Florea: Jurnal Biologi dan Pembelajarannya
Vol. 11, No. 1, May 2024, pp. 1~6
ISSN 2355-6102; e-ISSN 2502-0404 DOI: 10.25273/florea.v11i1.18308

The Effect of STEM-Based Biology Learning on Students' Critical Thinking Skills on Environmental Pollution Material

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Article Info

Article history:

Received February 27, 2024
Revised March 29, 2024
Accepted May 31,2024

Keywords:

Biology learning,
STEM approach
Critical thinking skills

ABSTRACT

This research aims to determine the effect of STEM-based biology learning on the critical thinking skills of class X MIPA students at SMA Negeri 4 Tasikmalaya on environmental change material. The population in this study was all 5 classes of class educate. Data collection was carried out by providing 13 questions describing critical thinking skills. The data analysis technique used was the independent t test with the help of the SPSS version 25 for Windows application with a significance level of 5%. Based on hypothesis testing, it was found that STEM-based biology learning had a significant effect of 0.01 or a significance value of <0.05 on critical thinking skills. In the research results, the experimental class was superior to the control class, seen from the average score achieved in critical thinking skills. So it can be concluded that STEM-based biology learning influences students' critical thinking skills on environmental change material.

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1. INTRODUCTION

Curriculum in the world of education is a series of plans, objectives and learning materials to facilitate a teaching and learning process. The educational curriculum is always changing, depending on developments over time as well as students' needs so that they can easily achieve their own learning goals [1]. The education system in Indonesia in facing the challenges of the 21st century uses the 2013 curriculum, one of the objectives of the 2013 curriculum is to build students' readiness so they can face developments in the future. 21st century education has various abilities in various fields that students need to have. Competence in the 21st century is divided into three domains, namely cognitive competence, interpersonal competence and intrapersonal competence [2]

21st century education has at least four learning competencies that must be mastered, namely high comprehension skills, critical thinking skills, collaboration skills and communication skills [3]. According to Dewi (2019), one of the demands for developing a 21st century curriculum in schools is changing the learning approach to be student-centred. This is in accordance with the thinking and learning skills that students must have. There are many learning phenomena, especially in biology learning, that teachers still need to pay attention to. One of the problems faced by biology learning is that learning is not student-centered, including a lack of critical thinking skills. The quality of learning can be said to be good if learning is centered on student activities

[4];[5];[6]. Biology learning is often based on theoretical exposure and passive understanding of information, rather than experiences that encourage students to develop critical thinking skills. Then, with the lack of application of scientific practice, sometimes biology learning is still limited to theoretical explanations and does not provide opportunities for students to carry out scientific practice. observations and experiments in biology learning to develop thinking skills and better mastery of concepts.

Based on the results of observations made at SMA Negeri 4 Tasikmalaya. Learning is carried out offline. Observation results show that there are still many students who do not ask challenging questions, which require deep thinking or critical evaluation, students are unable to recognize the assumptions or premises that form the basis of a statement or argument, some students have difficulty considering various factors or consequences before making a decision, most students are not able to effectively analyze complex information or break it down into smaller parts, and students do not have sufficient skills in logical or deductive reasoning. This description is part of the indicators of critical thinking skills according to ennis (2015). The results of these observations indicate that students' critical thinking skills still need to be paid attention to or pursued in learning

Teachers can strive for students' critical thinking skills in learning activities, including biology learning activities. Biology learning activities aim to equip students with basic competencies in high school biology subjects as stated in Ministry of Education and Culture Regulation No. 37 of 2018. One of the materials discussed in high school biology subjects is environmental pollution. Environmental pollution material is a material that is quite difficult for students to learn. The material on environmental pollution is one of the biology subjects in class human actions [7]

Pembelajaran materi pencemaran lingkugan agar dapat dipelajari dengan mudah dan tidak jenuh salah satunya dengan menggunakan pendekatan STEM. STEM merupakan suatu pendekatan pembelajaran yang efektif untuk memfasilitasi serta mempertahankan keterpaduan sains, teknologi, engineering dan matematika. STEM dapat melatih keterampilan berpikir kritis siswa melalui kegiatan memecahkan masalah, mengambil keputusan, menganalisis asumsi, mengevaluasi, melakukan penyelidikan dan dapat membantu siswa untuk mengkreasi suatu pengetahuan baru [8]. Literasi STEM yang dikembangkan dalam diri siswa memungkinkan mereka dapat bersaing dalam era ekonomi baru yang berbasis pengetahuan [9]

Students' critical thinking skills are still of greater concern to teachers, so researchers are also making innovations in their learning, namely using STEM to improve students' critical thinking skills.

Based on this description, researchers suspect that there is an influence on STEM-based biology learning on critical thinking skills. The aim of the research is to find out how STEM-based Biology Learning influences students' Critical Thinking Skills on environmental pollution material.

2. METHOD

The method used by researchers is a quantitative method with a Quasi experimental design or quasi experiment. This research was conducted in August 2023 and the population in this research was all class The sampling technique used purposive sampling, namely class X MIPA 1 as the experimental class with a total of 38 students and class X MIPA 2 as the control class with a total of 38 students. The research design used the matched-only posttest-only control group design and the data collection technique used a critical thinking skills test technique in the form of 18 item description questions. Data analysis consists of: 1) normality test using Kolmogorov-Smirnov, normality test criteria if the Sig.> 0.05 is declared normal, 2) homogeneity test using the Levene test, homogeneity test criteria if the Sig. > 0.05 is declared homogeneous, 3) independent t test hypothesis with the help of the SPSS version 25 for Windows application with a significance level of 5%, the criterion is if ($p < 0.05$) then there are differences in students' critical thinking skills.

3. RESULT AND DISCUSSION

Penelitian ini dilaksanakan di kelas X MIPA 1 dan kelas X MIPA 2 SMA Negeri 4 Tasikmalaya tahun ajaran 2023/2024 dengan jumlah peserta didik sebanyak 38 orang sebagai kelas eksperimen yaitu kelas X MIPA 1 dan juga 38 peserta didik sebagai kelas kontrol yaitu kelas X MIPA 2. Pelaksanaan pembelajaran teridiri dari 3 kali pertemuan dalam materi perubahan lingkungan dengan menggunakan model pembelajaran *project based learning* berbasis STEM untuk kelas eksperimen dan model pembelajaran *project based learning* pendekatan saintifik untuk kelas kontrol. Peneliti ini menggunakan tes tertulis berupa soa uraian untuk mengukur keterampilan berpikir kritis dengan jumlah soal sebanyak 18 butir soal.

Data obtained from the control class and experimental class in critical thinking skills can be seen from the average score of critical thinking skills results, the experimental class has a score of 27.60 while the control class has a score of 24.18 which can be seen from Figure 1.

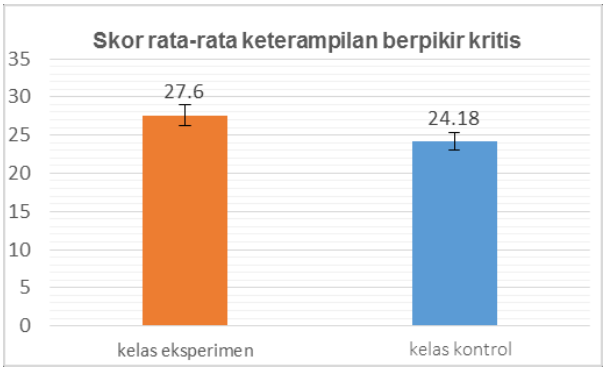

Figure 1. Critical Thinking Skills Average Score Diagram Source: Personal data processing

Based on diagram 1, it can be concluded that the difference in the average score of students critical thinking skills in the experimental class whose learning process uses STEM-based project based learning has experienced development compared to the average score in the control class even though the experimental class score is not much different from the control class. . STEM-based biology learning has a significant influence on students' critical thinking skills. In line with research by Tseng, et al (2013) which states that integrating a STEM approach can have a positive impact on improving students' critical thinking skills. Because the STEM learning approach can develop students' critical thinking skills, through questions that use indicators of critical thinking skills.

This STEM-based learning allows students to learn and apply it to problems that exist in real life [11]. However, the experimental class and control class in the histogram both still lack critical thinking skills, but the experimental class has a class limit that is higher than the class limit for the critical thinking skills score in the control class. So it can be concluded that critical thinking skills in the experimental class that uses a STEM approach have a higher posttest score than the control class. It can also be said that there is an influence on STEM-based biology learning on students' critical thinking skills. The STEM approach is a teaching and learning process that integrates content and skills in four fields, namely science, technology, engineering and mathematics [10]. These four fields in the STEM approach can train students to improve thinking skills, one of which is critical thinking skills. According to Ennis, there are 5 indicators of critical thinking skills, namely, 1) Giving a simple explanation. 2) Building basic skills 3) Making inferences. 4) Provide further explanation. 5) Set strategy and tactics. The average indicators of students' critical thinking skills in the experimental class and control class are presented in Figure 2

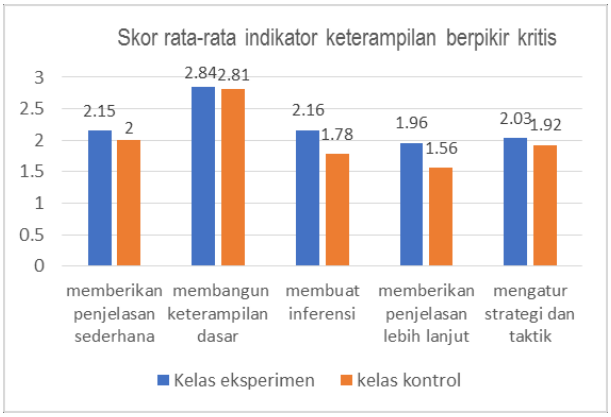

Figure 2. Average score of indicators of critical thinking skills in the experimental and control classes

Based on the graph in Figure 2, it is known that the average value of critical thinking skills indicators in the experimental class is higher than the control class. The experimental class had the highest average score on indicator 2 (building basic skills) with a score of 2.84. In the indicator of building basic skills in the learning process where students are guided and trained to discuss and design projects, at this stage students are also required to search for and sort logical data/information

that supports the project creation process. The lowest score that students answer correctly is the indicator 4 (making further explanations) with an average score of 1.96.

The indicator of building basic skills has the highest score in the experimental class. In the learning process, students are guided and trained to discuss and design the project that will be created. Because of this project-based learning, students must pay attention to whether the procedures are correct or not in designing the project. STEM-based learning where science, technology, engineering and mathematics are involved in learning, for example calculations or appropriate measurements of tools and materials used so that project designs can achieve goals, students carry out the process of making water filtration from various materials. Meanwhile, the control class did not use a STEM approach. Through these activities, students have the ability to build basic skills, guided by the teacher in creating and designing the projects they will work on. In line with [2] that in the indicator of building basic skills the subject is able to analyze problems by identifying relevant information and considering possible answers correctly. Meanwhile, the lowest score is in the indicator of providing further explanation, which means that the majority of students have difficulty in answer questions that require them to provide further explanation. Apart from that, students will also understand social problems in accordance with what they learned previously. In this section, the learning process involves students in deepening their understanding of the problem by seeking information from various sources to confirm and find solutions. In line with Putri's opinion (2018) that providing further explanation is an effort to gain more detailed knowledge regarding a problem in order to reassure yourself.

Other indicators in the experimental class, such as indicators 1 (giving a simple explanation), 3 (inference), and 5 (arranging strategies and tactics), respectively, the scores obtained are (2.15), (2.16), and (2.03). It was concluded that the research results showed that the experimental class scores were more significant than the control class, although improvements had to be made. From the posttest score data, it was seen that experimental class students had improved critical thinking skills compared to conventional learning methods that did not use project results testing and then not using the STEM approach.

Based on the results of the normality test using the Kolmogorov Smirnov test with the help of SPSS version 25 for Windows software with a significance level of 5%. In Table 1, it is known that the significance value for critical thinking skills data is 0.20 for the control class and 0.20 for the experimental class. This value has a significance of > 0.05 so it can be concluded that Ho is accepted. This means that the posttest data on critical thinking skills in the experimental class, namely class X MIPA 1 and the control class, namely class X MIPA 2, are stated to come from a normally distributed population.

Table 1 Summary of Research Data Normality Test

Data	Level	Significant Value	Analysis Results	Conclusion Analysis	Information
Value of skill questions critical thinking class	0,05	0,20	0,05 < Significant Value	Terima Ho	The data comes from a population normally distributed
Value of critical thinking skills questions for experimental class	0,05	0,20	0,05 < Significant Value	Terima Ho	Data comes from a normally distributed population

Source: Results of research data analysis

Based on the results of the homogeneity test of posttest data on critical thinking skills from the control class and experimental class in this study, a sig value of 0.88 was obtained, which means more than 0.05. So that the data can be stated to have homogeneous variance. The results of the homogeneity test can be seen in Figure 3 as follows:

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	.022	1	74	.883
	Based on Median	.018	1	74	.893
	Based on Median and with adjusted df	.018	1	73.824	.893
	Based on trimmed mean	.026	1	74	.873

Figure 3. Test of homogeneity of critical thinking skills

 ISSN 2355-6102; e-ISSN 2502-0404

Source: Results of personal data processing

After carrying out prerequisite tests in the form of normality tests and homogeneity tests, the conclusion was obtained that the data in this study came from a population that was normally distributed and had a homogeneous variance. So we can continue with hypothesis testing using the t test.

Hypothesis testing is used to determine whether there is an influence of STEM-based biology learning on students' critical thinking skills. All data has been taken from a normally distributed population and all data groups have homogeneous variants, so hypothesis testing is continued using the independent t test with the help of the SPSS version 25 for Windows application with a significance level of 5%.

Table 2. Summary of posttest t test of critical thinking skills of control class and experimental class students

Independent Samples								
t-test for Equality of								
		T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Critical thinking skills	Equal variances assumed	2,639	74	0,010	3,421	1,296	0,838	6,004
	Equal variances not	2,639	73,99	0,010	3,421	1,296	0,838	6,004

Source: Results of Personal Data Processing

The results of hypothesis testing regarding the influence of STEM-based biology learning on students' critical thinking skills can be seen in table 2. A significance value of 0.010 was obtained, which means significance < 0.05, indicating that Ho is rejected and Ha is accepted, so it can be concluded that there is an influence of biology-based learning. STEM on critical thinking skills of class X MIPA students at SMA 4 Tasikmalaya.

The results of hypothesis testing regarding the influence of STEM-based biology learning on students' critical thinking skills can be seen in table 2. A significance value of 0.010 was obtained, which means significance < 0.05, indicating that Ho is rejected and Ha is accepted, so it can be concluded that there is an influence of biology-based learning. STEM on critical thinking skills. From the results of this research, the difference between the scores of the experimental class and the control class for each indicator is not that big. This is because students are not yet accustomed to using the STEM-based project based learning model and students are still accustomed to following the learning model applied at school. The results of this research are supported by research conducted by Susanti (2020) which shows that learning by applying the Science, Technology, Engineering, and Mathematics (STEM-PjBL) approach has a significant influence on students' critical thinking skills. So it can be said that the STEM-based learning model influences the critical thinking skills of students in class X MIPA at SMA 4 Tasikmalaya.

Through the STEM approach, students are given the opportunity to conduct experiments, observe natural phenomena, and apply critical thinking in solving biological problems. Students are invited to ask questions, formulate hypotheses, and collect data to test their hypotheses. This helps students develop critical thinking skills such as analysis, evaluation, and problem solving. Thus, STEM-based biology learning is not only about understanding biological facts, but also about practicing critical thinking skills which are very important in solving problems in the real world.

The advantage of using STEM-based learning is that students are able to think logically according to the problems they face and students are able to solve a problem by providing different solutions. Apart from that, the learning process using the STEM-based project based learning model has obstacles, namely that it takes a relatively long time. This is in line with Izzani's (2019) opinion that it takes a long time to prepare to solve problems with STEM-based learning.

4. CONCLUSION

Based on the results of research, data processing and hypothesis testing, it can be concluded that there is an influence of the STEM-based biology learning model on students' critical thinking skills in environmental change material in class X MIPA SMA Negeri 4 Tasikmalaya City for the 2023/2024 academic year. This is shown by the hypothesis test which shows a significance value of 0.010 or a significance value of <0.05, which means reject Ho. Critical thinking skills in environmental change material can be seen from the average posttest score of students in the experimental class which uses a STEM-based project based learning model compared to the control class. The highest score in the experimental class was the same as in the control class, namely indicator 2 (building basic skills), and the lowest score was the same in the experimental class and control class, namely indicator 4 (making further explanations).

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RECOMMENDATION

Based on the results of the research that has been carried out, the author suggests STEM-based biology learning can be used as a reference for the learning process and it is hoped that teachers and students can maximize learning steps to achieve the goals as expected. STEM-based biology learning can be used as alternative learning to empower 21st century skills. Future researchers are expected to be able to apply STEM-based biology learning to other concepts and is appropriate to the concept being studied.

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