DIDAKTIKA
Jurnal Penelitian Tindakan Kelas
https://didaktika.lombokinstitute.com/index.php/JPTK

Vol. 2, No. 1 (April 2024)
e-ISSN: 2987-4343
pp. 16-21

Analysis of Student Responses at MA Al-Djufri to the Use of PhET Media as a Virtual Laboratory for Electromagnetic Induction

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Abstract: This study aims to analyze student responses to using the PhET simulation application in electromagnetic induction laboratories at MA Al-Djufri Blumbungan. A descriptive quantitative methodology was employed, with data collected through a survey using a questionnaire that gathered written verbal feedback from 17 twelfth-grade science students. The findings indicate that the PhET application was well-received by students and proved beneficial in enhancing their understanding of electromagnetic induction through virtual laboratories. Over 83% of the students agreed or strongly agreed on the effectiveness of the PhET application in the laboratory, demonstrating a high acceptance of this learning medium. This research supports the integration of virtual laboratories in science education as an effective way to improve student learning experiences and develop their conceptual understanding.

Article History
Received : January 10, 2024
Accepted : April 28, 2024
Published : April 30, 2024

Keywords:
PhET Simulation, Electromagnetic Induction, Student Response, Virtual Laboratory.

How to Cite: Mahrus, M., Hasanah, N., Jailani, A. Q., & Ibana, L. (2024). Analysis of Student Responses at MA Al-Djufri to the Use of PhET Media as a Virtual Laboratory for Electromagnetic Induction. *DIDAKTIKA : Jurnal Penelitian Tindakan Kelas*, *2*(1), 16–21.

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Introduction

The rapid advancement of science and technology has brought about significant innovations, including transforming learning methods. Traditional learning methods have shifted toward more interactive and collaborative approaches (Hali et al., 2021). A notable example of this transformation is using application-based technology in education (Fitriati et al., 2023). In the digital era, educational technology is crucial for addressing 21st-century skills, which include critical thinking, creativity, collaboration, and communication (Dudhat & Ardi, 2023). Virtual laboratories, a potential tool in educational technology, transform traditional learning environments by providing interactive and engaging ways to understand complex scientific concepts (Usman et al. 2021). Virtual labs allow students to conduct experiments and observations virtually without needing actual materials and equipment, saving costs and time and creating a more relevant and appealing learning experience for students (Adawiyah et al., 2021).

Virtual learning environments like the PhET Interactive Simulations created by the University of Colorado have proven effective in clarifying complex scientific phenomena, particularly in physics (Durkaya, 2023). PhET physics simulations allow students to explore various concepts interactively, from force and motion to properties of waves and atomic interactions (Rustana et al. 2021). By providing visual perception and practical experience in a virtual environment, PhET enables students to develop a deeper understanding of physics principles while maintaining the engagement and authenticity of physical experiments (Serevina & Kirana 2021).

Research indicates that the PhET platform can enhance understanding and retention of complex topics such as electromagnetic induction (Pacala, 2023). Furthermore, implementing virtual labs like PhET Interactive Simulations in physics education has also proven effective

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in developing students' critical thinking, problem-solving skills, and collaboration (Darmaji et al., 2023). Other studies have shown that using virtual labs like PhET in physics education can increase students' interest and motivation in science and strengthen the 21st-century skills necessary to face the challenges of the Fourth Industrial Revolution (Miftah 2022). Initial investigations, including interviews with physics teachers and students at MA Al-Djufri, revealed a dominant reliance on traditional educational models. Teaching approaches were limited to textbooks and worksheets, with minimal use of educational technology like projectors. Such methods were deemed insufficient to stimulate student interest or facilitate understanding of complex concepts like electromagnetic induction. Therefore, integrating PhET virtual laboratories into physics education must be incorporated into the curriculum to make abstract learning concepts more accessible, engaging, and understandable.

This study aims to analyze student responses to using the PhET simulation application in electromagnetic induction laboratories. It is expected to provide empirical support for integrating virtual laboratories in science education, contributing to a more interactive and effective learning environment. By investigating the specific context of MA Al-Djufri, this research will offer insights that can guide the adaptation of educational technology in similar institutions, promoting broader teaching strategies that align with the needs of contemporary learners.

Research Method

Research Design

This study employed a descriptive research design aimed at systematically analyzing the responses of MA Al-Djufri students to the use of PhET virtual labs in electromagnetic induction laboratories. The descriptive method was chosen to provide a detailed portrayal of student acceptance of this educational technology in the context of physics education at MA Al-Djufri.

Population and Sample

The population for this study consisted of students at MA Al-Djufri who participated or had participated in physics labs. The study sample was selected using a saturated sample technique, where all students participating in the electromagnetic induction physics lab using the PhET virtual lab were included. A total of 17 students from MA Al-Djufri's twelfth grade participated.

Data Collection

Data was collected using a student response questionnaire to determine student reactions to using PhET virtual labs. The questionnaire included questions about satisfaction, usability, and ease of use of the virtual lab and student perceptions of its effectiveness in understanding electromagnetic induction concepts. The questionnaire was structured using a Likert scale consisting of four assessments: strongly agree (score = 5), agree (score = 4), somewhat agree (score = 3), disagree (score = 2), and strongly disagree (score = 1).

Data Analysis

Quantitative data from the questionnaire were analyzed using descriptive statistics to identify general trends and distributions of student responses.

Results and Discussion

To understand the concept of electromagnetic induction, the virtual lab using the PhET "Faraday's Electromagnetic Lab" simulation proved to be a highly effective learning tool.

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This laboratory was designed to assist learners in visualizing and analyzing how changes in the magnetic field can induce electrical current in a conductor. Below is a summary of the process conducted during the virtual lab.

Initial Preparation and Introduction to Equipment. Before beginning the experiment, accessing, and familiarising oneself with the various components in the "Faraday's Electromagnetic Lab" simulation on the PhET website is essential. In this simulation, users interact with magnets, coils, and an ammeter. Understanding the basic functionality of each component, including how to adjust the magnetic field strength and change the speed of magnet movement, is crucial. **Experimental Process**. The experiment starts by placing the magnet near the coil to observe the initial effect on the ammeter without movement. Subsequently, the magnet is moved into and out of the coil at a constant speed while observing how this affects the readings on the ammeter, including changes in the direction of the needle indicating the direction of the induced current. Further experiments involve changing the speed of the magnet's movement and observing how this affects the induced current. The magnet's orientation is also altered to assess its impact on the generated current. Additionally, the number of turns on the coil is changed in the simulation to evaluate how this affects the intensity of the induced current. The virtual lab activities are displayed in Figure 1. **Analysis and Discussion**. Data obtained from various experimental settings were then analyzed. This included evaluating how the speed of magnet movement and the number of coil turns affect the magnitude and direction of the induced current. The discussion reinforces understanding of Faraday's Law and the concept of electromagnetic induction more broadly.

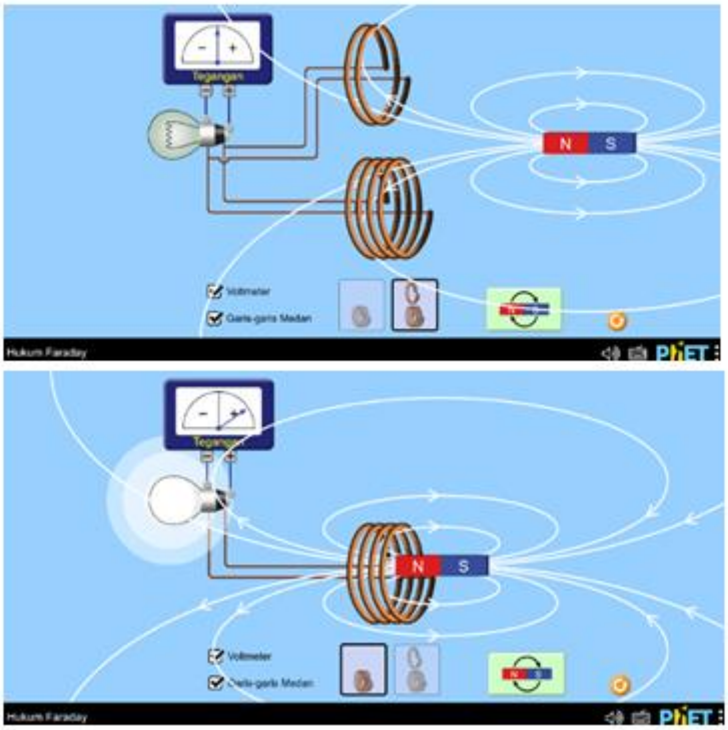

Figure 1. Simulation of Electromagnetic Induction Laboratory Using PhET

Student Response Analysis

Student responses were analyzed to determine their feedback regarding the virtual lab using PhET. Student responses were divided into five categories: strongly agree, agree,

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somewhat agree, disagree, and strongly disagree. The responses to the use of PhET media are displayed in Figure 2.

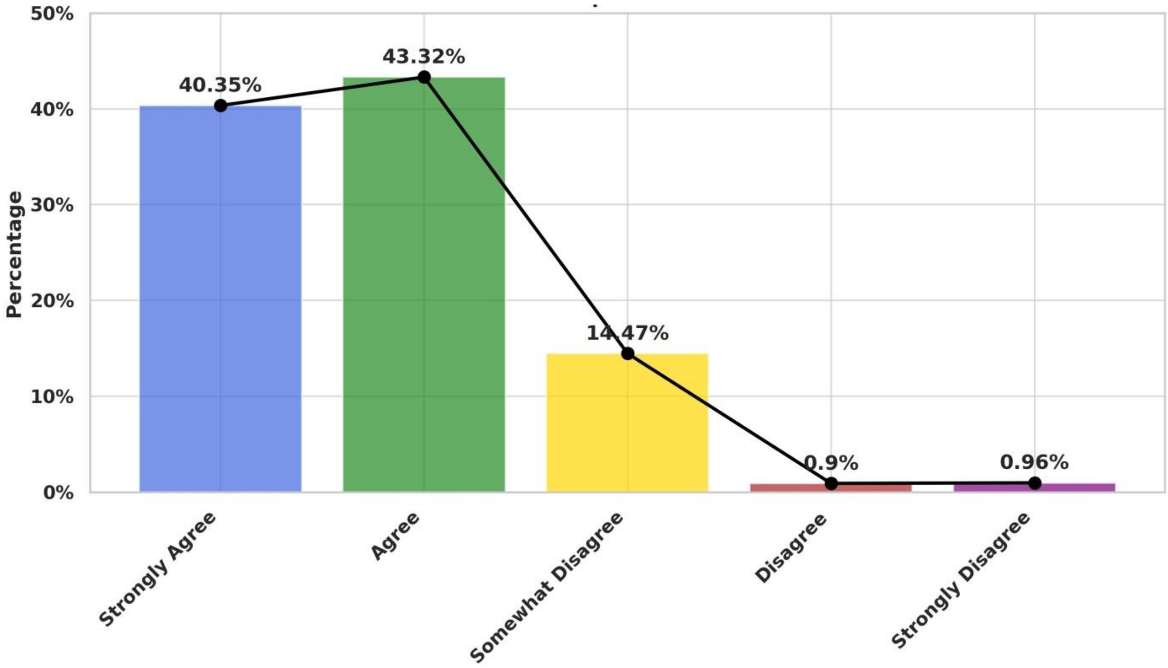

Figure 2. Student Responses to the Lab Using PhET Media

The analysis presented in Figure 2 shows various student responses to using PhET media in education. Further analysis revealed that 40.35% expressed strong agreement, 43.32% agreed, 14.47% somewhat agreed, 0.90% disagreed, and 0.96% strongly disagreed. This data indicates that most student responses fall within the "Agree" and "Strongly Agree" categories, encompassing more than 83% of the responses. The "Somewhat Agree" category also holds a significant portion, while negative responses ("Disagree" and "Strongly Disagree") constitute only a small fraction of the total.

The positive student response to using PhET media in the electromagnetic induction lab suggests high acceptance of this digital learning tool. Consistent with existing literature, computer simulations like PhET can enrich learning experiences and support conceptual learning in science fields (Bhat, 2023). The highly favourable student responses after using PhET media are likely due to several factors. Firstly, implementing PhET simulations enhances students' understanding of concepts, leading to positive responses (Novita & Fatmi, 2023). Secondly, students perceive the novelty, effectiveness, and new information provided by PhET simulations positively, contributing to their favourable responses (Azzubairiyah et al., 2022). Additionally, using PhET simulations in virtual laboratory practices has proven to enhance students' conceptual understanding and elicit highly positive responses (Anisa & Astriani, 2022). Furthermore, integrating PhET simulation media into physics teaching has increased student motivation and problem-solving capabilities, further solidifying positive student responses to this innovative teaching approach (Inayah & Masruroh 2021).

Conclusion

The use of the PhET simulation media in electromagnetic induction laboratories has significantly garnered a positive response from students. Most students, representing over 83% of the total respondents, fell into the "Agree" and "Strongly Agree" categories, indicating a high acceptance of this educational tool. The success of the PhET media in enhancing conceptual understanding among students is supported by the research literature,

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which highlights the effectiveness of computer simulations in science education. A substantial portion of students also fell into the "Somewhat Agree" category, showing broad recognition of the added value provided by the PhET simulations, albeit with varying levels of enthusiasm. Meanwhile, the tiny percentage of negative responses ("Disagree" and "Strongly Disagree") suggests that a minority of students might require additional approaches or support to appreciate or benefit from the use of this media entirely.

Acknowledgements

This research was made possible through the support from the school at MA Al-Djufri and the approval from the University of Islam Madura.

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