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Impact of AI Technology in Education System for Electrical and Electronics Engineering

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***Abstract*—The use of Artificial intelligence (AI) has been extensively used in electrical and electronic engineering (EEE) education since its start. This study aims to provide in depth understanding of how artificial intelligence is revolutionizing electrical and electronics engineering teaching and implications for further development. This study reviews some previous studies in which AI is applied in EEE education and it also perform AI application study in EEE education using a systematic literature review process and qualitatively combines these previous studies. Comparison research was done to compare different AI technologies and their effect on student engagement and performance. The analysis was also extended to some case studies and experimental implementations from some universities. Big information analysis, error detection and efficient circuit topology recommendation may be saved time and increase accuracy with AI-powered systems. Assessment factors were used to assess effectiveness of AI technologies in electrical and electronics engineering education.**

***Keywords*—Artificial Intelligence (AI), Electronics and Electrical Engineering, Intelligent Tutoring Systems (ITS), Virtual Labs, Machine Learning in Education, AI-Based Circuit Design**

I. INTRODUCTION

A. Background

The traditional approaches towards teaching are fundamentally changed with the use of artificial intelligence (AI) in the classroom [1]. The innovations in electrical and electronics engineering through the use of AI are changing the way in which teaching methods are done. Learners can make use of it to make learning dynamic, effective and flexible [2]. Artificial intelligence (AI) technologies such as ML, DL, NLP, computer vision are used through simulations and intelligent tutoring systems to automate evaluation, tailoring of instruction and improvement of practical skills [3].

In the past, there were problem-solving activities, theoretical lectures and practical laboratory experiments as the mainstays of electronics engineering education [4]. With the advancement of technology, it is inevitable to use AI-based technologies to motivate student participation and to ensure that students understand more complex designs of engineering [5]. With AI-powered simulations, automated assessment tools and intelligent tutoring systems, students can acquire practical skills in circuit design, embedded systems and signal processing with more success [6][7].

B. Research Gap

Although AI is used more in classrooms, teachers still do not know all its advantages and disadvantages in teaching electronics and electrical engineering [8]. Research on the unique demands of electronics engineering and the role of real-world experience is less common. Before, most studies focused on using AI in support of STEM learning in general ways [9]. There is no information about how effectively AI-supported solutions can help improve curriculum, get faculty approval or improve student outcomes [10]. One major problem is that AI is often expensive to implement, raises ethical issues and requires the training of staff which needs further study [11][12].

C. Research Objectives

The primary objectives of this review are:

- The present application of AI in teaching electrical and electronic engineering has been investigated [13].
- The objective is to evaluate how AI-driven teaching strategies and resources do affect student learning and engagement [14].
- To find out restrictions and difficulties for using AI in the area of electronics education.
- A way to suggest how AI can be integrated more effectively into engineering courses to optimize learning outcomes.

Tackling these objectives, this paper aims to give a comprehensive understanding of how AI is modifying the teaching of electronics engineering and propose further improvements.

II. METHEDOLOGY

The application of AI in electronics and electrical engineering education is examined by using a systematic literature review methodology. Reputable sources include peer-reviewed journals, conference proceedings, books and online databases data were collected. In order to ensure that the research was relevant and accurate, it only included studies published in the last decade [15].

A. Methods

A qualitative method was used to classify AI applications in electronics education and to synthesize previous research. To break down the investigation I classified it into the following few key categories: AI assisted circuit design, automated testing, virtual labs and simulations, AI driven tailored learning and learning analytics. A comparative analysis was done to assess the various AI technologies as well as their impacts on student performance and engagement. Also, case studies and experimental implementations by various universities were also studied to gain useful insights [16].

B. Validation & Evaluation Metrics

In order to evaluate the effect of AI technologies in electrical engineering education, several assessment indicators were considered [17]. The main techniques of validation were [18]:

- **Student performance measurements:** The use of AI tools also includes the improvement of conceptual understanding, problem solving ability and academic performance before and after the use of AI tools[19].
- **Engagement & Retention Rates:** Involvement and rates of course completion in AI-enhanced learning environments.
- **Faculty Feedback & Acceptance:** Surveys and interviews with educators to understand usability, effectiveness and challenges of integrating AI tools.
- **AI Precision & Efficiency:** AI-driven tools for grading accuracy, quality of feedback and error detection in circuit design exercises are evaluated.
- **Comparative Studies:** Measuring AI-driven education strategies through comparison with conventional teaching techniques for effectiveness and learning results.

This study attempts to present a thorough analysis of the variables that are connected to the effectiveness of AI in enhancing the teaching of electronics and electrical engineering, and to do this by carefully evaluating these variables [17].

III. AI Applications In Electronics Engineering Education

A. Personalized Learning and Adaptive Systems

AI driven technology has been applied to personalized learning and adaptive systems which customize each student's educational experience [20]. By utilizing machine learning algorithms these systems change course content and teaching tactics dynamically, depending on a student's knowledge level, learning rate and problem solving ability [21].

One main application of personalized learning is intelligent tutoring systems (ITS) which analyze the student interactions and answers to give personalized guidance to the student. Using these AI-powered tools, it recognizes knowledge gaps, suggests particular exercises to help fill in those gaps and adjusts the level of difficulty instantly. For example, an ITS may aid students in electronics engineering solving circuit analysis, signal processing and embedded systems problems by providing step-by-step problem-solving techniques and immediate feedback.

Adaptive systems also use the feature of Natural Language Processing (NLP) to provide interactive learning conditions. Virtual AI instructors are chatbots and voice assistants that allow pupils to pose queries and get conversational answers [22]. They help understanding and getting involved, especially in hard topics such as power electronics and microcontroller programming.

In addition, some learning management systems (LMS) powered by artificial intelligence watch over student progress and create statistics that help teachers to become better at their trade [23]. AI can improve learning results by teacher's use of the tool to pick up on problem students early and apply appropriate interventions.

In the electrical engineering education, there are some advantages of using individualized learning and adaptive systems which are [17]:

- **Enhanced Student Engagement:** AI increases motivation and engagement by tailoring content to the individual tastes of each student.
- **Efficient Learning Pathways:** Adaptive systems hammer home where students are most weak while shining light on their strengths so as to accelerate the acquisition of new skills.
- **Real-time Feedback:** The immediate evaluation of the AI powered solutions reduces the time required for the correction of the misunderstandings and mistakes.
- **Scalability:** Thanks to AI-powered systems, schools can provide tailored learning experiences to a large number of students without adding to the workload of teachers.

Notwithstanding these benefits, there are still obstacles in the way of the broad implementation of AI-powered personalized learning platforms [24]. The seamless integration of AI models into electrical engineering curriculum is hampered by high development costs, data privacy issues, and the requirement for constant upgrades. In order to fully utilize AI in engineering education, several issues must be resolved.

B. Virtual Labs and Simulations

Virtual labs and AI powered simulations have completely revolutionized electrical and electronic engineering taught to the students by giving them hands on experience in a digital environment. These virtual labs are replicated of power systems, electrical circuits and electronic devices in real time using AI algorithms. They support students in running experiments, debugging circuits and analyzing real world scenarios all without needing any actual lab equipment [25].

An actual example is Labster, a virtual laboratory platform powered by AI that provides engineering students with fun and gamified experiences [26][27]. For example, in Labster's virtual electronics lab, students can build and test circuits, analysed waveforms and do experiments that mirror real experiments[28]. NI Multisim is another example of software that helps students by designing and analysing

electrical circuits and provides real-time feedback through AI-driven simulation model [29]. These virtual laboratories span the gap between theoretical principles and real engineering practice and increase the affordability and accessibility of engineering education

C. Automated Assessments and Feedback.

AI driven automated assessment tools make the evaluation of the process more precise and allows you to receive immediate feedback along with very precise grades. Using machine learning algorithms, these tools evaluate student answers, find mistakes and provide tailored feedback.

An example of such AI services is Grades Cope and Codio, which use AI to automatically grade assignments and coding exercises [30]. In electrical engineering, these tools can assess circuit designs, detect computation errors and recommend procedures for students to apply their problem-solving skills in the right direction [31].

D. AI for Curriculum Design

Data analytics and machine learning help build dynamic, personalized, learning experiences for students through AI for curriculum design. Evaluation of such student performance data by AI may result in alternate learning courses, modification of difficulty of coursework and recommendation of certain learning materials. Adaptive learning platforms utilize artificial intelligence (AI) to bring just the right content to a learner at just the right time to ensure that it is a success [32].

This is one of the practical illustrations of using an AI powered course recommendation system which is a real example of an AI driven curriculum design system. Coursera uses artificial intelligence (AI) to look at students past interactions with, preferences for and progress through courses to suggest the courses that will be most appropriate. Using Carnegie Learning's AI based learning system, math and engineering courses are redefined to suit everyone's learning style hence students can be the best in their strengths while improving in their weaknesses [33].

The virtual laboratories in electronics and electrical engineering that students can perform experiments on alongside their learning curve are done through artificial intelligence (AI) powered platforms such as Labster. According to an article published by Teaching and Learning Research, through this customized method, students have easier learning difficult engineering principles at their own speed which improves their interest and retention [34].

E. AI-Assisted Circuit Design and Hardware Implementation

Artificial intelligence is shaping the way hardware implementation and circuit design are done, by automating complex design procedures and improving performance. Analysing large datasets, detecting errors and suggesting correct circuit topologies, AI powered solutions may save design time and enhance accuracy. These tools may let professionals make complex electrical systems more efficiently and help students learn circuit design concepts.

As a helpful illustration, Cadence's AI powered circuit design software serves [35][36]. Using machine learning techniques, it strives to improve power efficiency, detect signal integrity issues and lay out PCB (Printed Circuit Board) to optimum. Synopsys also uses AI to automate chip design, leading to a much shorter chip design time which amounts to a shorter period to produce semiconductor devices. Educational platforms like AutoCAD Electrical incorporates AI based automation features to aid circuit schematic design in circuit design and hardware projects. These AI driven developments now create new generation of engineers who are able to produce inventive technological solutions with enhanced efficiency and accuracy [37].

F. AI-Based Robotics and IoT Applications

The teaching of electrical and electronic engineering is revolutionized by the AI-based robots and Internet of Things applications by giving the students practical learning opportunities and real-world problem-solving challenges [38]. Unlike IoT applications which allow remote monitoring and management of smart objects, AI-powered robots teach students automation, control systems and embedded programming [39].

An example is the utilization of AI robotics kits, such as Arduino-based robotics and LEGO Mindstorms, that enable students to create and automate robots for various engineering applications. An example is the utilization of AI robotics kits, such as Arduino-based robotics and LEGO Mindstorms, that enable students to create and automate robots for various engineering applications. These tools allow students to learn hardware integration, AI methods, and machine learning.

Additionally, students may experiment with network automation, smart grid technologies, and industrial IoT systems through virtual laboratories and real-world IoT project simulations offered by IoT-based teaching platforms like Cisco's Networking Academy [40]. Students are prepared for jobs in automation, smart systems, and new AI-driven sectors via these AI-enhanced robotics and Internet of Things applications.

III. Challenges And Limitations

The use of AI in EEE education is fraught with difficulties, despite its many benefits:

- **High Implementation Costs:** AI-based learning resources need a large infrastructure and training expenditure.
- **Ethical and Privacy Concerns:** AI-driven systems collect substantial volumes of student data, posing privacy and data security issues[41].
- **Resistance to Change:** Traditional teaching methodologies are deeply rooted in education systems, making it challenging for educators to adopt AI-based approaches.
- **Need for Continuous Upgradation:** AI technologies evolve rapidly, necessitating regular updates to learning systems and teaching methodologies.

IV. Future Directions and Recommendations

Continuous research aimed at improving EEE education, AI-driven learning systems seem to have a promising future. Potential advancements include [42]:

- **Improved AI Algorithms:** Development of more sophisticated AI models for better adaptive learning and personalized tutoring.
- **AI Integration with Emerging Technologies:** Using AI in conjunction with blockchain, virtual reality, and augmented reality (AR) to improve learning outcomes.
- **AI-Powered Learning Together:** Using AI technologies that enable collaborative problem-solving and collaboration among students.
- **Policy and Regulatory Frameworks:** Establishing rules for the moral application of AI in education to address privacy concerns and standardize AI-based learning methodologies[43].

V. Conclusion

AI has improved learning experiences, increased student engagement, and automated assessment procedures, all of which have had a substantial influence on the teaching of electrical and electronic engineering. Even if there are obstacles, it is anticipated that further developments in AI-powered teaching resources would completely transform the way engineering education is provided. Establishments can design an adaptable and productive learning environment that equips students for the rapidly changing technology world by combining AI with creative teaching techniques.

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