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ARTIFICIAL INTELLIGENCE-ASSISTED METHODS FOR TEACHING ELECTRICAL ENGINEERING DISCIPLINES

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Abstract

This article explores the integration of Artificial Intelligence (AI) into the teaching and learning processes of electrical engineering disciplines. It describes methods for combining AI-assisted tools with traditional teaching strategies, including virtual laboratories, modeling, simulation, and adaptive learning systems. The study demonstrates how AI can enhance student engagement, facilitate the understanding of complex electrotechnical phenomena, and improve overall learning outcomes. Emphasis is placed on the synergistic interaction between teacher-led instruction and AI-supported student learning, as well as on the cognitive methods of abstraction, idealization, and deductive reasoning enhanced by intelligent systems.

Keywords

Artificial Intelligence, AI-assisted learning, virtual laboratories, modeling, simulation, adaptive teaching, electrical engineering education.

The educational process in electrical engineering is a dynamic interaction between the teacher's instructional strategies and the student's active learning. Traditionally, teaching methods focus on theoretical knowledge and experimental practice. With the rise of AI technologies, it is now possible to enhance this interaction by providing personalized, adaptive, and interactive learning environments.

A teaching method can be defined as "a systematic set of teacher actions that organizes the student's cognitive and practical activities, ensures knowledge acquisition, and achieves learning goals" [1]. In an AI-assisted context, the teacher's role evolves into facilitator and supervisor, guiding students while AI systems provide real-time feedback and adaptive exercises.

AI technologies enable the creation of virtual laboratories where students can experiment with electrical circuits, transformers, and other devices without physical constraints. Platforms such as NI Multisim, Ultiboard, and Electronics Workbench can be enhanced with AI algorithms to:

- Generate adaptive simulations based on student skill level
- Predict potential errors and provide corrective feedback
- Model complex transient processes and short-circuit scenarios that are unsafe to replicate physically

This integration allows students to explore phenomena such as current flow, voltage distribution, and transient responses through interactive simulations while AI systems guide their learning path.

AI systems can monitor student performance during theoretical and practical exercises and adapt the learning content in real time. For example:

- Students struggling with Ohm's law and resistance calculations may receive targeted simulations with step-by-step guidance
- AI tutors can suggest additional problems based on observed gaps in understanding
- Data-driven insights from AI analytics can help instructors optimize lesson plans

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Such AI-assisted methods ensure individualized learning trajectories, increasing engagement and knowledge retention.

Traditional cognitive methods—abstraction, idealization, modeling, thought experiments, analogy, and deduction—can be enhanced using AI technologies:

- Abstraction and Idealization: AI simulations allow students to focus on key parameters, ignoring secondary factors that complicate learning
- Modeling: AI-assisted modeling software can represent electrical systems mathematically and visually, helping students manipulate models to predict outcomes
- Thought Experiments: AI-driven virtual environments let students simulate otherwise impossible scenarios, such as three-phase short circuits, safely and efficiently
- Analogy and Deduction: Intelligent tutoring systems provide examples and analogies automatically, reinforcing logical reasoning skills

By combining traditional cognitive strategies with AI tools, students achieve deeper understanding and faster mastery of electrical engineering principles.

AI integration in electrical engineering education enables:

1. Enhanced Laboratory Work: Students conduct virtual experiments with real-time AI feedback
2. Simulation of Complex Phenomena: Transient responses in power systems, transformer magnetization, and reactive power calculations
3. Adaptive Assessment: AI evaluates student performance and adjusts difficulty dynamically
4. Efficient Knowledge Consolidation: AI provides personalized summaries, hints, and visualizations for challenging concepts

Overall, AI-assisted education bridges the gap between theoretical knowledge and practical application, promoting active learning and critical thinking.

For future vocational education teachers in electrical engineering:

- Mastery of AI-assisted teaching tools enhances their ability to design adaptive curricula
- Familiarity with virtual laboratories and AI simulations allows safe exploration of complex electrical phenomena
- Combining AI with traditional methods fosters flexible, dynamic professional competencies, critical for teaching the next generation of engineers

Integrating AI into electrical engineering pedagogy ensures students not only understand fundamental concepts but also develop practical skills using modern technologies, preparing them for professional careers in engineering and education.

The integration of AI into electrical engineering education enhances student learning, engagement, and understanding. AI-assisted tools, including virtual laboratories, adaptive simulations, and intelligent tutoring systems, allow for personalized, interactive, and safe learning experiences. Cognitive methods such as abstraction, idealization, modeling, and deduction are amplified by AI technologies, enabling students to master complex concepts efficiently.

Future research may focus on AI-based assessment, predictive learning analytics, and gamification in electrical engineering education to further improve student outcomes.

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