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Effectiveness of Project-Based Learning Model on Students' Natural Science Learning Outcomes

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ABSTRACT

This study aims to determine the effectiveness of the influence of the Project-Based Learning learning model on the learning outcomes of 9th-grade science students at Junior High School 5 Tuban. The type of research used is experimental research, and the research design is a one-group pretest-posttest Design. The population in this study was the ninth-grade students of SMP Negeri 5 Tuban as a whole, while the research sample was class IX-E students, totalling 31 students. The data collection techniques through learning outcome instruments include pretest and post-test scores. The data analysis techniques used are N-Gain Test analysis and descriptive analysis. The results showed that students' average score after applying the PjBL model increased by 29.03; in contrast, the results of the N-Gain analysis showed a value of 0.69 with a sufficient category. This study concludes that the effectiveness of the project-based learning (PjBL) model affects the results of students' natural science learning.

Keywords: Effectiveness, PjBL, Learning outcomes

Introduction

Education developments align with the times' demands and the current digital era (Undari et al., 2023). The advancement of education can change the pattern of learning strategies to be more competent to produce a quality generation (Putra, 2023). Effectiveness in the educational process oriented towards student independence and skills is needed, depending on the quality of learning (Rahayuningsih et al., 2022). Learning activities must use the creativity and innovativeness of educators to achieve optimal learning outcomes for students, and educators are required to design and provide innovative learning models and media (Qudsyi et al., 2015).

Learning outcomes are optimal indicators that can be used to measure student success during the learning process (Ratri & Nurfalah, 2023). This success cannot be separated from the influence of various factors, namely, internal and external. Internal factors exist within individual students during learning activities, while external factors are factors from outside individual students (Maula et al., 2015). In addition, improving good learning outcomes can be supported by learning strategies and models used by an educator (Kristin, 2019). The achievement component of learning outcomes can cover several aspects: the cognitive domain, attitudes, and skills students possess (Hutapea & Simanjuntak, 2021). In its implementation, students often face many problems, one of which is the weak learning activities in the classroom (Lestari et al., 2021). Student-centred learning models can be used as an alternative to overcome these problems; one is the Project Based Learning (PjBL) model, which offers a more interesting and practical approach to be applied to the learning process.

The Project-Based Learning (PjBL) learning model is a systematic learning model that requires students to produce contextual and creative work, both individually and in groups (Fauziah et al., 2020 ; Nugraha et al., 2023 ; Rahayuningsih et al., 2022). The characteristics of the Project Based Learning model are a learning model that is directly centered on students *(student-centered)*, students are actively involved in finding knowledge and ideas, and linking learning with everyday life (Arlianty, 2021; Sugiarsih, 2022; Winanda et al., 2021). In this case, students can explore their creativity to be more proactive in the learning process in class (Lestari et al., 2021). The implementation of the PjBL learning model in Science subjects aims to help students understand science concepts in the context of real life and can improve the ability to identify, analyze, and present (Fatimah et al., 2024 ; Lailtunnahar, 2021). The Project-Based Learning model is expected to provide more value for developing students' scientific performance and attitudes (Hutasoit, 2021). One of them is on biotechnology material.

Biotechnology is a field of biological science that combines technology with using living organisms to produce a product or service (Mursali et al., 2024). Biotechnology material has a crucial role in applying practical applications to learning activities. In its implementation, biotechnology material in science learning in junior high schools still faces many obstacles. Biotechnology materials are often considered difficult by students; there are some abstract concepts to understand, and students lack active roles during science learning (Basri, 2022). In this case, students are expected to be able to master the concept of biotechnology well to obtain optimal learning outcomes.

According to the results of observations made by researchers, student learning outcomes in science learning biotechnology material at SMP Negeri 5 Tuban are still relatively low. This is caused by several factors, including the lack of a varied learning model because most educators still apply conventional learning models. Therefore, this research makes a novelty by applying the PjBL learning model as an innovative learning model to improve student learning outcomes in biotechnology science learning. The PjBL learning model has a positive impact if applied to science learning. This can develop students' critical thinking abilities and skills, especially in learning Natural Sciences for optimal learning outcomes (Maula et al., 2015).

The last few studies conducted by Saragih et al. (2023) showed that the project-based learning model effectively improved students' mathematical literacy skills. Another research from Rahmawati, (2023) regarding using PjBL-based E-Modules can improve student learning

outcomes. Research showed that the PjBL model can improve students' creative thinking skills in science learning. Further, Izwar & Kristanti, (2023) showed increased student learning motivation after applying the PjBL model. Besides that, research by Larassary & Wulandari, (2022) about a project-based learning model with Instagram media can improve student learning outcomes in the new-normal period. Some previous studies show that the effectiveness of the influence of the Project-Based Learning model on learning outcomes of natural science subjects, especially conventional biotechnology material, by junior high school students, especially in Tuban district, has never been studied. Therefore, the novelty of this article is to specifically determine the effectiveness of the influence of the project-based learning model on student learning outcomes in natural science subjects.

Based on the background explanation above, the problem formulation in this study is: How effective is the influence of the project-based learning model on student learning outcomes in science and biotechnology materials? This study aims to determine the effectiveness of the influence of the project-based learning model on student learning outcomes in science and biotechnology materials.

Methods

This research uses experimental research with the research design of a one-group pretest-posttest design. The analysis scheme can be seen in Table 1 (Yudhistian & Wulandari, 2025):

Table 1. Scheme One-Group Pretest-Posttest Design

Class	Pretest	Treatment	Post-test
Experiment	O_1	X	O_2

Information:
X = Treatment (implementation of the Project-based learning model)
O_1 = Pretest (value before treatment)
O_2 = Post-test (value after treatment)

This research design is an experimental process in only one group without a comparison group (Sultan & Paurru, 2021). Treatment is given to the group, and the values are compared before (pretest) and after (post-test). The population in this study consisted of ninth-grade students at SMP Negeri 5 Tuban, while the research sample consisted of class IX-E students, totaling 31 students.

This research was conducted through 3 stages. In the first stage, students were given an initial test or pretest. The second stage applies the Project-Based Learning model (treatment), followed by the last stage, which involves giving the final test or post-test. The pretest is given to assess the mastery of the initial concept before being given a treatment. The post-test is given to students to determine the mastery of concepts after treatment, namely applying the PjBL learning model in learning activities. The learning outcomes assessment determines whether the learning activities have run effectively. The data collection technique in this study is the instrument of test results that student have completed. The research instruments used were formative tests of learning outcomes in the form of 25 multiple-choice questions and the distribution of questionnaires in the form of a list of 10 questions each student must answer. The questionnaire was distributed after the PjBL model was applied to learning.

The obtained N-Gain analysis results are then interpreted into Table 2 to show how much the PjBL learning model influences student learning outcomes in science and biotechnology material.

Table 2. Interpretation of N -Gain Score Percentage

Percentage (%)	Interpretation
< 40	Ineffective
$40 - 55$	Less effective
$56 - 75$	Moderately effective
> 76	Highly effective

The data analysis techniques used are N-Gain Test analysis and descriptive analysis. Assessment of the effectiveness of the Project Based Learning (PjBL) learning model on student learning outcomes using the N-Gain Test based on the difference in pretest and post-test scores. This analysis aims to determine the improvement of students' natural science learning outcomes, especially in the biotechnology material. The formula for determining normal gain, or N-gain, is as follows (Sondole et al., 2023):

$$\text{N-gain} = \frac{Score\ Posttest - Score\ Pretest}{Score\ Maks - Score\ Posttest}$$

Table 3. N-Gain assessment criteria

Interval	Category
$0,70 \leq n \leq 1,00$	High
$0,30 \leq n \leq 0,70$	Moderate
$0,00 \leq n \leq 0,30$	Low

Results and Discussion

The syntax of the PjBL learning model begins with giving students an initial test (pretest) to determine the ability and knowledge of the initial concept students possess. The pretest continued in the second stage, providing stimuli regarding biotechnology to determine the students' responses before treatment. The third stage is formulating a problem; the fourth stage is when students make a project design that will be carried out by preparing a scheduling plan. The fifth stage is monitoring the making of the project and then presenting it in front of the class; the next stage is the assessment and evaluation of the educator. After these steps are carried out, the teacher gives a final test (post-test) to students in order to find out a comparison between the initial value before treatment and the final value after treatment (treatment) of the Project Based Learning (PjBL) learning model in natural science subjects for class IX-E students at SMP Negeri 5 Tuban.

The overall student response through learning science biotechnology material using the PjBL model is very enthusiastic and fun; this can be seen from the attitude of students by playing an active role in class learning and the results of distributing questionnaires that have been done. The results of this study are to determine the effectiveness of the project-based learning model on student learning outcomes in science. Effectiveness is the impact that arises from a treatment. This study used it to determine the impact on students' science learning outcomes. The student learning outcomes studied in this study are the pretest and post-test scores that class IX-E students have achieved at SMP Negeri 5 Tuban. The following are the values of student learning outcomes pretest and post-test, which can be seen in Table 4.

Table 4. Students' pretest and posttest scores

Person	Measurement		Enhancement
	Pretest	Post-test	
1	44	80	36
2	66	92	26
3	71	88	17
4	66	84	18
5	60	88	28

Person	Measurement		Enhancement
	Pretest	Post-test	
6	60	96	36
7	54	96	42
8	68	92	24
9	62	92	30
10	60	80	20
11	60	80	20
12	74	92	18
13	56	92	36
14	54	76	22
15	56	96	40
16	52	68	16
17	72	96	24
18	72	92	20
19	63	72	9
20	70	96	26
21	54	96	42
22	53	68	15
23	78	88	10
24	48	92	44
25	60	92	32
26	29	92	63
27	47	92	45
28	43	76	33
29	60	88	28
30	34	92	58
31	70	92	22

Based on Table 4, the overall student learning outcomes show a significant difference, increasing from the previous value. This is because by implementing the PjBL learning model, students can improve their understanding of the biotechnology concepts taught. Through the PjBL model, students can collaborate with peers, create a product from scientific activities, and explore knowledge and contextual biotechnology materials. This will affect the increased understanding of the concept of biotechnology and student learning outcomes in science learning. This aligns with the statement (Dayanti et al., 2023) that the PjBL learning model can make it easier for students to understand the material given by the teacher and impact students' learning outcomes. In addition, learning using the PjBL model provides opportunities for students to build their knowledge to improve their learning outcomes (Khoiriyyah et al., 2022).

Table 5. Results of average pretest-posttest scores and N-gain

Average Value			
Pretest	Post-test	N - Gain Score	N - Gain Score Percentage
58, 58	87.61	0.69	69.1

Based on the data in Table 5, the average student learning results when applying the PjBL learning model have changed and increased. The average value of students' evidence before (pretest) is 58.58, while after applying the PjBL learning model, it is 87.61; this shows that the average value of student learning outcomes has increased significantly by 29.03. This

is because the project learning model in fermentation activities using conventional biotechnology principles can be used as students' capital in mastering the concept of biotechnology material, starting from the planning, implementation, presentation, and evaluation stages.

Projects that have been carried out in groups with their peers, and the project is contextual or closely related to everyday life. In this case, it can make it easier for students to understand the concept of learning materials. This is the opinion of Dayanti et al. (2023). In implementing the PjBL learning model, students can develop their abilities to create work according to their context and understand the material well about the project. In addition, according to Maula et al. (2015). Students can solve problems collaboratively and gain essential knowledge and concepts from the subject matter. The results were analyzed using the N-Gain test; student learning outcomes are 0.69 with a reasonably practical category. The Gain Score percentage value is 69.1, a relatively effective percentage. Using the PjBL learning model is quite effective if implemented in learning activities for natural science subjects. This is the opinion of Lantang et al. (2023) that the PjBL model can be used as an alternative to 21st-century science learning. In addition, according to Yulianti et al. (2023), the PjBL learning model effectively improves student learning outcomes at the junior high school level.

Conclusion

Based on the results and findings of the research that has been carried out, it can be concluded that the effectiveness of the Project Learning (PjBL) learning model affects students' natural science learning outcomes, as evidenced by the results of the analysis using N-Gain showing an average value of 0.69 with a relatively practical category and an average value of learning outcomes of 29.03. This means the PjBL learning model is effective if implemented in learning activities, especially natural science subjects at the ninth-grade junior high school level. This research is expected to be an alternative solution to overcome the problem of using a monotonous and boring learning model for students studying science at the junior high school level.

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