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The Effect of Problem-Based Learning in Biophysics on Science Education Students' Critical Thinking Skills

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Abstract: This study investigates the effectiveness of Problem-Based Learning (PBL) in improving the critical thinking skills of science education students in a biophysics course. The research employed a pre-experimental design using the One Shot Case Study method with posttest-only data. The participants were fourth-semester undergraduate students from the Science Education Study Program at the State University of Surabaya, who took the Biophysics course in the 2023/2024 academic year. The study was conducted in June 2023. Data analysis using the Shapiro-Wilk test showed a significance value of 0.086, indicating that the data were normally distributed. A one-sample t-test yielded a significance value of 0.417, which supports the conclusion that PBL has a positive influence on students' critical thinking skills. Overall, the implementation of PBL in biophysics lectures demonstrates its potential to enhance critical thinking among science education students.

Keywords: Biophysics; Critical thinking; Problem-**B**ased learning; Science Education Students

Introduction

Education is a deliberate and structured effort to create an attractive learning environment, so that learners can actively develop their potential in religious aspects, self-control, personality, intelligence, noble character, and skills needed for themselves and society (Pristiwanti et al., 2022). Education is considered the most crucial aspect of human life and is the right of every Indonesian citizen. Therefore, being an educated individual is considered very important especially in the current era of globalization (Alpian et al., 2019). In the era of globalization, advances in science and technology are developing rapidly, creating a significant impact on the increasing challenges and global competition faced by every country (Nazifah & Asrizal, 2022). This progress encourages today's youth to develop a skill to prepare them for future challenges (Jannah et al., 2021). These skills are better known as 21st century skills.

21st century skills are divided into 3 main categories, namely learning & innovation skills, digital literacy skills, career & life skills (González-pérez & Ramírez-montoya, 2022). In the learning skills category, there are four competencies that must be possessed which are commonly known as the 4Cs, namely: Communication, Collaboration, Critical Thinking, and Creativity (Aji, 2019). 21st century skills, especially 4C learning & innovation skills need to be integrated into various subjects, including Science subjects, so that every learner can explicitly develop these skills (Monica et al., 2021). If learners successfully master these skills, they will more easily overcome challenges throughout life, be able to adapt to new situations, solve problems independently, collaborate in sharing ideas, and reflect on how their actions impact others (Zubaidah, 2019).

Natural Sciences, or better known as science, consists of various branches of science, such as physics, biology, chemistry, astronomy, health, safety, environment, geology, and technology (Azizah et al., 2020). As part of the natural sciences, physics is specifically focused on understanding and analyzing natural events and phenomena (Ramadhanti et al.,

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2022). Physics is also a fundamental science that provides the conceptual basis and makes significant contributions to a wide range of other disciplines (Yusuf, 2023). The broad scope of physics has contributed to the birth of new disciplines that combine the principles of physics with various other disciplines. For example, the connection between physics and astronomy formed a branch of science known as astrophysics. Similarly, in the field of biology, its relationship with physics gave birth to the discipline of biophysics. As for the health sector, the relationship between physics and medical science resulted in medical physics, and so on (Lusiani et al., 2021).

Biophysics itself has the meaning of a study of biological processes from a physical point of view (Mierke, 2020). The discussion in biophysics learning has tremendous significance because it is the basis for integration between the disciplines of biology and physics (Putri & Oktavia, 2020). The hope is that students can master the integration between the disciplines of biology and physics and change their views so that they no longer view them separately, but rather see the harmony and interconnection between the two, so as to provide deeper insights to students (Oktavia, 2019). In biophysics learning, critical thinking skills are very important, considering that biophysics material involves theories related to natural conditions and the environment so that it allows students to better relate information from biophysics learning to daily life (Muharni et al., 2019).

The results of observations of Biophysics lectures in 4th semester students of the State University of Surabaya science education study program show that students' critical thinking skills are still relatively lacking. This limitation can be seen from the lack of student involvement in the lecture process, such as the lack of questioning and expressing opinions (Indriani et al., 2022). One of the causes is the use of conventional learning models that make students only focus on paying attention and listening to material without being actively involved during the teaching and learning process, creating a learning situation that is teacher-centered or dominated by teachers or lecturers (Kusumawati et al., 2022). As a result, interest in further exploration is low, and students' critical thinking skills are poorly honed, which in turn makes it difficult for them when faced with problems. To overcome this situation, lecturers need to wisely choose the appropriate learning model to create an optimal learning environment, so that students' critical thinking skills can develop well (Fadhilah et al., 2022).

The development of critical thinking skills in biophysics learning can be realized through various learning models, including problem-based learning (PBL) (Agnesa & Rahmadana, 2022). Problem-based learning model is a learning approach that focuses on solving real problems in everyday life as a foundation for acquiring knowledge and concepts, with an emphasis on critical thinking and problem solving skills (Ramadhani et al., 2019). The problem-based learning model also integrates the 4C principles, namely critical thinking, creativity, communication, and collaboration, so it is considered an ideal learning method to achieve educational goals in the 21st century (Nurhayati et al., 2023). Therefore, this study aims to examine the effect of implementing a problem-based learning model on the critical thinking abilities of science education students in biophysics courses.

Method

The type of research used is pre-experimental research with a One Shot Case Study design, which is a design that assesses the results (outcome) after being given treatment without taking an initial measurement (pretest). This design is used to test the effect of the problem-based learning model in the Biophysics course in improving the critical thinking skills of science education students. The research was conducted in June 2023 with the subject of 4th semester students of the Bachelor of Science Education Study Program, State University of Surabaya who took the Biophysics course in the 2023/2024 academic year. Although this research design does not compare changes in ability before and after treatment, this approach still provides an initial picture of the potential effectiveness of problem-based learning in the context of Biophysics learning.

The data collection method in this study was carried out through a test in the form of 5 description questions which were given in the form of a posttest through Google Form after attending the Biophysics lecture using the problem-based learning model. The posttest questions given were arranged based on five aspects of critical thinking according to Ennis (1996) which were then detailed into five questions according to the critical thinking indicators presented in Table 1.

Table 1. Grid of Critical Thinking Ability Posttest Questions

Critical Thinking Skills Aspects	Indicator
Elementary Clarification	Focusing the question
Basic Support	Consider the credibility of the source
Inference	Creating and considering inductive
Advanced Clarification	Defining the term
Strategy and Tactics	Determine the action

In this study, the preparation of critical thinking skills instruments was carried out through several stages, starting from the preparation of a question grid that refers to the Semester Learning Plan (RPS) of the Biophysics course in the undergraduate science education study program at State University of Surabaya in the 2023/2024 academic year to identify the basic competencies and learning objectives to be achieved. The question instrument then went through the validity test stage before being applied to lectures. Data analysis was conducted using normality test and one sample t-test with the help of SPSS software.

Result and Discussion

In this study, the implementation of lectures with the problem-based learning model has produced critical thinking skills instruments that have been tested for validity by three experts. In testing critical thinking skills, from three experts who are all master students of science education, it was found that the mode in which the five questions proposed were declared valid. Thus, the question instrument is suitable to be given to students as a posttest to measure critical thinking skills.

To analyze student test results using critical thinking question instruments, with the help of the IBM SPSS program, a normality test was carried out using the Shapiro-Wilk method by calculating the unstandardized residuals from the difference between student scores and expected scores (Muhid, 2019). In the process of making normality test decisions using the Shapiro-Wilk method, the guidelines used are if the significance value (Sig.) is less than 0.05, it can be concluded that the data does not have a normal distribution. Otherwise, if the significance value (Sig.) is greater than 0.05, it can be concluded that the data has a normal distribution (Raharjo, 2021). Based on the results of the analysis, the significance value is 0.086 which is greater than the value of 0.05. Therefore, based on the basis of decision making, it can be seen that the data has a normal distribution. As a result, it can be interpreted that the normality test results show an indication that the data distribution has a normal distribution.

Table 2. Test of Normality (Shapiro–Wilk)

Statistic.	df (degrees of freedom)	Sig. (Significance)
.942	28	0.086

In the next step, an analysis was conducted using the one sample t-test which aims to explore the impact of the instrument that was used in measuring the level of the students' critical thinking skills (Tureni et al., 2021). In this research, there are two hypotheses proposed. The alternative hypothesis (Ha) states that learning through the problem-based learning model does not have a significant effect on increasing the level of critical thinking skills in science students. On the other hand, the null hypothesis (Ho) states that learning through the problem-based learning model has a significant effect on increasing the level of critical thinking skills in science students.

In the decision-making process in the one sample t-test, it is necessary to consider several decision-making bases. Referring to Pituch (2015), if the significance value (Sig.) <0.05 then Ho is rejected, and Ha is accepted. However, if the value of Sig. ≥ 0.05 then Ha is rejected, and Ho is accepted. Based on the results of the one sample t-test analysis, a significance value of 0.417 was obtained, which exceeds the value of 0.05. This result indicates that although the implementation of Problem-based Learning may have been positively received by students, statistically the effect has not been proven significant. Therefore, the interpretation of the effect needs to be further examined through a reflective-descriptive approach to student learning outcomes or through data triangulation. Further research with a more robust design, such as a pretest-posttest control group design, is recommended to obtain more in-depth and convincing results.

This is consistent with the findings of Sari (2022) in her research which states that the implementation of the Problem-based Learning model in biophysics courses, which is supported by appropriate worksheets and receives regular guidance, can contribute to improving the problem-solving skills of the prospective science teachers. Subsequently, a study by Wahyudiati (2022) stated that the Problem-based Learning model can improve students' critical thinking skills because this learning model trains students to be actively involved in analyzing and predicting problems that come from daily experiences, which in turn have a positive impact on their scientific attitudes and critical thinking skills. It is important for students to develop critical thinking skills as a preparation step to face challenges and problems that may be faced both in the current situation and in the future (Riyanto et al., 2024).

Conclusion

Based on the results of data analysis and discussion, the conclusion of this research is that the implementation of lectures with the problem-based learning model produces valid question instruments to measure students' critical thinking skills. In addition, the normality test results using the Shapiro-Wilk method show that the data is normally distributed with a significance value of 0.086 (> 0.05). However, the results of the one sample t-test showed a significance value of 0.417 (> 0.05), which means that statistically there is no significant difference. Thus, although learning using the

problem-based learning model has been implemented and obtained positive results, its effect on improving students' critical thinking skills cannot be concluded significantly based on statistical results. Further research with a more robust design, such as the use of a control group and a larger sample size, is recommended to confirm the effectiveness of the problem-based learning model in improving students' critical thinking skills.

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The authors declare no conflict of interest

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