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# The Effect of Using PhET Simulation Media on Fifth Grade Students' Learning Outcomes on Electric Materials

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**Abstract:** This study aims to describe the implementation of Natural and Social Science learning using PhET simulation media and to examine its effect on students' learning outcomes. The research adopts a quantitative approach with a pre-experimental design, employing a one-group pretest–posttest model. The participants consisted of 26 students, and data were collected through teacher and student activity observation sheets, as well as pretest and posttest assessments. The findings indicate that the use of PhET simulation media in teaching electricity was highly effective, with teacher and student activity scores averaging 97.5% and 92.3%, respectively. The mean pretest score was 51.15, which increased to 84.23 in the posttest. Because the data were not normally distributed, the Wilcoxon test was applied, yielding a significance value of 0.000 (< 0.05). These results demonstrate a statistically significant difference between pretest and posttest scores, suggesting that PhET simulation media can significantly enhance student learning outcomes in Natural and Social Science instruction.
**Keywords:** Learning media, learning outcome, natural and social science instruction, PhET


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## A. Introduction

Indeed, quality education must evolve in accordance with societal developments, and thus Natural and Social Sciences instruction should likewise be adapted to contemporary contexts. Consequently, teachers are expected to adopt innovative approaches in their teaching practices, for instance, by integrating interactive media and stimulating students' interest through the use of digital-based tools (Syabrina and Sulistyowati, 2020). Digital media are particularly appealing and effective in capturing students' attention because they not only deliver instructional content but also provide opportunities for students to engage creatively with the material (Batubara, 2025; Silviyanti et al., 2023). Nevertheless, in many classroom settings, some teachers still rely predominantly on conventional media such as images and textbooks as their primary instructional resources. This tendency often stems from considerations of practicality and familiarity with these tools. However, the continued exclusive use of such traditional

media can render the learning process monotonous, leading to reduced student motivation and, consequently, lower learning outcomes. It aligns with the findings of Wijayanti & Widodo (2021), who assert that students' learning outcomes are closely linked to their motivation; insufficient motivation can result in suboptimal academic achievement.

In his book entitled "Multimedia Learning", Richard Mayer states that a combination of words and images is more conducive to learning than text or images alone. The study reveals that students do not engage more deeply in learning when the learning material consists of text alone, as it fails to connect what they read in the text with new or existing knowledge (Sugilar, 2019). Learning that consists only of text or images is not in line with the principles of constructivist theory. Constructivist theory believes that learning is a process of self-discovery, where a person learns and constructs their own knowledge through interaction and observation of their environment. Jean Piaget, a Swiss expert, is recognized as the founder of constructivism (Utami, 2016).

Data collected from the fifth-grade teacher showed that students' Natural and Social Sciences instruction learning outcomes on the topic of electricity remained relatively low, with around 60% of the class scoring below the criteria for achieving learning objectives. The criteria for achieving learning objectives has a benchmark score of 68 in this school. Learning outcomes serve as a key indicator to assess how well students comprehend the material they study and the extent of the changes that occur in their development. These changes may involve attitudes, cognitive abilities, or practical skills. When students demonstrate noticeable changes in these areas, they demonstrate successful learning (Ambarli et al., 2020; Faizah, 2017). Several factors contribute to their low learning outcomes, including limited motivation and a lack of interest in learning, both of which often lead to boredom during classroom activities.

Additionally, teachers do not encourage their students to engage in learning actively, where students are asked to think independently, and subjects are not given space to voice their opinions during the learning process (Yunarti, 2021). To address this challenge, educators can incorporate interactive media as an effective alternative to enhance students' learning experiences and promote greater active participation.

Many visual media are interactive and can attract students' attention, one of which is PhET simulation media. PhET simulation media is a website or application that can provide convenience for students and teachers in understanding science and math lessons (Arifin et al., 2022; Faizah et al., 2023). PhET media contains animations (moving images) that are created to resemble their original state and are designed like a game with supporting features that help students explore (Darwis and Hardiansyah, 2021). The features contained in the PhET simulation "Circuit Construction Kit: DC Virtual Lab" include a click-and-drag and drop feature that allows interaction with several available electrical components, such as cables, lights, batteries, switches, and resistors. As an interactive simulation, PhET features animated visuals that resemble a game, enabling students to explore concepts as they learn (Kristantiniati and Ishafit, 2022). Serving as a virtual laboratory, PhET simulation media helps address instructional challenges related to limited resources and high costs (Syar et al., 2023). Moreover, integrating PhET

electrical circuit simulations into instruction positively influences student learning outcomes, especially in understanding dynamic electricity concepts (Ramadhani et al., 2023).

Previous studies on the use of PhET media indicate its positive influence on learning outcomes. Riyanto, Khusniyah, & Susanto (2022) found that integrating PhET media significantly improved science learning results. Similarly, Ramadhani, Hamid, & Hikmawati (2023) reported that the use of PhET positively affected students' performance on learning assessments.

Compared with previous studies, this research offers novelty by detailing the process of using PhET media and its influence on student learning outcomes through observation, documentation, and interviews. Unlike earlier studies that relied solely on primary data from pretests and posttests, this study enriches its analysis with secondary data sources, including observational records, interview findings, and supporting documentation. The research aims to present a comprehensive description of Natural and Social Sciences instruction learning implementation on electricity material using PhET simulation media and to examine its impact on the learning outcomes of fifth-grade students in Natural and Social Sciences instruction classes at MIN 2 Palangka Raya.

## B. Method

This study adopts a quantitative approach using an experimental research design. Researchers used this type of research to examine potential causal relationships between variables. The study applied a pre-experimental design, specifically the One-Group Pretest–Posttest model (Sugiyono, 2019). However, because it did not involve a control group, the results reflect possible effects rather than definitive causal conclusions.

The population of this study comprised phase C students, specifically those in grades 5 and 6 at MIN 2 Kota Palangka Raya. The researchers selected the sample using a purposive sampling technique, focusing on class 5-D, which consisted of 26 students. The sampling criterion required a class with the most significant proportion of students identified as visual learners. Results from the learning style questionnaire revealed that 57.7% of the students demonstrated a visual learning style, making class 5-D the most suitable sample for analysis.

The data collection methods employed in this study included tests, observations, interviews, and documentation. The instruments included observation sheets for learning implementation and question sheets (pretest and posttest). Instrument validation was carried out using expert validation. However, for test instruments in the form of question sheets, instrument trials were conducted after undergoing expert validation. The expert validation process in this study was conducted through a validation test by the instrument validator. The research instrument was then assessed by the validator based on the aspects of content feasibility, presentation, and language. As a result, the instrument used in this study was declared valid. Meanwhile, the reliability of the instrument in the study was demonstrated by a Cronbach's alpha value of 0.719, indicating that the instrument was considered reliable.

The learning process was carried out following a structured scenario, as presented in Table 1, which outlines the stages of learning activities ranging from orientation to closing reflection.

Table 1. Learning Scenarios

| No | Learning Activities |
|---|---|
| 1 | Orientation activities (greetings, prayers, checking attendance, and asking about well-being) |
| 2 | Associating (relating material to everyday life) |
| 3 | Introduction (presenting learning objectives and prompting questions) |
| 4 | Pretest implementation |
| 5 | Introduction to PhET media |
| 6 | Presentation of learning materials |
| 7 | Demonstrating the simulation of electrical circuit creation through PhET |
| 8 | Divide into groups and conduct experiments or practice using PhET |
| 9 | Providing guidance and monitoring |
| 10 | Posttest implementation (evaluation) |
| 11 | Conducting reflection and closing activities |

The researchers collected data on the implementation of learning through observation sheets that used a rating scale ranging from 1 to 4. They then analyzed the data using the following formula:

$$P = \frac{n}{N} \times 100\%$$

Keterangan:
P = Percentage
n = Score obtained
N = Maximum score

The results of the observation were interpreted using the learning implementation assessment criteria shown in Table 2.

Table 2. Learning Implementation Assessment Criteria

| Score Range | Category |
|---|---|
| 76% - 100% | Very Good/Excellent |
| 51% - 75% | Good |
| 26% - 50% | Less Good |
| 0% - 25% | Poor |

Source: (Chasanah et al., 2022)

The researchers analyzed the learning outcomes data by first conducting a prerequisite test to determine whether to apply a parametric or nonparametric statistical approach. This process involved performing a normality test. After establishing data distribution, they proceeded with hypothesis testing. If the data met the assumptions for parametric testing, they used a Paired Sample *t*-test (Febriani and Faizah, 2025; Nuryadi et al., 2017). Conversely, if the data met the requirements for nonparametric testing, they

applied the Wilcoxon test. The normality tests and *t*-tests were conducted using SPSS version 16.0.

## C. Results and Discussion

### Results

This study presents its findings by describing the implementation of learning using PhET media and examining the effect of PhET simulation media on students' learning achievement. The results also include an analysis of the learning process and student achievement, supported by prerequisite testing (normality test) and difference testing.

### Learning Implementation Using PhET Simulation Media

The observation sheet for learning implementation (see Figure 1), which assessed both teacher and student activities, was designed based on teaching modules to evaluate the learning process. It examined activities across three stages: introduction, core, and closing. Two observers used this instrument to assess how the learning process unfolds. The teacher activity observation focuses on aspects such as interaction with students and the teacher's roles as facilitator and motivator. The observers' evaluation of teacher activities consists of 15 assessment items, as presented in Table 3.

Figure 1. Research Activity

Table 3. Assessment of Teacher Activities by Observers

| Information | Observer I | Observer II |
|---|---|---|
| Total Score | 58 | 59 |
| Maximum Score | 60 | |
| Percentage of Earned Score | 96.7% | 98.3% |
| Average Percentage | | 97.5% |

Based on Table 3, the average percentage of teacher activity reached 97.5%, which falls into the "very good" category according to the assessment criteria in Table 1. Observer I recorded a score of 96.7%, while Observer II recorded 98.3%. These results indicate that the learning process implemented by educators was highly effective. This finding aligns with previous research by Munfaridah (2017), which emphasizes that teacher activity in facilitating learning is generally categorized as good.

Meanwhile, the indicators seen on the observation instrument sheet are the responses given by students and the active participation shown by students. The observers' assessment of student activities, consisting of 13 assessment items, is contained in the following table:

Table 4. Assessment of Student Activities by Observers

| Information | Observer I | Observer II |
|---|---|---|
| Total Score | 47 | 59 |
| Maximum Score | 52 | |
| Percentage of Earned Score | 90.4% | 94.2% |
| Average Percentage | | 92.3% |

Based on Table 4, the average percentage of student activity reaches 92.3% so it can be categorized as very good according to the assessment criteria in Table 1. The assessment consists of the value obtained from observer I of 90.4% and observer II of 94.2%.

**Student Learning Outcomes Analysis**

A cognitive ability test consisting of 10 questions was administered as a pretest before treatment using PhET simulation media. The posttest was administered after treatment using PhET simulation media. The average pretest and posttest results of students are shown in Table 5.

Table 5. Average Pretest and Posttest Results

| Average Score Pretest | Average Score Posttest |
|---|---|
| 51.15 | 84.23 |

Based on Table 5, the data analysis results indicate an increase in the average student learning outcome score, rising from 51.15 on the pretest to 84.23 on the posttest. This 33.08-point improvement demonstrates a significant enhancement in students' understanding of the learning material.

The study conducted a normality test to assess the distribution of pretest and posttest scores. It employed the Shapiro–Wilk test, which states that a significance value above 0.05 indicates a normal distribution, while a value below 0.05 shows a non-normal distribution. Performing a normality test is a crucial step in meeting the assumptions required for data analysis. Researchers often use the Shapiro–Wilk test when the sample size is fewer than 50 participants (Chairini et al., 2023). The normality test results, analyzed using SPSS version 16.0 for Windows, are presented in Table 6.

Table 6. Normality Test Results

| | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Pretest of Learning Outcomes | .893 | 26 | .011 |
| Posttest of Learning Outcomes | .825 | 26 | .000 |

In Table 6, it is obtained that the pretest data on student learning outcomes has a significant value = 0.011 < 0.05, so the distribution of the data above can be concluded to be abnormally distributed. The student posttest data has a significant value = 0.000 < 0.05, which means that the data distribution is not normal.

The study conducted hypothesis testing using a nonparametric difference test, specifically the Wilcoxon test. This test serves as an alternative to the parametric Paired Sample t-test. Researchers apply nonparametric tests when certain conditions are met, such as a sample size of fewer than 30 participants, non-random sampling, or a non-normal data distribution. The test criteria state that a significance value greater than 0.05 indicates no difference, whereas a value below 0.05 shows a significant difference. The results of the hypothesis testing using the Wilcoxon test are presented as follows.

Table 7. Wilcoxon Test Results

| | Posttest – Pretest |
|---|---|
| Z | -4.315[a] |
| Asymp. Sig. (2-tailed) | .000 |

Table 7 presents the results of the Wilcoxon test, showing a significance value of 0.000, which is less than 0.05. This result leads to the acceptance of $H_a$, indicating a significant difference between the pretest and posttest data after the treatment. This finding aligns with the study by Andriany et al. (2022), which reported a significance value of 0.000 < 0.05, confirming the presence of an effect. Similarly, Rahmawati et al. (2024) obtained a significance value of 0.001 (< 0.05), further supporting the conclusion that the treatment had a significant impact.

## Discussion

### Learning Implementation Using PhET Simulation Media

The implementation of learning by teachers is essential to the success of learning, which consists of introduction, core, and closing activities (Hatanti et al., 2022). The teacher's activity in the introduction is an important element that intends to prepare students mentally and emotionally and create conditions that support the achievement of learning objectives. In this study, the researcher, as a teacher, did several things, including greeting students, guiding students to pray, taking attendance of students, asking about the news and condition of students, conducting associations, and presenting information about the topic being studied and learning objectives. This is in line with research Susanti et al. (2025), which states that preliminary activities include the teacher greeting, calling on students to pray, taking attendance, asking about the condition of the students, and conveying learning objectives.

The core activities in the learning process are closely related to the methods and media used by the teacher to achieve learning objectives. In this case, the teacher not only acts as an educator but also as a facilitator in helping students acquire their knowledge. As for the implementation of the research, the learning used demonstration and experimentation methods in the teaching modules that had been made. The demonstration

method is teaching by displaying events and sequences in performing activities, both those that occur without any intermediaries or by using learning media related to the topic/material (Syarifah et al., 2025; Wijayanto et al., 2021). The use of this method is in line with the teacher's activities carried out, namely, demonstrating the making of electrical circuits through the use of PhET media. The types of electrical circuits demonstrated by the teacher are series, parallel, and mixed (a combination of series and parallel circuits). The learning media used is PhET media. Through PhET media, it is expected to help students in visualizing abstract material, which will be difficult to understand if relying only on theory alone (Agustina et al., 2025).

Closing activities in learning are divided into two activities, namely teacher activities with students and teacher activities (Nathasia and Abadi, 2022). One of the activities carried out by students and teachers involves making conclusions together on the topics studied. Meanwhile, closing activities in the form of providing motivation are included in the teacher's activities.

The implementation of learning based on student activities in learning activities has an average percentage of 92.3%. With this average percentage, students have responded and actively participated very well. The most prominent active participation of students is in the core activities. The virtual experiment method using PhET simulation media includes students actively participating in their learning activities. This is indicated by some students being able to make electrical circuits independently, and some of them still need direction and guidance from the teacher to conduct experiments to make electrical circuits using PhET simulation media. As one of the virtual laboratories, PhET helps students to understand the relationship between theory and practice (Wibowo et al., 2023).

Based on the above description, through the use of PhET simulation media, students can build their knowledge by actively engaging in the learning process. In addition, visualizing electrical material becomes easier with PhET. Theoretically, the use of PhET simulation media refers to two types of learning theories, namely cognitive and constructivist. This aligns with research Witasari (2024) stating that cognitive theory refers to individuals/students who build their understanding based on experience, which is termed as learning. The constructivist theory outlined by Witasari (2024) and Pramusinta (2020) states that learning is an active process where students construct their knowledge through exploration and experience. Thus, the use of PhET simulation media is effective in teaching electrical concepts.

Integrating technology into the learning process, particularly through PhET simulation media, offers practical benefits for enhancing student learning outcomes. PhET serves as an effective instructional tool by presenting abstract concepts—especially in disciplines such as physics, chemistry, and mathematics—in a visual and interactive format, which helps students grasp the material more easily. This perspective is consistent with the findings of Hanikah et al. (2025), who reported that using PhET simulations in science education positively influences student achievement. Consequently, teachers, as facilitators, need to develop strong competence in using such media to ensure that complex and abstract concepts are delivered effectively to learners.

**Student Learning Outcomes Analysis**

The improvement in student learning outcomes closely relates to observations of teacher and student activities during the learning process, which demonstrated excellent performance. These findings indicate that the learning process was effective, with teachers delivering instruction optimally and students actively engaging in classroom activities. Therefore, the enhancement of learning outcomes was strongly supported by the quality of learning implementation. This improvement is evident not only statistically, as reflected in the average scores, but also practically through students' active participation and their ability to apply the concepts they learned.

Factors that influence learning outcomes consist of internal factors (sourced from within a person, such as intellect, behavior, motivation, talent, and interest) and external factors. This second factor comes from outside the individual, such as the learning environment, be it family, school, or community (Astiti et al., 2021). Factors that influence student learning outcomes in this study are interest and motivation to learn. The research conducted (Sunami and Aslam, 2021) shows that using teaching media can generate interest in learning in students. Because the use of media can make learning more interesting, so that students feel happy and interested, other research reveals that increasing student interest in learning can be done through the use of learning media as one of the efforts. Therefore, learning media has a fundamental involvement in increasing learning interest (Rayan et al., 2023; Supriyono, 2018). The increase in students' interest and motivation to learn in class is due to the use of PhET simulation media. This statement is what was conveyed by the observer that PhET makes students enthusiastic and happy when learning. In addition to being able to provide an increase in the interest and motivation of student subjects in learning, teaching media can provide an increase in learning outcomes (Agustira and Rahmi, 2022; Olugbade et al., 2024). The use of media can make learning material easy for students to understand, so that the results achieved by students will certainly be even better. Thus, the use of PhET media can increase students' interest and motivation to learn, which can affect their learning outcomes.

## D. Conclusion

The analysis of learning implementation based on teacher activities shows an average score of 97.5%, which meets the "very good" criteria. This result indicates that the teacher implemented the learning process effectively. Similarly, the analysis based on student activities reveals an average score of 92.3%, also categorized as "very good." This finding demonstrates that students were actively engaged and responded positively during the learning process. The statistical analysis using the Wilcoxon test produced a significance value of 0.000. Since this value is lower than $\alpha = 0.05$, the study rejects $H_0$ and accepts $H_a$. This result indicates a significant difference between the pretest and posttest scores, confirming that the use of PhET simulation media significantly improves student learning outcomes in the electricity topic among fifth-grade students at MIN 2 Palangka Raya City.

However, this study has a limitation, as it measures learning outcomes only within the cognitive domain. Therefore, future research should include other domains, such as affective and psychomotor aspects, to provide a more comprehensive evaluation of learning outcomes. Additionally, subsequent studies are encouraged to incorporate a control group in the research design to strengthen the validity of the findings.

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