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A brief exploration of teaching method reforms in the course "Principles and Techniques of Fuel Cells" under the context of production-education integration

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Abstract: Deepening production-education integration is an urgent requirement to advance the supply-side structural reform of human resources. The traditional indoctrination teaching method can no longer meet the needs of the production integration into education. Therefore, reforming teaching methods is necessary. This paper takes the course "Principles and Techniques of Fuel Cells" as an example and analyzes the current situation of the course. Furthermore, in order to adapt to the development of production-education integration, the authors have formulated reform strategies in recent years and summarized their work experience in the hope of inspiring future teaching research.

Key words: teaching method; reforms; production-education integration; full cells

1 Introduction

In 2015, the Ministry of Education proposed long-term adjustments to the structure of higher education in China [1]. The focus is on steadily promoting the transformation of general undergraduate institutions into application-oriented universities, gradually increasing the proportion of practical training in these institutions, enhancing the comprehensive quality of talents in application-oriented universities, and exploring the path of joint training of applied skilled talents between universities and enterprises [2]. Deepening the integration of production and education to promote the organic connection between the education, talent, and industrial chain is an urgent requirement for promoting the supply-side structural reform of human resources. Implementing teaching reform and practice through production-education integration platforms is significant for cultivating high-quality talents [3][4].

2 Analysis of the current status of the course "Principles and Techniques of Fuel Cells"

As an elective course, "Principles and Techniques of Fuel Cells" has not been emphasized much by the main teaching bodies--schools, students, and teachers. From the school's perspective, the focus of pedagogical reforms is typically on core specialized courses and schools often invest more effort in the integration of production-education in these courses instead of elective courses. From the students' perspective, they believe the course is hardly related to their employment or further education, thus placing the course in the "unimportant" category, with low enthusiasm and a perfunctory attitude. Core specialized course teachers continuously innovate their teaching methods and content in the reform process, making these

courses more attractive to students. As a result, students invest more time and energy in learning these core specialized courses and teachers lack the motivation to reform and innovate their teaching methods in elective courses. Gradually, due to their unpopularity, the content and format of these electives have become stale over time.

Under the dual pressures of energy and environment, the development of the new energy industry has become a significant pillar of technological and economic development [5]. Although the lithium battery industry has been in flourish and become a major pillar of China's industry, the diversification of the energy structure is a trend in the future. The development of hydrogen energy, represented by fuel cells, provides solutions for zero-emission energy utilization. With the global energy transformation, the hydrogen energy industry has gained attention from governments and enterprises. Although it cannot yet match the lithium battery industry, many governments and large energy enterprises have made preparations and deployments in the development of hydrogen energy [6]. Cultivating talents with relevant professional backgrounds is strategically significant for future hydrogen energy development, and universities should invest in related courses accordingly. Fuel cell is an important method of utilizing hydrogen energy. In the course "Principles and Techniques of Fuel Cells", relevant theories and technologies are systematically introduced and the implementation of this course can enrich the knowledge system of new energy majors, which is a forward-looking deployment in new energy talent cultivation. The traditional indoctrination teaching method no longer meets the industry's integration needs and reforming teaching methods is imperative. Teachers should explore how to help students understand hydrogen energy and fuel cells, foster new energy concepts and improve comprehensive qualities.

3 Exploration of teaching method reform

In the past two years, we have explored the production-education integration and the reform of teaching method during the implementation of the "Principles and Techniques of Fuel Cells" course. The following is a summary of our teaching methods.

(1) Interest-based teaching method: "Interest is the best teacher." We adopted this method to stimulate students' interest and learning enthusiasm. In response to the low attention and interest in the course, students were engaged by watching interesting animations, appreciating branded cars, and participating in auctions for lithium- and fuel- cell cars. This "play and learn" approach aims to increase course attention through engaging activities, thereby enhancing classroom participation and comprehensive abilities.

(2) Micro-topic teaching method: We refined different micro-topics based on the course content and guided students to collect and explain relevant materials independently before classes. We set at least two topics per chapter (see Table 1 for details), focusing on cultivating students' professional abilities, integrating innovation and entrepreneurship, academic competitions and postgraduate exam points, then their learning needs could be achieved. Through group teaching, students could engage in case analyses, PPT presentations and experiment demonstrations. As a result, students' interest and classroom participation have been enhanced.

Table 1. Micro-topic arrangement of "Principles and Techniques of Fuel Cells"

	Content	Micro-topic arrangement	Form of results display
Chaper 1	Overview of Fuel Cells	1. The past and future of fuel cells 2. What can fuel cells be used for?	Pictures and Videos
Chaper 2	Principle of Fuel Cells	1. Polarization of fuel cells 2. How to improve the efficiency of fuel cells?	Presentation, Experimental Demonstration, ect.

Chaper 3	Fuel Cell Type	1. Development status of fuel cell catalysts. 2. Which is the most potential type of full cell? 3. Fuel cell preparation technology	PPT/ Video Display, Scheme Design, Experimental Demonstration, Enterprise Research, etc.
Chaper 4	Preparation, Purification and Storage of Hydrogen Fuel	1. Hydrogen preparation method 2. Development of hydrogen storage materials	Enterprise Research, Case Analysis, Presentation

(3) Group teaching method: Large class sizes often disengage students, which makes it difficult for teachers to meet everyone's needs. We adopted a group teaching method, divided students into groups by content modules, and assigned each group a course module as a project. They researched related theories, current development and application status, then presented their findings as a team. This method encourages active participation, allowing students to utilize their strengths and complement each other, enhancing learning through the research and presentation process.

(4) Six-step teaching method: Addressing the background of production-education integration and the needs of fuel cell course development, we adopted the six-step teaching method which includes information collection, planning, decision-making, implementation, inspection and evaluation [7]. The core of six-step teaching method is task-driven. In the teaching process, teachers guided students to identify problems, analyze and solve problems in collaborative discussions. Finally, the comprehensive abilities of students could be enhanced. For instance, in the section of fuel cell polarization, knowledge points were divided into modules like thermodynamics, kinetics, charge transmission and substance transmission. Teacher can guide students on key knowledge points through exploration, demonstration and discussion.

4 Conclusion

This paper firstly analyzed the current situation of the course "Principles and Techniques of Fuel Cells" under the background of production-education integration. In response to the need for energy development changes and the construction of production-education integration, as well as the low attention and enthusiasm of teachers and students for fuel cell courses, the reform of teaching methods is crucial. Over the past two years, our teaching team has boldly explored the reform of teaching method, summarized teaching strategies that are more suitable for the integration of production and education, such as interest-based, micro-topic, group and six-step teaching methods. These methods effectively increased student participation, learning interest and teaching effectiveness. These pedagogical explorations may provide insights for future teaching research.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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