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The Influence of PBL Model with SDGs Approach on Students' Critical Thinking in Environmental Changes

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ABSTRACT

21st-century education demands 4C skills (communication, collaboration, creativity, and critical thinking) to support students' understanding and knowledge. Essential thinking skills that are classified as low can be influenced by learning models. The Problem-Based Learning-Sustainable Development Goals model can be applied to train critical thinking skills. This research aims to determine the influence of the PBL-SDGs on essential thinking skills in environmental change issues. The research method uses a pretest-posttest control Group Design. The sample consisted of 66 students at 44 Jakarta Senior High Schools, with 33 students in each class selected using Simple Random Sampling. The essay instrument measures critical thinking skills based on the Ennis indicators. The data analysis method used descriptive analysis (minimum score, maximum score, mean, and standard deviation) and inferential (normality test, homogeneity test, and hypothesis test) statistical analysis. The research results show that the PBL-SDGs model can improve critical thinking skills, as seen from the N-gain in the experimental class of 0.607 and the control class of 0.505 in the medium category. The highest aspect of critical thinking skills in the experimental and control classes is Basic Support, with scores of 60,00 and 56,94. Based on the independent t-test, a significance of 0.005 < 0.05 is obtained, meaning the PBL-SDGs model influences critical thinking skills.

Keywords: Critical thinking, Ennis dimensions, Environmental changes, Problem-based learning, Sustainable development

Introduction

Education is one area of life that can formally and informally increase human resources. 21st-century education demands skills known as the 4Cs, including communication, collaboration, creativity, and critical thinking (Aswan et al., 2018). In the scope of education, critical thinking skills support students in developing understanding and knowledge. However, Indonesia's level of critical thinking skills is still relatively low when researched at the assessment, inference, and strategy stages of solving scientific literacy problems with results below 20% (Pamungkas et al., 2018). Critical thinking skills are relatively low in urban and rural school students who are known to study biology (Ramadhani et al., 2023). Real global problems, such as changes in increasing global temperature conditions, have become a real visualization of sustainable environmental problems (Amalia & Hariyono, 2022). Environmental problems are a common concern and require sensitivity to the environment to analyze and decide on solutions to problems driven by critical thinking skills.

The inability to apply learning models in conveying basic knowledge is a limitation in developing students' critical thinking (Rijal et al., 2021). The learning model focuses on students (student-centered), encouraging students' active role in constructing learning (Wright, 2011). Problem-Based Learning (PBL) as a student-centered learning model is effectively implemented if it embeds public discourse to develop students' cooperative attitudes (Seibert, 2021). However, implementing the PBL model for teachers has increasingly greater challenges with the educational transition, which involves demands for student-centered learning, increasing 21st-century competencies, information content, and learning implementation. Adapting to teaching strategies and authentic task designs is a challenge and a concern for teachers in adapting to the Problem-Based Learning model (Tawfik et al., 2021).

One strategy to face the challenges of implementing the PBL model is to integrate the inclusion of Sustainable Development Goals (SDGs). Sustainable Development Goals in education have considerable potential to overcome problems based on pedagogy and competencies such as systematic thinking, problem-solving skills, and authentic, real-world learning (Jones & Akura, 2017; Leicht et al., 2018; Bramwell-Lalor, 2020). SDG learning encourages the development of critical thinking skills through the interactive and collaborative role of the PBL learning model. The PBL-SDGs model, as an integrative pedagogical approach, is a solution to moving students to question opinions and help them think (Lozano et al., 2017). Efforts to integrate sustainability competencies into academic fields help provide more knowledge and skills for innovative sustainability education strategies (Covers et al., 2016). Achieving environmental development goals can involve strategy, tactics, and operations in education and relevant areas of life (Gustafsson & Ivner, 2018).

Learning with SDGs encourages the development of critical thinking skills through the interactive and collaborative role of the PBL Learning model. However, the potential of SDGs is still minimally applied in the education process because the implementation of the PBL-SDGs model cannot be separated from the constraints of adjusting and delivering material information according to curriculum achievements. Implementing SDGs in education requires consideration and adjustment between SDGs indicators, learning objectives, and real-life problems. As a lesson closely related to changes in life, biology learning is studied with the orientation of SDGs, the pillar of environmental development, through problem-based learning. This research aims to determine the influence of the PBL–SDGs model in improving critical thinking skills and forming knowledge passed on to problem-solving by students related to environmental change.

Methods

This research is quantitative research with a quasi-experimental method. The research design used was a pretest-posttest control Group Design with two groups: an experimental class group with the PBL–SDGs model and a control class group with the PBL model. This research used a target population of class X students at SMAN 44 East Jakarta. The affordable population was selected as two classes, X as the experimental and control classes, using the Cluster Random Sampling technique. In determining the number of research samples, the Simple Random Sampling technique was used with 72 students from two classes, each with 36 students. The total research samples were taken randomly based on Simple Random Sampling, so there was a sample framing limit, and 66 students were obtained, with 33 students in each class.

Data collection techniques were carried out using critical thinking skills, instruments, and observation of learning implementation. Test instruments were given to students before the intervention as a pretest and after the intervention as a posttest. The critical thinking skills test refers to Ennis (2016) and adaptation by Sunarti et al. (2021), which is presented in Table 1.

Table 1. Critical thinking skills test instrument grid

Indicator	**Sub-indicator**	**Number of Items**
Basic clarification	Focusing questions	2
	Analyze arguments	1
	Identifying the facts of an explanation or challenge	1
The basic support	Consider the credibility/authenticity of the source	1
	Consider the aspects/results of observations	1
Inference	Concluding the deduction results	1
	Summing up the results of induction	1
	Create and summarize results	2
Further clarification	Identify terms and consider definitions	1
	Identify assumptions	1
Strategy and tactics	Determining an action	1
	Combining information and reasoning through interaction	2
Total items		**15**

According to Riduwan (2013), the average results of the pretest and posttest in both classes are calculated based on the critical thinking skills category.

Table 2. Critical thinking skills value categories

Interval	**Category**
81 - 100	Very high
61 - 80	High
41 - 60	Medium
21 - 40	Lower
0 - 20	Very low

Critical thinking skills test scores are collected and analyzed using descriptive and inferential statistics. Descriptive statistics include calculating maximum, minimum, mean, standard deviation, and variance. Improving critical thinking skills is categorized based on the Normalized gain value criteria in Table 3.

Table 3. Normalized gain score categories (Hake, 1999)

Gain score	**Interpretation**
$g > 0,7$	High
$0,3 < g < 0,7$	Medium
g	Lower

Inferential statistical analysis begins with prerequisite tests, including the normality test with the Kolmogorov-Smirnov test at $\alpha = 0.05$ and the homogeneity test with the Levene test at α = 0.05. Data analysis used IBM SPSS Statistics 25. The data analysis technique in this research used an independent t-test to compare differences in the significance of the model's influence on critical thinking skills.

Results and Discussion

Students' Descriptive Statistical Values

The results of descriptive statistical calculations show that the experimental class has a higher score than the control class. The average value of the experimental and control classes is higher than the standard deviation, meaning that the data deviation is low and the values are spread evenly (Solichah & Sari, 2023).

Table 4. Descriptive statistics of the critical thinking skills test

Data	Experiment class (PBL-SDGs)		Control class (PBL)	
	Pretest	Posttest	Pretest	Posttest
Minimum score	21	63	23	57
Maximum score	49	84	45	79
Mean	34,30	74,30	32,61	66,94
Standard Deviation	7,406	5,347	5,448	5,623
Samples	33			

The results of calculating the average pretest critical thinking skills in the two classes did not significantly differ due to the equality of conditions before learning took place. This agrees with research, which states that low category results assume that students are not used to having questions answered critically, especially as an initial learning skill (Mustajab et al., 2018).

After the learning intervention with the experimental class using the PBL-SDGs model and the control class using the PBL model, the average score was increased in both classes. The increase in the critical thinking skill scores in experimental and control class students was influenced by the PBL model intervention, which trains problem analysis, fact identification, and problem-solving processes during the learning process. Experimental class students have increased superior critical thinking skill scores, which are influenced by SDGs interventions in the PBL model during the learning process. Learning that involves environmental development goals can train students' character and competence to analyze more from other points of view (Wang et al., 2022); this has an impact on improving critical thinking skills.

The Problem-Based Learning-Sustainable Development Goal model is applied to experimental classes using Problem-Based Learning syntax designed with SDG competencies and indicators related to learning material (Carrio Llach & Llerena Bastida, 2023). The PBL-SDGs syntax applies guidance to develop and analyze a problem by exploring SDG indicators supporting problem-solving during learning. The implementation of the PBL-SDGs model learning syntax has a good percentage of implementation, as summarized in Table 5.

Table 5. Percentage of PBL-SDGs learning implementation observations

Stages of Learning	Teacher		Students	
	I	II	I	II
Orientation to students	100%	33%	100%	33%
Focus on problems in the group	100%	100%	100%	100%
Problem investigation	100%	100%	66%	100%
Exploratory analysis of results and presentation of results	100%	50%	75%	50%
Evaluate the problem-solving process	75%	50%	75%	50%
Average syntax (%)	80%		75%	

Appropriate implementation of problem orientation syntax will build a better classroom atmosphere. This is known to occur in experimental classes with students' ability to express opinions through a brief analysis of a problem and additional confirmation or explanation from the teacher. It is also important not to miss the group learning process in the second stage as a form of development and involvement of critical thinking skills, problem solving, communication and collaboration opportunities compared to without group learning (Noorrizki et al., 2023). Some activities in the third syntax are still not optimally implemented, even though in this syntax the teacher plays an important role in guiding students to achieve understanding through critical thinking to solve problems. The facilitator's role in guiding will encourage students to have credibility in their answers and a good collaborative attitude (Mansor et al., 2015). This role is also strengthened by the findings, namely that students who study with PBL experience anxiety about this learning stage due to a lack of support, feedback and encouragement from the facilitator, which affects the final learning outcomes (Seibert, 2021).

The results export analysis stage in the experimental class trains students to carry out analyses and decisions based on data obtained by identifying SDG indicators in the results of their analysis. Experimental class students missed further explanation of the results and conclusions of the analysis. These deficiencies are minimized by allocating learning time to inter-group discussions that form critical thinking, exploring points of view, answers, and arguments held by students. This strategy can be implemented because students present the results to other groups to practice effective communication and explain solutions clearly (Istiqomah et al., 2023). The stage of analyzing and evaluating the problem-solving process based on the results of joint discussions is carried out as the final syntax of the learning model. The teacher's weakness in this syntax is that it skips the students' part in asking questions to the presenting group. Question and answer activities in the experimental class were not carried out well, even though it was hoped that students would ask questions and relate environmental problems to environmental SDG aspects. Lack of implementation of the learning process on the part of teachers and students is a factor in the success and mastery of students' skills. However, experimental class learning with the PBL-SDGs model is superior so that it impacts the results of students' critical thinking skills at the end of learning.

The Influence of Learning Models on Students' Critical Thinking Skills

The pretest and posttest scores were analyzed to determine the increased critical thinking skills. Analysis of gain score data for both classes using an independent t-test obtained $p < \alpha$ ($0.005 < 0.05$), thus strengthening the assumption that there is a statistically significant difference between the experimental class with the PBL-SDGs model and the control class with the PBL model.

Table 6. Normalized gain categories

Learning model	Normalized Gain	Category
PBL-SDGs	0,607	Medium
PBL	0,505	Medium

However, the N-gain category for both classes is in the medium category, indicating that the PBL-SDGs model and the PBL model influence critical thinking skills at the same level. The learning process in the experimental class is carried out by exploring aspects of sustainable development, which encourages students to review problems from various aspects of the environment so that better analytical skills are formed compared to those in the control class. This assumption aligns with previous research stating that learning experiences help students have a good analogical thinking process, so the experimental class results are better than the control class (Suryanda et al., 2020).

Table 7. Normality test results

Class	Kolmogorov-Smirnov			
	Statistics score (gain score)	**p - value (Sig.)**	*α*	**df**
Experiment	0,69	0,200	0,05	33
Control	0,94			

The pretest and posttest data in both classes were then analyzed for hypothesis testing, which had previously carried out normality and homogeneity tests. Based on Table 6 above, the normality test results on the pretest and posttest scores are normally distributed with $p > 0.05$.

Table 8. Homogeneity test results

Data	*Levene* Statistics	df1	df2	*p − value* (Sig.)	*α*
Gain score	0,421	1	64	0,519	0,05

Based on Table 7, the homogeneity test calculation using Levene's test produces p > α (0.421 > 0.05), which means that the variance of the experimental class and control class data is homogeneous. The gain score data from each class was analyzed to determine significant differences in applying the model to critical thinking skills, which were calculated using the independent t-test. The independent t-test results stated that H0 was rejected, so there was a significant difference in the application of the PBL-SDGs model to students' critical thinking skills, with p < α (0.005 < 0.05), which is presented in Table 9.

Table 9. Independent t-test results

Data	Uji-t			
	t	**df**	*p − value* **(2-tailed)**	*α*
Gain score	2,901	64	0,005	0,05

The application of the control class learning model with the Problem-Based Learning model and the experimental class with the PBL-SDGs model to see the influence on critical thinking skills can also be seen from the average value of essential skills of thinking indicators on instrument questions, which refer to 5 aspects according to Ennis (2016). The average gain score for each indicator item shows that the experimental class has a higher increase in critical thinking in every aspect than the control class presented in Figure 1.

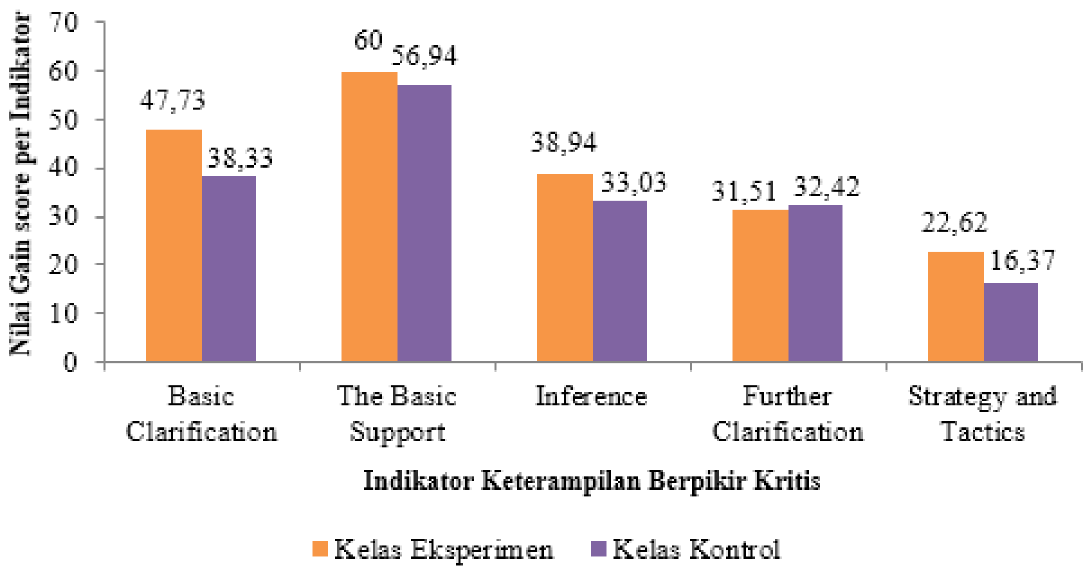

Figure 1. Comparison of critical thinking skills indicator values

Differences in improving aspects of critical thinking skills can occur due to differences in metacognition, which impact students' critical thinking skills in solving problems. Research strengthens this assumption, stating that metacognitive abilities play a role in the critical thinking stage in solving scientific problems (Pamungkas et al., 2018). In this regard, different treatments during the learning process also trigger differences in the value of aspects of students' critical thinking abilities.

The Basic Support aspect reviews thoughts that consider credibility, sources, and observations of the problem topic. This aspect received the highest score for the experimental and control classes, which came from the gain score calculation. A series of student answers that properly involve facts and cause and effect will provide answers with strong reasons. Basic Support focuses on students' ability to express rational opinions based on observational evidence to compile accurate information (Afandi et al., 2021).

The Strategy and Tactics aspect concerns students' responses in designing problem solutions to obtain the lowest gain score. The strategy and tactics indicators that get the lowest scores are related to the results of learning implementation at the individual and group investigation stage and the stage of developing results where, in the learning process, students have not been able to follow the learning optimally due to a lack of instruction from the teacher or individual understanding factors. Students have low critical thinking skills in this aspect because they have been unable to conclude a concept, impacting their mindset in determining an action or problem-solving plan (Afandi et al., 2021).

Based on research analysis, proven by hypothesis testing with $p < \alpha$ ($0.005 < 0.05$), the PBL-SDGs significantly differ significantly from the PBL model on critical thinking skills. This aligns with previous research that revealed that the PBL-SDGs model was effectively applied to train competencies, collaborative attitudes, and learning reflection (Carrio Llach & Llerena Bastida, 2023). Apart from that, the PBL-SDGs model can improve all aspects of critical thinking skills (Sobari et al., 2022).

Conclusion

The research results conclude that the Problem-based Learning-sustainable development goal (PBL-SDGs) learning model influences students' critical thinking skills in environmental change material. Based on the gain score, the influence of the PBL-SDGs model is in the medium category, meaning that it greatly influences students' skills compared to just the PBL model. Implementing the PBL-SDGs model emphasizes conceptual understanding through finding solutions to a problem faced using a broader integration of environmental development points.

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