JPPIPA 10(9) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Influence of the Project-Based Learning (PjBL) Model on Student's Science Process Skills and Critical Thinking

Triah Wulandari[1], Ervan Johan Wicaksana[1*], Evita Anggereini[1]

[1] Biology Education, Faculty of Teacher Training and Education, Jambi University, Jambi, Indonesia.

Received: July 3, 2024
Revised: August 26, 2024
Accepted: September 27, 2024
Published: September 30, 2024

Corresponding Author:
Ervan Johan Wicaksana
ervan_jw@unja.ac.id.

DOI: 10.29303/jppipa.v10i9.8367

Abstract: Applying the project-based learning model in learning can train and develop scientific attitudes and problem-solving skills so that students can increase creativity, innovation, and critical perspectives. This research aims to determine the effect of the project-based learning model on student's science process skills and critical thinking. The research subjects of class X Phase E. This research was quantitative research with a quasi-experimental research design with a non-randomized control-group pretest-posttest design. The instruments used are essay questions on science process skills and critical thinking. The test results were analyzed using Quade's rank analysis of covariance statistical test and the One Way Ancova test. The research results show that the average pretest-posttest score of experimental class students taught using the project-based learning model is higher than that of control class students taught using the problem-based learning (PBL) model. Hypothesis testing using Quade's rank analysis of Covariance and One Way Ancova tets informs that the use of the project-based (PjBL) model affects student's science process skills and critical thinking.

Keywords: Critical Thinking; Project Based Learning; Science Process Skill

Introduction

21st century learning provides very prominent changes in the world of education (Tdjandra, 2020). The 21st-century learning process does not only rely on knowledge, but skills also play a role in the learning process (Mardhiyah, 2021). 21st-century learning creates challenges to change all indicators of teaching and learning, Students are required to be able to achieve various competencies known as 4C in learning, namely creative thinking, critical thinking, communication, and collaboration (Damayanti et al., 2021). Science process skills and critical thinking are two important and related components in education that can support cognitive development for students (Muntari et al., 2018).

Science process skills are mental skills expressed in the form of thinking abilities and scientific behavior skills (Senisum et al., 2022). The developing science process skills and the concepts studied can be understood by students more deeply and are stored relatively longer in students' memories so that students not only learn and listen to explanations given by the teacher but students are directly involved in carrying out the science process (Sholihah & Anantyarta, 2021).

Critical thinking skills are very necessary for students to face problems in everyday life (Yunita et al., 2019). Because it can encourage appropriate and focused decision-making, provide logical reasons, and be able to make correct conclusions, to achieve the desired results (Bassham et al., 2011). The ability to think critically is an important aspect that students must have because it is very useful for being able to solve problems. Problems and provisions for present and future life (Ennis, 2011). A critical thinker always questions sources of knowledge, tests the validity of information, and analyzes facts from information to provide appropriate information (Halpern, 2014). This is in line with research that states that PjBL has the potential to improve students' critical thinking abilities (Matahari et al., 2021; Zharoh, 2020).

How to Cite:
Wulandari, T., Wicaksana, E. J., & Anggereini, E. (2024). The Influence of the Project-Based Learning (PjBL) Model on Student's Science Process Skills and Critical Thinking. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6720–6725. https://doi.org/10.29303/jppipa.v10i9.8367

Science process skills cannot be separated from critical thinking skills, because several indicators of critical thinking are interrelated with science process skills such as analyzing, evaluating, and concluding (Irwanto et al., 2017). Science process skills greatly influence student's critical thinking abilities in solving problems (Sinaga et al., 2022). Therefore, science process skills and critical thinking are competencies needed when conducting experiments to gain new knowledge in science, especially in biology learning (Darmawan et al., 2021). Biology learning is closely related to practice and is not only mastery of a collection of existing knowledge in the form of facts, concepts, or principles only, but can be obtained through a discovery process (Alimah, 2019).

The problems faced in the world of education are related to the use of learning models. The learning process in class only focuses on theory, there is a lack of interest and motivation to learn, and students tend to listen, memorize, and copy the contents of the learning material presented by the teacher without finding meaning and understanding its application (Erayani & Jampel, 2022). The project-based learning (PjBL) model is a student-centered learning model and can train students in thinking, problem-solving skills, and creativity (Supiati, 2020). The project-based learning (PjBL) model has great potential to create a more memorable and useful learning experience for students (Nair & Suryan, 2020). Project Based Learning (PjBL) model can help students become more creative in understanding material combined with real situations (Abidin, 2014). Through the project-based learning (PjBL) model students can provide opinions by thinking flexibly and originally and producing different thoughts in solving problems by providing opportunities for students to explore content using various meaningful ways, carrying out experiments collaboratively (Mursid et al., 2021; Iskandar et al., 2019).

Choosing the right learning model is one tactic that can be used (Amalia et al., 2024). One alternative that can be used to improve student's science process skills and critical thinking is by using a project-based learning model. The project-based learning model can have a positive impact on student activity (Hadi et al., 2020), can emphasize student's abilities in terms of solving the problem, taking risks, making decisions, thinking critically and creatively, and can create memorable learning for students (Sari et al., 2020). In connection with this problem, this research aims to determine the effect of the project-based learning model on student's science process skills and critical thinking.

Method

This research is quantitative research with a quasi-experimental research design with a non-randomized control-group pretest-posttest design (Leedy, 2019). The research design can be seen in Table 1.

Table 1. Non-randomized control group pretest-posttest research design

Group	*Pre-test*	Treatment	*Post-test*
Experimental	T_1	PjBL	T_2
Control	T_1	PBL	T_2

Information:
T_1 : pretest for experimental and control groups
T_2 : Posttest for experimental and control groups

The population in this study were all students of class X Phase E of SMAN 10 Jambi City. A purposive sampling technique was used to select samples, with class X Phase E6 as the experimental class and X Phase E7 as the control class. The data collection instrument in this research is an essay test on science process skills and critical thinking which has previously been validated by experts and tested for validity, discrimination test, reliability test, and difficulty level test using SPSS software. Data analysis in this research begins when data collection begins and continues until data collection is complete. Data were analyzed using the Quade's rank analysis of covariance statistical test and the One Way Ancova test.

Result and Discussion

This research was conducted at SMAN 10 Jambi City, in the even semester of the 2023/2024 academic year. The Project Based Learning (PjBL) model in this research goes through a series of stages, to create interactions between teachers and students that follow the characteristics of the project-based learning (PjBL) model (Almulla, 2020). The implementation of the project-based learning (PjBL) model follows the model syntax developed by Jalinus, Nabawi, & Mardin (Jalinus et al., 2017). The syntax of the project-based learning (PjBL) can be seen in Figure 1.

Data obtained on science process skills were measured twice through pretest and posttest. Based on the pretest results of the experimental class and control class. The average scores were 43,52 and 43,21. Meanwhile, the average post-test scores for the experimental class and control class were 58,61 and 47,39. Based on the results of the average value of science process skills, it can be concluded that the average value of science process skills in the experimental class is

higher than the control class. The average results of science process skill scores can be seen in **Figure 2**.

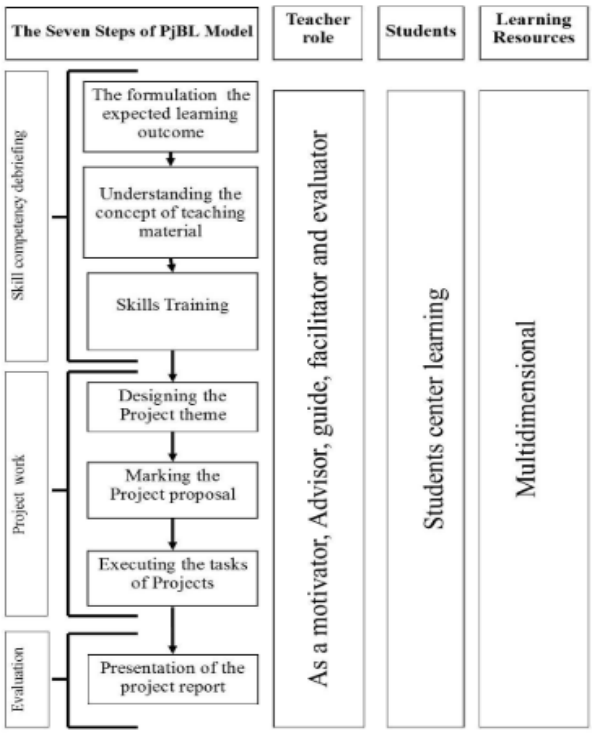

Figure 1. Syntax of the Project-Based Learning (PjBL) *(Source: Jalinus et al., 2017)*

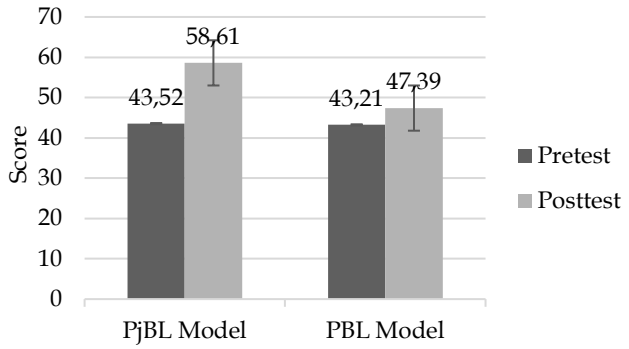

Figure 2. Graph of Average Student Science Process Skills

Data obtained on students' critical thinking abilities was measured twice through pretest and posttest. Based on the pretest results of the experimental class and control class, the average scores were 40 and 37,5. Meanwhile, the average post-test scores for the experimental class and control class were 45 and 43. Based on the results of students' critical thinking scores, it can be concluded that the average critical thinking score for the experimental class was higher than control class. The average results of critical thinking scores can be seen in Figure 3.

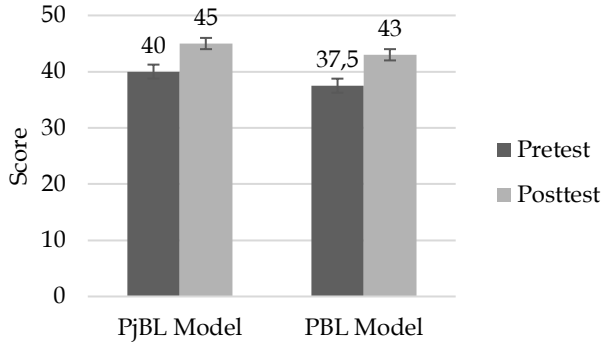

Figure 3. Graph of Average Student Critical Thinking

The Quade's rank analysis of covariance test in this research aims to determine the effect of using the project-based learning (PjBL) model and classes using the problem-based learning model on science process skills. The results of Quade's rank analysis of the covariance test showed that there were significant differences in student's final science process skills between the experimental class and the control class. The results of Quade's rank analysis of the covariance test inform that the PjBL model has a large influence on student's science process skills [F(1,64) =99,899, p <0,001, ηp2 = 0,610]. The results of Quade's rank analysis of the covariance test can be seen in Table 2.

Table 2. Quade's rank analysis of covariance test results

	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Between Groups	12971.799	1	12971.799	99.899	<.001	.610
Within Groups	8310.340	64	129.849			.451
Total	21282.139	65				.706

The experimental class taught using the Project Based Learning (PjBL) model of student's science process skills is better than the control class. This happens because the project-based learning model can create learning that focuses on students and the teacher only as a facilitator so that students can learn from the experience gained in solving a problem (Harlis et al., 2022). The project-based learning (PjBL) model can improve aspects of science process skills, this is because it involves skills related to science in the learning stage (Rahmadani & Albeta, 2018). Students can practice to develop science process skills so that the essence of biology as a science can be implemented optimally (Anggereini et al., 2019). A project-based learning model

gives students the freedom to plan learning activities, carry out projects, and produce a product and can have an influence on student's science process skills (Anggriani et al., 2019).

The One Way Ancova test in this research aims to determine the effect of classes using the project-based learning (PjBL) model and problem-based learning classes on students' critical thinking. One way Ancova test criteria, namely if the sig value is > 0,05 then H_0 is accepted, but if the sig value is <0,05 then H_0 is rejected. The One Way Ancova test table can be seen in Table 3.

Table 3. One-Way Ancova Test Results

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	986.228[a]	2	493.114	22.880	<.001	.421
Intercept	1391.161	1	1391.161	64.548	<.001	.506
PRE_BK	360.064	1	360.064	16.707	<.001	.210
KELAS	618.642	1	618.642	28.704	<.001	.313
Error	1357.794	63	21.552			
Total	114168.334	66				
Corrected Total	2344.022	65				

a. R Squared = .421 (Adjusted R Squared = .402)

Test results of the One Way Ancova test show that there is a big difference in the critical thinking of experimental class students. The one-way ANCOVA test informs that the project-based learning (PjBL) model has a large influence on students critical thinking [F(1,63) = 28,704, p <0,001, ŋp2= 0,313]. This shows that Project Based Learning (PjBL) can help students develop critical thinking abilities and creativity (Fadhil et al., 2021). Critical thinking influences students in responding to various activities related to mastering the concepts being studied (Mega et al., 2022). The Project Based Learning (PjBL) model allows students to develop critical and creative thinking skills by paying attention to indicators of observing, asking, trying, processing, reasoning, creating, and communicating in the form of a project report (Martinez, 2022).

The application of the project-based learning (PjBL) model can help students express their ideas and can increase active student involvement in solving problems by providing projects so that student creativity in critical thinking increases (Wicaksana & Sanjaya, 2022). The PjBL model aims to train students to think critically, creatively, and rationally, actively collaborate and communicate (Elisabet et al., 2019). Critical thinking is needed in creative investigations, which are related to the concept being investigated to find solutions with stages of critical, creative, and innovative thinking in completing tasks (Maksum et al., 2022). Student's critical thinking abilities are related to students understanding of concepts (Von Dohlen et al., 2020). The use of the PjBL model has been proven to improve student's learning outcomes and critical thinking related to understanding concepts in learning (Tuaputty et al., 2023).

Conclusion

Based on research that has been conducted, the average score for the experimental class taught using the project-based learning (PjBL) model is higher than the control class taught using the problem-based learning (PBL) model. It can also be seen from the results of the analysis test of student's science process skills using the Quade's rank analysis of covariance test which informs that the value [F(1,64) =99,899, p <0,001, ŋp2 = 0,610]. And the results were also obtained from the One Way Ancova test to determine students' critical thinking abilities which informed their grades [F(1,63) = 28,704, p <0,001, ŋp2= 0,313]. It can be concluded that the use of the project-based learning (PjBL) model has a significant effect on student's science process skills and critical thinking.

Acknowledgments

The author would like to thank all parties who have contributed to the completion of this article. The author hopes that this article can be useful in the realm of education and science.

Author Contributions

Conceptualization; TW and EJW, Methodology; data analysis; TW, Instruments, and Validation; EJW and EA, review writing and editing; TW, EJW, and EA; data collection; TW, all authors contributed to the article and approved the submitted version.

Funding

The researchers involved in this study funded the research independently.

Conflicts of Interest

In this study, none of the authors have conflicts of interest. The sole aim of researchers is to contribute to the field of education, which ultimately benefits readers.

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