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Application of the Problem-Based Learning Model to Improve Grade 8 Students' Critical Thinking Skills on Respiratory System Material

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ABSTRACT

Biology is part of the natural sciences, which include laws and principles resulting from scientific processes that require problem-solving through critical thinking skills. However, critical thinking in biology learning is still relatively low. Training students' critical thinking skills can be enhanced by combining the use of models, media, strategies, and learning approaches that stimulate their critical thinking abilities. This research aims to determine the effect of implementing problem-based learning with E-LKPD as an effort to improve the critical thinking skills of Grade 8 SMP students in relation to the respiratory system. This research is considered quasi-experimental, utilizing a non-equivalent control group design. The sampling technique for the essay is purposive sampling. Critical thinking skills are evaluated through standardized tests. The data analysis technique employed the independent sample T-test. The effectiveness of the PBL model, after being implemented, shows that students' critical thinking skills have increased, as evidenced by a Cohen's d value of 1.0. These results were then interpreted to show that the problem-based model with E-LKPD influenced critical thinking skills, ranking in the high category with a percentage of 84%. The conclusion is that the Problem-based Learning model can be used to improve students' critical thinking skills in science learning, especially in the context of the respiratory system.

ARTICLE INFORMATION

Keywords:
critical thinking skills; problem-based learning; respiratory system

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INTRODUCTION

One important factor that can support progress and improve the quality of society in a country is education. Education is interpreted as a conscious and planned effort to create an atmosphere that fosters the learning process, enabling students to actively develop their potential and acquire religious, spiritual strength, self-control, noble morals, and the skills necessary for themselves, their nation, and their state. Education in Indonesia continues to change in an effort to improve the quality of education. In this case, there has been a change to the 2013 curriculum. Critical thinking skills are one of the skills that need to be improved in the 2013 curriculum to address the challenges arising in the era of Industrial Revolution 4.0 (Sudrajat et al., 2020). Critical thinking skills refer to a student's ability to analyze an argument, formulate conclusions through their own reasoning, assess and evaluate a problem, and make informed decisions and solve existing problems (Wahyuni et al., 2021).

Critical thinking is a structured process that enables students to evaluate problems encountered in everyday life and devise effective solutions to them. Biology is part of the natural sciences, which encompass laws and principles derived from scientific processes that necessitate problem-solving through critical thinking skills. However, in reality, critical thinking in biology learning remains relatively low; this could be because the learning process is often dominated by rote memorization. According to Ariantini et al. (2014), biology learning has so far tended to focus on

aspects of remembering and understanding associated with low thinking abilities, resulting in students memorizing and taking notes on the material presented by the teacher, and being less active in their learning.

The low critical thinking skills of students are evident in the average test score on respiratory system material for students at SMP Negeri 15 Grade 8 in the 2021/2022 academic year, with an average of 53%. Learning outcomes that are less than optimal suggest that students' critical thinking skills are also suboptimal. In connection with this, teachers need to create learning conditions that encourage students to become more active and develop critical thinking skills by combining various learning components, such as teaching materials and learning models. One of the learning models recommended in the curriculum is Problem-Based Learning (PBL). The PBL model presents various real-world problems in students' daily lives (contextual in nature), thereby stimulating students to learn (Siregar et al., 2020). Training students' critical thinking skills can be combined with the use of models/media/strategies/learning approaches that stimulate students' critical thinking skills evenly (Prameswari et al., 2018).

Learning that applies PBL aims to train groups of students to find solutions to the problems they face, which helps train critical thinking skills. According to Vegas (2018), the Problem-Based Learning model had a significant effect on the critical thinking skills of eleventh-grade students at SMA Negeri 1 Prambanan. In the learning process, teachers can combine the PBL model with the teaching materials used, thereby enabling them to develop students' critical thinking skills actively. One of the teaching materials that can be used is the Lembar Kerja Peserta Didik (LKPD), also known as student worksheets. LKPD is a guide that students use to conduct investigations and develop skills in both cognitive and non-cognitive aspects (Trianto, 2014). Along with technological developments, the presentation of teaching materials, which was initially printed, has now been transformed into electronic teaching materials. Haqsari (2014) stated that E-LKPD is a work guide that can facilitate students' learning.

The student worksheets used do not meet the demands of 21st-century learning and lack the important components of 4C (Critical Thinking, Creativity, Collaboration, Communication). The science student worksheet used does not clearly outline learning steps in solving problems that help students improve their critical thinking skills. LKPD is a tool that can facilitate and construct students' knowledge to create a positive atmosphere. LKPD needs to be supported by an appropriate learning model so that learning is more focused, engaging, and easier to achieve learning objectives, thereby optimizing the benefits of using LKPD (Prastowo, 2012).

The use of E-LKPD, based on problem-based learning, can motivate and encourage students to interact physically and emotionally, thereby arousing their curiosity. The results of informal interviews with Grade 8 science teachers at SMP N 15, Tebo Regency, revealed that in some materials, particularly those related to breathing, the teachers still employed the lecture method in their teaching. Teachers usually also provide LKPD for students to work on. The LKPD provided is still in the form of questions, allowing students to achieve a general understanding of the concepts. Teachers have also never made teaching materials in electronic form. Based on the explanation of the problems obtained, research is needed to determine the use of problem-based E-LKPD in learning respiratory system material.

The use of the PBL model can improve students' critical thinking skills (Chairani & Muchlis, 2019). PBL is a learning model that utilizes problems as a basis for developing new student knowledge, with the primary objectives of implementing the PBL model being to foster critical thinking skills, problem-solving abilities, and students' ability to actively construct their own knowledge (Amini et al., 2019). PBL is a forum for developing critical and analytical thinking for students (Gunantara et al., 2014). The PBL model is considered effective and highly suitable for developing critical thinking skills

(Wati & Yuliani, 2020). This research aims to determine the effect of implementing problem-based learning with E-LKPD as an effort to improve the critical thinking skills of Grade 8 students in relation to the respiratory system.

METHOD

This study employed a quasi-experimental design with two groups: the experimental group and the control group. This research was conducted with the participation of all 24 Grade 8A students and their science teachers. Each class, both the experimental and control classes, is divided into five groups, each consisting of five students. This design consists of two groups of subjects who are given a pretest and a posttest to determine their critical thinking skills before and after receiving treatment (Table 1). Figure 1 illustrates the research stages.

Table 1. Non-equivalent control group design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O4

*Information:
O_1: Experimental class pretest scores
O_2: Experimental class posttest scores
O_3: Control class pretest scores
O_4: Control class posttest scores
X_1: Use of PBL-based E-LKPD
X_2: Use of Conventional LKPD

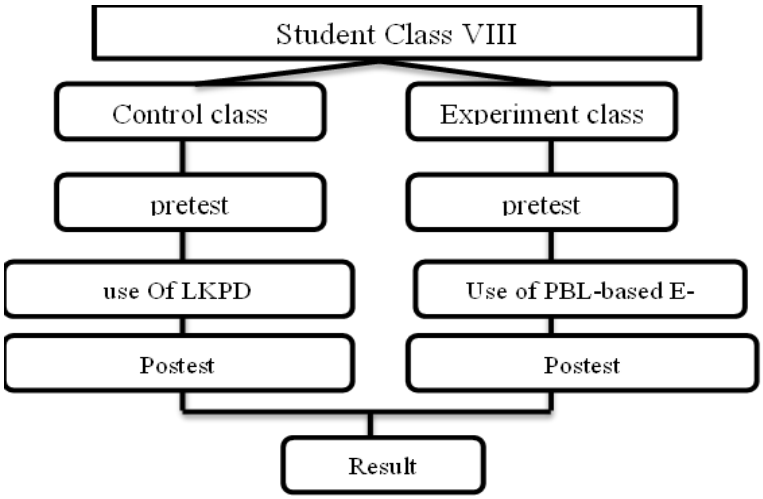


Figure 1. Research Stages

Effectiveness trials were conducted with Grade 8 students at SMPN 15, Tebo Regency. The trial was carried out using a test instrument with a non-equivalent control design (Sugiyono, 2016). The samples in this research were collected from two classes using purposive sampling, a technique that selects samples based on specific considerations (Sugiyono, 2016). Collecting data on students' critical thinking skills using test instruments. The critical thinking skills (CTS) data obtained are then analyzed.

The data were also subjected to statistical inferential tests using several methods, including prerequisite tests (normality and homogeneity tests), an Independent Simple T-Test, and effect size

tests. The independent sample t-test was calculated to determine whether there were significant differences between two groups that were not paired with each other. Hypothesis testing was carried out with the help of the SPSS for Windows 20.0 program, with the decision criteria that H0 was rejected, and Ha was accepted if the significance value was <0.05. The effect size test shows the extent to which a variable influences another variable in a study (Diani et al., 2016). According to Santoso (2010), effect size is defined as a measure of the significance of research results, as indicated by the magnitude of the differences, correlations, or effects of one variable on other variables. It can then provide effect size estimates that can be compared across various research designs (Olejnik & Algina, 2003). The effect size calculation in the t-test uses Cohen's formula, which categorizes results as high, medium, or low.

RESULTS AND DISCUSSION

Active learning, such as problem-based learning, has learning characteristics that not only facilitate knowledge acquisition but also positively impact students' critical thinking skills. E-LKPD learning steps are arranged according to PBL syntax. This is in accordance with research by Astuti et al. (2018), which states that the combination of PBL-based and worksheet approaches is practical, addressing all aspects of learning and students' responses to problems. PBL-based E-LKPD is considered capable of helping students hone their critical thinking skills, as noted by Saputra et al. (2024) and Aisyah et al. (2025). They demonstrate that the PBL and worksheet-based model has a positive impact on education and can be applied at all levels of education. Table 2 and Figure 2 present the results of measuring students' critical thinking skills in the pretest and posttest on the respiratory system material.

Table 2. Results of Measuring Critical Thinking Skills

Description Data	Critical thinking skills measurement result			
	Experiment class		Control class	
	Pretest	Posttest	Pretest	Posttest
Total of the sample	24	24	24	24
Maxium value	65	92	65	75
Minimum value	14	48	12.5	27.5
Standart devitiation	11.60	12.28	10.93	12.35
average	27,08	71.37	37.70	59.79
Flat increase	**44.29**		**22.09**	

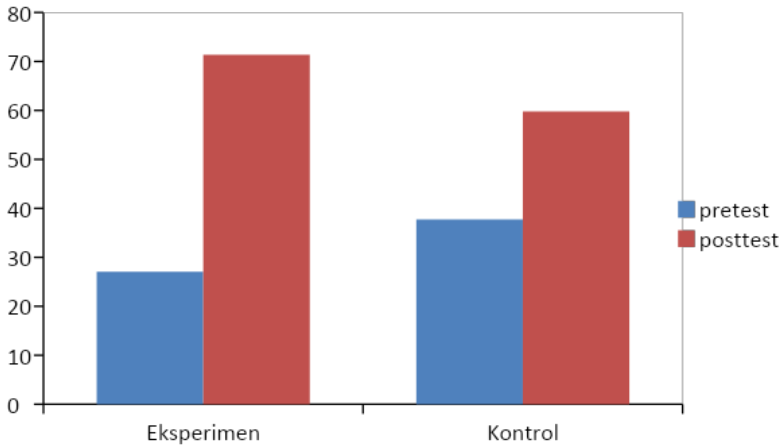


Figure 2. Average Critical Thinking Skills in Pretest and Posttest

Both the control and experimental classes experienced an increase in average scores. However, in the experimental class, which was taught using problem-based learning (E-LKPD), the average increase in critical thinking skills that students obtained was greater, and they experienced noticeable changes, transitioning from being quite critical to being highly critical (Table 3).

Table 3. Critical thinking skills Categories in Pretest and Post-test

Class	Pretest	Category	Post test	Category
Experiment	27.08	Less critical	71.37	Critical
Control	26.87	Less critical	59.79	Quite critical

Prerequisite tests are conducted by performing normality and homogeneity tests. The results of the normality test show that the Sig value for the pretest and posttest data on critical thinking skills in the experimental and control classes is greater than 0.05, indicating that all data are normally distributed (Table 4). In Table 4, it is also noted that the pretest and posttest data from both classes have a significant value ($p > 0.05$), indicating homogeneous data.

Table 4. Test of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Unstandardized Residual	pretest experiment	.105	24	.200*	.973	24	.736
	posttest experiment	.161	24	.108	.953	24	.322
	pretest control	.269	24	.954	.823	24	.001
	posttest control	.205	24	.323	.869	24	.005

Table 4. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.782	3	92	.507

To determine whether the data groups are different, the T-test can be used to examine the Sig value (2-tailed) in the section assuming equal variances. If the Sig value is <0.05, then the two groups of data have significant differences. If the sig value is > 0.05, then the two groups of data have no significant differences. The results of the normality test showed a pretest significance of 0.736 and a posttest significance of 0.322, indicating that the significance level is greater than 0.05, so the data are normally distributed, and the homogeneity test was continued. The results of the homogeneity test showed a significance level of 0.730, indicating that the significance level is greater than 0.05; therefore, the data are homogeneous. These results mean that there is no significant difference between the pretest data for the experimental class and the control class. This indicates that the critical thinking skills in the two classes, prior to being assessed by researchers, did not exhibit significant differences.

Furthermore, the posttest data obtained a Sig (2-tailed) value of 0.000. From these results, it is known that the p-value is <0.05, so that Ha is accepted and H0 is rejected. These results indicate that the posttest data between the experimental class and the control class have significant differences. Thus, the critical thinking skills of the experimental and control classes after treatment also showed significant differences. The experimental class was treated using E-LKPD based on problem-based learning, while the control class used LKPD practice questions. Based on the results of the independent sample t-test, it can be concluded that the use of problem-based E-LKPD has a significant influence on the critical thinking skills of Grade 8 students regarding respiratory system material.

With PBL learning, students are expected to work on authentic problems, aiming to compile their own knowledge, develop inquiry and higher-order thinking skills, and foster independence and self-confidence. The series of learning activities used in PBL-based E-LKPD certainly follows the PBL learning steps, which include activities such as orienting students to problems, organizing students to learn, guiding individual or group investigations, developing and presenting work results, and the final stage, namely, analyzing and evaluating the process.

This learning is conducted entirely in groups. There were 4-5 groups formed. In the experimental class, five groups were formed. Meanwhile, in the control class, the LKPD, which contains practice questions, does not address a specific problem that occurs in everyday life but focuses on questions that are explanatory and deepen the material from reading activities, such as books or other library sources. Work on LKPD in the control class was also carried out in five groups. According to the pretest results, the average pretest score in the experimental class is 27.08, which is higher than the average pretest score in the control class of 26.87.

The critical thinking skills of students in the experimental and control classes, which are not significantly different, are a good indicator of whether the treatment differences in final critical thinking skills can be clearly seen to have significant differences or not. The posttest data results in the experimental class, with an average of 71.37, were also higher than those in the control class, which had an average of 59.79. Supported by the t-test results of post-test data in both classes, which show significant differences between the experimental class and the control class. This indicates that the use of problem-based E-LKPD has a significant influence on critical thinking skills. This aligns with Nafiah and Suyanto (2014), who state that the PBL model is based on problem situations that can arouse students' curiosity about the problem and encourage them to conduct investigations. When students conduct investigations, they utilize their critical thinking skills to examine and analyze the problems they encounter. Table 5 illustrates that the measurement of critical thinking skills is evident from the difference in the percentage of pretest and posttest scores between the experimental and control classes.

Table 5. Difference in Average Score per Indicator of Critical Thinking Skills

An aspect of critical thinking	**Indicator of critical thinking**	**Indicator of the average difference of indicators (pretest-posttest)**	
		Experiment (%)	**control (%)**
Provide an explanation	Focus the question	1.42	1.37
	Analyzing argument	1.42	1.12
Build basic skills	Consider whether the source is trustworthy or not	1.6	1.54
Conclude	Create and conclude a balanced result	1.3	1.21
Provide further explanation	Define after and consider it	5.63	5.49
Organize strategy and tactics	Determine an action	3.65	4.03

Based on the detailed description of the problem-based E-LKPD for each aspect of critical thinking skills, of the 5 indicators included in the pretest and posttest questions, 4 have a greater percentage than the control class. The indicator with the highest percentage is the one that requires

further explanation. This happens because in problem-based E-LKPD, students are trained to formulate various questions that refer to problems in order to find answers. During class learning, students in the experimental class interact more actively with their group friends or with students from other groups.

The pretest and posttest questions used in this research took five aspects and six indicators of critical thinking skills. The first aspect is to provide a simple explanation. The aspect of providing a simple explanation can be broken down into two indicators: focusing the question and analyzing the argument. In the first indicator, namely focusing on questions, the difference in indicator percentage between the posttest and pretest scores in the experimental class was 1.42%, which was greater than that of the control class, 1.37%. Similar to the indicator for answering a question, the indicator in the experimental class is greater than that in the control class, with a value of 1.42% compared to 1.12%. From these data, it is known that the percentage of critical thinking indicator scores in the aspect of providing simple explanations is higher in the experimental class that uses PBL-based E-LKPD compared to the control class. According to Rahmawati et al. (2016), critical thinking skills can be trained through the habit of formulating problems and answering questions that require explanation. In a problem-learning-based E-LKPD, students are assigned and trained to create problem formulations and answer hypotheses based on problems that occur in everyday life, such as kidney failure. Therefore, the percentage increase in the two indicators in this aspect provides a simple explanation in larger research on classes that use problem-based E-LKPD. This finding aligns with research by Noprianda et al. (2019), which states that the aspect of providing simple explanations in experimental classes using PBL has increased more than in control classes. Observations by researchers during learning in PBL classes revealed that students were more active in asking and answering questions, whether the questions were posed directly by the teacher or arose during group discussions.

The second aspect is 'Build Basic Skills.' This aspect has indicators, namely, considering whether the source is trustworthy or not. It was found that the results for the experimental class were 1.6% and for the control class 1.54%. These data indicate that the source indicators in the control class remained lower than those in the experimental class. This can happen because students' skills in determining a source or statement in experimental classes tend to become honed. Apart from that, this can also be influenced by students' focus when working on pretest and posttest questions. For the observing indicator, the class that uses problem-based E-LKPD has a higher value compared to the control class. In a problem-based e-LKPD, students are guided to conduct observation activities based on practical data from experiments involving excretory system materials. Practical data is obtained from experiences carried out in everyday life, which makes it easier for students to understand and reason. According to Rahmawati et al. (2016), critical thinking can be trained through a process of rigorous intellectual activities, carried out by observing phenomena that occur, which in turn causes the percentage increase in observed indicators to be higher compared to the control class.

The third aspect is making conclusions, which involves making deductions and considering the results of those deductions. For this indicator, the percentage in the experimental class was 1.3%, while the control class obtained a percentage of 1.21%. This data shows that the indicator for making deductions (conclusions) in the control class is lower than in the experiment. The low results in the control class could be attributed to the students in this class not being as proficient as those in the experimental class, which implemented problem-based E-LKPD. The next critical thinking skills aspect is making further explanations. This aspect is divided into two indicators: defining terms and identifying assumptions. The results obtained in the experimental class were 5.63%, and in the control class, 5.49%. This indicates that the critical thinking skills of participants who applied E-LKPD based on problem-based learning had a higher score compared to the class that applied practice worksheet

questions. Based on this data, the percentage of students identifying assumptions in the experimental class is greater than in the control class. Based on the data above, it can be seen that the application of problem-based E-LKPD is effective in training critical thinking skills, as evidenced by the higher percentage of indicators in the experimental class compared to the control class. In PBL, the processes that occur in the respiratory system are linked between one problem and another problem, so that the experience of improving students' critical thinking is greater compared to students who use worksheet practice questions.

The last critical thinking skills aspect is organizing strategies and tactics. The indicator used in this aspect is determine an action. In this indicator, the increase in the experimental class was 3.65%, while in the control class it was 4.03%. This data shows that the indicator value in the class that uses problem-based E-LKPDs is lower than that of the control class. The problem-based e-LKPD does not optimally guide students in finding solutions to the presented problems. In developing strategies, students are still not taking it seriously enough, resulting in many mistakes, which in turn yield low results.

Students' ability to discuss, ask, and answer questions appears to be more evident in classes that use problem-based E-LKPDs. The results of the effect sizes test revealed that the use of problem-based E-LKPD had a moderate effect. According to Dores et al. (2020), one factor that can influence critical thinking skills is independent learning, which involves an effort to understand material independently, both within and outside formal learning settings. What happens during learning in experimental classes, even though the majority of students are actively involved and exhibit several indicators of critical thinking, is not necessarily when students outside of the learning environment independently re-study the material being taught. So, this will also provide different readiness for students in carrying out the posttest, so that the results obtained are not optimal. The application of the problem-based learning model and the use of student E-LKPD also provide a new learning experience for students, enabling them to master technological developments in the learning process. Overall, the use of the electronic worksheet and the problem-based PBL model significantly improved students' critical thinking skills in the respiratory system, with the effect being in the high category.

CONCLUSION

Based on the research analysis, it was found that the application of the PBL model using a PBL-based E-LKPD had a significant influence on students' critical thinking skills regarding respiratory system material. Based on the detailed description of the problem-based E-LKPD for each aspect of critical thinking skills, of the five indicators included in the pretest and posttest questions, four have a greater percentage than the control class. The indicator that has the highest percentage is the indicator for making further explanations. During class learning, students in the experimental class interact more actively with their friends or between groups. The significant influence shown is because students are trained to analyze problems that occur in everyday life. These problems will raise questions and solutions that can be provided by students. This is what makes it possible to train students' critical thinking skills.

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