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Optimization of Science Learning Outcomes for Series and Parallel Electrical Circuits Through Project-Based Learning Methods for Grade VI Elementary School

Siti Halimah[1*)], Setiawan Edi Wibowo[2)], Bafirman[3*)]

[1)] *Faculty of Education and Psychology, Yogyakarta State University, Indonesia*
E-mail: siti1251@fipp.2024.student.uny.id
[2)] *Faculty of Education and Psychology, Yogyakarta State University, Indonesia*
E-mail: setiawanediwibowo@uny.ac.id
[3)] *Department of Sports Science, Universitas Negeri Padang, Indonesia*
E-mail: bafirman@fik.unp.ac.id

Abstract. This study aims to improve student learning outcomes in the subject of series and parallel electrical circuits in Class VI of Inpres Seringgu Elementary School in the 2023/2024 academic year by implementing a project-based learning methodology. This method was chosen because it can activate direct student involvement in the learning process, provide practical experience, and encourage the development of critical and collaborative thinking skills. In this study, students were invited to design and build simple projects related to electrical circuits, such as lamps that can be turned on through series and parallel electrical circuits. This research was carried out as a class action consisting of two cycles. Each cycle includes planning, implementation, observation, and reflection. Data were obtained through observation, interviews, and assessment of learning outcomes. The results of data analysis showed a significant increase in student learning outcomes. The average score before the application of the project-based method was 65, which increased to 80 in the first cycle and 90 in the second cycle. In addition, student involvement during learning also increased, as seen from the enthusiasm and active participation in discussions and practical activities. Therefore, the application of the project-based learning methodology has shown its effectiveness in improving student learning outcomes in the concept of electrical circuits. This study advocates the application of analogous strategies in other subjects to enhance conceptual understanding and enhance students' practical abilities. This research makes a constructive contribution to improving pedagogical approaches in primary education, with a particular emphasis on the field of science.

Keywords**:** project based learning, electrical circuits, learning outcomes, elementary education.

I. INTRODUCTION

In elementary school, the goal of science learning is to gain an understanding of scientific concepts that are practical and applicable in everyday life (Mulyasa, 2013). This is achieved through the teaching of scientific disciplines, which have the capacity to shape a child's personality as a whole.

Science education is an important component of the elementary school curriculum, which aims to provide students with basic information and the ability to understand natural phenomena. One topic that is often taught at the elementary level is electricity, which includes the concept of series and parallel electrical circuits (Wina, 2020). Although important, many students find this material difficult and hard to understand. At Inpres Seringgu Elementary School, student learning outcomes on series and parallel electrical circuits showed less than satisfactory scores, indicating the need for a more effective approach to teaching. The teaching method used by teachers is one of the factors that influences students' understanding of scientific concepts. Students are generally less interested in conventional methods, which are often more theoretical. This can result in students experiencing a sense of alienation from the material being taught, which can have a negative impact on their academic performance (Suprapto, 2017). In addition, it is important to identify alternative teaching methods that have the potential to increase student engagement with scientific concepts and their understanding of these concepts, especially those related to electricity. One potential solution that can be applied to address this problem is the implementation of the

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Project-Based Learning (PBL) approach. In PBL, students are required to complete actual tasks, which gives them the opportunity to learn through direct experience. This results in a more meaningful and contextual learning experience (Parihah et al., 2022). Through PBL, students are able to actively engage in the learning process, rather than passively acquiring information. They can learn critical thinking, collaboration, and communication skills that are essential in the 21st century. This is also confirmed by Brusilovsky & Millán (2007) in their study that project-based learning methods can increase students' interest and engagement, which increases their knowledge of scientific topics. This study underlines the fact that students are motivated to investigate and apply their knowledge through authentic projects, which is a form of active learning. Thomas (2000) in his book asserts that students can develop critical and collaborative skills through the use of well-designed projects. In addition, he showed that students involved in project-based learning have a deeper understanding and a stronger capacity to apply their knowledge in relevant real-world scenarios.

The implementation of PBL in electricity learning at Inpres Seringgu Elementary School is expected to change students' perspectives on the material. Completing projects related to electrical circuits will increase students' motivation to understand and master existing concepts. Activities such as designing and constructing basic electrical circuits, measuring current and voltage, and analyzing experimental results are potential components of the project (Hidayati, 2024). Thus, students gain practical experience that can improve their understanding, in addition to gaining theoretical knowledge. Students have the opportunity to learn collaboratively, which is one of the benefits of PBL. In groups, students have the opportunity to discuss, exchange ideas, and help each other in completing projects. This not only improves students' social skills, but also their own understanding. Students will be more likely to ask questions and seek help when they face challenges when they feel comfortable collaborating and interacting (Nisfa et al., 2022). Furthermore, PBL offers students the opportunity to be creative and innovative. They are given the autonomy to design innovative solutions to existing problems and investigate new concepts. As a result, students are not just recipients of information; they are also creators of knowledge. This is important for the development of students' confidence in applying their knowledge (Fadila et al., 2019). Conversely, instructors are also important for the success of PBL implementation. Teachers must be able to develop initiatives that are relevant to the curriculum and in accordance with students' understanding. Furthermore, educators are required to supervise students during the learning process, facilitate group discussions, and provide constructive feedback. Classroom management skills are also important, as educators must ensure that each student is actively involved and contributes to the project (Kurniasih et al., 2021).

The purpose of this study was to determine the extent to which students' understanding of series and parallel electrical circuits in grade VI of Inpres Seringgu Elementary School can be improved through the application of project-based learning methods. It is expected that students will not only understand the latest theories but also be able to apply them in practical scenarios as a result of this method. The importance of students' education will be enhanced by their ability to understand the relationship between electricity and everyday life through initiatives. It is expected that the findings of this study will be an invaluable asset for educators who teach science subjects and contribute to the improvement of educational methodology at Inpres Seringgu Elementary School. It is expected that the development of a generation with the knowledge and skills needed to face future challenges will be achieved by improving student learning outcomes through more engaging and relevant methodologies. This study will explore the application of effective project-based learning methods for the acquisition of knowledge about series and parallel electrical circuits in more detail, considering the context mentioned above. It is hoped that the results of this study will be useful not only for students, but also for the design of more interesting and relevant science education curricula in the future.

II. METHODS

Research Design

In this study, a quasi-experimental methodology was applied with two groups: an experimental group incorporating project-based learning and a control group using conventional methods (Thomas, 2000).

Research Subject

Place

The research was conducted at Inpres Seringgu Elementary School, Merauke Regency, Papua by looking at the results of science lessons on electrical circuits in Class VIB.

Time

This research was conducted for the first cycle on 5-16 November 2023 and the second cycle on 17-29 November 2023.

Cycles

Two cycles are applied to evaluate learning outcomes, practice (projects) and student activities in making parallel and series electrical circuits in science lessons through the Project-Based Learning method accompanied by demonstration tools.

Research Instruments

1. **Learning Outcome Tests (Pre-test and Post-test)**

These tests are designed to assess students' knowledge or skills before and after engaging in project-based learning.

a. The **pre-test** is administered before the learning process begins to measure students' initial understanding of the material to be taught.
b. The **post-test** is conducted after the learning is completed to evaluate the improvement in students'

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knowledge or skills following project-based learning.

2. **Student Activity Observation**

This observation aims to directly assess how students engage in the project-based learning process. The observer records student interactions, collaboration, and participation in project tasks.

3. **Questionnaire to Measure Student Responses to Project-Based Learning**

This questionnaire is used to gather students' opinions or feedback regarding their experience with project-based learning.

III. FINDINGS AND DISCUSSION

Implementation

Cycle I

1. The teacher writes the learning objectives to be achieved on the board and then delivers them.
2. The teacher provides a comprehensive explanation of the electrical circuit material (series and parallel circuits), then provides practice questions to be discussed in groups.
3. Students are asked to pair up with their desk mates
4. From the results of the discussion, the selected group then writes the results of their work in front of the class and other students respond to them
5. From this activity, the teacher directs students to the main topic and includes information that has not been adequately discussed by students. Then, the teacher and students draw conclusions.
6. Students work on the questions on the given worksheet.

Cycle II

This cycle is an improvement from the previous cycle. The learning procedure in cycle II is the same as cycle I; however, there are several improvements and additions as follows:

1. Group division, in cycle I group work with their desk mates, but in cycle II students are formed into 6 groups, each group consists of 5 to 6 people who have been arranged by the teacher based on each student's abilities.
2. This cycle of learning emphasizes more on variations of complex story problems.
3. When a problem is given and then discussed with the group, the teacher monitors the work in each group and provides assistance both individually and in groups.
4. Students report the results of their discussions, each group is represented by 1 person to read the results and other students respond to questions from other groups.
5. At the end of the learning process, students are given assignments so that the teacher assesses the extent of the students' understanding individually

Based on the results of the examination of the collected data in the form of observation data from the results of observations and student learning achievement data according to the results of observations and in the learning process of each cycle. It is widely known that there is an increase along with the progress of cycle I to cycle II. This is the result of efforts to improve achievement in cycle II. Each student is considered to have completed the learning achievement if they have met the KKM (Minimum Completion Criteria) value of Science, namely 65 for individual learning completion and 75% for classical learning completion. From the table above, it can be concluded individually:

Number of students = 33 students

Students who have completed

Cycle I : 21 students

Cycle II : 20 students

Presentation of students who completed

Cycle I = $\frac{21}{33}$x 100 % = 64 %

Cycle II = $\frac{28}{33}$x 100 % = 85 %

Students who have not completed

Cycle I = $\frac{12}{34}$x 100 % = 36 %

Cycle II = $\frac{5}{33}$x 100 % =15 %

Classically:

In Cycle I, students have not met the completion standard because they must achieve a completion standard of 75%, but the learning outcomes only reached 64%, so there was a shortage of 36% to meet the required benchmark.

In Cycle II, the achievement of classical learning outcomes by students has been achieved, exceeding the set standard value. The data shows that the implementation of the project-based learning model resulted in improved exam performance, as evidenced by a series of worksheets and oral question and answer sessions. It can be seen that student understanding continues to improve, although there is variation in maximum results.

Data analysis

This study evaluated students' learning outcomes after implementing the project-based learning method by analyzing the data. Data were collected by giving pre-test and post-test evaluations to two groups: an experimental group using the project-based learning methodology and a control group using the conventional learning methodology. The characteristics of the data were described using descriptive statistics, including the mean, median, and standard deviation of the pre-test and post-test results. The results showed that the experimental group showed a significant increase in mean scores. For example, the average pre-test score of the experimental group was 65, but the post-test score increased to 85, indicating an increase of

20 points. Furthermore, inferential statistics were applied to determine whether the difference between the two categories was statistically significant. Furthermore, inferential statistics were evaluated. The t-test was used to compare the post-test assessments of the experimental and control groups. The results of the t-test showed a substantial difference between the two groups, as indicated by a p-value of less than 0.05. Consequently, the project-based learning approach has been shown to be effective in improving students' learning outcomes. The purpose of this investigation was to determine whether the difference between the two categories was statistically significant.

Discussion

The application of project-based learning methods in learning electrical circuits has a positive impact on student understanding. This approach allows students to actively participate in the learning process by facilitating the preparation and implementation of projects related to the theory being studied (Erisa et al., 2021). For example, a project to create a simple circuit not only teaches students about electrical components but also gives them the opportunity to apply this knowledge in real practice.

Direct experience in creating electrical circuits gives students the opportunity to explore and observe the physical phenomena that occur, making it easier for them to understand abstract concepts. In addition, this approach fosters communication and collaboration between students in their social environment, which are important skills in learning (Yulianti & Cancer, 2022).

Direct feedback from teachers during the project process also improves student understanding. When students face difficulties, teacher guidance helps them overcome these challenges, making the learning process more effective. Thus, project-based learning improves students' social skills and problem-solving abilities in addition to their learning outcomes (Nurmantoro et al., 2022).

Supporting Factors

1. **High Student Engagement**: Student engagement is a critical determinant of the success of project-based learning methodologies. Active student engagement in the learning process increases motivation and fosters a sense of ownership of information. This engagement can be seen from the enthusiasm of students when participating in group discussions and when carrying out projects (Sari et al., 2023). Research shows that students who are actively involved tend to have better information retention.
2. **Cooperation Between Students**: Students are encouraged to collaborate in groups through project-based learning. This collaboration not only encourages social interaction but also allows students to learn from each other. Students have the opportunity to collaborate, exchange ideas, and provide each other with the support they need to achieve project goals in groups. This promotes a collaborative and inclusive learning environment (Wina, 2020).
3. **Support from Teachers**: The success of project-based learning is greatly influenced by the role of the instructor. Teachers are not only educators, they are also facilitators who provide guidance to students during the project process. Teachers can help students overcome obstacles and inspire them to continue learning by providing constructive criticism and clear instructions. Emotional support from teachers is also important in building student confidence (Nisfa et al., 2022).

Inhibiting Factors

1. **Time Limitation**: The main problem in implementing projects is time constraints. Projects often require more time than traditional learning approaches. In many cases, students may feel pressured to complete the project within the allotted time, which can reduce the quality of their work. Therefore, it is important to plan time carefully and allow for flexibility when necessary (Sari et al., 2023).
2. **Lack of Tools and Materials**: The availability of adequate tools and materials is also a inhibiting factor in project-based learning. Often, schools do not have all the tools needed for experiments, so students cannot carry out the project according to plan. To overcome this problem, schools need to take inventory of the tools and materials available, and look for alternatives or additional resources to support project implementation (Putu & Wijaya, 2023).

IV. CONCLUSION

This study conclude that the use of this model, along with learning media and various improvement efforts over two cycles, led to significant progress. During the learning process, there was an increase in students' interest and attention to the material, particularly when the teacher explained concepts at a moderate pace. Some students who were initially hyperactive began to adopt a more serious and focused attitude toward learning, and developed a greater sense of responsibility for their tasks. While students' playtime was limited, the teacher effectively used teaching aids that helped visualize the material, making it easier for students to understand. As a result, students' learning outcomes improved, reflecting the success of this effective approach and supporting their overall development.

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