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Optimizing biology learning outcomes: Uncovering the impact of the student project-based learning model

Optimalisasi hasil belajar biologi: Mengungkap dampak dari model pembelajaran berbasis proyek siswa

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Abstract
Project-Based Learning (PjBL) is a learning model that actively engages students in educational activities, particularly those emphasizing creativity aimed at developing both products and conceptual understanding. This approach focuses on designing and implementing projects to solve problems while enhancing students' learning outcomes. The purpose of this study is to explore the impact of project-based biology learning (PjBL) on students' academic performance. The research method involves analyzing data sourced from Google Scholar over the past five years. A number of relevant articles were identified and used as reference materials, with 10 articles selected for further analysis. These articles were examined based on the skills developed and their influence on students' learning outcomes in project-based biology education. The findings from the review of these articles conclude that the PjBL model has a positive impact on improving students' academic performance in both high schools and vocational education institutions.

Keywords: project-based learning; optimization of learning outcomes; learning impact

Abstrak. *Project Based Learning (PjBL) merupakan model dalam pembelajaran yang melibatkan peserta didik dalam kegiatan pembelajaran khususnya yang berkaitan dengan suatu kreatifitas yang berorientasi pada perolehan produk dan konsep baik dalam merancang maupun membuat proyek yang bertujuan untuk pemecahan masalah dan peningkatan hasil belajar pesertaa didik dalam pembelajaran. Tujuan dalam penelitian ini untuk mengungkapkan dampak pembelajaran biologi berbasis proyek (PjBL) terhadap hasil belajar peserta didik. Metode penelitian ini menggunakan analisis hasil pencarian dari data Google Scholar dengan rentang waktu 5 tahun terakhir. Berdasarkan hasil pencarian diperoleh banyak artikel relevan yang dipergunakan sebagai bahan studi rujukan dalam penelitian. 10 jumlah artikel di data, kemudian dianalisis berdasarkan kemampuan yang dikembangkan dari hasil penelitian pada hasil belajar peserta didik dalam pembelajaran biologi berbasis proyek. Hasil dari analisis telaah dalam review artikel dapat disimpulkan bahwa temuan model pembelajaran PjBL berdampak baik untuk meninkatkan hasil belajar peserta didik baik pada satuan pendidikan di SMA maupun SMK. Kata kunci: pembelajaran berbasis proyek, optimalisasi hasil belajar; dampak belajar.*

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INTRODUCTION

Educators who are skilled in providing knowledge to students or students effectively through an efficient learning model. Learning objectives can only be met by using the learning model (Chaniago & Dafit, 2024). A learning model refers to a structured framework designed to establish learning objectives, develop instructional materials, and guide learning activities within a specific timeframe. (Maisyarah, 2023).

Based on the results of the analysis of the facts in the school, the learning that took place was not as targeted. Many studies mention that problems in biology learning that often arise, one of which is the way teachers apply learning or convey learning with theoretical methods only (Astriani, 2022). There are several problems in biology learning. Firstly, there is a lack of effort from teachers in discovering new learning resources. Secondly, some teachers struggle to fully understand the teaching materials, leading to inadequate explanations that hinder students' comprehension of the subject matter (Winda & Dafit, 2021). Thirdly, there is limited initiative from teachers to adopt more engaging teaching methods or innovative learning models, making it challenging to foster students' enthusiasm during the learning process. Lastly, not all students are actively involved or motivated in learning, which negatively impacts their academic performance (Wibowo, 2016). Addressing these challenges requires a shift in students' mindset towards biology lessons, as suggested by Aryani et al. (2022).

The PjBL (Project Based Learning) paradigm, sometimes referred to as project-based learning, is appropriate for helping students develop critical abilities like critical thinking, creativity, decision-making, and problem-solving (Cahyadi, 2019). Therefore, using the PjBL model will certainly make student's learning outcomes improve. This is in line with research conducted by Simangunsong et al. (2023) which states that using the PjBL learning model can improve student learning outcomes. In addition, Pratiwi et al. (2018) stated that project-based learning is a learning modal that requires teacher or students to develop more critical questions. So that it can help students hone their skills and can improve student learning outcome.

The first research finding found was a study from Yovanes Chaniago, Riau on May 2, 2024 entitled The Influence of the Project Based Learning (PjBL) Learning Model on Student Motivation and Learning Outcomes Information from students and teaching staff was collected through interviews. The results of interviews with the homeroom teacher of class V (C) and a number of students of class V showed that in general, students had difficulties in reading the teaching materials, making it difficult for them to master the material and achieve learning goals. less than ideal. The learning outcomes of students who generally tend to be low from 34 students in class V (C), 18 students (52.94%) get KKM and 16 students (47.06%) do not get KKM as evidence.

By utilizing this Project Based Learning model, it is hoped that it can create a situation where individual success is influenced by collective success. This can maximize students' learning results regarding the content by helping them comprehend challenging and practical concepts in both lower and upper groups of students who collaborate with one another. Based on the description above, this study aims to determine the impact of the PjBL model in students biology learning. This literature review research is expected to be useful in the field of education, especially in learning by providing insight into the impact of the PjBL model in the biology learning process.

review research is a type of study that systematically collects, evaluates, and synthesizes existing research on a particular topic. Instead of conducting original experiments or gathering new data, the purpose of a review is to summarize, analyze, and interpret the findings from previously published studies. This process allows researchers to identify trends, gaps, and patterns in the existing body of knowledge.

RESEARCH METHOD

A research review (often called a literature review) is a comprehensive and systematic evaluation of existing research on a particular topic. It involves summarizing, synthesizing, and critically analyzing the findings from various studies to provide an overview of the current state of knowledge in a specific field. The purpose of a research review is not to generate new data but to identify patterns, trends, gaps, and contradictions in the existing literature, helping to inform future research directions and decision-making Cooper, H. (2017). The research was conducted following a literature review process in several stages, including defining the writing objectives, selecting database sources, choosing keywords during the

database search, performing the literature search, setting inclusion criteria for the articles to be used, selecting articles based on these criteria, and synthesizing the findings. Keywords such as "Project Based Learning" were used for the article search, with the ERIC database and Google Scholar as primary sources Fink, A. (2019). The articles included in this literature review must meet specific inclusion criteria: they must be in English or Indonesian with free full-text access, relevant to the research objectives in both title and content, and published between 2019 and 2024.

This study employed content analysis, also known as content review, as its data analytic method. The author looks at study findings about the effects of the Project-Based Learning (PjBL) model on students that have been published in both domestic and foreign journals. This approach entails a careful and comprehensive analysis of the literature sources cited in the research. In this study there are several stages carried out, the following are explained in Figure 1.

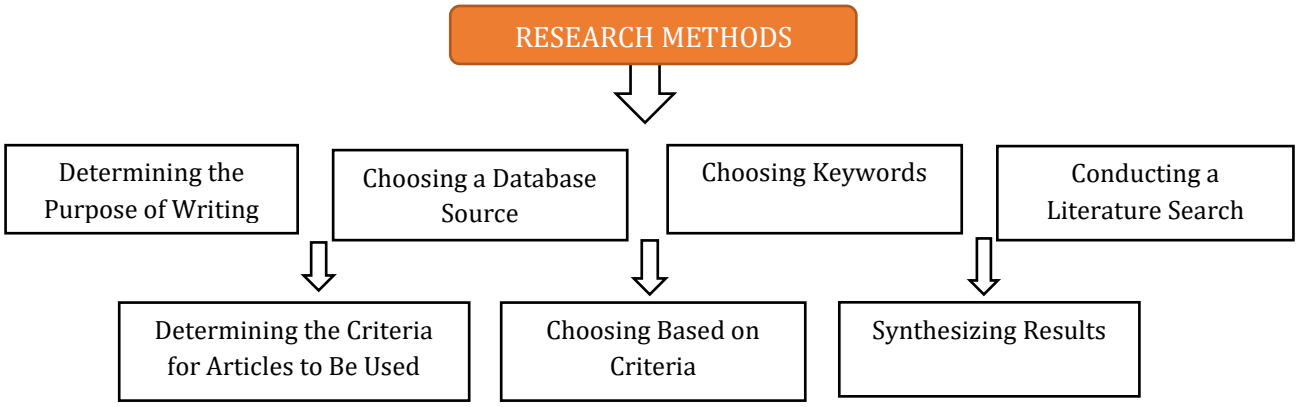


Figure 1 Research method

RESULTS AND DISCUSSION

Here are three previous studies related to project-based learning published in journals, in the conrext of review research.

1. “A Systematic Review of Project-Based Learning in Engineering Education" (2019) This systematic review examined the application of Project-Based Learning (PJBL) in engineering education. The study analyzed a wide range of literature from engineering programs worldwide, evaluating how PJBL has been integrated into curricula, its impact on student learning outcomes, and the challenges faced by instructors. The authors found that PJBL enhances critical thinking, problem-solving, and teamwork skills in engineering students but also noted that proper training for instructors and careful design of projects are crucial for its success.
2. "Project-Based Learning in the K-12 Classroom: A Review of the Literature" (2017) This review focused on the implementation of Project-Based Learning in K-12 education, specifically assessing its effectiveness across different subject areas and grade levels. The study synthesized results from multiple empirical studies, highlighting how PJBL improves student engagement, motivation, and learning outcomes, particularly in subjects such as science and social studies. The review also identified key success factors, such as clear goals, collaboration, and authentic assessment practices.
3. "The Effectiveness of Project-Based Learning in Promoting Critical Thinking Skills: A Review of the Literature" (2021) This review explored the effectiveness of Project-Based Learning (PJBL) in fostering critical thinking skills across various disciplines. The paper highlighted studies from diverse educational contexts, including higher education and secondary school settings, and analyzed how PJBL contributes to the development of critical thinking, creativity, and problem-solving abilities. The review concluded that PJBL has a positive effect on students' critical thinking skills but emphasized the need for more research into long-term outcomes and best practices for PJBL implementation.

This study utilized research articles in English or Indonesian with full-text access, featuring titles and content aligned with the research objectives, and published between 2019 and 2024. The findings indicate that implementing the Project-Based Learning (PjBL) model in biology education enhances students' critical thinking skills. The review outcomes are summarized in a table containing the article code, title, and the results of the article analysis. The results of the article review are described in detail in Table 1.

Table 1 Results of article review

No.	Article Title	Result
1.	The impact of project-based learning on raising upper basic students' critical thinking skills as perceived by teachers (Issa & Khataibeh, 2021)	Project-based learning (PjBL) enhances learners' skills needed to face the global community. The use of project-based learning as a teaching strategy. Contribute to developing students' scientific thinking skills.
2.	Project-Based Learning In Biology Lessons (Shirinzade, 2022)	Project-based teaching is one of the most important teaching methods for biology learners. Research over the past 30 years has shown that high student skills and motivation also lead to high academic performance.
3.	Teachers' Views on Project-Based Learning in Science and Mathematics (Viro dkk., 2020)	PjBL encourages students to develop their conceptual knowledge of the subject and relate knowledge to its application. Students are encouraged to carry out a project through inquiry-based and constructive inquiry. PjBL is a student-centered learning process where students are empowered and actively engaged.
4.	The Analysis of Studens' Critical Thinking Skill on Biology Subject (Mahanal dkk., 2019)	The results of the study show that pupils from a number of high schools in Batu, Indonesia, still lack adequate critical thinking abilities. When compared to other student groups, male students with weaker academic aptitudes had the lowest average scores in critical thinking ability.
5.	Evaluation of Project-Based Learning (Pusztai, 2021)	The learning process in Project-Based Learning, gets higher grades than students in traditional education. The right and more meaningful learning model for students is a model that focuses on skills in problem-solving that requires students to think critically. While project-based learning is a method or solution to deal with difficulties in the learning process, the problem-based learning model is one that can affect critical thinking abilities.
6.	Analysis of Students' Critical Thinking Skills and Community in Biology Subjects (Putri & Darussyamsu, 2022)	By asking questions that align with critical thinking indications, teachers can assess their students' critical thinking abilities. A number of variables can contribute to students' poor critical thinking abilities, such as the fact that they are still used to responding to questions that ask about their critical thinking abilities.
7.	The Influence of the PJBL Learning Model on Students' Critical Thinking Skills (Jeniver dkk., 2023)	The study analyzed 20 research articles from both Indonesian and English-language journals to investigate how the Project-Based Learning (PjBL) model affected students' critical thinking abilities. The results show that students' critical thinking skills are much improved by the PjBL paradigm.
8.	Implementation of the STEM-PJBL Learning Model on the Topic of Microbial Cultivation in Microbiology Courses for Biology Education Students (Luthfiana & Putra, 2023)	PjBL learning can be applied to microbial cultivation materials through the syntax of Reflection, Research, Dicovery, Application, and Communication. The syntax is in helping students collaborate with their groups to complete projects.
9.	Meta-Analysis of the Impact of the Project-Based Learning Model on High School Students' Critical Thinking Skills (Jeniver dkk., 2023)	The project-based learning model is a new approach to education that puts teachers in the role of facilitators and motivators. Learners can be led by teachers to real problems, and they can solve them through project work that requires them to act or think critically. The meta-analysis of this study led the researchers to the conclusion that using the Project-Based Learning (PjBL) model to teach.

No.	Article Title	Result
10.	Application of the Project-Based Learning Model to Enhance Class X Students' Ecosystem Materials Learning Outcomes and Critical Thinking Capabilities (Fazriah & Putra, 2024)	The results of these methods and media show an improvement in concept understanding, critical thinking skills, analytical, and relevant psychomotor skills. Positive responses include some high engagement, interest, motivation, and learning satisfaction. Students feel motivated and satisfied with an active and relevant learning process to their lives, which ultimately contributes to improved learning outcomes.

Based on the analysis data of 10 articles in the table above, it can be explained that the application of the PJBL model has an influence on student learning outcomes. The learning outcomes of students from 2019-2024 get quality and improve learning achievement while using PJBL (Sahtoni et al., 2017). In the study, Anggraini P. D (2021) found that the activeness of students has many benefits for the students themselves and is able to realize students to think critically, independently and improve learning outcomes while applying the PJBL model in learning. Husna & Sudarti (2023) and Filmi et al. (2024) argues that active students can learn more, will have the initiative so as to create opportunities for students.

This research has 10 articles taken by the author and will be presented with the title and year of the article in Table 2.

Table 2 Title and year of the article

No.	Article Title	Year
1.	An examination of students' critical thinking abilities in the field of biology	2019
2.	Meta-Analysis of the Impact of the Project-Based Learning Model on Students' Ability to Perform Critical Analysis	2019
3.	Teachers' Views on Project-Based Learning in Science and Mathematics	2020
4.	The impact of project-based learning on raising upper basic students' critical thinking skills as perceived by teachers	2021
5.	Assessment of Project-Based Learning	2021
6.	Biology Lessons Using Project-Based Learning	2022
7.	Examination of Biology Students' Critical Thinking Capabilities and Community	2022
8.	Application of the STEM-PJBL Learning Model to the Study of Microbial Cultivation in Biology Education Students' Microbiology Courses	2023
9.	The Impact of the PJBL Learning Model on Students' Capabilities for Critical Thought	2023
10.	Application of the Project-Based Learning Model to Enhance Class X Students' Ecosystem Materials Learning Outcomes and Critical Thinking Capabilities	2024

Based on the presentation in Table 2, articles about the PJBL model were published in the last 5 years from 2019 to 2024. In 2019 there were 2 articles, in 2020 there were 1 articles, in 2021 there were 2 articles, in 2022 there were 2 articles, in 2023 there were 2 articles and in 2024 there was 1 article. In this study, there are 10 articles that are reviewed and concluded into data from 2019-2024 and presented in Table 3. Table 3 illustrates how the PJBL model's use over the previous five years has increased evidence that it is appropriate for use in the teaching and learning process, particularly in biology classes.

Table 3 Annual data results

No.	Year	Data
1.	2019	75%
2.	2020	78%
3.	2021	80%
4.	2022	84%
5.	2023	8,47%
6.	2024	88%

The next data is percentage based on the year of publication of the article from 2019-2024 through Figure 2. From figure 2, it can be seen that articles using the PJBL model over the past 5 years have increased the use and improved learning outcomes of students. This can be seen from 2019 to 2024 there is an increase in using this PJBL (Project Based Learning) model.

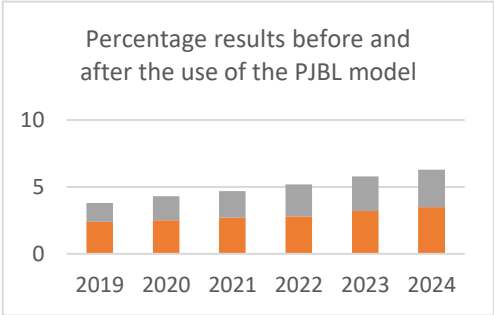


Figure 2 Percentage results of chart shapes

The purpose of this review-based study is to look into how students' critical thinking abilities are affected by the Project-Based Learning (PjBL) model. The study used a descriptive survey methodology. According to the results, the PjBL model has a major positive impact on students' critical thinking skills. Yance's research highlights that project-based learning enhances biology learning outcomes across affective, cognitive, and psychomotor domains, while Condliffe's study shows that this approach also fosters collaboration skills among students. It is expected that students will have ample opportunities to engage in learning during biology lessons using a project-based approach.

The PjBL model aims to improve students' thinking skills. Directing students to work by carrying out activities so that they are able to complete a project", requires in-depth research, critical thinking, various forms of communication, and cooperation between teachers and students. Through PjBL activities, students will develop understanding, creativity, confidence, and admiration for themselves in addition to developing a sense of confidence (Allanta & Puspita, 2021).

Teachers play a significant role in helping students develop their critical thinking skills. Designing learning procedures that support the growth of critical thinking in the classroom is crucial for educators. To encourage students' critical thinking and active participation, teachers might use a variety of tactics, approaches, and strategies. It is important to explicitly teach critical thinking (Zubaidah, 2019). Critical thinking abilities in science classes, particularly biology, can be developed through problem-based learning and practical laboratory investigations. The use of diverse learning strategies helps students make connections between different concepts, allowing them to sharpen their critical thinking abilities. Employing these strategies can be an effective approach to developing critical thinking skills in both high- and low-ability students.

CONCLUSION

This literature review-based research aims to reveal the impact of the influence of the learning model (Project Based Learning) on students conducted by reviewing 10 research articles from Indonesian journals and English-language journals. The results obtained show that the PjBL model is influential for students from 2019 to 2024. Based on research data, learning using the PjBL model can improve students' way of thinking and learning outcomes, especially in biology learning, and PjBL has been applied from year to year producing increasing data. This research is expected to provide practical recommendations for educators in the use of PjBL learning models in learning biology now and in the future.

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