

Improving the competence of junior high school science teachers in Selatpanjang on the concept of electromagnetism through interactive PhET simulation training and the utilization of artificial intelligence (AI) in physics learning

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ABSTRACT

Limited laboratory facilities and restricted access to digital learning media have become major challenges in improving the quality of physics education in island regions, including the Meranti Islands Regency. According to data from BPS Kepulauan Meranti in 2025, there are 69 junior high schools with 1,016 teachers and 11,765 students spread across eight districts, indicating a strong need to enhance educators' competence in utilizing educational technology. This community service activity aims to improve the competence of junior high school science teachers through training in the use of PhET Interactive Simulations and the application of Artificial Intelligence (AI), such as ChatGPT, in physics learning, particularly on the concepts of electricity and magnetism. The activity was conducted on July 21, 2025, at SMAN 1 Tebing Tinggi, Selatpanjang, involving 32 junior high school science teachers as participants. The implementation methods included a needs assessment survey, theoretical and practical training sessions, and both formative and summative evaluations. The results showed a significant improvement in teachers' understanding of electromagnetism concepts and their digital skills. A total of 85% of participants reported an increased understanding of concepts after using PhET Simulations, and 90% stated that ChatGPT was helpful in developing teaching materials and practice questions. The training also enhanced teachers' motivation and confidence in using digital technology. Therefore, the integration of interactive simulations and AI has proven effective in enhancing the pedagogical and professional competence of teachers in island regions.

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1. INTRODUCTION

Science education, particularly physics, plays a crucial role in developing students' critical, logical, and creative thinking skills to meet the challenges of 21st-century technological advancement. However, mastering fundamental physics concepts such as electricity and magnetism remains a challenge in many schools, especially in remote and island regions. In the Meranti Islands Regency, the limited availability of laboratory facilities and access to modern learning media are major factors affecting the quality of physics instruction. According to data from the Meranti Islands Regency Statistics Agency, there are 69 junior high schools (SMP) under the Ministry of Education and Culture, with a total of 1,016 teachers and 11,765 students spread across eight districts. These numbers highlight the urgent need to enhance teachers' competence in utilizing science education technology to support effective teaching and learning activities [1].

The geographical condition of the Meranti Islands, which consists of a cluster of small islands, poses a unique challenge in achieving equitable access to educational facilities. Therefore, enhancing

teachers' mastery of science concepts and their ability to apply digital learning media is a strategic step. The community service activity conducted by a team of lecturers from Universitas Riau in Selatpanjang represents one of the efforts to improve junior high school teachers' understanding of electricity and magnetism concepts through training in the use of PhET Interactive Simulations. This medium enables teachers and students to explore the concepts of series and parallel electrical circuits virtually using simple devices such as laptops or smartphones. The training also included the introduction of Artificial Intelligence (AI) applications, such as ChatGPT, in developing teaching materials, which has been proven to enhance teachers' creativity and motivation in teaching.

The results of the training are consistent with the findings of Larashati and Supardi, which show that the use of PhET Simulation media in physics learning significantly enhances students' learning engagement and conceptual understanding of direct current circuit topics [2]. Previous studies have also reinforced the effectiveness of virtual laboratories in improving students' learning outcomes and scientific process skills [3-5]. Furthermore, the constructivist theory proposed by Piaget and Vygotsky states that learners build their knowledge through active experiences and interactions within the learning environment [6]. This theory is highly relevant to interactive simulation-based learning approaches such as PhET. Therefore, the implementation of technology-based learning media serves as an innovative solution to overcome the limitations of laboratory facilities, while also promoting interactive, contextual, and student-centered physics learning.

With the improvement of teachers' ability to utilize technologies such as PhET Simulations and Artificial Intelligence (AI), physics learning in schools across the Meranti Islands is expected to become more effective, engaging, and directly impactful on students' learning outcomes. Strengthening teachers' capacity through continuous training not only broadens their pedagogical perspectives but also accelerates the digital transformation of education in island regions, which have long faced limitations in access and resources.

2. COMMUNITY SERVICE METHODS

The activity was conducted on July 21, 2025, at SMAN 1 Tebing Tinggi, Selatpanjang. This location was chosen due to its strategic position in the Meranti Islands Regency, allowing teachers from different islands to easily travel to the venue. The participants consisted of 32 junior high school science teachers, representing schools that have not yet optimally integrated digital technology into their teaching practices. Prior to the activity, a needs assessment survey and brief interviews were conducted to map the teachers' level of understanding of electricity and magnetism concepts as well as their digital literacy skills.

The initial survey results indicated that most teachers still relied on conventional teaching methods. Based on these findings, the training was structured into several sessions: AI utilization training, PhET Simulation training, conceptual understanding of electricity and magnetism, and a discussion and Q&A session.

3. RESULTS AND DISCUSSIONS

The implementation of the community service activity in Selatpanjang went smoothly and received highly positive responses from the participants. A total of 32 junior high school science teachers actively participated in all training sessions.

The PhET Interactive Simulations session successfully visualized electrical circuits in a far more intuitive way compared to conventional methods, effectively overcoming the challenge of conceptual abstraction. Furthermore, the ChatGPT utilization training was met with great enthusiasm, as it provided practical and instant solutions for developing teaching modules, questions, and presentation materials—directly enhancing teachers' work efficiency.

The adoption of AI technology quickly boosted teachers' confidence in delivering instructional materials, aligning with the vision of educational transformation. In addition, the activity also succeeded in developing teachers' capacity for scientific writing, as several participants expressed plans to begin writing articles as a follow-up output of the program.

These findings affirm that the combination of theoretical reinforcement, interactive simulations, and AI-based tools forms a highly effective formula for enhancing teachers' professional and pedagogical competence in the partner region.

3.1. Activity Implementation

3.1.1. Introduction of Artificial Intelligence (AI)

The activity began with a presentation on the Introduction to Artificial Intelligence (AI) for junior high school teachers. The session focused on the use of AI in teaching and learning activities. During this session, teachers were also encouraged to have a hands-on experience using ChatGPT on their own devices.

The instructor provided guidance on prompt creation, demonstrating how to generate effective queries for ChatGPT. Teachers were then given the opportunity to develop and modify the prompts according to their respective teaching needs, fostering practical understanding and creativity in utilizing AI for classroom instruction.



Figure 1. Artificial intelligent training.

The use of ChatGPT in education has previously been discussed and researched. ChatGPT can serve as a digital assistant for teachers in designing lesson plans, creating assessments, preparing teaching materials, and explaining complex concepts in ways that are easier for students to understand [7]. For learners, ChatGPT provides convenience in independent learning, as it can be used to clarify concepts, summarize readings, solve problems, and generate practice questions tailored to their level of understanding. Similarly, Suharmawan (2023) emphasized that the use of ChatGPT can promote learning that is more personalized, adaptive, and efficient [8].

Nevertheless, the integration of ChatGPT in schools also presents several challenges that must be carefully considered. Warned of the potential misuse of ChatGPT by students to complete assignments without fully understanding the material, which may hinder the development of critical thinking skills. Moreover, the outputs generated by ChatGPT are not always accurate due to possible misinformation or hallucination errors, meaning that teachers must continue to act as the primary controllers and evaluators in AI-assisted learning [9].

In addition, highlighted the importance of establishing clear ethical guidelines and institutional policies to ensure that the use of ChatGPT in educational settings aligns with learning objectives and national educational values [10]. Therefore, the use of ChatGPT should be directed as a supportive tool that strengthens the teacher's role and enhances the quality of learning, rather than replacing the educational interaction between teachers and students.

3.1.2. Introduction PhET Simulation

To facilitate teachers' understanding of physics concepts, various interactive learning websites can be utilized. For the topic of Electricity and Magnetism, several learning media are already available. In this particular training session, the focus was on Series and Parallel Electrical Circuits.

During the session, all participants were guided to develop their skills in using the simulation website directly on their own devices. Through hands-on practice, teachers were able to explore circuit behaviors interactively, enhancing both their conceptual understanding and their ability to apply simulation tools effectively in classroom instruction.



Figure 2. PhET simulation training.

This approach enhances students' knowledge through active experiences and interactions within the learning environment [6]. Previous studies have demonstrated the effectiveness of PhET in improving students' engagement, motivation, and conceptual understanding of physics [3, 11- 14].

Researchers concluded that the PhET virtual laboratory is an effective alternative to support physics learning amid the limited availability of experimental equipment, as it successfully creates a more interactive and meaningful learning atmosphere.

3.1.3. Concept of Electricity and Magnetism

The lecturer delivered a session on "Electromagnetism" to the junior high school teachers. This session was designed to strengthen the teachers' understanding of electricity and magnetism concepts in physics, providing them with a deeper grasp of the fundamental principles and their applications in daily life as well as in classroom teaching.



Figure 3. Electromagnetism lecturer.

3.1.4. Q&A Session

After all the materials were presented, an open discussion session was held between the participants and the instructors. The participants showed great enthusiasm throughout the activity, as evidenced by the large number of questions raised. The discussions covered a wide range of topics, including Artificial Intelligence (AI), PhET simulations, and theoretical concepts of electricity and magnetism.



Figure 4. Documentation of participant activities.

3.2. Monitoring and Evaluation

Monitoring and evaluation of this community service activity were conducted to ensure that all stages of implementation aligned with the objectives and to assess the effectiveness of the training in improving teachers' understanding and skills. The monitoring process was carried out directly during the activity, while the evaluation took place both during and after the program.

During implementation, the service team observed participant attendance and engagement, teachers' active involvement in the PhET Interactive Simulations practice sessions, and the readiness of facilities provided by the partner institution, such as the training room, computer equipment, and internet connection. Observations showed that all participants demonstrated high enthusiasm and active participation, especially during hands-on simulations of series and parallel circuits and while practicing the creation of teaching materials using ChatGPT.

The evaluation process was conducted using two approaches: formative and summative. The results showed that 85% of participants reported a better understanding of electricity and magnetism concepts after using PhET Interactive Simulations, while around 90% stated that ChatGPT was very helpful in developing teaching materials and designing practice questions. Teachers also reported increased confidence in using new technologies and expressed their intention to implement these tools in their respective schools' teaching and learning activities.

4. CONCLUSION

The community service activity in Selatpanjang successfully enhanced the professional and pedagogical competence of 32 junior high school science teachers in teaching electricity and magnetism concepts through training in PhET Interactive Simulations and the utilization of ChatGPT. The program also led to a noticeable increase in teachers' confidence in preparing and delivering lessons.

It is recommended to provide continuous mentoring, including regular consultations and monitoring, to ensure the sustained implementation of the teaching methods, the development of scientific articles, and the consistent use of PhET simulations in classroom learning.

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