The Effect of Problem-Based Learning Model on High School Students' Critical Thinking Ability in Biotechnology Viewed from the Level of Confidence

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Abstract: Learning using the problem-based learning (PBL) enables students to solve problems as well as improve their science knowledge and skills. This study aims to investigate the effect of the use of PBL on critical thinking skills of high school students in biotechnology. Various levels of students' self-confidence are used as a moderating variable for PBL in producing the effect. A total of 64 students of SMAN 8 Batanghari Jambi were involved in this study. Some 32 students were allocated each to the experimental class which was learning using PBL and the control class which was learning using the expository learning. Data were collected using a pre-validated self-confidence questionnaires and tests of critical thinking skills. The factorial type of quasi-experimental with pretest posttest nonequivalent control group design was used in this study. The collected data were analyzed using a two-way ANOVA test. The results showed that PBL-students had a higher average score of critical thinking skills (85.87) than their counterpart (78.80). The data also showed that the students with better self-confidence also have a higher average score of critical thinking skills (85.32) than those with lower self-confidence (79.34). The results of the two-way ANOVA test showed that there was an effect of the use of PBL and the students' self-confidence on students' critical thinking skills. Even though it is very weak, the interaction between the learning model and the self-confidence was seemingly existed in affecting the students' critical thinking skills. It can be concluded that the appropriate learning model and appropriate self-confidence can affect student learning critical thinking skills.

Keywords: Critical thinking skills; Problem-based learning; Self-confidence

Introduction

Education is very important to create the quality of human resource. The quality of human resource needs to be improved in order to be able to produce new scientific inventions. The teacher as the main facilitator in school functions to explore, develop and optimize the potential of students (Rahmawati et al., 2020). In addition, school functions to instill character values by creating the school's environment that reflects good character (Sole & Anggraeni, 2017; Suhada, 2019).

Science subjects are relevant to real-world situations that give students the opportunity to learn contextual materials. Trianto (2010) stated that biology is a contextual subject that is fully related to the everyday real life of students. One learning model that can be used to learn the contextual material is problem-based learning (PBL). PBL is a learning model that can train students to solve problems in science. The PBL model in learning biology trains students to solve problems in biology material while at the same time focusing students on learning the concepts. This allows students to solve problems and find solutions in biology.

Learning with PBL is useful for making students able to face future challenges including technological developments, communication skills, and critical

thinking skills in problem solving (Astika et al., 2013; Apriana & Anwar, 2017; Erma et al., 2019; Budiarti & Airlanda, 2019; Cahyani et al., 2021). As a result, by implementing the PBL learning model students feel happy and more interested in the learning process (Qomariyah & Utama, 2021). With an interesting and innovative learning system, students are expected to be more active and innovative so as to achieve completeness in Biology lessons (Ismail, 2020).

Critical thinking is currently one of the important goals of education. In various countries critical thinking has become one of the competencies, goals and objectives to be achieved in education. Critical thinking is a very essential ability for life and functions effectively in all aspects of life (Umamah et al., 2018). Educators have long realized the importance of critical thinking skills as one of the outputs of the learning process. Critical thinking is the ability to question every important aspect of a problem. When practicing this ability, you are required to analyze a topic or problem objectively. That way, the results obtained will not be biased and are truly based on existing facts. Not only that, the ability to think critically also allows you to sort out information that is important or not to solve problems. Critical thinking also helps you make important decisions in various aspects, from life, work, to career.

Not only improving the critical thinking skills, PBL model is also able to provide a positive impact on student self-confidence. Self-confidence and learning motivation are needed by every student to be successful in learning process (Mustofa et al., 2019). Without self-confidence and motivation to learn, the learning process is not optimal.

Confidence is the ability that students have in their actions or attitudes towards themselves, feeling fearless in action and being responsible. Students can adapt to changes, both changes in physical conditions, ways of thinking, emotions, and social interactions with other students (Noviandari & Mursidi, 2019). Self-confidence can also provide impetus for achieving a student's success in solving his problems. Students who have a high level of self-confidence are able to solve problems calmly, being positive and do not give up easily. The school's efforts to instill cultural character values through the school's vision and mission and programs (Suhada, 2019).

Based on the background above, researchers have used PBL to improve students' critical thinking skills in biology lessons. The effect of PBL has also been investigated for its interaction with various levels of student self-confidence. Therefore, this article aims to describe the effect of applying the PBL learning model on the critical thinking skills of high school students in biotechnology. The effects of PBL and its interactions with students' self-confidence will also be discussed.

Method

Research Design

This study used a quasi-experiment with the type of Pretest Posttest Unequal Control Group design. This study involved two classes; the first class adopted the PBL learning model and the second class adopted the expository model. The research procedure can be observed in Table 1.

Table 1. Research Procedure

Group	Pre-test	Questionnaire	Treatment	Post-test
Treatment	T_1	T_2	X_1	Q_3
Control	T_1	T_2	0	Q_3

Description:
T_1 : Pre-test
T_2 : Questionnaire
Q_3 : Post-test
X_1 : Use of PBL and the level of confidence in critical thinking skills
0   : Use of the expository model

This research also applies the type of 2 x 2 factorial design. The first factor is the independent variable, namely PBL and Expository. The second factor is the moderator variable, the level of self-confidence; the level of high and low self-confidence. The design structure can be seen in Table 2.

Table 2. 2 x 2 Factorial Research Design

Level of self-confidence	Learning model	
	PBL (X1)	Expository (X2)
Height (Z_1)	$X_1 Z_1$	$X_2 Z_1$
Low (Z_2)	$X_1 Z_2$	$X_2 Z_2$

Population and Sample

The population in this research is all class XII IPA SMAN 8 Batanghari Jambi in the academic year of 2022/2023. The number of samples is 64 students, divided into 12 boys and 52 girls who were selected by random method. Sampled students were allocated to the experimental and control classes, each of which consisted of 32 students.

Research Instruments and Data

Data from students were collected using pretest and posttest. Data about self-confidence was collected using a questionnaire and observation sheets as well as a rating scale rubric.

Hypotheses

The hypotheses in this research are: There is an effect of the learning model on students' critical thinking skills; there is an effect of self-confidence on students' critical thinking skills; there is an interaction between the learning model and the student self-confidence.

Data Analysis Techniques

The data obtained is in the form of numbers. To test the hypothesis, two-way analysis of variance (2-way ANOVA) was used under assumptions that the data were normally distributed and homogeneous (Uyanto, 2009). Testing was carried out using SPSS 25. The

acceptance criteria are: If p-value > 0.05, then Ho is accepted; If the p-value < 0.05, so Ho was rejected.

Result and Discussion

The Effect of Learning Models on Students' Critical Thinking Skills

Based on the results of 2-way ANOVA, it can be seen that the p-value for the learning model is .003 (Table 3). This value is smaller than alpha .05 then Ho must be rejected. This means that there is an effect of the learning model on the sampled students' critical thinking skills in the concept of biotechnology.

Table 3. The Results of Two-Way ANOVA Test

Tests of Between-Subjects Effects

Dependent Variable: POSTEST

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1312.750 a	3	437,583	6,298	001	.239
Intercepts	437582.250	1	437582.250	6297658	.000	.991
Learning Model	650,250	1	650,250	9,358	003	.135
Self-Confident	552,250	1	552,250	7,948	007	.117
Model_Learning* Believe_Self	110,250	1	110,250	1,587	.213	.026
Error	4169,000	60	69,483			
Total	443064000	64				
Corrected Total	5481750	63				
a. R Squared = .239 (Adjusted R Squared = .201)						

These results are in line with the results of descriptive statistical tests (Table 4) which showed that the PBL students have a higher average score of critical thinking skills (85.87) than those the expository students (78.80).

Table 4. Results of Critical Thinking Scores

	PBL (H1)	Expository (H2)	Average
High PD (P1)	90.12	80.53	85.32
Low PD (P2)	81.62	77.06	79.34
Average	85.87	78.80	

That such difference in critical thinking scores between the two classes occurs because the PBL learning model has several advantages compared to the expository students. Some of those are:
1. The problems provided in PBL is quite good for the students to mastering the science lessons
2. The problems provided in PBL is beneficial as long as they are challenging students and gives happiness to students.
3. The problems provided in PBL may enhance learning activities.
4. The problems provided in PBL is helping students to solve problems in everyday life.

5. The problems provided in PBL help students develop their knowledge and improve responsibilities in learning.

In addition, PBL learning model is beneficial to train students to observe and to find solutions of problems posted in student worksheet. It is focusing students on questions which are related to the problems relevant to the learning material (Rushiana et al., 2023). PBL is simply a learning strategy which is developed with the aim to make students more productive and have a meaningful learning (Centea & Srinivasan, 2017; Aisyah et al., 2022).

Moreover, in PBL, students are required to be able to solve learning problems using critical thinking skills by some indicators; 1) Focus: Focusing on existing questions or issues in order to make decisions about what is believed, 2) Reason: knowing the reasons that support or reject decisions based on relevant situations and data, 3) Interference: making reasoned or convincing conclusions, 4) Situation: understanding situations and always keeping the situation in mind to help clarifying questions and find out key terms, 5) Clarity: explaining the meaning or terms used, 6) Overview: reviewing and thoroughly examining the taken decisions (Finken & Ennis in Zubaidah et al., 2015). The steps above are a system of critical thinking skills, content planning and teaching methods with higher

quality can make students to become critical thinking oriented (Hashemi, 2011). Students are active in learning, discussing, and collaborating with friends or solving problems independently (Fatimah et al., 2023). With the hope that collaboration and communication will encourage students to increase HOTS and creativity (Hadiati et al., 2023).

The results obtained indicate that the PBL is sufficient and effective in improving students' critical thinking skills in biotechnology. That skill can be acquired by the students because the learning activities were carried out through the process of thinking using the syntax that has been made. This provides opportunities to focus on questions, to find reasons, to manage information, to make inferences, to understand situations, to explain meaning and to research decisions.

The Effect of Self-Confidence on Students' Critical Thinking Skills

Based on the results of two-way ANOVA, it can be seen that the p-value is .007 (Table 3). This value is smaller than alpha .05 then the Ho must be rejected. This means that there is an effect of self-confidence on the sampled students' critical thinking skills in the concept of biotechnology.

The finding is reasonable as confidence is highly needed by every person. If students have a good self-confidence, then they will be ready to face the dynamics in life and in schools which is full of challenges (Awami et al., 2022). Good confidence can encourage students to express opinions, to perform, to ask questions, and to be able to make students more notable compared to those with less confidence (Asiyah et al., 2019). Students who lack of self-confidence tend to be introvert, being afraid of expressing their opinions, being shy of asking questions, and prefer not to try. This will result in a lack of motivation in learning.

Moreover, self-confidence in ability and not hiding self-weaknesses can lead students to become successful in study and to become independent persons. This is parallel with what written in the dictionary that self-confident is needed as a belief to do something successfully (Rizqi et al., 2016; Fardani et al., 2021). The results about the effect of the self-confidence on the students' critical thinking skills are confirmed by the data in Table 4. It is clear that students with high self-confidence have a higher average of critical thinking score (85.32) than the students with low self-confidence (79.34). This finding is in line with the results of Febriyandari et al. (2022) which stated that there is an effect of self-confidence on students' learning outcomes. In addition, self-confidence may improve students' critical thinking skills because they are triggered to continue to be active in the learning process

so that they grow their enthusiasm by themselves (Erma et al., 2019; Rezkillah & Haryanto, 2020; Istiqomah & Indarini, 2021).

The Interaction between Learning Models and Self-Confidence

Based on the results of two-way ANOVA, it can be seen that the p-value is .213 (Table 3). This value is higher than alpha .05 then the Ho must be accepted. This means that there is no interaction between the model and the high school students' confidence on the sampled students' critical thinking skills in the concept of biotechnology.

However, Figure 1 shows that there is a potential interaction between the two variables in the future since the two lines have different slopes. This projection was reasonable as Suartika et al. (2015) states that there is interaction between self-confidence and learning models on student learning outcomes. Pranoto (2016) also stated that cooperative learning can increase self-confidence.

The fact that the results of the two-way ANOVA test showed there was no interaction between the two variables may be due to the number of samples in this study that did not adequate to represent the population. This may also be because of the number of the experiments conducted in this study that was not adequate to provide adequate data representing the varied characteristics of the students' and schools in Jambi city.
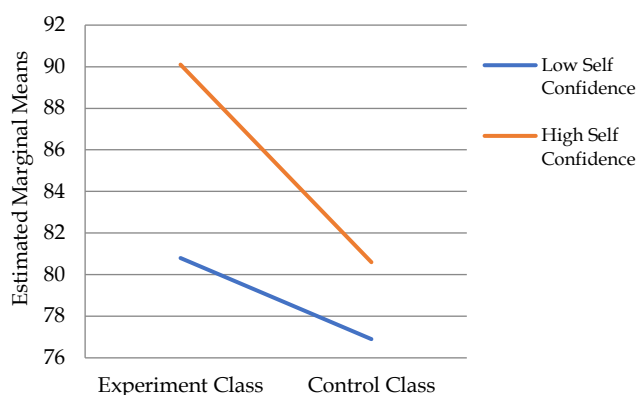
Figure 1. Interaction curve

The finding about the interaction is not surprising as Rushiana et al. (2023) and Aisyah et al. (2022) have examined the efforts to develop students' critical thinking skills in chemistry learning was difficult. The results showed that using problems in everyday life or contextual is the better way to do it than the higher level of content such as biotechnology. This made clear that the students were lack of confidence or courage in learning to express their opinions. Even if they do so, they can only express opinions but have not been able to

provide reasons and evidence to support their opinion or statement.

In general, the weaknesses of the students in arguing were because the students were not used to do it. That was because their teachers have not trained students to debate in learning. Teachers tend to test the ability of student to answer questions to grab content understanding, to ask students to provide brief explanation, and to ask students to give conclusions which are prevalently not deep (Witri et al., 2020; Suzanti et al., 2023).

Conclusion

Based on the results of the analysis, it can be concluded that there is an effect of the PBL model on the critical thinking skills of high school students in the concept of biotechnology. It can be concluded that there is an effect of self-confidence on the critical thinking skills of high school students in the concept of biotechnology. Finally, there is no official interaction between the model and high school students' confidence in the concept of biotechnology. However, the opportunity for interaction between models and confidence is wide open if the extent of the study is enlarged

Author Contributions
M. Helmi conceptualized the research idea, designed of methodology, management and coordination responsibility; Asrial analyzed data, conducted a research and investigation process; Bambang Hariyadi conducted literature review and provided critical feedback on the manuscript.

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