and an evaluation of empirical validity was conducted. The correlation coefficient of the Pearson product-moment was used to evaluate empirical veracity. Item quality was evaluated based on discrimination power (DP) and difficulty level (DL), Cronbach's Alpha was employed to evaluate the instrument's dependability. A test item is considered good if it demonstrates significant validity at  $\alpha = 0.05$ , high internal consistency (reliability coefficient approaching 1.00),  $0.25 \leq P \leq 0.75$  is the moderate difficulty index, and satisfactory discrimination power within an acceptable range (Saputri et al., 2024). Based on the results of the empirical testing, five items met all predetermined criteria for validity, reliability, discrimination power, and difficulty level and were therefore selected for use in the pretest and posttest. The selected items represented all five critical thinking indicators proposed by Ennis, namely giving simple explanations, building basic skills, drawing conclusions, providing further explanations, and setting strategies and tactics, with one item representing each indicator. This selection ensured that all dimensions of critical thinking were measured while maintaining the use of items with satisfactory

psychometric properties. Reliability was confirmed using Cronbach's Alpha ( $\alpha = 0.864$ ), which was classified as high, while all selected items demonstrated acceptable validity, difficulty, and discrimination indices. According to the instrument analysis results, among the ten test items evaluated, Five items met the criteria for validity, discriminant power (DP), difficulty level (DL), and reliability and were therefore selected as the final research instrument. The results of the investigation into the empirical validity of the instrument are presented in Table 2.

**Table 2.** Results of the Empirical Validity Analysis of the Instrument

Dimension Critical Thinking	Item Number	Item Validation			
		Coefficient r (criteria)	p-value (criteria)	DP (criteria)	TK (criteria)
Providing simple explanation	2a	0.388* (low)	0.034 (valid)	0.294 (adequate)	0.332 (moderate)
	2b	0.498** (enough)	0.005 (valid)	0.394 (fair)	0.6 (moderate)
Developing fundamental abilities	4a	0.613** (high)	<0.001 (valid)	0.569 (good)	0.207 (difficult)
	4b	0.429* (moderate)	0.018 (valid)	0.329 (good)	0.557 (moderate)
Summarizing	6a	0.678** (high)	<0.001 (valid)	0.610 (good)	0.632 (moderate)
	6b	0.772** (high)	<0.001 (valid)	0.727 (very good)	0.4 (moderate)
Giving additional explanations	8a	0.661** (high)	<0.001 (valid)	0.613 (good)	0.167 (difficult)
	8b	0.551** (moderate)	0.002 (valid)	0.483 (good)	0.207 (difficult)
Developing techniques and strategies	9a	0.646** (high)	<0.001 (valid)	0.587 (good)	0.2575 (moderate)
	9b	0.677** (high)	<0.001 (valid)	0.627 (good)	0.31 (moderate)

Note: \*\*  $p < 0.01$ ; \*  $p < 0.05$

Considering the findings of the investigation of empirical validity, all test items showed correlation coefficients greater than the table r value and were therefore deemed valid. Each item represents one indicator of critical thinking ability according to Ennis. Additionally, The Cronbach's Alpha value for the dependability test was 0.864. classified as high. Thus, The tool is thought to be trustworthy and appropriate for use in research data collection tool.

Descriptive and inferential statistics were employed to evaluate data collected from pretest and posttest findings for the experimental and control groups about the critical thinking skills of 10th grade students. The pretest and posttest data were processed using descriptive statistics to find the maximum, minimum, mean, and standard deviation of students' critical thinking skills. Next, inferential statistics were applied as an initial step before hypothesis testing, beginning with tests of normality and homogeneity. If  $p > 0.05$ , the data's significance level were deemed homogenous and regularly distributed.(Sonjaya et al., 2025). Data analysis employed descriptive statistics, normality and homogeneity tests, and the nonparametric Mann-Whitney U test due to non-normal distribution of posttest scores. Effect size and normalized gain (N-gain) were calculated to provide a more comprehensive measure of treatment effectiveness.

Additionally, the effect size by Peres (2026) was calculated to determine the extent of the results of using the PBL model with Wizer's assistance.e-LKPD on pupils' capacity for critical thought using the following Equation 1:

$$r = \frac{Z}{\sqrt{N}}$$

(1)

Explanation

r: Effect size

Z: Nonparametric test result

$\sqrt{N}$ : Sample size

Where r indicates the effect size, Z is the nonparametric test value, and The sample size, N. The r value is then interpreted based on Cohen’s recommendations. These criteria classify the absolute value of r into several categories, as seen in Table 3.

**Table 3. *Effect Size (r) Interpretation Criteria***

r Value	Category
$0.1 \leq r < 0.3$	Small
$0.3 \leq r < 0.5$	Medium
$g \geq 0.5$	Large/Tall

Source: (Peres, 2026)

In addition to calculating the effect size, normalized gain Additionally, the relative development in (N-gain) analysis is used to evaluate pupils' critical thinking skills based on a comparison between pretest and posttest scores, thereby providing a more accurate picture of the effectiveness of physics learning using the *PBL* model supported by the Wizer.me e-LKPD. The N-gain is then interpreted using the standards given in Table 4.

**Table 4. *N-gain Interpretation Criteria***

N-gain Value (g)	Category
$g < 30$	Low
$0.30 \leq g < 0.70$	Medium
$g \geq 70$	Large/Tall

Source: (Wahab et al., 2021)

### 3. RESULT AND DISCUSSION

Table 5 displays the findings of the descriptive study of the pupils in the experimental and control groups' capacity for critical thought.

**Table 5. Descriptive Analysis (n = 33)**

Test	Group	Min	Max	Mean	Standard Deviation
Pre	Control	2.5	65.0	25.455	14.888
	Experimental	2.5	67.5	26.591	16.616
Post	Control	27.5	82.5	49.015	16.874
	Experimental	40.0	95.0	77.803	16.414

Based on Table 5, the initial average critical thinking ability in both groups was relatively similar. After the treatment was administered, the experimental class's posttest average was higher than the control class's. Additionally, the minimum score for the experimental class rose more than that of the control class.

The normalization of critical thinking ability data was analyzed using a significance level of  $\alpha = 0.05$  (Quraissy, 2020). The test results showed that the pretest data for both groups had a normal distribution ( $p > 0.05$ ), whereas the posttest data did not have a normal distribution ( $p < 0.05$ ). Therefore, the analysis continued with a test of homogeneity of variances using a significance level of  $\alpha = 0.05$  (Usmadi, 2020). Since the post-test data were not normally distributed, the homogeneity test

was conducted using the median-based Levene's test (Isnawan, 2020). The results showed a significance value of 0.416 ( $> 0.05$ ), indicating that the variances of the two groups could be considered homogeneous. Thus, although the normality assumption was not met, the data still met the homogeneity requirement. Therefore, the analysis of differences in critical thinking ability between the experimental and control classes proceeded using the nonparametric Mann–Whitney U test as an alternative to the independent t-test (Mashuri, 2022). The results of the Mann–Whitney U test are presented in Table 6.

**Table 6.** Results of the Mann-Whitney U Test

	Sig.
Mann-Whitney U	129.000
Wilcoxon W	690.000
Z	-5.340
Asymp. Sig. (2-tailed)	<0.001

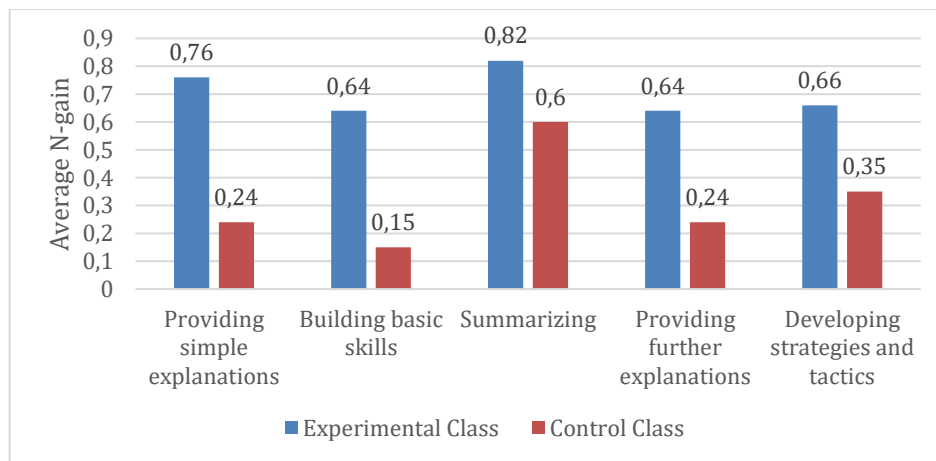
Based on The p-value was less than 0.001, or less than 0.05, according to the Mann-Whitney U test findings of the hypothesis test. These findings show a significant difference in the critical thinking skills of the students in the experimental and control groups. As a consequence, the experimental class's training produced better outcomes than the control group. The extent of the therapy effect was then analyzed using the effect size formula in Equation 1, resulting with a 0.66 effect size, which falls into the high category (Peres, 2026). This result indicates that the observed improvement was not only statistically significant but also educationally meaningful. The high effect size suggests that the integration of Wizer.me e-LKPD into the PBL model provided substantial support for students in identifying problems, analyzing information, evaluating evidence, and drawing conclusions during the learning process. Therefore, the improvement in students' critical thinking skills can be considered practically important for physics learning, particularly in the context of renewable energy topics that require analytical and evidence-based reasoning.

Furthermore, the improvement in students' critical thinking skills was analyzed using the normalized gain (N-gain) score (Wahab et al., 2021). The results of the N-gain analysis for the experimental and control classes are presented in Table 7.

**Tabel 7.** N-gain Results

Group	N-gain	Category
Experimental	0.71	High
Control	0.32	Moderate

Table 9 shows that the experimental class was in the high group with an N-gain score of 0.71, whereas the control class was in the moderate group with a score of 0.32. These results demonstrate that students in the experimental class outperformed those in the control group in developing their critical thinking skills. Further analysis was conducted on each critical thinking ability indicator to compare the improvement in each indicator across both classes. Figure 2 displays the analysis's findings.



**Figure 2.** N-gain analysis diagram by indicator

Based on Figure 2, all critical thinking ability indicators revealed a greater rise compared to the control group in the experimental class. The “drawing conclusions” indicator achieved the highest N-gain value in the experimental class (0.82), whereas the control class achieved an N-gain value of 0.60. The significant improvement in the “drawing conclusions” indicator indicates that the implementation of the *PBL* model supported by the Wizer.me e-LKPD effectively helped students draw conclusions through discussion activities, problem analysis, and solving contextual problems during instruction. Meanwhile, the indicator for "building basic skills" demonstrated the least amount of development in the control group with a 0.15 N-gain value. This is likely because students still struggled to understand basic concepts and independently identify key information during learning using printed worksheets. The differences in improvement across each indicator suggest variations in students’ critical thinking performance influenced by the indicators’ characteristics, the complexity of the problems, and the implemented learning activities. Overall, these findings demonstrate that the integration of Wizer.me e-LKPD into the *PBL* framework provides stronger support for the development of students’ critical thinking skills compared to the use of printed worksheets.

The higher improvement in students’ critical thinking skills can also be associated with the characteristics of renewable energy topics used in this study. Renewable energy content contains contextual issues closely related to students’ daily lives, such as solar energy utilization, hydropower generation, biomass processing, and environmental sustainability. These topics require students to analyze real-world situations, evaluate alternative solutions, and make decisions based on scientific evidence and reasoning. Therefore, the characteristics of renewable energy material are closely aligned with the inquiry, investigation, and problem-solving processes emphasized in the Problem-Based Learning model. This alignment provides opportunities for students to actively construct knowledge while developing critical thinking skills through the analysis of authentic problems.

The process of learning throughout the implementation of the *PBL* model supported by the Wizer.me e-worksheets is directly linked to the greater improvement in critical thinking skills observed in the experimental class. Learning began with the presentation of contextual problems related to students’ daily lives, after which students worked in groups using the Wizer.me e-worksheets accessed via school tablets. During the learning process, students in the experimental class were observed to be more active in identifying problems, discussing ideas, and analyzing information available in the Wizer.me e-LKPD. The interactive features on Wizer.me also contributed to improvements in every measure of critical thinking abilities. Contextual videos and visual representations presented in the Wizer.me e-LKPD helped students identify the main problem and build a foundational understanding before conducting further analysis. Additionally, the progressively structured questions in the e-LKPD helped students think systematically, from identifying problems and evaluating information to drawing conclusions. Thus, the use of interactive features on Wizer.me not only increased student engagement during learning but also helps train the critical thinking process in a more focused manner. The use of Wizer.me e-LKPD via school tablets helped students follow the learning stages more systematically compared to the control class that used printed LKPDs. This is evident from student engagement during group discussions, where most students actively shared their opinions and answered questions available

on the Wizer.me e-LKPD, as shown in Figure 3. Conversely, in the control class, student interaction tended to be more limited because learning focused more on completing written worksheets and using textbooks as the primary learning resource. Furthermore, the printed worksheets in the control class were not specifically designed to guide students' critical thinking processes, whereas the Wizer.me e-LKPD used in the experimental class were systematically structured based on the stages of critical thinking skills, ranging from problem identification, information analysis, to drawing conclusions. These differences in instructional design are suspected to be one of the reasons why the experimental class's critical thinking abilities increased more than those of the control group. The findings of this study are consistent with those of Dwiyanti & Wiyatmo (2026) who reported that Wizer.me-based physics e-LKPD integrated with the PBL model effectively improved students' learning interest and critical thinking skills, achieving a moderate N-Gain score. Both studies reinforce the results of this study that the application of systematically designed Wizer.me e-worksheets is better able to guide students through the stages of critical thinking compared to printed worksheets.



**Figure 3.** Students accessing the Wizer.me e-LKPD

The research results also show that the “drawing conclusions” indicator showed the highest N-gain value of 0.82 indicates an improvement in the experimental class. Students received instruction throughout the learning process to draw conclusions based on data analysis and group discussions found in the Wizer.me e-worksheets. At each stage of education, pupils were not just required to respond to questions but also to interpret information and summarize the results of discussions before proceeding to the next stage. The recurring conclusion-drawing activities at each learning stage are suspected to be one of the factors causing this indicator to show the highest improvement. This finding corresponds with research by Pratiwi et al., (2024) which reported that the implementation of PBL backed by the Wizer.me. The critical thinking abilities of high school pupils were greatly enhanced by me e-LKPD, particularly in the aspect of drawing conclusions from data analysis results. Similarly, Siregar et al., (2025) confirm that interactive e-LKPDs based on Wizer.me using the PBL model effectively train students to interpret information and draw conclusions from group discussions, with an effectiveness rate reaching 90%. Both studies reinforce the findings of this research that the activity of drawing conclusions, which occurs repeatedly at every stage of learning, is the primary factor driving a higher improvement in the conclusion-drawing indicator compared to other indicators.

The indicator showing a simple explanation also demonstrated a notable rise in the experimental class. During the lesson, Students were assisted in determining the root of the issue through structured questions in the Wizer.me e-worksheets, facilitating their comprehension of the issue before moving on to the analysis stage. Additionally, group discussion activities help students become accustomed to rephrasing information in their own words. This indicates that the initial stages of PBL play a role in helping students develop the ability to provide simple explanations. This aligns with research by Emiliyasi et al., (2019) which emphasizes that the early stages of PBL focus on *elementary clarification*—training students to identify the core of the problem and rephrase it using simple language. Similarly, Sulaiman & Azizah (2020) found that the implementation of PBL effectively enhances students' critical thinking skills, particularly regarding the indicators of problem clarification and simple explanation. Furthermore, Jamilah et al., (2023) also demonstrated that the consistent PBL implementation improves students' capacity for critical thought, especially in the aspect of simple explanation through structured questions and group discussions.

Regarding the indicator for building basic skills, improvements in critical thinking skills occurred when students searched for information, observed data, and evaluated information sources during the inquiry process. However, In comparison to other indicators, this one showed a somewhat lesser growth, particularly in the control class. This is likely due to the fact that pupils in the control group depended more heavily on textbooks and printed worksheets, thereby limiting their exploration of information. Conversely, The experimental class's pupils were more engaged, in evaluating information through analytical questions available in the Wizer.me e-worksheets. The study supports this conclusion. (Sari et al., 2022) which shows that *PBL*-based e-worksheets can enhance HOTS and student engagement in the investigation and information analysis processes during learning. Additionally, the study by (Susana et al., 2025) also explains that *PBL*-integrated e-LKPD helps students become more active in developing science process skills and critical thinking through independent inquiry and information evaluation activities.

Indicators of strategy and tactic development also showed a significant improvement in the experimental class. Throughout the educational process, pupils were expected to ascertain problem-solving steps through group discussions and the gradual formulation of answers on the Wizer.me e-LKPD. These activities helped students become more accustomed to systematically determining problem-solving strategies and considering various alternative answers before making a decision. The process of discussion and problem-solving in *PBL* helps students develop the ability to design problem-solving strategies independently because kids participate in the process firsthand of investigation and decision-making. These results are consistent with studies conducted by Misidawati & Sundari (2021) which shows that via active problem-solving and decision-making exercises, *PBL* adoption may improve critical thinking abilities. Additionally, research by Supratikto (2024) also indicates that during the strategy and tactics stages of *PBL*, students are better able to determine problem-solving steps through the process of exploring questions and group discussions.

The "Provide Further Explanation" indicator showed the lowest improvement compared to the other indicators. Based on observations during instruction, some students still struggled when asked to provide more in-depth reasons or develop complete arguments. This was evident when students were asked to explain relationships between concepts or provide explanations requiring more complex analysis. Furthermore, although the Wizer.me e-LKPD has been designed to systematically guide the critical thinking process, the scope of the material and stimuli presented remains relatively limited compared to the number of questions in the "providing further explanation" indicator. Consequently, students have not acquired sufficiently broad information to develop more in-depth answers. The results of the instrument analysis also indicate that the test items under this indicator fall into the "difficult" difficulty category, meaning students require higher analytical skills to achieve the maximum score. This finding aligns with research by (Septiany et al., 2024) which shows that advanced-level critical thinking indicators tend to be more difficult for students to master, resulting in relatively lower improvement compared to other indicators. Thus, the low improvement in the "providing further explanation" indicator is influenced not only by the difficulty level of the questions but also by the limited depth of the material students acquire during instruction.

An effect size of 0.66 indicates that the implementation of the *PBL* model supported by Wizer.me e-LKPD had a substantial effect on students' critical thinking skills. This finding suggests that the observed improvement was not only statistically significant but also educationally meaningful. The magnitude of this effect was reflected in students' engagement during the learning process, particularly in discussion activities, problem analysis, evidence evaluation, and independent answer formulation. The use of Wizer.me e-LKPD encouraged students to participate more actively in each stage of learning compared to the use of printed worksheets. The findings further demonstrate that integrating Wizer.me e-LKPD into the *PBL* model created a more dynamic, interactive, and structured learning environment. Learning was not merely focused on task completion but also encouraged students to analyze information, discuss alternative solutions, and make decisions based on evidence throughout the learning process. These experiences contributed to improvements across all measured critical thinking indicators. Therefore, the use of the *PBL* model supported by Wizer.me e-LKPD can be considered an effective alternative for enhancing students' critical thinking skills in physics learning.

Nevertheless, this study still has limitations. The study was conducted at only one school with a limited sample size, so the results cannot yet be widely generalized. In addition, the indicator of providing further explanations is a critical thinking indicator with a higher level of complexity because

it requires in-depth analytical and argumentative skills. In this study, the density of the material and learning stimuli provided did not yet fully encourage the best possible development of these abilities. Therefore, future research is recommended to use more dense and complex materials and stimuli so that students' ability to provide further explanations can develop to their fullest potential, as well as to test Wizer.me's assistance in implementing the PBL model in different school contexts and with a larger sample size.

#### 4. CONCLUSION

The study's findings show that Wizer assisted in the PBL model's adoption. Students' critical thinking abilities are greatly improved by me e-LKPD, as demonstrated by high effect size values and N-Achieve higher grades in the test class. These results show that using the Wizer.me e-LKPD in the classroom not only makes learning more engaging and dynamic, but it also benefits students enhance their critical thinking abilities. This kind of education can be a creative way for physics professors to improve the caliber of their lessons and promote active student engagement in the classroom.

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