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ARTICLE

The implementation of the problem-based learning model to improve learning outcomes in static electricity

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Abstract
Low student learning activity impacts their academic achievement, which tends to be low or results in poor learning outcomes. To address this issue, the researcher examined one instructional model, namely Problem-Based Learning. This study implemented PBL in the context of physics learning to improve students' learning outcomes on the topic of static electricity. The research employed a quantitative method with a Control Group Pretest-Posttest Design. The participants were ninth-grade high school students, where the control class received a lecture-based method, while the experimental class used the Problem-Based Learning model. The average pretest and posttest scores in the experimental class increased from 6.32 to 10.72, reflecting a 70% improvement, with significant changes observed in the learning process. Similarly, students' learning outcomes in the conventional lecture-based learning model also improved. The average pretest and posttest scores increased from 6.32 to 7.60, showing a 20% improvement. The percentage comparison of the average posttest scores between the experimental and control classes was 41%. The experimental group was categorized as having a moderate improvement, indicating that the PBL model had a moderate effect on learning outcomes. Meanwhile, the control group was categorized as having a low improvement, showing that the lecture method had a low effect on students' learning outcomes.

Keywords: Problems based learning, learning outcome, static electricity

1. Introduction

The success of a country's development is linked to the improvement of human resource quality. The quality of education in Indonesia is still not considered satisfactory, as there are numerous challenges within the country's education system. One major issue is the low quality of human resources produced by formal educational institutions, which play a crucial role in preparing the nation's future generations. Education in Indonesia has undergone many changes aimed at improving human resource quality. These efforts are necessary to address the challenges of globalization and can be carried out by families, communities, and the government through teaching, guidance, and training activities—both in formal education within schools and informal education outside of schools. The learning process using a scientific or inquiry-based approach encourages students to actively observe, ask questions, experiment, associate, and communicate.

The 2013 curriculum is an improvement from previous curricula, emphasizing a student-centered learning process. This approach requires students to actively seek knowledge through various sources of information. When the 2013 curriculum was introduced, student-centered learning methods were emphasized for implementation, and this emphasis has continued with the introduction of the Merdeka Curriculum. Research findings indicate that both the 2013 curriculum and the Merdeka Curriculum emphasize student-centered learning.

Based on field observations and interviews conducted by researchers during the Kampus Mengajar program, many students still rely heavily on teachers to solve problems in class. Their confidence in speaking up is also lacking, which is partly due to teachers not encouraging students to actively seek answers and ask questions. As a result, students tend to remain silent and wait for teacher instructions. This issue may arise because teachers have not fully utilized effective teaching models that actively engage students in the learning process. To address this problem, researchers have examined one instructional model: Problem-Based Learning (PBL)(Hmelo-Silver 2004).

The PBL model is a student-centered learning approach that enhances students' problem-solving skills (Rahmadani 2019). PBL engages students in solving problems through a structured scientific process, enabling them to acquire relevant knowledge while developing problem-solving abilities (Andiniati, Tahir, and Rahmatih 2023). Research by Implementing the Problem-Based Learning model can improve learning outcomes among high school students. Therefore, PBL, as a learning approach that uses real-world problems as a context, encourages students to actively engage in critical thinking and problem-solving. This provides students with valuable experiences in acquiring essential knowledge and concepts related to the subject matter. Furthermore, research on classroom action studies has demonstrated that the application of PBL in mathematics education can enhance both learning processes and outcomes (Nugroho et al., 2018). The implementation of PBL in science subjects has also been shown to improve student achievement, as evidenced by an increase in students' mastery from the initial to the final assessment stage.

Thus, applying the PBL model can enhance student learning outcomes. To further explore the effectiveness of PBL, this study implements PBL in the context of physics education, aiming to improve students' learning outcomes in the topic of static electricity. Based on this background, the researcher has chosen the study title: "The Implementation of the Problem-Based Learning (PBL) Model to Improve Ninth-Grade Students' Learning Outcomes in Static Electricity." The findings of this study can be utilized to develop training modules for teachers on how to effectively implement the PBL model in classrooms.

2. Literature Framework

2.1 Problem based learning

The Problem-Based Learning (PBL) model is an instructional approach designed to help students develop critical thinking skills and prepare them to tackle real-world problems, particularly those relevant to their daily lives. PBL provides students with opportunities to engage in authentic learning experiences, allowing them to become more active in the learning process, construct their own knowledge, and integrate school learning with real-life situations in a scientific manner (Firmansyah Ayub, 2015). In PBL, students are expected to take an active role in learning, while the teacher serves primarily as a facilitator who presents problems for students to solve.

Trianto (2010: 94-95) explains that the goals of PBL include developing students' thinking and problem-solving skills. Previous studies have demonstrated several benefits of PBL, such as increasing students' interest in learning, enhancing their social interactions and collaboration with peers and teachers, promoting student-centered learning, encouraging critical thinking, and ultimately improving student learning outcomes. While PBL emphasizes independent learning, the teacher's role remains essential as a designer, facilitator, and motivator throughout the learning process. The implementation of PBL is supported by various learning and developmental theories. Some of the key theoretical foundations of PBL include Piaget's Cognitive Development Theory, Vygotsky's Social-Constructivist Theory, Bruner's Discovery Learning Theory, and John Dewey's Educational Philosophy. However, in this study, the Cognitive Development Theory of Piaget serves as the primary theoretical basis for PBL.

Piaget's Cognitive Development Theory suggests that children are naturally curious and constantly strive to understand the world around them, constructing their own mental representations of their environment. This intrinsic motivation drives them to explore and clarify their understanding of concepts. Piaget argues that students actively acquire information and construct their own knowledge. When faced with new experiences, they must adapt and modify their pre-existing knowledge to accommodate new insights. According to Agung et al. (2019), Piaget's theory emphasizes that humans are not passive organisms in their genetic development. Instead, they actively construct knowledge through mental schemas, which integrate their understanding of the environment. Piaget believed that cognitive development results from the interaction between brain maturation, the nervous system, and experiences, helping individuals adapt to their surroundings.

Problem-Based Learning (PBL) is a learning approach that begins with problem-solving. However, to solve a given problem, students need to acquire new knowledge. The PBL learning strategy starts with the following steps. Students read a case study, determine the most relevant questions related to the learning objectives, formulate the problem statement, develop hypotheses, identify sources, discuss and assign tasks, engage in preparation, discuss possible solutions, report progress within the group, and present findings in front of the class. Among the three main activities in PBL—group work, individual tasks, and class discussions—the most essential element of the strategy is problem formulation (Capon and Kuhn 2004).

According to Arends (2012: 397), there are five steps in the PBL process: Students orient themselves to the problem; the learning process is organized for students; students conduct individual and group research; students create and present their work or products., and students perform analysis and evaluation of the problem-solving process.

2.2 Learning outcomes in physics

Similar to previous studies on Problem-Based Learning (PBL), this research will examine the implementation of the PBL model. However, the differences lie in the research background, theories used, research time and location, data collection methods, and the researchers involved in data collection. Learning outcomes refer to changes in an individual's behavior, including cognitive, affective, and psychomotor aspects. Students who are actively learning or have completed learning have utilized their cognitive, affective, and psychomotor abilities in response to their environment (Deta et al. 2021).

1. Knowledge (C1) – The ability of students to recognize and recall facts, concepts, and terminology.
2. Comprehension (C2) – The ability to translate, interpret, and expand upon given data.
3. Application (C3) – The ability to apply general ideas, procedures, methods, or theories to new and concrete situations.
4. Analysis (C4) – The ability to break down information into its components and explain the relationships between elements, enabling students to understand its structure.
5. Synthesis (C5) – The ability to create or produce a product based on the relevant concepts.
6. Evaluation (C6) – The ability to assess conditions, statements, or concepts based on specific criteria.

3. Research Method

3.1 Research design

This research was conducted using a quantitative approach. The method used in this study is a quasi-experimental method. The research aims to determine the effect of Problem-Based Learning (PBL) on students' learning outcomes. The study design used is the Control Group Pretest-Posttest Design, where both groups (experimental and control) were given a pretest before the learning session. The experimental class implemented the PBL learning model, while the control class used a conventional teaching model, such as the lecture method. After the learning process, both the experimental and control classes took a posttest. The difference in learning outcomes between the pretest and posttest scores is assumed to represent the effect of the treatment applied. The participants in this study were middle school students, specifically 50 ninth-grade students, divided into two groups: 25 students in the control class and 25 students in the experimental class. Each participant was given a pretest to collect initial data. The participant selection method followed the Non-Equivalent Group Design research framework.

3.2 Instruments

Instrument in this test was a test to explore learning outcomes. Students are given a pretest and a posttest in both the experimental and control classes, which will be administered to the classes being studied. The purpose of these tests is to assess the improvement in students' learning outcomes. In this test, the researcher evaluates cognitive domains based on Bloom's taxonomy, but only the following levels are used:

1. Knowledge (C1) – includes recognizing terms, facts, rules, methods, and so on.
2. Comprehension (C2) – involves interpreting, predicting, determining, explaining, and analyzing
3. Application (C3) – includes problem-solving, creating graphs, and similar tasks.
4. Analysis (C4) – involves analyzing, identifying problems, providing facts, and more.

The test consists of essay questions, with a total of six questions, each worth three points. Thus, the maximum total score is 18. The criteria for each answer can be found in the appendix. Since the test consists of essay-type questions, the researcher provides an ideal answer key to facilitate the grading process.

3.3 Data analysis

This data analysis technique is an alternative approach to answering the research questions. To determine the answers to these questions, the researcher conducted a study on an experimental class (using Problem-Based Learning/PBL) and a control class (using the lecture method) for both pretest and posttest learning outcomes. The data analysis was performed using SPSS software version 16.0. The following are the data analysis techniques used:

1. Descriptive Analysis: Before conducting further tests, a descriptive analysis is necessary to determine the average scores of students in both the pretest and posttest for the experimental and control classes. This descriptive analysis helps in summarizing and presenting the research data, which includes the number of data points (N), maximum value, minimum value, mean, total score (Sum), and other relevant statistics.
2. The Homogeneity Test is used to determine whether the variance (diversity) of data from two or more groups is homogeneous (similar) or heterogeneous (different). This test helps answer whether the variance of posttest data from the experimental class (PBL) and the control class (lecture method) is homogeneous or not. In this study, the homogeneity value was obtained using the Homogeneity of Variance Test. A sample is considered homogeneous if the Sig. Based on Mean value is greater than 0.05. If the data is normally distributed and has either homogeneous

or heterogeneous variance, but the samples are independent (not related), the next test used is the Independent Sample t-Test.

3. The Independent Sample t-Test is used to determine whether there is a significant difference in the mean between two independent (unpaired) samples. This test is applicable when the data follows a normal distribution. The criteria for the Independent Sample t-Test are: if the significance value less thab 0.05, there is a significant difference in the mean, meaning the null hypothesis is rejected. If the significance value more than 0.05, there is no significant difference in the mean, meaning the null hypothesis is accepted.
4. Normalized Gain (N-Gain Test): The Normalized Gain Test (N-Gain Test) is a statistical method introduced by Richard Hake (1999) to measure the effectiveness of a research method by comparing learning outcomes before and after treatment.

4. Result of the research

Before conducting further tests, a descriptive analysis is necessary to determine the average student scores in both the pretest and posttest for the experimental and control classes. This descriptive analysis helps summarize and present the research data, including the number of data points (N), maximum score (Maximum), minimum score (Minimum), average score (Mean), total score (Sum), and other relevant statistics. In the experimental class, the pretest average score was 6.32. After applying the Problem-Based Learning (PBL) model to improve learning outcomes, the posttest average score increased to 10.72. Meanwhile, in the control class, the pretest average score was also 6.32. The students in this class received instruction using the lecture method, as commonly practiced by teachers, resulting in a posttest average score of 7.60.

From this analysis, it can be observed that both the experimental and control classes had the same average score during the pretest. However, after applying different instructional approaches and conducting the posttest, both classes showed an improvement in average scores, but with different final results. Despite both groups experiencing an increase, this study focuses only on the impact observed in the experimental class.

From the results of the normality test, we can conclude that the students' learning outcomes, both in the pretest and posttest for the experimental class (PBL), have a significance (Sig.) value > 0.05 for all Kolmogorov-Smirnov and Shapiro-Wilk tests. This indicates that the research data follows a normal distribution. Since the data is normally distributed and consists of two independent (unpaired) groups, the next test conducted is a parametric statistical test, specifically the Independent Sample t-Test.

Based on the output above, the Levene's Test for Equality of Variances resulted in a significance value of 0.014. Since 0.014 < 0.05, this indicates that the variance between the experimental class and the control class is not homogeneous. Referring to the Independent Sample t-Test table, under the "Equal variances not assumed" section, the Sig. (2-tailed) value is 0.000. Since 0.000 < 0.05, it can be concluded that the null hypothesis (H) is rejected and the alternative hypothesis (Ha) is accepted. This means there is a significant difference between the average learning outcomes of students taught using the Problem-Based Learning (PBL) model and those taught using the lecture method.

From the output table, the Mean Difference value is 3.120, which represents the difference between the average learning outcomes of the experimental class and the control class. To better understand the posttest average scores for both the experimental class (PBL) and the control class (lecture method), please refer to the statistical table below.

Referring to the N-Gain value in percentage and the descriptive output table above, a table summarizing the N-Gain score calculation results can be found in the appendix. The increase in learning outcomes before and after applying different instructional models can be calculated using the normalized gain (N-Gain) formula. Based on the N-Gain score calculation results: the N-Gain score for the experimental class (PBL) is 0.38, which falls into the moderate improvement category, and the average N-Gain score for the control class (lecture method) is 0.1, which falls into the low improvement category.

5. Discussion and conclusion

Based on data analysis, students' learning outcomes improved after implementing the Problem-Based Learning (PBL) model. This improvement is attributed to the use of PBL, where students can solve problems through structured PBL steps. The experimental class, which applied the PBL model, showed an increase in learning outcomes in the static electricity topic (Dulyapit, Supriatna, and Sumirat 2023).

The pretest results indicated an average score of 6.32, which was below the minimum passing grade for science. After applying the PBL model, the posttest score increased to an average of 10.72, representing a 69.62% (approximately 70%) improvement. This study aligns with previous research showing that PBL can enhance students' learning outcomes. PBL, which is based on constructivism, helps students understand concepts and problems more effectively. Besides improving learning outcomes, PBL also positively influences students' behavior in cognitive, affective, and psychomotor aspects. Students become more active, collaborative, and gain a deeper understanding of the material when using PBL (Iskandar 2021).

The control class, which applied the lecture method, also showed an improvement in learning outcomes. The lecture method can still enhance learning, although it is more teacher-centered. Students in the control class experienced a 20% improvement after using the conventional lecture model. This research supports the importance of innovative teaching methods like PBL while also acknowledging that lectures can be effective in improving students' learning outcomes. Participation and collaboration in PBL help students grasp concepts more deeply, leading to improved learning outcomes. The PBL model guides students in overcoming initial learning difficulties, fostering positive changes in cognitive, affective, and psychomotor aspects (Nugroho, Harjono, and Airlanda 2018). Moreover, PBL enhances student participation, peer interaction, and material comprehension more effectively than traditional lectures.

However, students in the control class, who were taught using lectures, also showed improvement. Previous research has found that students taught using lecture methods achieved higher learning outcomes than those taught with inquiry-based methods. This study highlights a 41% difference in learning outcomes between the experimental and control classes in the posttest results. The lecture method tends to make students more passive due to the lack of teacher-student or student-student interaction. As a result, students may feel awkward, shy, or hesitant during learning, which can hinder their understanding of the material. While the lecture method has advantages, such as efficient content delivery and developing students' listening skills, it can also lead to student inactivity during lessons (Siahaan et al. 2023).

The implementation of PBL has been proven to enhance students' learning outcomes in static electricity. The findings indicate that PBL has a significant impact on students' learning outcomes. Students who used PBL were able to understand concepts better and improve their problem-solving skills. Although the lecture method also influenced students' learning outcomes, the impact of PBL was greater. This research supports the conclusion that PBL significantly enhances students' learning outcomes and has a stronger effect compared to the lecture method (Yusita, Rati, and Pajarastuti 2021).

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References

Andiniati, Mauly Rizki, Muhammad Tahir, and Aisa Nikmah Rahmatih. 2023. Pengaruh model pembelajaran problem based learning (pbl) terhadap hasil belajar ipa siswa kelas iv sdn 45 mataram. *Jurnal Ilmiah Profesi Pendidikan* 8 (3): 1639–1647.

Capon, Noel, and Deanna Kuhn. 2004. What's so good about problem-based learning? *Cognition and instruction* 22 (1): 61–79.

Deta, UA, FK Kurniawan, NA Lestari, M Yantidewi, MNR Jauhariyah, BK Prahani, et al. 2021. Literature review on the use of educational physics games in improving learning outcomes. In *Journal of physics: conference series,* 1805:012038. 1. IOP Publishing.

Dulyapit, Apit, Yayat Supriatna, and Fanny Sumirat. 2023. Application of the problem based learning (pbl) model to improve student learning outcomes in class v at uptd sd negeri tapos 5, depok city. *Journal of Insan Mulia Education* 1 (1): 31–37.

Hmelo-Silver, Cindy E. 2004. Problem-based learning: what and how do students learn? *Educational psychology review* 16:235–266.

Iskandar, Dedi. 2021. Peningkatan hasil belajar siswa pada materi report text melalui pembelajaran berdiferensiasi di kelas ix. a smp negeri 1 sape tahun pelajaran 2020/2021. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)* 1 (2): 123–140.

Nugroho, Damasus Fajar, Nyoto Harjono, and Gamaliel Septian Airlanda. 2018. Peningkatan proses dan hasil belajar matematika menggunakan model problem based learning (pbl) berbantu media kartu soal pada siswa kelas 5 sd negeri sidorejo lor 03 salatiga semester genap tahun ajaran 2017/2018. *Pendekar: Jurnal Pendidikan Berkarakter* 1 (1): 197–206.

Rahmadani, Rahmadani. 2019. Metode penerapan model pembelajaran problem based learnig (pbl). *Lantanida Journal* 7 (1): 75–86.

Siahaan, Amiruddin, Rizki Akmalia, Aina Ul Mardiyah Ray, Ari Wibowo Sembiring, and Era Yunita. 2023. Upaya meningkatan mutu pendidikan di indonesia. *Journal on Education* 5 (3): 6933–6941.

Yusita, Ni Ketut Pebry, Ni Wayan Rati, and Desak Putu Pajarastuti. 2021. Model problem based learning meningkatkan hasil belajar tematik muatan pelajaran bahasa indonesia. *Journal for Lesson and Learning Studies* 4 (2): 174–182.