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The Effectiveness of Project-Based Learning Models On Students' Learning Outcomes in Fourth Grade: Animal Metamorphosis Modeling

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Abstract

The aim of this study was to address the issue of low student learning outcomes in the Natural Sciences Subject, specifically in the "Animals Life Cycle" topic. The researchers sought to assess the effectiveness of the Project-based Learning (PjBL) model in improving learning outcomes. The study employed an experimental method with a "one-group pre-test-post-test design." Data was collected through tests, documentation, and observation. Tests were used to measure learning outcomes, observation was conducted to assess the implementation of the PjBL model, and documentation was employed to record students' progress. The study population consisted of fourth-grade students in one of the state elementary schools in Yogyakarta. The researchers used saturated sampling, meaning that all members of the population were included as samples. Data analysis involved the paired t-test and n-gain test. The findings revealed significant differences in student outcomes before and after the implementation of the treatment. The n-gain test demonstrated that the PjBL model effectively improved student learning outcomes.
Keywords: animal life cycle; learning outcomes; problem-based learning

Introduction

Curriculum exchanges that have taken place in Indonesia emphasize students' understanding of learning (Permendikbud, 2016). This is important because the nation's next generation is faced with challenges in the 21st century (Malik, 2018). Provisions to face the challenges of the times are not only in the form of natural resources and physical capital but also intellectual and social. The era of the digital economy in the 21st century requires a workforce that has extensive knowledge, is able to create innovations, and raises the country's productivity (Turiman, 2011). In order to face the challenges of the 21st century, students need to be equipped with skills that include creative thinking, digital literacy, and communication skills (Frasandy, 2018). The ability to think critically is one of the abilities that must be grown and accustomed to in students. Critical thinking skills are needed in solving various life problems (Kosdin, 2012).

An educator, in delivering material, needs to consider the model to be used so that students are interested and want to be part of the learning process (Harandi, 2015).

A learning model is needed that places students as subjects (main actors) (Saifulloh & Mohammad Darwis, 2020) and places the teacher only as a facilitator so that students' critical abilities will be formed. Based on the results of observations in the field, it was found that students were still passive in learning and were less able to integrate the constructs of everyday life experiences outside of school with their knowledge in the classroom. When taking tests, students find it difficult and get low scores. This can be seen from the results of the mid-semester exam, which showed that more than 50% of students did not pass the minimum completeness criteria. From the results of observation, it is also known that many educators still apply conventional learning—such learning results in students being less enthusiastic about participating in learning (Afandi, 2018). There needs to be creativity and innovation so that learning can attract students' attention. Learning that can facilitate students to work both individually and in groups is PjBL (Nisah et al., 2021). PJBL is able to stimulate students' thinking power in accordance with Nurfitriyanti, who stated that the result of implementing PJBL is that students are able to work so that they can improve their learning outcomes (Nurfitriyanti, 2016). The PjBL model has the following characteristics: it provides PjBL with the process of solving problems, making decisions, conducting experiments, and compiling reports (Melinda & Melva Zainil, 2020). The steps that need to be followed in implementing the PjBL model namely: (1) providing stimulation in the form of questions, (2) designing project plans, (3) compiling timelines, (4) monitoring students, (5) conducting proofs, (6) drawing conclusions (Devi et al., 2019).

One method that can activate students is to encourage students to be productive in producing work, both individually and in groups (Guo et al., 2020). One approach that can be applied is PjBL. Through this model, students are facilitated in improving their self-quality and solving problems(Karan & Lisa Brown, 2022). Apart from that, this model also encourages students to produce work (Surya et al., 2018). According to Kurniasih & Sani (Kurniasih, I., & Sani, 2014), PjBL is an innovative learning model that emphasizes contextual learning through complex activities. Involving students in working in groups to prepare reports, experiments, or other projects is one of the activities of this model (Mudlofir, A., & Rusydiyah, 2017).

Core competencies, basic competencies, and learning indicators related to gathering information to produce something useful for the lives of students and others are

the emphasis of implementing this model (Nakada, A., Kobayashi, M., Okada, Y. & A., & Hiroi, 2018). The implementation of PjBL encourages students to play an active role in learning (Uno, Hamzah, 2012). The learning process is not possible without the active role of each student in the learning process (Sundahry, S., Fitria, Y., & Rakimahwati, 2018).

Students can do many activities while learning. Students can not only listen or take notes but can also discuss and find ideas for creating a work. Innovations in the application of learning models need to be developed by teachers so that teachers do not only rely on experience and are less able to use innovative learning models (Fitria, Y., Hasanah, F. N., & Gistituati, 2018). The implementation of PjBL is characterized by positioning students as learning centers and preparing them for real life by attempting to present learning that is close to student life. Education places the student at the center and brings the conditions of everyday life into classroom learning. (Marza, A., Adnan, F., Fitria, Y., & Montesori, 2019). Learning in PBJL not only constructs knowledge but also produces work as a result of problem-solving so that students are actively involved. (Fitria, 2014).

The use of PjBL is expected to provide opportunities for students to enhance learning outcomes by building the four pillars of learning, as student understanding can increase (learning to know). (S. Prajoko et al., 2023) through scientific work processes (learning to do), which are carried out collaboratively (learning to live together). This will help achieve independent learning in students (learning to be). Rohana further explained that the PJBL model is one of the learning models suggested by the Ministry of Education and Culture so that students are more active in learning. (Rohana, 2020).

The product of creativity resulting from PjBL can, of course, be used as a student tool in understanding learning material (Prasetyo, 2017). The use of creative and innovative media in learning has a positive impact on increasing mastery of concepts (Hasiru et al., 2021), learning achievement, and critical thinking (Kurniawati & Sekreningsih Nita, 2018). Not only that, the use of appropriate media can encourage the conclusion of a concept in its own language (Novanto et al., 2021) through the process of interpreting, classifying, concluding, comparing, and explaining (Antasari, 2017). Emphasized (Mulyono & Hapizah, 2018) that students with a better understanding of concepts are able to construct new knowledge from experience.

Student learning outcomes are divided into cognitive, psychomotor, and affective (Ofem et al., 2024). According to Hamalik (Hamalik, 2004), learning outcomes, which are the impact of changes in a student's behavior, can be measured in the form of cognitive, psychomotor, and affective. In addition, learning outcomes are also patterns of behavior, understanding, values, attitudes, appreciation, and skills (Suprijono, 2016). This research focused on student learning outcomes in the cognitive domain. This means that this research is oriented towards students' cognitive thinking abilities (Supardi, 2015).

Cognitive thinking skills, according to Bloom's taxonomy, include remembering, understanding, applying, analyzing, evaluating, and creating (Effendi, 2017). Supa'at also mentions the six hierarchical levels in two main sections: knowledge and abilities (Supa'at, 2017). In addition, Kurniawan divides cognitive learning outcomes into seven levels, including knowledge, understanding, application, analysis, synthesis, evaluation, and creativity (Kurniawan, 2019).

Cognitive learning outcomes are related to the ability to think and remember (Dakhi, 2020), as well as combining several ideas, ideas, methods, or procedures learned to solve problems (Suhartono & Rosi Patma, 2018). The achievement of cognitive learning outcomes obtained by students can be seen through the minimum completeness criteria (KKM) (Ambaryani & Gamaliel Septian Airlanda, 2017). Minimum completeness criteria is a criterion used as a benchmark for students' success in receiving learning (Sulfemi, 2019). Therefore, cognitive learning outcomes in this study were obtained from the tests given (Oktaviana & Iwit Prihatin, 2018).

Previous research conducted by Fitri et al. stated that the PjBL model had a significant influence on high-level thinking abilities. There is a correlation between achievement motivation, high-level thinking abilities, and the PjBL model, which together influence high-level thinking abilities (Fitri et al., 2018).

Research Methods

This research is experimental. According to (Sugiyono, 2013), an Experiment is a method that can be used to prove the effect on research subjects after giving treatment. Researchers conducted research with the conditions encountered in the field. This research was conducted to find the effect of PjBL as an independent variable on student learning outcomes as the dependent variable. Scientific literacy is foundational for many

young learners in primary school grades when they have mastered the ability to comprehend vocabulary terms and the science concepts behind them. Text with engaging visual imagery can improve students' comprehension, enhance retrieval, and increase retention when it is integrated into either reading or science instruction (Choiriyah, 2021).

This study uses a form of pre-experimental experiments, such as the one-group pre-test-post-test research design. The research design was conducted with one group only. In this study, only one class was conducted, namely class IV. According to (Sugiyono, 2013), the results of the treatment design of this study will be more accurate because it directly compares the situation before being given treatment.

A pretest was conducted to obtain data on students' initial learning outcomes. After being given a pretest, treatment with the PjBL model was given. After being given treatment, a posttest was then given to find out the learning outcomes of the treatment effect.

Table 1
One-Group Pre-test- Post-test Design

Pre-test	**Treatment**	**Post-test**
O_1	X	O_2

Information :

O1 = Pretest

X = Treatment

O2 = Posttest

Source: (Sugiyono, 2013)

The study took place in a public elementary school located in Yogyakarta. The target population for the research consisted of all fourth-grade students. The sampling technique employed was saturated sampling, which involves including all members of the population in the sample. The research utilized various instruments, including observation tools, test instruments, and documentation. The observation instruments were used to collect data regarding the implementation of learning with the PjBL model. Observing the implementation of the PjBL model was crucial to ensure that all the prescribed components of the PjBL model were being implemented effectively during the learning process. The instrument used for observing the implementation of the PjBL model can be found in Table 2.

Table 2
Observation Instruments for the Implementation of the PjBL Model

No.	PjBL Syntax	Number Of Indicator
1	Find problems	1-5
2	Develop of problem-solving	6-9
3	Develop a project completion schedule	10-14
4	Project Monitoring	15-20
5	Delivery of the final result of the project task	21-25

Source: Personal Document Authors

The test instrument is used to obtain data on students' cognitive learning outcomes, both on the pretest and posttest. The test instrument grids can be seen in Table 3. The test is in the form of formative questions in the form of multiple choices of 10 questions. The questions are given during the pre-test and post-test.

Table 3
Test Instrument Grids

No.	Objective	Question Indicator
1	Understand the meaning of the animal life cycle.	Presented questions, students are asked to identify a deep-meaning question.
2	Students are able to name the order of the life cycle of one animal	Presented a question, students are ordered to sort the life cycle of one animal.
3	Students are able to identify imperfect metamorphosis.	Presented questions students were asked to identify the characteristics of metamorphosis not perfect.
4	Students are able to mention the life cycle of an animal.	Presented the questions, students were asked to name the cycle stage of one of the animals.
5	Knowing the stages of the animal life cycle.	Presented a question, students are asked to name the stages of the life cycle of one of the animals that can be dangerous.
6	Students are able to sequence the stages of the life cycle of one animal.	Presented a question, students are asked to sort the stages of the life cycle one animal.

No.	Objective	Question Indicator
7	Students analyze the differences between perfect and imperfect metamorphosis.	Presented a picture, students are asked to analyze the differences in the metamorphosis of the animal.
8	Identifying the sequence of life cycle stages one animal	Presented a problem, students are able to know the stage of the life cycle of one of the animals that results in an problem
9	Students are able to sequence the stages of the life cycle of an animal.	Presented an image with the stages of gaps, students are able to mention the order of the life cycle stages of one of the animals at the stages of gaps in the
10	Finding examples of animals that are included in metamorphosis perfect	Presented a problem, students are able to name animals that are included in metamorphosis perfect.

Source: Personal Document

Documentation is used to obtain student data, lesson plans, lesson schedules, and other administrative information. In addition, photo documentation is also used to devote to PjBL.

Moreover, the data obtained for learning outcomes were subjected to analysis using the SPSS software application, employing a normality test. This test aims to ascertain whether the data originates from a population that follows a normal distribution, as outlined by (Faizi & Yasir Alvi, 2023). The Kolmogorov-Smirnov test (One Sample K-S) was utilized for the normality test. According to (Madrid, 2023), the data is considered normal if the probability or significance (Sig.) value is more significant than 0.05. If the data is found to be normally distributed, the analysis proceeds with the independent-samples t-test through the SPSS program. In the hypothesis formulation, if the obtained P-value (significance) (2-tailed) is greater than or equal to α, where $\alpha = 0.05$, then the null hypothesis (H0) is accepted, indicating no significant difference. The normalized gain test (N-Gain) was conducted to evaluate the effectiveness of students' cognitive learning outcomes following the treatment. The N-Gain, which stands for normalized gain, compares the actual gain score with the maximum gain score, as mentioned by (Lynn et al., 2024). The actual gain score represents the improvement achieved by students, while the maximum gain score denotes the highest potential

improvement attainable. Subsequently, the normalized gain score is calculated based on the formula provided by (Hake, 1999), which is as follows:

$$\text{N-Gain} = \frac{\text{Skor } \textit{Postestt} - \text{Skor } \textit{Pretestt}}{\text{Skor Maks} - \text{Skor } \textit{Pretestt}} \text{ x } 100$$

The results of the Normalized Gain score are divided into three categories, namely:

Table 4
Normalized Gain Criteria

Criteria	Effectiveness Criteria
0,7≤g<1,0	Tall
0,3<g<0,7	Currently
0<g<0,3	Low

Source:(Hake,1999)

Result

The purpose of this research is to find out whether the PjBL model is able to improve student learning outcomes. The project in this research is the project of making animal metamorphosis modeling. This is in accordance with the explanation in the method section, where this research is quantitative research with the type of experimental research. The design used in this experimental research was a "pre-test posttest one group design." In this study, there were two research variables, namely the independent variable (X) and the dependent variable (Y). The independent variable (X) in this study is a treatment using the PjBL model, while the dependent variable (Y) in this study is the students' cognitive learning outcomes.

The subject that is the focus of research is IPAS (Natural and Social Sciences), namely, the material life cycle of living things. The researcher's teaching module adapts to the latest curriculum, namely the independent curriculum. Teaching modules are made to make it easier for educators to present material and guide teachers in designing learning so that learning is more efficient, precise, and varied. So, with the preparation of teaching modules, it is able to achieve competency standards (Maulida, 2022).

The researcher also compiled a student worksheet with the title "Living Things: The Life Cycle of Living Things." The worksheet was made to facilitate teaching and learning activities. Learning was carried out in a PjBL model so that the activities

contained in the LKPD encouraged students to make or produce something. Ramadianti et al. also used LKPD in their research on project-based learning. The results of this research show that the use of LKPD is able to increase classical completeness by a percentage of 44.83% (Ramadianti et al., 2021).

This study consisted of three stages, namely, pretest, treatment, and posttest. The pretest in this study was conducted to obtain initial data on students' cognitive learning outcomes before being given the PjBL learning model treatment. The pretest data on cognitive learning outcomes can be seen in Table 5.

Table 5

Pretest Data on Students' Cognitive Learning Outcomes

Component	Score
The Highest Score	75
Lowest Value	50
Average ($\bar{x}$)	60,8
Standard Deviation (s)	8.858455
Variance (s)	78.47222

Source: Personal Document

After being given the pretest, the next stage is giving treatment, namely learning with the PJBL model. In this activity, students are invited to work on a project to model animal metamorphosis in groups. In carrying out this project, the teacher prepared a work guide in the form of student worksheets (LKPD). In LKPD, students are given activity objectives, tools and materials, work steps, and project schedules. In addition, LKPD is equipped with instructions for each activity, which makes it easier for students to complete projects. Students are expected to be able to make animal life cycle modeling products to help students understand the animal life cycle. PjBL juga efektif digunakan dengan metode lain berupa penggunaan Biskuit oleh King Dow Su di Amerika Serikat, bahwa model PjBL juga efektif diterapkan dengan STEM. Additionally, the study revealed that students can benefit from STEM interdisciplinary learning approaches and PBL training. Based on the above findings, this study offers theoretical and practical underpinnings for STEM interdisciplinary learning in hospitality education using PBL learning settings (Su, 2024). The detailed activities in this treatment can be seen in Table 4.

In the PjBL Model learning, teachers are also assisted with teaching materials. The instrument can be in the form of a bag or a non-test instrument (S & Ahmadi K. I, 2010). These views are also complemented by Pannen Dalam (Prastowo, 2014, p. 17), who revealed that teaching materials are materials that are arranged systematically for use in learning (Prastowo, 2014). The teaching materials used by the teacher to learn the life cycle of living things are handouts made by the teacher.

Table 6
Learning Activities with the PjBL Model

No.	Activity
1	Get to know the life cycle of animals.
2	Observing the Life Cycle of Some Animals
3	Classify animal life cycles into perfect and imperfect metamorphosis.
4	Design of Animal Metamorphosis Modeling Project
5	Project Schedule Creation
6	Progress presentation
7	Final presentation

Source: Personal Document

The final bill of learning with the PjBL model is the product of animal metamorphosis modeling, which is collected in groups. The product images produced by students are shown in Figure 1

Figure 1
Animal Metamorphosis Modeling Products
Source: Personal Document

Based on the analysis of the implementation PjBL Model, 100% implementation data was obtained. This shows if the PjBL model is implemented well in learning.

After being given treatment with the PjBL model, it is then given a posttest. This posttest was conducted to find out the learning outcomes after being given treatment with the PjBL model. The posttest questions given are the same as the pretest questions in the amount of 10 multiple-choice questions. The pretest scores are shown in Table 7.

Table 7
Posttest Data on Students' Cognitive Learning Outcomes

Component	Score
Highest Score	90
Lowest VScore	70
Average ($\bar{x}$)	83,6
Standard Deviation (s)	5.676462
Variance (s)	32.22222

Source: Personal Document

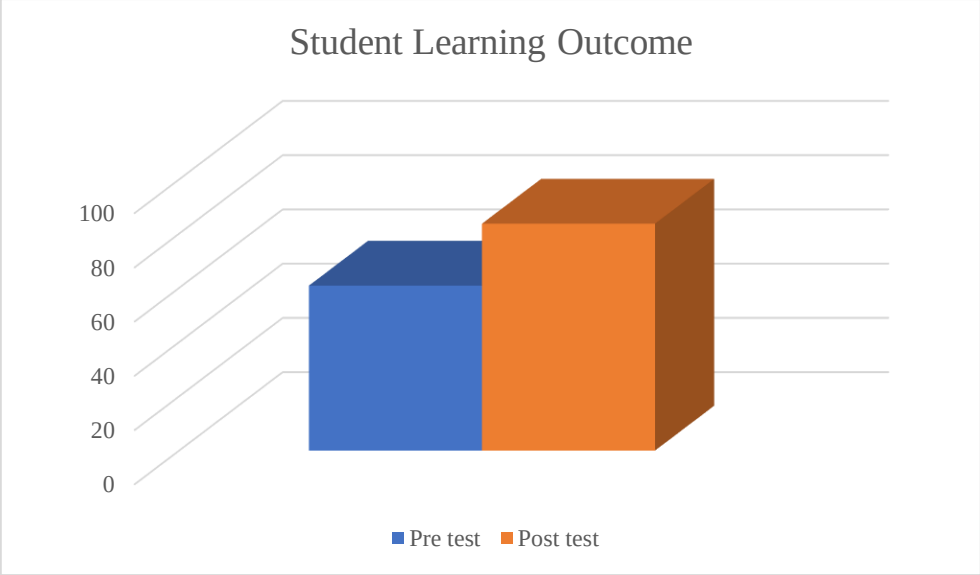

Figure 2
Student Learning Outcomes
Source: Personal Document

Discussion

A comparison of the average pretest and posttest scores can be seen in Figure 2. Based on these results, it is known that there has been an increase in the average scores for the pretest and posttest results. Increasing the average score of learning outcomes by 22.8.

Hypothesis testing was conducted to determine the effectiveness of the PjBL model in enhancing learning outcomes. Before proceeding with the hypothesis testing, a prerequisite assessment was performed, which involved conducting a normality test. The normality test comprises a series of tests that aim to determine whether the data follows a normal distribution. In essence, the normality test is an attempt to provide evidence that the data is distributed normally. The normal distribution of data can be identified based on its significance value. If the significance value is greater than 0.05, the data is considered to be normally distributed. Conversely, if the significance value is less than 0.05, the data is deemed not to follow a normal distribution (Fahmeyzan et al., 2018). Based on the normality test performed, the pre-test data obtained a value of 0.53 and a post-test of 0.60, meaning that the data is > 0.05 or has a normal distribution.

In this study, the t-paired test was utilized to examine whether there were any disparities between pretest and posttest scores. Additionally, the n-gain test was employed to assess the effectiveness of the treatment on learning outcomes. The paired t-test is a statistical method used to determine the extent of the treatment's effectiveness. According to Montolalu, the paired t-test is characterized by calculating the average difference between the data before and after the treatment is administered. A difference is considered significant if the p-value is less than 0.05. The obtained two-tailed significance value was 0.000, indicating a significant difference between the pretest and posttest scores after the treatment was administered (Montolalu & Yohanes A.R. Langi, 2018).

Once it is known that there are differences in learning outcomes between before and after being given treatment, then the n-gain test is carried out. The results obtained based on the analysis using the gain n test obtained a value of 0.57. According to (Nismalasari et al., 2016), the n-gain test is used to measure the increase between the pre-test data and the post-test data. The value of 0.57 indicates that there is an increase in the average of the research sample in the medium criteria, so based on the results of the n-gain analysis, the PjBL model is effective in increasing learning outcomes. The results of this analysis are in line with other research, which states that learning outcomes can be influenced through the integration of project-based learning (Kumar, 2021).

The implementation of the PJBL model in learning necessitates students engaging in group activities. Moreover, students are expected to generate products through the process of making or creating after the learning process. These activities aim to promote

a more realistic and meaningful learning experience, enabling students to comprehend the subject matter more easily. As previously mentioned, the primary emphasis of PJBL-based learning is on grasping concepts. Consequently, PJBL encourages students to employ investigative and problem-solving thinking skills to develop products based on their own thoughts and ideas.

Student learning outcomes are directly influenced by the teaching patterns used. Quoting from research (Syukriah et al., 2020), this learning model has a direct influence on the learning process. Therefore, maximizing this learning model can increase students' understanding of the learning material. As highlighted by Muakhirin, the teacher holds a significant role in facilitating continuous learning. The primary responsibility of the teacher during the teaching and learning process is to provide stimulation to students, encouraging their active participation and aiming for the highest level of achievement, as evidenced by improved learning outcomes (Muakhirin, 2014).

Conclusion

According to research findings from the PjBL model, students demonstrate increased levels of engagement and enthusiasm in their learning process. With individual project responsibilities, students actively participate in their learning, which ultimately impacts their learning outcomes. Statistical analysis using t and n-gain tests confirms the effectiveness of implementing the PjBL model in improving learning outcomes. The significance value (sig-2) obtained from the t-test is 0.000, which is less than 0.05. This indicates that there are significant differences in learning outcomes before and after implementing the PjBL model. The N-gain test reveals a score of 0.57, which falls under the effective category.

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