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The Influence of Problem Based Learning (PBL) Model Based on STEM Approach on Critical Thinking Ability Phase-E in Biology Learning

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Abstract: This study aims to determine The Effect of Learning Models Problem Based Learning (PBL) Based on STEM Approach to E-Phase Critical Thinking Ability in Biology Learning. Research using type experimental research pretest-posttest control grup design with technique random sampling. So that phase E-5 was chosen as the experimental class, phase E-7 as the control class, with a total of 36 students in each class. The data analyzed were the results of the initial test and the final test on questions of critical thinking ability, with data analysis using the SPSS, testing the hypothesis using the ANOVA test. The results of the ANOVA test analysis show that the application of the Problem Based Learning (PBL) model based on the STEM approach has a significant effect on students' critical thinking skills at SMA Negeri 4 Jambi City. The data collection method used is a critical thinking ability test, response questionnaire, activity observation.

Keywords: Biology learning; Critical thinking; Problem based learning (PBL); STEM (Science, technology, engineering, and mathematics)

Introduction

The educational framework in the 21st century expects students to have knowledge that is not only limited to content, but also includes various skills both in the form of learning, seeking information, media, technology and innovation (Suwandi et al., 2017). Learners need 21st century skills which are abbreviated as 4C i.e. critical thinking, collaboration, creativity, and communication (Sanjayanti et al., 2020). That's why there is the term 6C (Critical Thinking, Collaboration, Communication, Creativity, Citizenship, and Character). Critical thinking is a learning process skill that is being looked at by many researchers, especially in education research. The independent curriculum is the application of the curriculum in the context of learning recovery. However, in classroom implementation, teachers have not integrated STEM in the biology learning process to train students' critical thinking skills. This research was carried out in an effort to improve the critical thinking skills of phase E students at driving schools on living things in ecosystems. If integrated, it will help students solve a problem in a much more comprehensive way (Mulyani, 2019).

Lesson activities focus on the creativity of students to develop scientific knowledge. Students are trained to think critically by solving observational problems, testing hypotheses, making conclusions and predictions in order to gain their own insight (Fatonah et al., 2014). Biology learning activity is the transfer of a set of insights from learning resources found in the surrounding environment provided by the teacher's facilities. There are biology learning activities where students are expected to gain skills or proficiency in studying objects, finding facts and developing concepts (Santosa, 2018). Biology learning emphasizes the interaction between students and living things and their lives as learning objects. One of the materials contained in phase E of the even semester is living things in ecosystems.

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Problem Based Learning (PBL) is a model of problem-based learning activities. This model has a role in the study of a problem and then students are asked to explore this problem with a series of understandings from the results of the investigation which are based on concepts, theories, and principles from various fields of science. The PBL model is considered effective in improving students' critical thinking skills because it makes students accustomed to dealing with problems that exist in everyday life and makes them more challenged to solve them (Rahmaniar et al., 2022).

In this model, the ability of students to personally improve their writing and search so that they are required to learn independently and then convey it (Aziz et al., 2014). PBL that uses contextual problems found in the environment. PBL for biology lessons is in line because some of the biology material is related to health and the environment. The PBL learning model affects increasing students' environmental literacy skills (Anggraini et al., 2022).

The selection of learning models and approaches can be adapted to the knowledge conditions of students, conditions of implementation by remote or face-to-face, even to the conditions of existing facilities. "One approach that is quite interesting to research is the STEM approach, because there have been several countries that have begun to integrate STEM learning which makes students act as the center of activity. An approach using STEM can also seek to bring out skills in students, for example the ability to solve problems and the ability to conduct investigations" (Khoiriyah et al., 2018). Learning model that is integrated with Science Technology Engineering Mathematic (STEM) makes it easier for teachers and students (Zulkifli et al., 2022).

The results of interviews conducted at one of the driving schools, namely SMAN 4 Jambi City, to the E-phase biology teacher illustrate that students have not been able to analyze problems in learning so that their critical thinking skills are still low. Students have not been able to focus on questions, analyze arguments and decide on an action. Regarding the implementation of the independent curriculum in schools since 2021, that in implementing the independent curriculum policy a Pancasila student profile is needed. The Pancasila student profile is a policy in education as a reference for educators to build the character and competence of students. The learning profile of Pancasila consists of six dimensions, namely: 1) faith, piety to God Almighty, and noble character, 2) independence, 3) mutual cooperation, 4) global diversity, 5) critical reasoning, 6) creative. The learning done by the teacher already uses the learning model Problem Based Learning. But in the implementation in the classroom the teacher has not integrated STEM in the biology learning process to train students' critical thinking skills. Based on the description of the need for research to apply the learning model Problem Based Learning (PBL) which is integrated using the STEM (science, technology, engineering, and mathematics) approach. STEM applies problem-based learning that deliberately places scientific inquiry and the application of mathematics in the context of designing technology as a form of problem-solving (Lestari et al., 2020).

Integrated STEM activities that fit into the overall science course objectives and goals (Ntemngwa et al., 2018).This research plan was carried out in an effort to improve the critical thinking skills of Phase E students in driving schools on living things in ecosystems. So the title for this thesis is "The Influence Of Problem Based Learning (PBL) Model Based On STEM Approach On Critical Thinking Ability Phase-E In Biology Learning Mobile School High School.

Method

Research Design

This research is an experimental research type pretest-posttest control group design (Sugiyono, 2019). This study used a research sample which was divided into two classes, namely the experimental class and the control class. The two classes used for this study were given the same treatment, namely pre-test as initial testing and administration post-test as a final test. The research design can be seen in the following figure:

$$\begin{array}{c} O_1 \ X \ O_2 \\ \hline O_3 \ Y \ O_4 \end{array}$$

Figure 1. Research Design

The population in this study were all Phase-E students of SMAN 4 Jambi City which consisted of 12 classes. The research sample was Phase E of SMAN 4 Jambi City, 1 experimental class and 1 control class. To determine the class of the research sample, 2 classes of Biology teachers were conducted randomly. Class E-5 was selected as the experimental class consisting of 36 students and E-7 as the control class consisting of 36 students. The data collection technique used was a written test (pretest-posttest) critical thinking skills in the form of descriptions according to indicators of critical thinking skills, questionnaires and observations. The data analysis technique used is descriptive statistical analysis to analyze the percentage of scores obtained. For the initial data analysis technique homogeneity test and normality test, the final analysis technique is the increase test (N-Gain) and hypothesis testing of the variables studied.

Result and Discussion

The results of this study include data pretest and posttest critical thinking skills, student response questionnaires to the PBL model, as well as student activity observation sheets during the learning process. Data on the results of students' critical thinking skills are obtained in table 2.

The value in table 2 is the average value of the critical thinking skills test in the experimental class indicating that the value has increased from pretest 69 and posttest 85. This study uses 5 indicators of critical thinking skills according to Ennis cited Costa (1985). The gain value between the two classes is the experimental class with a value of 16, and it can be seen from the results of the gain index of 0.51 that the category obtained is moderate. For the average value of the control class, even though the pretest value obtained was higher than the experimental class, namely 75, the gain value only got a score of 12 so that the gain index obtained was 0.48 in the moderate category.

Table 1. Average Test Results for Students' Critical Thinking Ability with the Application of the STEM-Based PBL Learning Model

Variable	Class	Pre- test	Post-test	Gain	Index Gain	N-Gain (%)	Category
Critical Thinking Ability	Experiment	69	85	16	0.51	51	Currently
	Control	75	87	12	0.48	48	Currently

Table 2. Average Pretest-Posttest Scores for 5 Critical Thinking Indicators

Class	Critical Thinking Ability Indicator	Pretest	Posttest	Gain	N-Gain	N-Gain Score (%)	Category
Experiment	Simple Explanation	60	81	21	0.53	53	Currently
	Basic Skills	55	83	28	0.62	62	Currently
	Conclude	62	89	27	0.71	71	Height
	Further Explanation	50	64	14	0.28	28	Low
	Strategy and Tactics	53	72	19	0.4	40	Currently
	Average	56	78	22	0.51	51	Currently
Control	Simple Explanation	50	74	24	0.48	48	Currently
	Basic Skills	40	69	29	0.48	48	Currently
	Conclude	42	59	17	0.29	29	Low
	Further Explanation	53	77	24	0.51	51	Currently
	Strategy and Tactics	60	85	25	0.63	63	Currently
	Average	49	73	24	0.48	48	Currently

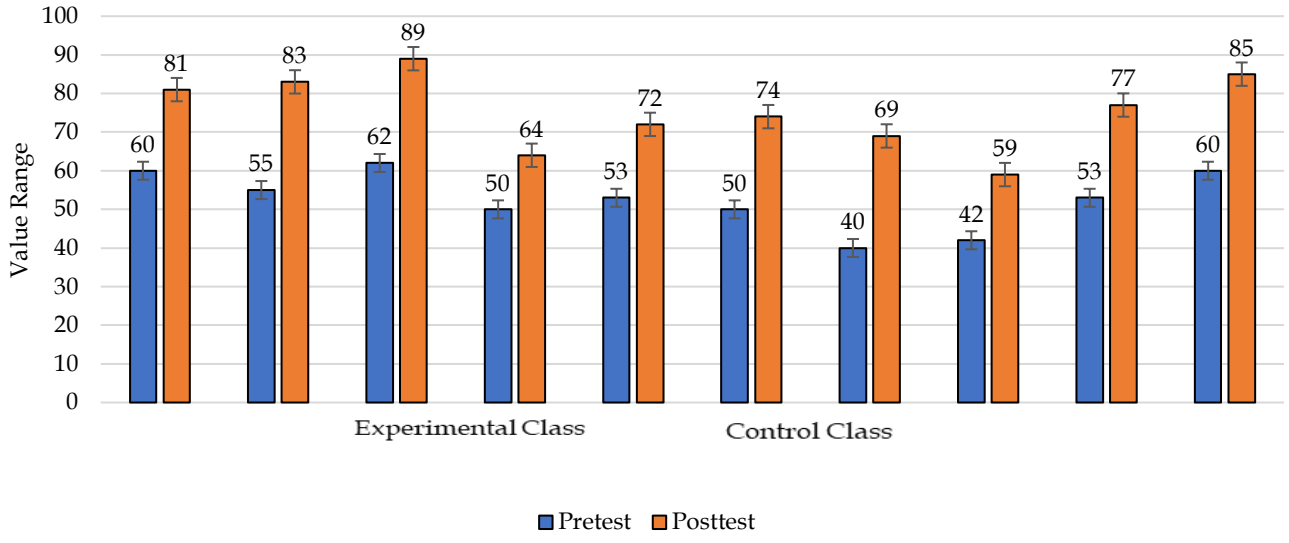

Figure 2. Average value of critical thinking ability indicators

Based on Table 2, it is known that there is an increase between the initial and post-test scores for each indicator of critical thinking ability. The difference in the highest pre-test and post-test scores in the experimental class is shown in the third indicator, namely concluding with the acquisition of a gain value of 0.71. The lowest

difference in pre-test and post-test scores is shown in the fourth indicator, further explanation with again 0.28. Value acquisition n-gain based on the table in the control class shows that of the five indicators have two categories, namely the medium and low categories. Moderate categories are obtained on simple explanation indicators 0.48, basic skills 0.48, explanations 0.51 and strategies and tactics 0.63. For the low category, a value of 0.29 is obtained on the concluding indicator.

At this stage the students did not make many mistakes, only some students were less careful in reading and understanding the meaning of the questions (Afriana et al., 2021).

Table 3. Value Normality Test Results *Pre-test* and *Post-test* Students' Critical Thinking Ability

Mark	Class	Shapiro-Wilk	
		Significance	Category
Pre-test Critical Thinking Ability	Experiment	0.136	Normal
	Control	0.266	Normal
Post-test Critical Thinking Ability	Experiment	0.093	Normal
	Control	0.081	Normal

(Sig.2-tailed>0.05)

Table 4. Homogeneity Test Results

Mark	Test Levene's	
	Significance	Category
Critical Thinking Ability	0.103	Homogeneous

Based on Table 4 shows the value pretest and posttest critical thinking skills in the experimental and control classes obtained a significant value greater than 0.05 (Sig. > 0.05). So it can be concluded that the data pretest and posttest in the experimental class and the control class on the results of critical thinking skills are normally distributed.

Based on Table 5 it can be seen that the homogeneity test obtained a significance value of 0.103 > 0.05 H0 accepted, it can be concluded that the data distribution is homogeneous.

Table 5. Test Results One-Way ANOVA

Mark	Sum of Squares	Df	Mean Square	f	Say.
Between Groups	122.722	1	122.722	4.811	0.032
Within Groups	1785.722	70	25.51		
Total	1908.444	71			

(Sig.2-tailed <0.05)

The criteria in the test are if it is significant (Sig.) > 0.05, then there is no difference between treatments. If significant (Sig.) <0.05 then there is a significant difference between treatments. Based on test results One-Way ANOVA Table 5 shows that the significant value of the ANOVA test is 0.032 <0.05 and H0 rejected, it can be concluded that there is a model influence Problem Based Learning (PBL) based on the STEM approach to the critical thinking skills of E-Phase in Biology Learning at the School of Mobilization.

Table 6. Results of Hypothesis Testing with Test Paired Sample T-Test

Indicator	Class	Signification
Critical Thinking Ability	Experiment	0.000< 0.05
	Control	0.000< 0.05

Based on the value of Sig. (2-tailed) of 0.000 <0.005, it can be concluded that there is a difference in the average results of students' critical thinking skills for the class pretest experiment with posttest PBL model experiment based on STEM approach. For the value of Sig. (2-tailed) of 0.000 <0.005 in the control class it can be concluded that there is a difference in the average results of students' critical thinking abilities for the control class when pretest-posttest model Direct Instruction. The PBL model is a learning model that encourages critical thinking that is relied on to train students' decisive reasoning power (Sagita, 2021). From the posttest results, problem-based learning with STEM has a positive impact on improving students' critical thinking skills (Febrianto et al., 2021).

Table 7. Average Percentage of Student Response Questionnaire Category Statements to the PBL Model

Statement Category	Response Assessment Criteria (%)			
	Very good	Good	Not good	Very Not Good
Teacher teaching skills	58	42	-	-
Learning model Problem Based Learning STEM based	44	56	-	-

Table 8. Percentage of Student Activity on the Application of the PBL Model Based on the STEM Approach

Indicator	Average Activity Category (%)			
	Very Active	Active	Not active	Very Inactive
Student organization on the problem	83.33	16.67	-	-
Organizing students to learn	83.33	16.67	-	-
Guiding individual as well as group investigations	83.33	16.67	-	-
Develop and present results	56.67	20	23.33	-
Analyze and evaluate the problem solving process	90	10	-	

Overall, the categories of students' responses to the learning process that have been carried out are included in the very good criteria, meaning that students respond well to the STEM-based PBL model which has been applied to the learning process of Living Things in Ecosystems material to measure students' critical thinking abilities. Increased learning effectiveness can occur because learning with this model can improve attention and aspects motivate students to follow the series of learning that will be given (Agnesa et al., 2022).

The average acquisition of all activity indicators studied is in the very active category. The results obtained show that during the learning process three meetings the average value of the activity of students in the E-phase class with the application of the PBL model based on the STEM approach is very good. Students are more enthusiastic in attending learning because they are faced with real problems and are involved in finding the right solution (Kardoyo et al., 2020). STEM education and the development and demonstration of 21st century skills, and so may be a way forward for any country wishing to pursue and improve the uptake of STEM, as is the case for Indonesia (Blackley et al., 2018).

Research on the application of the Problem Based Learning (PBL) model with the STEM approach in learning critical thinking skills was conducted in 3 meetings. This research was carried out on students at SMA Negeri 4 Jambi City. The material in this study is Living Things in Ecosystems according to the E-phase biology learning objectives. Initial tests and final tests are carried out outside the meeting. The aspect of critical thinking skills in this study refers to each indicator that is measured, namely simple explanations, basic skills, concluding, further explanations and strategies and tactics (Ennis cited Costa 1985). The instrument used to measure critical thinking skills in this study consisted of 5 essay questions. In learning biology, STEM conditions students in learning to use technology in experimental activities to prove a science concept (Sirajudin et al., 2021).

This is in line with Fadhilah's research (2022) that there is an effect of applying the STEM-integrated PBL model on critical thinking skills. This can be seen from the acquisition of the N-gain values of the two classes conducted in the study, there were moderate category gains. The highest increase in critical thinking skills is in the indicator of concluding and the lowest is in the indicator of further explanation. The PBL learning model has the potential to improve critical thinking skills similar to the conclusions in research conducted by (Fuadiyah et al., 2022). Biology learning by applying STEM-based PBL had a significant effect on the critical skills of high school students compared to direct learning (Shamdas et al., 2023).

The results of the ANOVA hypothesis test based on Table 4.5 show that the significance value is less than 0.05 for the value of critical thinking skills. Then H0 rejected, it can be concluded that there is a model influence Problem Based Learning (PBL) based on the STEM approach to the critical thinking skills of E-Phase in Biology Learning at the School of Mobilization. Positive results where the application of the PBL learning model was able to improve high school students' critical thinking abilities (Mutia et al., 2021). The results of the significance test showed an increase in students' critical thinking skills through PBL-STEM learning and students also gave a good response to the application of PBL-STEM in learning (Putri et al., 2020).

Learning with STEM makes students discuss with each other expressing their ideas and thoughts to answer questions in LKPD according to the steps in learning. In learning, students get information or new things from what has been observed and describe new ideas by understanding experiments and answering questions according to ability and knowledge (Hasanah et al., 2021). So this research can be said to be successful because the research objectives have been achieved according to plan even though there are still some deficiencies that must be corrected. STEM in biology learning can be linked to various learning models and materials appropriate so that it can have a positive influence on improving student learning outcomes, students' critical thinking skills (Syarah et al., 2021).

Learning using the PBL model based on the STEM approach has a positive impact on the responses generated by students from the questionnaire given by

the teacher at the end of learning and the ability to think critically with the application of the PBL model has an effect on student activities in learning activities. That the problem-based learning model has an effect on increasing students' critical thinking skills (Ratnasari et al., 2022). Application of PBL-STEM is determined by the learning experience in the classroom and other learning environments (Widowati et al., 2021).

The activities in this study were five indicators that were measured, namely of the five indicators, most were in the very active and active category. The research can be concluded that the application of the integrated problem based learning model STEM has a significant effect on students' critical thinking skills (Ariyatun et al., 2020).

Conclusion

There is a model influence Problem Based Learning (PBL) based on the STEM approach to the critical thinking skills of E-Phase in Biology Learning at the School of Mobilization. The data is shown from the difference in the acquisition of students' scores in the experimental class that uses a higher STEM-based PBL model, namely N-Gain 51 compared to students in the control class who use the model direct instruction namely N-Gain 48. The critical thinking skills of the E-Phase of the experimental class are higher than the control class in Biology Learning at the Mobilization High School.

Author Contributions

Arinda Jayanti Putri, Master Program in Natural Science Education, Postgraduate from Jambi University. Tedjo Sukmono, lecturer Master Master Program in Natural Science Education, Postgraduate from Jambi University. Ervan Johan Wicaksana, lecturer Master Master Program in Natural Science Education, Postgraduate from Jambi University.

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Conflicts of Interest

The authors declare no conflict of interest.

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