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Reform and Exploration of AI Empowered-Energy System Integration and Optimization Curriculum

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Abstract

This article discusses energy as the foundation of human survival and technological development, but due to accelerated industrialization and population growth, the energy crisis is becoming increasingly severe and has become a global focus of attention. The article analyzes the main reasons for the energy crisis, including excessive exploitation of fossil fuels, environmental pollution caused by reliance on traditional fossil fuels, and low energy utilization efficiency. To cope with the crisis, countries are developing new energy sources such as solar energy, ocean energy, and nuclear energy, and conducting in-depth exploration in energy system optimization. The course of "Energy System Integration and Optimization" combines various new energy generation technologies and control theories, emphasizes the cultivation of theoretical and practical abilities, and uses artificial intelligence (AI) to empower educational reform, improve teaching quality, and enhance students' learning interest. AI promotes students' learning and collaboration abilities through personalized learning, teaching assistant systems, and experimental simulations, contributing to the innovative development of the new energy field. The article summarizes the positive impact of AI empowerment on curriculum reform, pointing out the important role of AI in answering questions, providing computational support, and promoting teamwork, with the aim of improving the teaching quality of courses.

Keywords

Artificial intelligence; Energy system; Optimization; New energy.

1. Introduction

Energy is the cornerstone of human survival and the driving force behind modern technological development. However, with accelerated industrialization and population growth, global demand for energy continues to rise, exacerbating the energy crisis. Energy issues have become a major focus of attention and discussion worldwide.

The current energy crisis primarily stems from the following factors, first, excessive exploitation of fossil fuels leads to increased extraction difficulties and costs, as well as more severe environmental damage during the extraction process. Second, fossil fuels still dominate the current energy consumption structure. The byproducts of these carbon- and sulfur-rich traditional energy sources not only intensify the greenhouse effect but also release harmful gases such as sulfur dioxide, causing serious environmental pollution. Third, low energy efficiency results in significant energy loss during transportation and conversion, further aggravating energy shortages [1,2].

To better address the energy crisis, countries around the world are actively exploring and developing new energy sources. Currently, technologies for solar, ocean, and nuclear energy have become relatively mature and are deeply integrated into daily life. To improve energy

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transmission efficiency and application safety, some countries with advanced research in new energy are shifting their focus to optimizing energy system design.

As one of the core courses in Energy Storage Science and Engineering, "Energy System Integration and Optimization" primarily covers the modeling and control theories, structural composition, and control technologies of new energy power generation systems, including biomass, solar, wind, nuclear, geothermal, ocean, and fuel cell energy. It also addresses fast deep load cycling control models and strategies for thermal power generation, the characteristics and complementary mechanisms of different power generation processes, optimized dispatch of new energy power systems, their stability and safety control, demand-side response characteristics, and supply-demand coordination mechanisms. Additionally, the course explores the comprehensive utilization of distributed new energy power generation and microgrid technology based on its features [3].

Artificial intelligence (AI) is one of the most innovative technologies of the 21st century, penetrating numerous fields and bringing forth new technologies, devices, and products. In education, AI also offers endless possibilities for curriculum reform and exploration. Compared to traditional learning methods, AI-enhanced courses stimulate students' enthusiasm and interest in learning, significantly improving teaching quality. This paper discusses the AI-enabled reform and exploration of the "Energy System Integration and Optimization" course, focusing on analyzing the teaching content and objectives enhanced by AI [4-7].

2. Teaching Objectives

2.1. Knowledge proficiency

Students should acquire a comprehensive understanding of China's current energy landscape and the development status of new energy technologies. They are expected to master the power generation principles, system architectures, and application scenarios of solar, wind, biomass, geothermal, and ocean energy. Additionally, they should develop a profound understanding of the fundamental principles and practical applications of various fuel cell technologies, as well as deepen their knowledge of key control technologies for microgrid systems, microgrid energy storage solutions, and the underlying principles of grid integration control for energy storage systems. Furthermore, the course will incorporate an intelligent AI-powered teaching assistant system to identify, address, and systematically categorize students' questions and challenges encountered during their learning process, thereby enhancing both students' knowledge mastery and the overall teaching quality of the course.

2.2. Theoretical knowledge and practical skills

Cultivate students' ability to analyze and evaluate the strengths and weaknesses of various energy sources and systems in practical applications, as well as to solve related problems. Provide hands-on opportunities in relevant laboratories, enabling students to design, build, test, and optimize energy systems while mastering the use of relevant equipment and tools. By integrating virtual simulation labs and the powerful computational capabilities of AI, students will acquire systematic computational methods for the integration and optimization of energy systems and develop corresponding computational skills. They will learn to combine theoretical knowledge with real-world data for research purposes and, through methods such as literature review, be able to analyze and propose solutions to complex engineering challenges arising in the integration and optimization of energy system.

2.3. Interdisciplinary competence and innovative mindset

Develop students' interdisciplinary application skills across multiple fields such as materials science, energy technology, and engineering design, enabling them to effectively contribute in team settings to address complex interdisciplinary real-world engineering challenges. The

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program encourages students to propose innovative ideas and applications during their studies, fostering their ability and motivation to explore and master emerging technologies. This foundation empowers them to contribute intellectual and innovative advancements to the future development of the energy sector.

3. Methods of AI Incorporation in the Curriculum "Energy System Integration and Optimization"

Certain instructional components of the Curriculum "Energy System Integration and Optimization", such as the design of variable-speed constant-frequency control strategies for wind turbine generators, and the development of fast deep load cycling control models and strategies for thermal power generation—incorporate fundamental theories and applied technologies from AI fields including machine learning, deep learning, and natural language processing. The course design aligns with interdisciplinary trends and practical application needs, ensuring both cutting-edge relevance and real-world usability.

3.1. AI-assisted Learning

AI can provide personalized learning experiences tailored to each student's abilities, interests, and needs. By analyzing students' learning data from the "Energy System Integration and Optimization" Curriculum, AI can develop customized study plans and recommendations, helping students learn at their own pace and in their preferred style.AI-driven learning platforms and applications are typically accessible around the clock, allowing students to study anytime and anywhere. This flexibility enables learners to fit education into their own schedules, free from the constraints of traditional classroom hours.

AI systems can assess student performance in real time and deliver immediate feedback. This timeliness helps learners quickly identify and correct mistakes, leading to more effective mastery of the material.AI technology can automatically adjust course content and difficulty based on a student's progress. This adaptive learning approach ensures that each student is challenged at an appropriate level, avoiding both boredom and frustration.

Based on individual interests and needs, AI can recommend relevant learning resources, such as books, videos, and online courses covering topics like the characteristics and comprehensive utilization of distributed new energy generation, as well as microgrid technology. This recommendation system helps students discover new materials and broaden their knowledge.

3.2. AI Teaching Assistant

AI tools can assist teachers in automatically grading and evaluating student assignments. Particularly for standardized tests and multiple-choice questions, AI enables fast and accurate assessment.AI-powered chatbots can provide students with instant support and resources. When students encounter questions after class, they can receive answers and explanations through these chatbots.

Based on students' interests and learning progress, AI can recommend suitable educational materials—such as videos, articles, exercises, and other learning resources—thereby enriching course content and boosting engagement.AI can analyze classroom data to help identify learning trends, difficulties, and achievements among students. This information supports instructional decision-making and improves teaching strategies.AI can assist in designing course syllabi and lesson plans by offering best practices and recommendations. By analyzing successful course models, AI helps build more effective learning pathways.AI systems can monitor student behavior during class to detect possible issues such as lapses in attention, and provide timely feedback to facilitate appropriate intervention measures.

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3.3. AI Teaching Assistant

Laboratory facilities and concrete case studies are indispensable components of teaching, particularly in the field of AI. Students need hands-on experimentation and case analysis to understand the practical application and optimization processes of AI-enhanced course content. The on-campus high-performance computing center provides strong support for AI-enabled courses: the powerful computational capabilities of AI simplify complex calculations generated during experiments; in the virtual simulation laboratory, AI offers students more realistic feedback, enabling them to better grasp key knowledge points through experimentation and ensuring balance and stability during the implementation of specific course cases. Furthermore, the School of New Energy and Materials has an independent computer experimental center, which provides students with ample operational and storage space, and fosters their ability for self-directed learning and teamwork after class.

4. Conclusion

In this study, we explore the reform of the course "Energy System Integration and Optimization" enhanced by AI. The AI teaching assistant system serves as a "helpful partner" to both students and instructors: it provides timely answers to students' questions while encouraging extended reasoning and application of knowledge, and helps instructors identify and organize challenging course concepts for subsequent teaching. The powerful computational capabilities of AI play a critical role in supporting experiments and calculations involved in the course. Furthermore, the project-driven learning approach adopted in the AI-enabled course encourages teamwork among students, cultivates their collaborative skills, and enhances the overall teaching quality.

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