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The Role of Artificial Intelligence in Developing Applied Engineering Education and Electrical Engineering Skills in Libyan Technical Colleges

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Abstract

Artificial intelligence (AI) has increasingly influenced the evolution of engineering education, particularly within applied fields such as electrical engineering. Rather than serving solely as a technological tool, AI has begun to reshape how engineering knowledge and skills are developed. This paper examines the role of AI in advancing applied engineering education and strengthening electrical engineering competencies in Libyan technical colleges.

The study critically discusses the long-standing reliance on conventional simulation tools in engineering education and argues that, while pedagogically valuable, these tools alone are insufficient to address the skill requirements imposed by the Fourth Industrial Revolution. Using a descriptive–analytical approach, relevant academic literature is reviewed, and representative AI applications in power systems, smart grids, predictive maintenance, and intelligent control are analyzed.

The findings suggest that AI-based approaches enable adaptive learning, predictive reasoning, and real-time system optimization, extending beyond the capabilities of traditional simulation environments. Based on this analysis, the paper proposes practical recommendations for integrating AI into electrical engineering curricula in Libyan technical colleges to enhance graduate readiness for contemporary labor market demands.

Keywords: Artificial Intelligence, Electrical Engineering Education, Applied Engineering, Technical Colleges, Libya, Simulation Tools.

الملخص

أصبح الذكاء الاصطناعي (AI) محركا رئيسيًا للتحول في التعليم الهندسي، ولاسيما في التخصصات التطبيقية مثل الهندسة الكهربائية. تحلل هذه الورقة دور الذكاء الاصطناعي في تطوير التعليم الهندسي التطبيقي وتعزيز مهارات الهندسة الكهربائية في الكليات التقنية الليبية. وتسلط الدراسة الضوء على محد ودية الاعتماد الحصري على أدوات المحاكاة التقليدية التي هيمنت على التعليم الهندسي لعقود، وتؤكد أن هذه الأدوات لم تعد كافية لتلبية متطلبات الثورة الصناعية الرابعة .وباستخدام المنهج الوصفي – التحليلي، تستعرض هذه الورقة الأدبيات ذات الصلة وتتناول تطبيقات الذكاء الاصطناعي في أنظمة القدرة الكهربائية، والشبكات الذكية، والصيانة التنبؤية، والتحكم الذكي. ويُظهر التحليل أن الذكاء الاصطناعي يتيح التحليل التنبؤي، والتعلم التكيفي، والتحسين الآني بما يتجاوز قدرات المحاكاة التقليدية. وتختتم الورقة بتقديم توصيات عملية لدمج الذكاء الاصطناعي في مناهج الهندسة الكهربائية بالكليات التقنية الليبية بما يحقق مواءمة أفضل بين مخرجات التعليم ومتطلبات سوق العمل الحديث

الكلمات المفتاحية: الذكاء الاصطناعي، تعليم الهندسة الكهربائية، الهندسة التطبيقية، الكليات التقنية، ليبيا، أدوات المحاكاة

I. Introduction

The emergence of the Fourth Industrial Revolution has fundamentally altered engineering practice by embedding data-driven intelligence into design, operation, and decision-making processes. Within this transformation, artificial intelligence (AI) has become a central enabling technology across multiple engineering disciplines. Consequently, the professional role of the electrical engineer has expanded beyond classical modeling and control based on fixed mathematical formulations to encompass data analysis, intelligent system development, and autonomous decision-making in complex operational environments. Machine learning, in particular, has been recognized as a key technological driver underpinning this shift [1].

For more than two decades, simulation tools such as MATLAB/Simulink, PSpice, and ETAP have formed the backbone of applied engineering education. These platforms have offered students accessible and cost-effective environments for modeling electrical circuits, power systems, and control applications. Despite their undeniable educational benefits, conventional simulation tools depend heavily on predefined models and idealized assumptions. As a result, they exhibit limited capacity to capture uncertainty, nonlinear dynamics, and real-world variability features that increasingly characterize modern systems such as smart grids and renewable energy networks.

AI represents a further stage in the evolution of engineering education by enabling systems to learn directly from historical and real-time data, identify latent patterns, and optimize performance dynamically. International policy frameworks emphasize that the integration of AI into education is a strategic priority for developing future-oriented competencies and improving educational quality [2]. This imperative is particularly pronounced in Libyan technical colleges, where curricular modernization is essential to align educational outcomes with the rapidly evolving electrical power sector.

II. Related Work

A growing body of literature highlights the global trend toward incorporating artificial intelligence into engineering education. Baltaci and Herrmann investigated the integration of AI concepts within electrical engineering curricula and reported notable improvements in students' problem-solving abilities and data-driven analytical skills [3]. In a similar vein, Naidoo proposed a curriculum redesign framework that embeds AI competencies into core electrical engineering programs in response to the demands of the Fourth Industrial Revolution [4].

Within applied electrical engineering, predictive maintenance has emerged as one of the most prominent domains for AI deployment. Carvalho et al. conducted a systematic literature review demonstrating that machine learning-based predictive maintenance strategies significantly outperform traditional maintenance approaches in terms of fault reduction and operational cost efficiency [5].

AI has also been extensively applied in smart grid systems, particularly for load forecasting, energy management, and reliability enhancement. Survey studies in this area emphasize the critical role of data-driven intelligence in managing the complexity of modern power systems [6], [7]. Although these studies collectively underscore the importance of AI in both engineering practice and education, relatively limited attention has been paid to its integration within technical colleges in developing contexts such as Libya.

III. Methodology

This study adopts a descriptive–analytical research methodology. Peer-reviewed journal articles, conference proceedings, and international policy reports were systematically reviewed to examine the evolution of engineering education tools and the growing role of artificial intelligence in electrical engineering applications.

In addition, a comparative analytical approach was employed to contrast traditional simulation-based educational practices with AI-driven learning approaches. This comparison focused on theoretical foundations, educational applications, and their implications for engineering learning outcomes. Selected international case studies were considered to contextualize best practices and identify lessons applicable to Libyan technical colleges.

IV. From Simulation to Artificial Intelligence: Theoretical Framework

Engineering education has progressed through several distinct stages. The earliest stage relied primarily on theoretical instruction supported by physical laboratories, which were often expensive to maintain and limited in experimental scope. A subsequent stage introduced simulation tools that allowed students to model known systems and explore "what-if" scenarios based on predefined mathematical equations. While effective for conceptual validation, such tools lack the capacity for learning and adaptation.

The current stage is characterized by the emergence of artificial intelligence, where models are constructed directly from data rather than predefined equations. AI-driven systems are capable of learning system behavior, predicting faults, and optimizing performance in real time. This transition reflects a fundamental shift in educational philosophy—from applying established laws toward extracting system behavior from data—bringing engineering education into closer alignment with contemporary industrial practice [1].

V. AI Applications in Electrical Engineering Education

Several AI applications are particularly well suited for integration into electrical engineering education. These include load forecasting and demand management in smart grids, predictive maintenance of electrical equipment using sensor data, intelligent control systems based on neural networks and fuzzy logic, as well as advanced signal processing and communication system optimization.

Embedding these applications within coursework and graduation projects enhances the connection between theoretical knowledge and practical implementation, while simultaneously improving graduates' employability in data-driven engineering environments [5], [6].

VI. Results and Discussion

The results discussed in this section are derived from analytical comparison and synthesis of existing studies rather than experimental evaluation. The analysis indicates that reliance on traditional simulation tools alone is no longer sufficient to prepare electrical engineering graduates for contemporary engineering challenges. While simulation-based education remains essential for developing foundational understanding and modeling skills, modern engineering practice increasingly demands adaptability, predictive reasoning, and data-driven intelligence.

Comparative Educational Analysis

A comparison between traditional simulation-based education and AI-driven educational approaches reveals substantial differences in learning outcomes and skill development. Simulation-based education primarily emphasizes verification of predefined mathematical models and deterministic "what-if" analyses. This approach strengthens analytical reasoning and system modeling skills but provides limited exposure to uncertainty and adaptive decision-making.

By contrast, AI-based educational approaches allow students to work with real or semi-real datasets, construct predictive models, and design adaptive systems capable of learning and optimization. From an educational standpoint, simulation-based learning supports analytical verification skills, whereas AI-driven learning fosters higher-order cognitive competencies, including pattern recognition, predictive reasoning, and autonomous decision-making. These findings suggest that AI does not replace traditional simulation tools but rather extends their educational value by addressing competencies increasingly required in modern electrical engineering practice. To further clarify the key differences between the two educational approaches, Table I summarizes a comparative overview of simulation-based and AI-based engineering education.

Table I: Comparison Between Simulation-Based and AI-Based Engineering Education

Aspect	Simulation-Based Education	AI-Based Education
Model Type	Predefined mathematical models	Data-driven models
Learning Focus	Verification and analysis	Prediction and optimization
Adaptability	Static	Adaptive and learning based
Handling Uncertainty	Limited	High
Data Usage	Idealized or synthetic data	Real or large-scale datasets
Skill Developed	Analytical and modeling skills	Predictive, autonomous, and decision-making skills
Alignment with Industry Needs	Moderate	High

VII. Recommendations

Based on the comparative analysis presented in the preceding section, several recommendations are proposed to support the effective integration of artificial intelligence into electrical engineering education. These include updating curricula to incorporate compulsory AI-related courses, providing targeted professional development programs for faculty members, establishing AI-focused educational laboratories, and encouraging data-driven graduation projects in collaboration with industry partners. Such measures are consistent with international policy guidance on the integration of AI in education [2].

VIII. Conclusion

The transition from simulation-based education toward AI-driven approaches is no longer optional but represents a strategic necessity for contemporary engineering education. Although this study draws primarily on international literature, its findings are contextualized to address the specific challenges, constraints, and development needs of Libyan technical colleges. By systematically integrating artificial intelligence into electrical engineering programs, these institutions can enhance educational quality and better prepare graduates to contribute to national infrastructure development and sustainable growth.

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