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Enhancing high school physics teachers' conceptual understanding of mechanics using deep learning and artificial intelligence-based training in Selatpanjang

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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

A comprehensive understanding of fundamental mechanics is an essential foundation for effective physics education at the high school level. Mastery of core topics such as force, motion, energy, and momentum enables students to relate physical laws to real-world situations and strengthens their analytical thinking in scientific contexts. Many educators in various regions encounter difficulties in teaching these concepts because of limited laboratory facilities, lack of instructional media, and teaching methods that do not emphasize conceptual reasoning [1, 2]. The situation in coastal regions such as Selatpanjang reflects similar conditions, where constraints in educational infrastructure often limit the development of interactive and contextual learning environments in physics.

Efforts to improve the quality of physics learning require the integration of conceptual understanding, contextual learning, and technological literacy. The advancement of artificial intelligence (AI) provides new opportunities to support teachers in developing engaging and adaptive learning materials. Tools such as ChatGPT can assist educators in preparing lesson plans, designing conceptual questions, and creating formative assessments that promote active participation in learning

[3, 4]. AI-based approaches also enable teachers to generate examples and simulations that help students visualize physical phenomena more effectively, creating learning experiences that encourage exploration and deeper comprehension [5].

This program was implemented as part of a community service initiative conducted by the Department of Physics at Universitas Riau. The activity aimed to strengthen the pedagogical and technological competencies of high school physics teachers in Selatpanjang through structured training based on deep-learning strategies supported by AI-assisted instructional design. The program emphasized collaboration between university lecturers and school teachers to enhance teaching practices, promote professional growth, and establish long-term academic partnerships. The initiative is expected to contribute to the improvement of physics education quality in coastal schools and to provide a model for integrating AI-based learning innovations in teacher development programs across Indonesia.

2. COMMUNITY SERVICE METHODS

The training program was conducted from July to September of 2025 at SMA Negeri 1 Selatpanjang with support from the Meranti Islands Regency Education Office. Twenty-seven physics teachers five secondary schools participated in this program. The methodology included three primary phases.

2.1. Reflective Training on Conceptual Mechanics

This training session aimed to strengthen teachers' understanding of the main ideas in mechanics such as force, energy, Newton's laws, and momentum through reflective, context-based learning. The discussion began with examples drawn from coastal life, such as rowing, the motion of boats, and water resistance. These familiar situations helped participants interpret physical principles as part of daily experience rather than as isolated theoretical rules.

Particular attention was given to Newton's Third Law, since many teachers and students tend to think that the action and reaction forces act on the same object. In a series of guided reflections, this view was reconsidered by analyzing how each force in the pair acts on a different body. The case of a rower pushing the water backward while the boat moves forward served as a simple yet effective example to illustrate the law in a real setting.

Through small-group discussion, case review, and concept mapping, participants reorganized their understanding of mechanics and improved the way they explain it in class. The reflective process encouraged them to connect theory with observation and to use these insights in developing a more coherent and meaningful approach to teaching physics.

Figure 1. Documentation of session 1 of the high school teacher training program in Selatpanjang.

2.2. Application of Artificial Intelligence (AI) in Physics Education

This session introduced the practical use of Artificial Intelligence (AI) to support physics instruction at the secondary level. Teachers were trained to employ ChatGPT as an instructional partner for developing learning materials, composing conceptual questions, and designing digital quizzes aligned with classroom needs. The workshop was conducted through guided, hands-on activities led by members of the academic team, allowing participants to explore the use of AI-based tools in preparing physics lessons.

Throughout the session, emphasis was placed on the pedagogical value of AI in improving the efficiency and creativity of lesson design [6]. Participants learned how to generate contextually appropriate examples, construct interactive simulations, and adapt learning resources to promote conceptual understanding in various physics topics. This approach encouraged teachers to view AI as an integral element of instructional innovation that enhances engagement and conceptual clarity in science education.

The experience broadened teachers' perspectives on the integration of digital technology into classroom practice. By applying AI tools to topics such as motion, energy, and electromagnetism, participants developed practical skills in designing more interactive and student-centered learning environments. The session contributed to strengthening teachers' technological literacy and pedagogical competence, supporting a more dynamic and context-driven approach to physics education.

Figure 2. Documentation 1 of session 2 of the high school teacher training program in Selatpanjang.

2.3. Academic Socialization and School-University Networking

This session focused on strengthening academic collaboration between the Department of Physics, Universitas Riau, and high schools in the Selatpanjang region. The activity aimed to expand outreach and communication by providing information about admission pathways, graduate profiles, and career opportunities in the field of physics. Faculty members presented the available university entry routes such as SNBP, SNBT, and independent selection, and explained the academic and research strengths of the department. The presentation also introduced research and community service programs that can involve both teachers and students from partner schools.

The discussion highlighted the role of academic socialization in encouraging students' interest in physics and science-related disciplines. Teachers participated actively in sharing classroom experiences and discussing strategies to prepare students for university admission. The dialogue allowed the academic team and school representatives to exchange ideas about learning approaches that connect school-level physics with higher education practices.

This activity also served as a platform for developing long-term collaboration between Universitas Riau and regional schools. The engagement strengthened communication networks and opened opportunities for future cooperation in education, research, and student mentoring. The outcomes of the session were evaluated through post-activity questionnaires measuring participants' satisfaction with the content, clarity of presentation, and perceived benefits, which indicated positive and constructive feedback from the participants.

Figure 3. Documentation 2 of session 2 of the high school teacher training program in Selatpanjang.

3. RESULTS AND DISCUSSIONS

3.1. Participant Feedback and Satisfaction

According to questionnaire responses collected after the sessions, all participants found the training highly beneficial as it equipped them with new knowledge on effectively teaching physics concepts. Most expressed satisfaction with the course material due its practical application and simplicity within their educational settings. Additionally, participants noted that their exposure to ChatGPT provided fresh perspectives on leveraging AI technology for enhancing physics education, particularly helpful for those lacking previous experience with such platforms.

3.2. Influence on Occupational Expertise and Behavioral Tendencies

The training enhanced teachers' comprehension of mechanics as a representation of real physical phenomena. Participants developed stronger confidence in teaching and demonstrated greater motivation to apply innovative approaches in classroom practice. Many expressed interest in further training programs to deepen their understanding and strengthen their instructional competence. These outcomes align with findings by Irshid et al. (2025), which emphasize the role of understanding-focused training in advancing teachers' pedagogical knowledge [7].

3.3. Strengthening School-University Collaboration

The program fostered collaboration between Universitas Riau and high schools in Selatpanjang through activities that integrated academic engagement and professional networking. Teachers actively exchanged ideas with faculty members, received information about admission pathways, graduate profiles, and career opportunities, and expressed commitment to sharing this knowledge with their students. The initiative strengthened institutional partnerships and promoted the use of AI-based teaching tools, contributing to improved teacher competence, professional growth, and sustainable collaboration in physics education.

The training successfully advanced both conceptual understanding as well as utilization of AI-based educational technologies among high school physics instructors situated in Selatpanjang yielding positive outcomes across both focus areas addressed herein, ultimately enriching teacher capabilities while increasing collaborative tendencies alongside greater recognition afforded pedagogical innovations amidst our current digital era.

4. CONCLUSION

This community service program successfully enhanced the conceptual understanding and pedagogical skills of high school physics teachers in Selatpanjang by integrating deep-learning strategies with AI-assisted instructional tools such as ChatGPT. Through activities focusing on mechanics reinforcement, practical AI application in lesson design, and strengthened academic networking between Universitas Riau and regional schools, participants demonstrated improved confidence, motivation, and readiness to implement innovative, student-centered teaching approaches. The high level of participant satisfaction indicates that the training was both relevant and impactful, offering a sustainable model for improving physics education in coastal regions while promoting long-term collaboration between higher education institutions and secondary schools to support the broader advancement of science education in Indonesia.

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