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Teaching Reform and Practice of New Energy Battery Technology Course

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Abstract: New energy battery technology is a core course in the new energy science and engineering discipline, holding significant educational value within the context of the "dual carbon" strategy. Current teaching practices face several challenges, including a disconnect between theoretical instruction and practical application, outdated textbook content relative to industrial technological advancements, slow updates to experimental equipment, and insufficient development of students' engineering innovation capabilities. Based on the requirements of emerging engineering education, this paper proposes a pathway for teaching reform from four dimensions: curriculum content restructuring, teaching methodology innovation, experimental system reform, and integration of industry and education. By incorporating cutting-edge industry case studies, implementing project-based learning, establishing hybrid virtual-physical experimental platforms, and building collaborative industry-university education mechanisms, the reform aims to stimulate students' learning interest, enhance their engineering practical skills and innovative thinking, and cultivate high-quality, application-oriented talent for the new energy industry.

Keywords: New Energy Battery Technology; Curriculum Reform; Integration of Industry and Education; Project-Based Learning; New Engineering

Introduction

The advancement of the global energy transition and the "dual carbon" goals have spurred explosive growth in the new energy battery industry, leading to an increasingly urgent demand for relevant professionals. As a core course in new energy science and engineering, new energy battery technology involves interdisciplinary fields such as electrochemistry, materials science, and engineering thermal physics, emphasizing both theoretical knowledge and practical application. In this context, based on the educational philosophy of new engineering disciplines and the actual needs of the industry, this paper systematically explores pathways for teaching reform in new energy battery technology courses. It aims to shift the focus from knowledge transmission to capacity building, thereby enhancing the quality of talent cultivation.

1. Analysis of the Current Teaching Status and Issues in New Energy Battery Technology Courses

1.1 Disconnect between Teaching Content and Industry Development

The field of new energy battery technology is evolving at an extremely rapid pace, with advancements ranging from lithium iron phosphate to solid-state batteries and sodium-ion batteries, constantly reshaping the technological landscape. However, most current textbooks are classic editions published earlier, focusing on traditional systems like lead-acid batteries and nickel-metal hydride batteries. They provide only brief discussions on lithium-ion batteries and rarely cover cutting-edge technologies such as solid-state batteries and lithium-sulfur batteries. This creates a significant generational gap between what students learn and the practical applications in the industry. Such lag forces graduates to spend considerable time relearning mainstream technologies after graduation, increasing corporate training costs and undermining their competitiveness in the job market. Additionally, the curriculum heavily emphasizes fundamental principles and theoretical derivations, while offering insufficient coverage of engineering practices such as battery manufacturing processes, failure analysis, and safety testing. As a result, students struggle to develop a comprehensive engineering understanding from materials to cells and ultimately to battery packs.

1.2 The Teaching Methods Are Monotonous, Resulting in Low Student Engagement

The current teaching of this course remains predominantly lecture-based, relying on traditional methods of explaining principles combined with formula derivation. The course involves abstract concepts and complex mechanisms—such as lithium-ion intercalation/deintercalation, solid-electrolyte interface formation, and thermal runaway propagation—which are difficult for students to grasp intuitively through static presentations and verbal explanations alone. Surveys indicate that over 60% of students find the course challenging and dull, with generally low classroom engagement. Due to a lack of interactive and experiential teaching components, students are often stuck in passive listening and last-minute exam preparation, resulting in superficial understanding rather than deep learning [1]. Meanwhile, the scarcity of post-class extension resources limits students' avenues for independent exploration, further exacerbating uneven learning outcomes.

1.3 Weakness in Experimental and Practical Components

Experimental teaching faces three main challenges. Firstly, the equipment is outdated and insufficient. Key instruments like battery testing systems and electrochemical workstations are expensive, leading to limited availability in most institutions. Experiments are often conducted as teacher demonstrations, leaving students with few opportunities for hands-on practice. Secondly, the content of experiments is predominantly verification-based. Existing projects mostly focus on fundamental tests such as charge-discharge performance and internal resistance measurements, lacking design-oriented, comprehensive, or innovative experiments. Students can complete these tasks by following step-by-step instructions, missing out on opportunities for deep thinking and developing autonomous design skills. Thirdly, there is a lack of safety operation training. Batteries can experience thermal runaway under conditions like overcharging, short circuits, or compression, yet teaching lacks corresponding safety training. As a result, students entering the workforce have a notably insufficient understanding of battery safety risks.

1.4 Inadequate Integration of Industry and Education

The new energy battery industry is technology-intensive and rapidly evolving, with industry-university collaboration serving as a crucial pathway for cultivating applied talent. However, current industry-education integration efforts often remain superficial. On one hand, enterprises show limited enthusiasm for participating in curriculum development, lacking motivation to bring technological resources into the classroom. On the other hand, teachers have insufficient connections with industry and lack practical engineering experience, making it difficult to integrate real-world case studies into teaching. Student internships are often limited to company visits or simple operational roles, rarely allowing deep engagement in actual R&D or production projects. This disconnect between industry and education creates a persistent gap between what students learn and what the industry needs.

2. Teaching Reform Pathways for New Energy Battery Technology Courses

2.1 Reconstructing the Curriculum Content System to Align with Cutting-Edge Industrial Technologies

Curriculum content reform lies at the heart of teaching innovation. First, establish a mechanism for dynamically updating course content by convening seminars each semester involving professional teachers, enterprise engineers, and industry experts to adjust teaching materials based on developments in industrial technology. While ensuring the integrity of fundamental electrochemical theory, significantly increase the proportion of content covering new systems such as lithium-ion batteries, solid-state batteries, and sodium-ion batteries, keeping the curriculum aligned with mainstream industry technologies. Second, construct a knowledge system comprising five modules: fundamental theory, key materials, cell manufacturing, system integration, and failure analysis. These modules respectively cover basic principles of electrochemistry, material properties and selection, manufacturing process flows, structural design and thermal management, and failure modes and diagnostic methods [2]. Third, introduce real-world industry cases by collaborating with leading enterprises to transform practical examples such as product development, production processes, and failure analysis into teaching resources. This enables students to engage with authentic engineering problems in the classroom.

2.2 Innovate Teaching Methods to Stimulate Students' Interest in Learning

To address the issue of courses being abstract and difficult to understand, diversified teaching methods should be introduced. First, visual teaching should be promoted by utilizing technologies such as 3D animation and virtual simulation to dynamically display battery working principles, ion migration processes, and thermal runaway propagation pathways, helping students intuitively understand the working mechanism of rocking-chair batteries. Second, project-based learning should be implemented by breaking down complete battery design projects into subtasks throughout the semester. Students work in groups to complete tasks such as cell selection, solution design, thermal management calculations, and safety assessments, culminating in a final presentation and defense, transforming passive knowledge acquisition into active problem exploration. Third, a flipped classroom model should be introduced by recording micro-lesson videos on foundational theories for students to study before class, while classroom time is used for interactive activities such as case discussions, Q&A sessions, and project presentations. Fourth, specialized seminars and debate activities should be organized, encouraging students to consult literature and engage in debates on hotly contested issues in the battery field, thereby deepening their understanding of technical problems through critical thinking.

2.3 Establishing a Virtual-Physical Combined Experimental Teaching System

The reform of experimental teaching should start from two aspects: hardware upgrading and content innovation. In terms of hardware, investment in core equipment such as battery testing instruments, electrochemical workstations, and constant temperature and humidity chambers should be increased, and dedicated laboratories should be established. Meanwhile, virtual simulation platforms should be introduced, with projects like charge-discharge simulation, thermal runaway simulation, and battery management system simulation developed to compensate for teaching in hazardous scenarios that cannot be conducted in physical experiments. In terms of content, a three-level system should be constructed: basic verification experiments, comprehensive design experiments, and innovative inquiry experiments. Basic verification experiments ensure that students master fundamental testing methods; comprehensive design experiments require students to independently select battery systems, assemble them, and test performance based on performance indicators, fostering system design capabilities; innovative inquiry experiments are open-ended projects targeted at students with spare capacity, encouraging their participation in research projects to promote learning through research. Additionally, safety training for experiments should be strengthened, systematically teaching safety operation procedures and emergency response methods.

2.4 Deepening Industry-Education Integration and Promoting Collaborative Talent Cultivation between Schools and Enterprises

Integration of industry and education is an effective approach to cultivating applied talents. (1) Establish a joint curriculum development mechanism between universities and enterprises, inviting corporate technical experts to participate in course syllabus design, textbook compilation, and case development. Corporate experts enter classrooms to deliver lectures on industry frontiers and share practical engineering experiences. (2) Co-construct off-campus internship and training bases by establishing stable partnerships with battery manufacturing and new energy vehicle enterprises. Arrange for students to engage in practical work processes such as production line shadowing, quality inspection, and battery pack assembly to ensure internships are substantive rather than superficial. (3) Implement a dual-mentor system, where on-campus instructors provide theoretical guidance and corporate engineers impart practical skills. Encourage students to select actual engineering challenges from enterprises as graduation project topics, promoting real-world problem-solving and enhancing the engineering value of graduation projects [3]. (4) Launch order-based talent cultivation programs. Collaborate with key battery enterprises in the region to establish customized corporate classes. Tailor course modules according to the talent needs of enterprises, enabling students to directly enter partner companies upon graduation, thereby achieving seamless alignment between talent cultivation and industry demands.

3. Reform of the Course Assessment and Evaluation Mechanism

3.1 Establish a Multidimensional Assessment System

Traditional closed-book final examinations fail to comprehensively assess students' overall competencies. It is essential to establish a diversified assessment system that combines formative evaluation and summative evaluation. The proportion of formative evaluation is recommended to be increased to more than half, encompassing aspects such as classroom participation, completion of project assignments, quality of experimental reports, and performance in group presentations. Summative evaluation should retain the closed-book final examination, but the direction of question design should reduce rote memorization tasks and incorporate more analytical and comprehensive questions, with a focus on assessing students' ability to apply fundamental principles to solve practical problems. For example, presenting a specific battery failure case and requiring students to analyze potential causes and propose improvement solutions.

3.2 Improving Evaluation Criteria and Feedback Mechanisms

For project-based learning and experimental teaching, detailed evaluation rubrics should be developed to conduct comprehensive assessments across multiple dimensions, including project design, implementation process, result analysis, teamwork, presentation, and communication. The evaluation criteria should be clearly communicated to students before the task begins, ensuring they understand the direction of their efforts [4]. Simultaneously, establish a timely feedback mechanism, with teachers providing detailed comments and improvement suggestions within one week after task completion, helping students recognize their shortcomings and continuously improve. Additionally, encourage students to participate in second-classroom activities such as research training, academic competitions, and innovation and entrepreneurship projects. Achievements in these activities can be converted into course credits or grade bonuses, motivating students to actively engage in extracurricular practical activities.

4. Practical Outcomes and Reflections on Teaching Reform

4.1 Reform Implementation Outcomes

A two-semester teaching reform practice was implemented among two grade levels of students majoring in New Energy Science and Engineering at a university. The effectiveness of the reformed teaching was evaluated through student evaluations, performance analysis, and questionnaires. Data indicated that student evaluation scores increased from 82 before the reform to 91, classroom attendance rose from nearly 80% to over 90%, and student participation in project-based learning reached 100%. In final exam results, the scoring rate for comprehensive analysis questions improved from around 50% to over 70%, indicating a significant enhancement in students' engineering analysis skills. Questionnaire surveys showed that over 80% of students found the reformed course more engaging and rewarding, with nearly 80% reporting a deeper understanding of battery technology. In terms of academic competitions, students involved in the reform won multiple provincial-level or higher awards in events such as the National College Student Energy Conservation and Emission Reduction Competition. Regarding employment quality, the job-matching rate for graduates increased from nearly 70% to over 80%, with companies generally giving positive evaluations of the students.

4.2 Shortcomings and Areas for Improvement

The practice of educational reform has also exposed some problems and deficiencies. Firstly, there is room for improvement in the engineering capabilities of the teaching staff. Although some teachers possess a solid theoretical foundation, they lack practical experience in corporate engineering, making it difficult for them to provide targeted engineering guidance when mentoring student projects. In the future, a system should be established to facilitate teacher secondments to enterprises, requiring young teachers to regularly engage in corporate practice. Secondly, insufficient investment in experimental equipment makes it challenging to meet the demand for large-scale students to simultaneously conduct comprehensive design experiments. Efforts should be made to actively secure special funding support from the university while exploring models for co-building laboratories with enterprises [5]. Thirdly, the depth and stability of industry-university collaboration need to be strengthened. The enthusiasm for collaboration among some enterprises fluctuates with personnel changes, making it difficult to sustain the effectiveness of cooperation. A long-term mechanism for industry-university collaboration should be established, involving formal cooperation agreements that clearly define the rights and obligations of both parties. Additionally, dedicated funding for industry-university collaboration should be allocated to ensure its stable and continuous operation. Fourthly, the evaluation system for project-based learning remains incomplete, leading to instances where some students free-ride on the efforts of others. In the future, a peer assessment mechanism should be introduced to differentiate the contributions of team members, ensuring fairness in evaluation.

Conclusion

The teaching reform of the new energy battery technology course is an inevitable choice to adapt to the development needs of the new energy industry and cultivate high-quality applied talents. This paper proposes a systematic reform path from the perspectives of teaching content, teaching methods, experimental systems, industry-education integration, and evaluation mechanisms, and verifies the effectiveness of the reform plan through teaching practice. The reformed course has achieved significant results in stimulating learning interest, enhancing engineering practice capabilities, and promoting high-quality employment. In the future, it is essential to continuously track the dynamic development of industrial technology, constantly improve course content, deepen the collaborative education mechanism between universities and enterprises, strengthen the engineering capacity building of the teaching team, promote the in-depth development of course reform, and provide the new energy battery industry with more outstanding talents who understand theory, master technology, and can innovate.

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