

CRITICAL THINKING SKILLS IN STEM INTEGRATED PjBL LEARNING WITH BIOTECHNOLOGY MATERIAL CLASS XII IPA SMAN 5 SURAKARTA TA 2023/2024

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ABSTRACT

Education has an important role in preparing quality human resources. Therefore, one suitable learning model to apply is PjBL. STEM is an approach that combines four disciplines in learning related to solving real-life problems. The STEM-integrated PjBL model aims to improve students' critical thinking skills. Critical thinking skills are one of the skills that students must possess in the 21st century. The purpose of this study is to determine the critical thinking skills of grade XII IPA students of SMAN 5 Surakarta TA 2023/2024 on biotechnology materials using a STEM-integrated PjBL approach. The research method uses quasi-experiments. This critical thinking skill is measured through posttest questions with cognitive C4-C6. The results showed that from the results of the t-test it was known that the sig (2-tailed) value was $0.000 < 0.005$ so it could be concluded that the STEM-integrated PjBL approach was able to improve the critical thinking skills of grade XII IPA students of SMAN 5 Surakarta biotechnology material TA 2023/2024. Based on the T-test curve of critical thinking skills, it is known that H_0 is rejected because the calculated t value is greater than the table t, which is $7.566 > 1.99714$ so that the STEM-integrated PjBL approach can improve the critical thinking skills of grade XII IPA students of SMAN 5 Surakarta biotechnology material TA 2023/2024. So it can be concluded that the PjBL-STEM learning model can improve students' critical thinking skills with an average score of 87,15 %.

Keywords: *Critical thinking, PjBL-STEM, Biotechnology, 21st century skills, Class XII IPA*



INTRODUCTION

The development of science and technology has an impact on many things, including education. Education has an important role in preparing quality and highly competitive human resources to meet 21st-century skills (Badan Standar Nasional Pendidikan (BSNP), 2012). The Indonesian government has done many things to advance the quality of education, such as improving the curriculum and working with educational institutions to measure the success of the curriculum and learning model (Virtanti & Yuniastuti, 2021).

Indonesia is one of the countries that participated in the survey conducted by TIMSS 2015 (International Trends in International Mathematics and Science). The survey results show that the score of Indonesian students in science is 397, placing Indonesia in 45th place out of 48 countries (Martin et al., 2016). According to survey results from the Program for PISA in 2018, Indonesia was ranked 75th out of 80 countries with reading, mathematics, and science scores of 371, 379, and 396 (McComas, 2014).

From these results show that Indonesian students still have low science skills, so they need to be improved. According to the (OECD, 2019), the PISA assessment aims to assess the quality of education based on students' academic abilities in the fields of science, mathematics, and reading, this test is taken by students aged 15-16 years. The PISA test was participated in by 40 OECD countries and 53 partner countries consisting of several continents including Asia, Europe, North America, South America, and Africa (OECD, 2022). This is because this age is considered ready to face various global demands and challenges so 21st-century learning needs to be implemented in schools.

21st-century learning combines literacy skills, knowledge, skills, attitudes, and mastery of technology (Mu'minah, 2021). The 21st-century skills that students are expected to have are communicating, collaborating, creative thinking, and critical thinking.

However, in reality, the learning process that has been taking place so far has not been able to direct students to develop 21st-century skills, especially critical thinking. The level of critical thinking ability of students tends to be low. This is because, during the learning

process, students are passive and only depend on the teacher as the main source of knowledge. Apart from that, in the learning process, students only rely on memory and do not apply concepts in everyday life. From the results of (Mustajab et al., 2018), the average score of student's initial critical thinking skills is around 49.35 (low category), this was because students were not used to doing questions with cognitive levels C4-C6 or HOTS questions.

Critical thinking is a way of thinking at a high level and is very complex, this is because the critical thinking process will direct students in identifying, analyzing, and determining steps to solve existing problems, and draw conclusions (Maryam et al., 2020). Critical thinking skills are cognitive skills that cannot be acquired briefly but can be developed through a planned learning process.

Therefore, an approach is needed that can develop students' critical thinking skills, one of which is using STEM (Science, Technology, Engineering, and Mathematics). STEM approaches can be used to achieve educational goals that can develop science and technology. STEM can be applied in the science learning process with various learning models, one of which is PjBL. The main activity of the PjBL learning model is to run projects and the result is a product (Cahyani & Sulastri, 2021). The results of (Hakiki et al., 2022) research (2022) show that the STEM-PjBL model learning tools have a significant effect on improving students' critical thinking.

Based on the results of STEM research in the last five years, from 2015 to 2019 show that in Indonesia the application of integrated STEM PjBL has not been widely employed. (Setyaningsih et al., 2021). The results of preliminary observations conducted on Thursday, September 21, 2023, show that SMAN 5 Surakarta is one of the high schools in Indonesia, especially in Central Java, which has not implemented STEM-integrated PjBL.

SMAN 5 Surakarta is one of the schools in the city of Solo that has not implemented the PjBL-STEM learning model. PjBL-STEM learning is a learning model that has only been used in a few high schools in the city of Solo. This learning model has a student-oriented learning

system, where students can develop their potential by creating a project at the end of learning. The PjBL-STEM learning model has the advantage that students can participate actively in learning through project research and gain more meaningful learning experiences in understanding various concepts (Capraro et al., 2013).

One of the science materials that can be delivered using the STEM-integrated PjBL learning model is biotechnology. This biotechnology material was chosen because it has content that is relevant to everyday life, where students can learn about and consume various products resulting from biotechnology. However, most students do not know that the products consumed are the result of a scientific process from material to the creation of a biotechnology product. Apart from that, biotechnology is multidisciplinary so it can be integrated into other scientific fields, for example, technology, engineering, and mathematics in learning biotechnology science (Ma'wa et al., 2022).

The purpose of this study, based on the background that has been described, is to determine the critical thinking skills of students in grade XII IPA at SMAN 5 Surakarta TA 2023/2024 on biotechnology materials by using a STEM-integrated PjBL approach.

RESEARCH METHOD

To get an idea of students' critical thinking skills, a type of descriptive research with a quasi-experimental method is used. Meanwhile, the research design is a non-equivalent pretest-posttest control group design.

This study used a control class and an experimental class, where the selection of these classes was not done randomly, but based on certain considerations. This research was located at SMAN 5 Surakarta with research samples XII IPA 5 (control class) and XII IPA 4 (experimental class). Critical thinking skills are measured through post-test questions with cognitive levels C4-C6.

DISCUSSION

Table 1. Normality test of students' critical thinking skills data

Kelas		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Nilai siswa	Kelas_eksperimen	.154	33	.044	.931	33	.036
	Kelas_kontrol	.209	34	.001	.940	34	.061

a. Lilliefors Significance Correction

The normality test in table 1, shows that the significant values were 0.36 and 0.61 so that the data on student's critical thinking skills were normally distributed.

Table 2. Homogeneity test of student critical thinking skills data

		Levene Statistic	df1	df2	Sig.
Nilai siswa	Based on Mean	.468	1	65	.496
	Based on Median	.235	1	65	.629
	Based on Median and with adjusted df	.235	1	65.000	.629
	Based on trimmed mean	.470	1	65	.496

Data in Table 2, is obtained that the significance value is 0.496 so the data is homogeneous.

Table 3. Independent sample t-test of critical thinking skills

Independent Samples Test

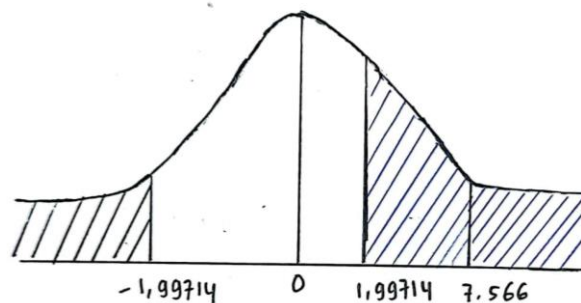
		Levene's Test for Equality of Variances					t-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai siswa	Equal variances assumed	.468	.496	7.572	65	.000	12.563	1.659	9.250	15.877
	Equal variances not assumed			7.566	64.512	.000	12.563	1.661	9.246	15.880

From the results of the calculations that have been carried out, the F value in Levenes's test is obtained with a value of 0.468 with a significance value of 0.496 was found, which means that the significance value > 0.05 . The independent sample t-test was performed on the data listed in the assumption section for equal variances not assumed. The calculated t-value is 7.566 with a significance value (2-tailed) of 0.00, where $0 < 0.05$ so H_0 is rejected. Based on statistical testing criteria, it can be said that the PjBL- STEM can improve student's critical thinking skills in class XII IPA SMAN 5 Surakarta biotechnology material TA 2023/2024.

$$t < -t(0,025; 65) \text{ atau } t > t(0,025; 65)$$

$$t < -1,99714 \text{ atau } t > 1,99714$$

$$\text{Nilai } t = 7,566$$



Based on the curve, it is known that H_0 is rejected because the calculated t value is greater than the t table, namely $7.566 > 1.99714$ so that the STEM integrated PjBL approach

can improve the critical thinking skills of students in class XII IPA SMAN 5 Surakarta biotechnology material TA 2023/2024.

Applying the PjBL learning model requires students to be more critical in solving problems and determining the right solution. Critical thinking skills are one of the demands of learning in the 21st century. Where in 21st-century learning, students are expected to be able to compete globally and be able to overcome problems that exist in society.

Critical thinking is a logical way of thinking centers on making decisions about what to do and what to believe (Ennis, 2011). According to (Wijaya, U.R.B., Sumarwni, W., & Haryani, 2017), this critical thinking learning process involves students learning from their own experiences, constructing knowledge, and then give meaning to the knowledge learned, so that critical thinking becomes a necessity that students must get.

The t-test result data is listed in Table 3, the sig (2-tailed) value is 0.000. It is known from testing that the value of sig (2-tailed) is $0.000 < 0.005$, so it can be said that students' critical thinking skills on biotechnology materials have increased after the application of the PjBL-STEM learning model. This indicates that the STEM approach integrated with the Project-based learning method is very suitable to be applied in learning science, especially on biotechnology material at the C4-C6 cognitive level, where students' critical thinking skills increase to 87.15%.

The results of this study are in line with research (Aini et al., 2022), the use of the PjBL-STEM can improve students' critical thinking with an average score of 96.1%. According to research (Sambite et al., 2019), PjBL can improve their higher-order thinking skills in each cycle because they are more actively involved in the learning process, increasing their interest and desire to learn. PjBL is a student-centered education model that can be applied in a variety of fields. Where this learning model connects what is learned with real life to produce more meaningful learning for students (Baharin et al., 2018)



STEM-integrated PjBL can increase students' interest in learning, create more meaningful learning, and help them solve problems. In addition, STEM-based PjBL can also motivate and challenge students by training students to improve their ability to analyze and think critically (Afifah et al., 2019). By systematically integrating knowledge, ideas, and skills, STEM approaches in education can help students contextualize and solve complex problems (Parreira & Yao, 2018).

Therefore, the PjBL learning model integrated with the STEM approach has a significant influence on student's critical thinking skills on biotechnology material. PjBL-STEM has followed the trend in the current era of globalization, which means that PjBL-STEM already has goals that are characteristics of the 21st century which require critical thinking skills for students.

CONCLUSION

Based on analysis and discussion, t-value of 7.566 and a significance value of 0.00, from the test result the sig (2-tailed) value was $0.000 < 0.005$, so it can be concluded that the application of learning using PjBL-STEM can improve students' critical thinking skills on biotechnology material, where students' critical thinking ability scores have increased by 87.15%.

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