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Exploration and Practice of Artificial Intelligence-Empowered Teaching of New Energy Materials and Applications in Universities

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Abstract: New Energy Materials and Applications is a core engineering course featuring strong interdisciplinarity, cutting-edge content and high practicality. It integrates knowledge of materials science, energy engineering, chemical engineering, physics, and many other disciplines, serving as a vital course driving the development of the new energy industry. The rapid advancement of artificial intelligence technology offers new support for curriculum teaching reform in universities, capable of reshaping the teaching system and teaching methods of new energy materials courses in an all-round manner. Taking the course New Energy Materials and Applications offered by the major of New Energy Science and Engineering at University of Shanghai for Science and Technology as the research object, this paper starts with the current teaching status of this course in universities, thoroughly analyzes prominent teaching pain points in classrooms, proposes a new paradigm of artificial intelligence empowered teaching, and conducts in-depth discussion on how artificial intelligence addresses the teaching pain points of New Energy Materials and Applications. It is expected to provide new ideas for teaching reform and talent cultivation of new energy majors in institutions of higher education.

Keywords: Artificial intelligence; New Energy Materials and Applications; Curriculum teaching; Teaching exploration

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1. Introduction

New Energy Materials and Applications is an essential course for majors such as New Energy Science and Engineering and Materials Science and Engineering in universities. It undertakes the critical task of imparting basic theories, preparation technologies, performance applications, and innovative research knowledge of new energy materials, acting as a key link connecting university talent cultivation and industrial development. At present, most domestic universities still adopt traditional teaching modes for this course, dominated by teacher lecturing and textbook knowledge delivery. Deficiencies including outdated teaching content, weak practical teaching, and single evaluation methods make it difficult to adapt to the educational development trends and industry talent demands in the intelligent era. Therefore, universities need to thoroughly explore reform paths for artificial intelligence-empowered teaching of New Energy Materials and Applications, transforming the course from traditional indoctrination teaching to intelligent, inquiry-based, and innovative teaching, so as to cultivate more new energy professionals of the new era with solid theoretical foundations, strong practical capabilities, and innovative thinking.

2. Current teaching status of New Energy Materials and Applications in universities

At this stage, the teaching of New Energy Materials and Applications occupies a pivotal position in the talent cultivation system of domestic universities. Nevertheless, restricted by multiple factors including traditional teaching concepts, teaching conditions, teachers' capabilities, and the inherent characteristics of the course, the overall teaching quality and educational outcomes have many deficiencies, failing to satisfy the dual demands of higher education reform and industrial development in the new era [1]. The main pain points existing in the current teaching are as follows.

First, the update of teaching content lags behind with insufficient cutting-edge information. The field of new energy materials witnesses rapid technological iteration, with continuous emergence of new technologies, new materials, and new processes such as novel photovoltaic materials, energy storage materials, hydrogen energy materials, and power battery materials. However, textbooks have long update cycles, and classroom teaching mainly revolves around classic basic theories. A large number of cutting-edge research achievements and industrial technical applications cannot be integrated into teaching in a timely manner, resulting in a disconnection between students' acquired knowledge and actual industrial progress and obvious hysteresis in their knowledge system [2].

Second, the teaching mode is rigid with poor classroom interaction. The course still adopts the cramming teaching mode of "teachers lecture while students listen," where teaching mainly focuses on theoretical knowledge output. Teachers dominate the whole teaching process while students passively receive knowledge. Many abstract knowledge points such as material mechanisms, microstructures, and reaction principles can hardly be intuitively understood by students merely through textual explanations and static pictures. The classroom becomes dull, and students lack initiative and enthusiasm in learning.

Third, the teaching evaluation system is unitary and lacks educational orientation. Current course evaluation takes final written examination scores as the primary indicator, supplemented by limited assignments and attendance records. The evaluation dimension is single with fixed standards. Such an evaluation mode can only examine students' memory of theoretical knowledge, failing to comprehensively measure their autonomous learning ability, practical operation ability, innovative thinking ability, and comprehensive application capacity [3].

3. Significance of artificial intelligence-empowered teaching of New Energy Materials and Applications

3.1. Enriching the teaching content system and strengthening the cutting-edge and interdisciplinary nature of the course

Cutting-edge features and interdisciplinarity are core characteristics of New Energy Materials and Applications. Restricted by slow textbook updates and limited information access, traditional teaching is plagued by outdated content and unitary knowledge systems [4]. Artificial intelligence boasts powerful capabilities in information crawling, intelligent screening, and integrated analysis. It can timely integrate the latest research findings, industrial technological innovations, and practical industrial cases in domestic and international new energy materials sectors, breaking the content limitations of traditional textbooks and realizing dynamic updating of teaching content. Relying on AI teaching platforms, teachers can rapidly screen cutting-edge knowledge including novel energy storage materials, perovskite photovoltaic materials, intelligent material modification technologies and intelligent material detection, and integrate research hotspots, industrial challenges and industrial cases into classroom teaching in real time, keeping course content aligned with industrial technological progress.

3.2. Restructuring classroom teaching modes and improving classroom interaction and efficiency

Aiming at the rigid traditional cramming teaching, artificial intelligence can reconstruct a modern classroom teaching system centered on students and guided by teachers, effectively resolving teaching problems such as dull classrooms, insufficient interaction, and barriers to knowledge comprehension. By adopting AI virtual simulation, 3D visualization, intelligent animation, and other technologies, abstract theoretical knowledge can be converted into intuitive, three-dimensional, and dynamic visual scenarios. Students can immerse themselves in observing material preparation processes, microstructure evolution, and performance decay rules. Abstract micro material structures and complex chemical reaction mechanisms in the course can be presented vividly to students, lowering learning difficulties and deepening their understanding and memorization of core knowledge points [5]. In addition, the construction of AI intelligent interaction platforms, online Q&A systems, and classroom interactive tools diversifies teaching forms. Combined with intelligent Q&A, online tests, group inquiry, and personalized content push, students' enthusiasm for autonomous learning can be fully stimulated.

4. Practical paths of artificial intelligence-empowered teaching of New Energy Materials and Applications

4.1. Optimizing and upgrading the course teaching content system based on artificial intelligence technology

Teaching content serves as the core carrier of curriculum instruction. To address the problems of outdated, unitary, and weakly interdisciplinary content in traditional courses, artificial intelligence technology is adopted to build a dynamic, cutting-edge, and comprehensive new teaching content system. The Intelligent Innovation Space of the University of Shanghai for Science and Technology integrates multiple large language models, providing efficient platforms and tools for updating teaching content.

Firstly, establish an intelligent content update mechanism to break the limitations of textbook content [6]. Leverage AI literature retrieval, hotspot analysis, and industrial big data platforms to track the latest scientific research achievements, technological innovations, industrial policies, and application cases in the new energy materials field in real time. Teaching content shall be updated regularly, incorporating cutting-edge content such as new types of new energy materials, intelligent preparation technologies, intelligent detection methods, and novel material performance optimization approaches into daily teaching [7]. Meanwhile, obsolete and backward content shall be eliminated to keep course content in pace with industrial development. Combining core curriculum knowledge points, teachers shall further explore integrated content of artificial intelligence and new energy materials, add interdisciplinary teaching modules including intelligent material design, material big data analysis, AI-assisted material modification and intelligent simulation, and improve the interdisciplinary knowledge system of the course.

Secondly, construct hierarchical and modular teaching content supported by artificial intelligence. In view of differences in students' academic foundations, majors and abilities, course content can be divided into four modules: basic theory module, core technology module, frontier innovation module and engineering application module. AI data analysis of students' learning characteristics enables targeted content push: students with weak foundations receive enhanced basic theoretical resources, while outstanding students are provided with cutting-edge research cases, innovative design topics and complex industrial engineering problems, realizing hierarchical adaptation of teaching content.

Finally, teachers can utilize AI lesson preparation tools to integrate high-quality MOOC resources, research videos, simulation cases, and industrial practical tutorials, forming a systematic curriculum resource library covering diversified teaching materials including courseware, exercises, experimental guides, frontier literature, and project cases. Sufficient support is provided for students' autonomous learning and in-depth inquiry, thoroughly solving the shortage, rigidity and hysteresis of traditional teaching resources.

4.2. Integrating artificial intelligence tools to innovate diversified classroom teaching modes

Teachers shall deeply integrate artificial intelligence technology with teaching to build a visualized, inquiry-based and intelligent new classroom teaching mode and revitalize classroom instruction.

On one hand, adopt AI visualized immersive teaching to tackle abstract teaching difficulties. For obscure core knowledge points including microstructures of new energy materials, crystal growth mechanisms, electrode reaction processes, and material aging failure, AI 3D visualization, virtual animation, and immersive simulation technologies convert static theories into dynamic evolution processes, allowing students to intuitively grasp the whole process of material preparation, structural changes, and performance responses [8]. For example, when teaching lithium-ion electrode preparation, AI simulation training software is adopted for classroom practice. Students can fully simulate operational steps including slurry mixing, electrode coating, and high-temperature sintering on computers, while dynamic 3D models synchronously display ion migration inside electrodes during charging and discharging, enabling students to observe internal electrode changes at each step in a timely manner. In classroom teaching, intelligent interactive screens and virtual teaching equipment deliver immersive demonstrations, allowing students to directly observe micro-level evolution rules, breaking the limitations of traditional text and picture teaching, lowering learning thresholds and deepening thorough understanding of core principles.

On the other hand, teachers shall establish an AI inquiry-based interactive teaching mode to further highlight students' principal status. Relying on AI classroom interaction platforms, teachers can design diverse teaching links: before class, the intelligent platform assigns preview tasks, micro-lessons on basic knowledge and preview exercises, and intelligently screens students' weak preview points for teachers to accurately identify key and difficult teaching content; during class, functions such as intelligent Q&A, random spot checks, group discussions, online quizzes and real-time mutual evaluation mobilize students' classroom participation enthusiasm; after class, the platform pushes personalized review resources, extended exercises and inquiry topics to effectively extend classroom teaching. In this way, teachers can flexibly utilize AI tools to assist students' learning in class and answer students' questions online after class to provide timely guidance. Meanwhile, teachers can obtain feedback data from the background to identify students' general confusion, adjust subsequent teaching arrangements in a timely manner, and guarantee overall learning outcomes.

4.3. Reconstructing practical teaching and evaluation systems empowered by artificial intelligence

Practical teaching constitutes an important component of talent cultivation for new energy materials courses. Artificial intelligence technology can reconstruct the practical teaching system to resolve problems such as insufficient physical experimental resources and weak innovation capabilities.

Specifically, build an AI virtual simulation practical teaching platform to enrich practical teaching content. For high-risk, high-cost, high-difficulty new energy material preparation and detection experiments with equipment shortages, teachers can adopt AI virtual simulation technology to create fully simulated experimental environments. Students can independently complete various experimental operations such as material synthesis, microstructure characterization, performance testing, and parameter optimization via the platform without restrictions of venue, equipment, and safety conditions, greatly expanding students' practical training opportunities [9].

In addition, teachers shall establish an AI-based whole-process diversified teaching evaluation system to replace the traditional summative evaluation model. Supported by AI big data analysis technology, a whole-process, all-round, and personalized comprehensive evaluation system shall be constructed [10]. Evaluation contents cover students' pre-class preview, classroom performance, after-class assignments, autonomous learning, simulation experiment operations, completion of innovative projects, and group collaboration. Teachers can rely on AI platforms to automatically generate, count, and analyze all types of student learning data and form dynamic evaluation reports on students' learning conditions. In terms of evaluation methods, intelligent system quantitative assessment, targeted teacher evaluation, student mutual evaluation, and self-assessment are combined to realize objective and comprehensive assessment. Meanwhile, based on evaluation data, teachers can accurately analyze students' knowledge gaps, ability deficiencies and learning problems, providing data support for adjusting teaching plans and carrying out personalized tutoring. This enables students to clearly recognize their own learning shortcomings, truly realize "promoting learning and teaching through evaluation," and comprehensively improve the educational quality of the course.

5. Conclusion

New Energy Materials and Applications is a core course for new energy majors in universities, whose teaching quality directly determines the cultivation effect of innovative and applied new energy talents. The in-depth integration of artificial intelligence technology and curriculum teaching opens up a new development path for university teaching innovation. It can not only enrich course teaching content and renovate classroom teaching forms, but also comprehensively elevate the educational quality of new energy materials courses, continuously delivering high-quality, interdisciplinary, and innovative professional talents for the high-quality development of the national new energy industry.

Disclosure statement

The author declares no conflict of interest.

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