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Problem-Based Learning (PBL) Model Assisted by E-Booklet to Improve Students' Critical Thinking Skills on Environmental Change Material

Nanang Kurniawan[a*], Novianti Muspiroh[a]

[a] Biology Education, Faculty of Education and Teaching Sciences, IAIN Syekh Nurjati Cirebon, Indonesia

*Corresponding author: Jl. Perjuangan by Pass Sunyaragi Kesambi, Kota Cirebon, Jawa Barat, 45123. E-mail address: 1 nangkurniawan2003@gmail.com

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abstract

The study aimed to analyze the difference in improving critical thinking skills between students who applied with the Problem-Based Learning (PBL) model assisted by E-Booklet and those who did not applied with the Problem-Based Learning (PBL) model assisted by E-Booklet. This research was conducted in an Islamic School in Cirebon City with a Quasi-Experimental design in the form of a Pretest-Posttest Control Group Design. Sampling using the Positive Random Sampling technique with a sample size of 64 students. Data collection techniques in the form of essay instrument tests, as many as six questions, with Bloom's taxonomy levels C4-C6 declared valid and reliable. The data analysis technique consists of the N-Gain Test and Statistical Test in the form of a normality test, a homogeneity test, and hypothesis testing with the Mann-Whitney U test. The results showed that the average N-Gain in the experimental class and control class fell into the moderate category, with the acquisition of an average index of 0.61 and 0.47. In the hypothesis test, the experimental and control classes were stated with a significance value of 0.001 ≤ 0.05, meaning Ho is rejected and Ha is accepted. It can be concluded that the application of the Problem-Based Learning (PBL) model assisted by an E-Booklet in learning biology on environmental change material can improve students' critical thinking skills.

1. Introduction

Technology is important in supporting efficient learning, such as distance learning, which is influenced by 21st-century learning (Lase, 2019; Moshinski et al., 2020). Teachers must design 21st-century learning to form quality human resources with student-centered learning to improve important skills (Elitasari, 2022; Jannah et al., 2020). 21st-century skills include critical thinking, creative thinking, innovation, communication, and collaboration (Liesa-Orús et al., 2020; Malik & Ubaidillah et al., 2020). Critical thinking is an important skill in 21st-century learning (Mardhiyah et al., 2021; Felitasari & Rusmini, 2022). Facione (2011) explains that critical thinking is an intellectual process that involves in-depth assessment to produce strong interpretations, analyses, evaluations, and conclusions. Therefore, students must be trained to think critically to prepare for future challenges.

Observations of biology learning show that out of 34 students, 15 are still passive, only listening to the teacher without being active in discussions or class activities. This passive attitude hinders understanding of the material and the development of critical thinking skills, negatively impacting

their learning outcomes. Biology learning is not yet satisfactory regarding students' critical thinking skills. The study results indicate that students' critical thinking skills still need improvement (Sary et al., 2023; Hasan et al., 2020; Lapuz & Fulgencio, 2020). The suboptimal critical thinking skills of students are thought to be caused by learning that does not train students in problem-solving, the use of teacher-centered learning methods, and the use of inadequate teaching materials (Fajari, 2021; Sarwanto et al., 2021; Harasym et al., 2008). Therefore, teachers need to design active, innovative, and meaningful learning.

Learning must have variations in learning models to improve critical thinking skills. One learning model that can improve students' critical thinking skills is Problem-Based Learning (PBL). Problem-based learning (PBL) helps teach high-level thinking processes in problem-oriented situations, including learning and how to learn (Hartati & Billa, 2023; Tsani & Saptono, 2023; Ubaidillah et al., 2023). The Problem-Based Learning (PBL) model is learning that trains students to think critically, creatively, and rationally, improves understanding of the material, and provides real experiences. Problem-based learning (PBL) focuses on the main concepts of the discipline, involves students in problem-solving meaningful tasks, and provides opportunities to work independently, producing valuable and realistic work (Carrió et al., 2011; Dwi et al., 2013; Arsyad, 2014). Learning with abstract material is often difficult for students to understand. In addition to the learning model, teaching materials are needed to support the learning process. Teaching materials are important as a guide for teachers and students. Learning materials can help improve students' thinking skills (Efwinda et al., 2023; Daulay & Ridhatullah, 2023). Good teaching materials can help students visualize abstract material more realistically or easier to understand (Darnita et al., 2014; Aslam et al., 2021). Setiawan and Wardani (2018) stated that an E-Booklet is a learning media that can be used in any situation. The visualization of the context of the material in digital electronic form can be accessed via electronic devices (Azinar & Fibrina, 2019). E-Booklet is designed to help students achieve their learning goals (Hanifah et al., 2020)—the results of Fajarianingtyas et al.'s research. (2023) stated that using e-booklets in learning can improve critical thinking skills.

Many studies have discussed biology learning using the PBL model and e-booklet media. Previous research has been conducted by Fajarianingtyas et al. (2023), who developed an e-booklet with a socio-scientific issue approach to mangrove material. Tsani and Saptono's (2023) research examined interactive e-booklets to improve critical thinking skills and learning motivation. Meriza et al. (2023) have examined how the role of e-booklets improves students' critical thinking skills in environmental pollution material. Wahyuni et al. (2020) stated that using PBL assisted by booklets can improve students' conservation attitude skills. However, research that uses problem-based learning assisted by e-booklets to train critical thinking skills in environmental change material. This study focuses on applying learning methods using Problem-Based Learning (PBL) assisted by E-Booklets to train students' critical thinking skills. This study aimed to analyze the differences in critical thinking skills between students who apply the Problem-Based Learning model assisted by E-Booklets and those who do not.

2. Method

This study uses a quantitative research method with a Quasi Experimental design (quasi-experiment). The type of Quasi Experimental research used is the Pretest-Posttest Control Group Design using an experimental class and a control class (Creswell, 2017; 132). The population consists of all 10th grade students in one of the MA Negeri schools in Cirebon City. The sample used consists of two classes selected by Random Sampling which is carried out randomly from the population. Creswell (2018) explains that the Random Sampling technique aims to give each individual in the population an equal opportunity to be selected as a research sample.

This study uses two research variables, namely the independent variable and the dependent variable. The independent variable is the Problem Based Learning (PBL) Model assisted by E-

Booklet, while the dependent variable is students' critical thinking skills. The indicators of critical thinking skills used, according to Ennis (2011), consist of 5 indicators; basic clarification, providing reasons for a decision, further clarification, guesswork and integration.

The data collection technique used a test sheet containing 6 essay questions of type C4 (Analyze), C5 (Evaluate), and C6 (Create) which have been tested and declared valid and reliable by experts. Data analysis techniques include the Kolmogorov-Smirnov normality prerequisite test and the Levene homogeneity test using the SPSS Statistics 25 application. Data is declared normal and homogeneous if the significance value (Sig.) Is greater than 0.05 (> 0.05). The N-Gain level analysis uses the Hake (1999) criteria: $g \geq 0.70$ (High), $0.30 \leq g < 0.70$ (Medium), and $g \leq 0.30$ (Low) (Malik & Ubaidilla, 2020). Hypothesis testing uses a non-parametric test, namely the Mann Whitney-U test. If the probability/significance/P-value ≤ 0.05, then Ho is rejected and if the probability/significance/P-value ≥ 0.05, then Ho is accepted (Istimewa et al., 2021).

3. Result and Discussion

The improvement of students' critical thinking skills was measured using Pretest-Posttest value data in the experimental class and control class. The average results of students' scores in both classes can be seen in Figure 1.

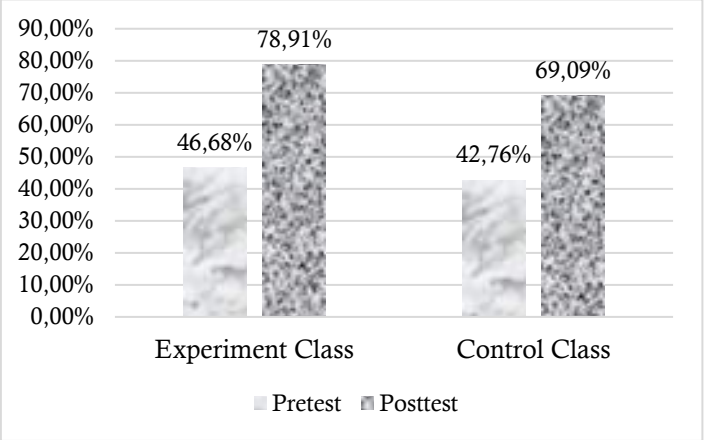

Figure 1. Average pretest-posttest score

Figure 1 shows the difference in the average Pretest-Posttest scores between the experimental and control classes. The average Pretest-Posttest score of the experimental class is greater than that of the control class. Applying the Problem-Based Learning (PBL) model assisted by E-Booklet can affect student learning outcomes. Student learning outcomes in the experimental class increased after implementing the Problem-Based Learning (PBL) model assisted by an E-Booklet. Meanwhile, the control class using the scientific method also showed increased learning outcomes. However, the increase in the experimental class was more prominent and superior to the control class.

The Problem-Based Learning (PBL) model assisted by E-Booklet effectively improves critical thinking skills. Problem-based learning (PBL) provides opportunities for students to be actively involved in their learning process by focusing learning on problem-solving. Active participation of students in solving problems systematically in the learning process can improve critical thinking skills (O'Reilly et al., 2022; Xu et al., 2023; Khasanah, 20204). In addition, this E-Booklet learning media makes the learning process simpler and more efficient. Efficient ease of access by integrating technology into the learning process can improve critical thinking skills because it allows students to access information quickly and deeply and stimulates them to analyze, evaluate, and synthesize information better (Ahmad et al., 2024; Febliza et al., 2023). The results of research conducted by Putri & Fitri (2022) show that the Problem-Based Learning (PBL) model increases students' active involvement and can express their opinions, which contributes to improving students' learning

outcomes and critical thinking skills (Wiznia et al., 2012; Haque, 2023; Mumtaz & Latif, 2017). In addition, E-Booklets play a role in improving learning outcomes by providing concise and systematic explanations and illustrations that facilitate understanding and encourage students' critical thinking (Enawaty & Lestari, 2015; Gultom et al., 2020). The average pretest score for each critical thinking ability indicator, according to Ennis (2011), can be seen in Figure 2 as follows.

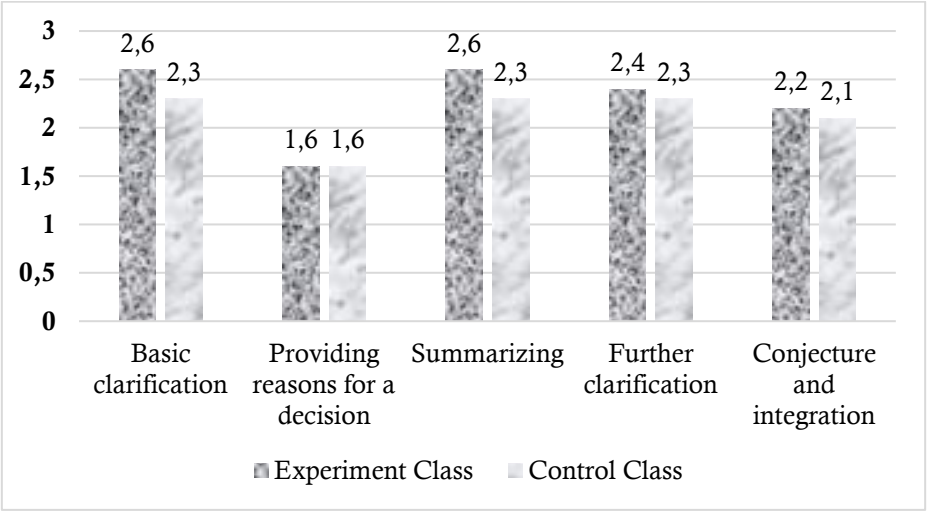

Figure 2. Average pretest score for each critical thinking indicator

Figure 2 shows that the average score for each indicator is different; the first, third, and fourth critical thinking indicators show the highest scores. On the other hand, the second indicator related to the ability to provide reasons for a decision obtained the lowest score. This indicates that there is potential to improve students' ability to provide reasons that support the decisions taken, thus completing their overall critical thinking skills.

The provision of Pretest questions was distributed before the learning was carried out to evaluate whether the two classes had equivalent critical thinking skills before the learning process began. This is in line with the research of Effendy & Hamid (2016), who stated that the results of the Pretest help integrate students' knowledge with new information, adjust learning materials to students' abilities, and allow cognitive adjustments if new material has not been mastered. The average posttest score for each critical thinking ability indicator, according to Ennis (2011), can be seen in Figure 3.

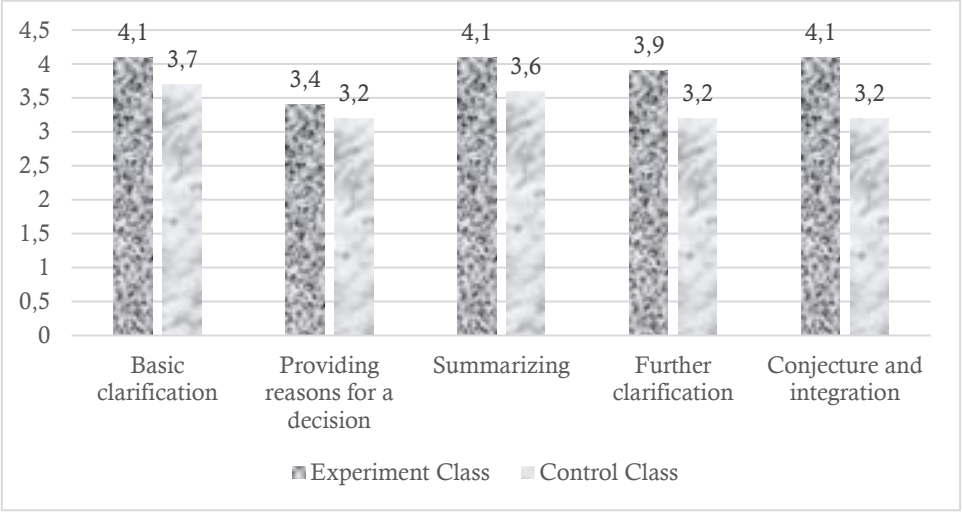

Figure 3. Average Posttest Score for each Critical Thinking Indicator

Figure 3 shows that the average score for each indicator has increased from the average value of the experimental and control pretests. This analysis shows that the average value of the experimental class is always higher in each indicator compared to the control class. This indicates that the implementation of the Problem-Based Learning model using E-Booklet provides better results in improving students' understanding and application of critical thinking concepts compared to using conventional learning methods. The Problem-Based Learning (PBL) model uses problems as a starting point for collecting and integrating new knowledge, so that students acquire the knowledge and skills needed to solve problems (Kwan, 2009; Fauzia, 2008; Fitriani et al., 2020). The increase in critical thinking skills can also be seen from the N-Gain statistical test scores in Figure 4.

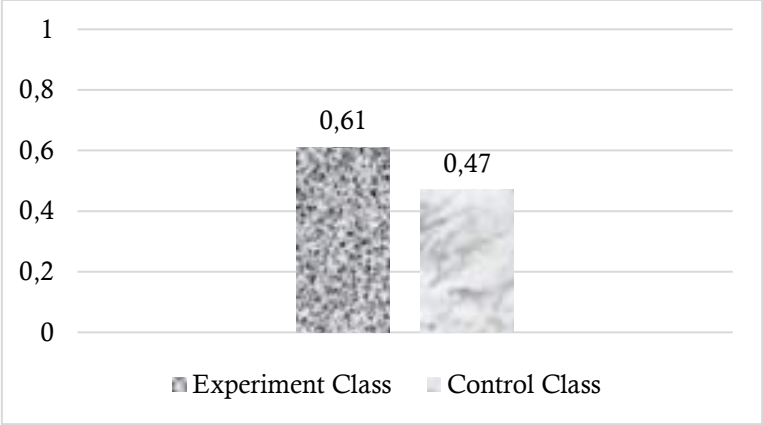

Figure 4. Average n-gain value

Figure 4 shows that the average N-Gain value in the experimental and control classes is different; the experimental value is higher than the control class, where the average N-Gain value of the experimental class reaches 0.61, while the average N-Gain value of the control class only reaches 0.47. This indicates an increase in critical thinking skills in the experimental class compared to the control class. The increase in critical thinking skills can also be seen from the results of the statistical test analysis. The results of the Normality and Homogeneity prerequisite tests can be seen in Table 1.

Table 1. Normality and Homogeneity tests

Class	Normality	Homogeneity
	Sig. / Interpretation	Sig. / Interpretation
Experiment Pretest	0.035 / No Normal	0.035 / Homogen
Experiment Posttest	0.004 / No Normal	0.004 / Homogen
Control Pretest	0.037 / No Normal	0.037 / Homogen
Control Posttest	0.123 / No Normal	0.123 / Homogen

Based on Table 1 regarding the prerequisite tests, including normality tests and homogeneity tests, it was found that the data were not normally distributed but were homogeneous. Therefore, the Mann-Whitney U test, or non-parametric test, was chosen, which does not require parameter assumptions for the population being tested. The results of the Mann-Whitney U test can be seen in Table 2.

Table 2. Mann-Whitney U test results

	Statistic
Mann-Whitney U	316.500
Wilcoxon W	911.500
Z	-3.246
Asymp. Sig. (2-tailed)	0.001

Table 2 shows the results of the Mann-Whitney U test with Asymp.Sig. (2-tailed) of 0.001, Hypothesis Ho is rejected because the prob. p-value ≤ 0.05. This shows a significant difference in critical thinking skills between classes that apply the Problem-Based Learning (PBL) model assisted by an E-Booklet and classes that only apply the conventional model. The application of Problem-Based Learning (PBL) has been proven to be more effective in developing critical thinking skills in collaboration, discussion, and solution exploration. The Problem-Based Learning (PBL) model effectively improves students' critical thinking skills and learning outcomes (Nasrullah et al., 2018; Lubis et al., 2019).

Critical thinkers can analyze data or information systematically and logically (Agnafia, 2019) in line with the objectives of biology learning that encourage students towards evidence-based knowledge (Kind, 2019; Moon et al., 2021; Scott et al., 2021). Prospective biology teachers must understand the concepts and features of biology learning to provide effective learning. Science comprises four elements: process, product, attitude, and technology. The "process" in science refers to the scientific method for explaining natural phenomena and producing products such as data, principles, theories, or laws (Carin, 1997; Dodick et al., 2009; Windschitl et al., 2008). Therefore, biology learning can be directed at problem-solving to provide meaningful experiences for students. Contextual learning that trains students to think can strengthen students' cognitive structures.

4. Conclusion

There is a significant difference in critical thinking skills between classes that implement the Problem-Based Learning (PBL) model assisted by E-Booklet compared to classes that do not implement the Problem-Based Learning (PBL) model assisted by E-Booklet. Biology learning using problem-based learning encourages students to solve problems so that it can improve students' critical thinking. Interactive e-booklets with videos and real-world problem-solving related to environmental change provide a deeper biology learning experience. Student participation and collaboration in learning have helped students construct knowledge. Recommendations for future research can apply learning models that focus on current issues with projects inside and outside the classroom.

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