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Teaching Reform of "Fuel Cells Technology" Course Based on PBL+ Online and Offline

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Abstract: *At present, the focus of college education and teaching reform is to realize the deep integration of information technology and education and teaching. Based on the analysis and summary of the existing problems in the Fuel Cell Technology course, this paper analyzes the feasibility of PBL+ online and offline mixed teaching. The curriculum reform content of "Fuel Cell Technology" based on PBL+ online and offline hybrid is outlined. This reform hopes to cultivate applied talents and improve teaching quality.*

Keywords: *"Fuel Cell Technology" Course; PBL Teaching Method; Online-Offline Hybrid Teaching Model*

1. Introduction

With the rapid development and increasing popularity of information technology, the education system and model are undergoing significant changes. Education is shifting from a teacher-led, passive learning "cramming" mode to a student actively participating in learning, guided by teachers in a two-way educational model[1]. This transformation aims to cultivate new era applied talents who possess innovative thinking, creative abilities, self-learning capabilities, and critical thinking skills that meet the requirements of the times[2]. Based on this, in the teaching process of the "Fuel Cell Technology" course, we attempt to integrate the PBL teaching method with blended online and offline teaching. By using current hot topics and practical examples of fuel cell market applications as references, we adopt flipped classroom and online/offline discussion learning methods to enhance students' interest in learning and make them become masters of the classroom. Teachers combine discussion results with problem-oriented guidance to provide practical guidance for university curriculum reform.

2. Current problems in the teaching of "Fuel Cell Technology" course

2.1. Limited availability of professional textbooks and course resources

As the commercialization of fuel cells progresses, fuel cell technology is advancing at a rapid pace. However, there is a scarcity of textbooks on this subject in the market with slow content updates. The knowledge points covered in these textbooks are dispersed and each teaching unit stands alone without sufficient coherence or continuity, making it challenging to meet the demands for nurturing talent in fuel cell technology that aligns with contemporary needs.

There are few universities offering the "Fuel Cell Technology" course, and limited online teaching resources related to this course exist. The lack of practical training videos on the disassembly of fuel cell internal structures makes it difficult to enhance students' learning impressions solely through theoretical teaching methods.

2.2. Monotonous teaching methods

Due to the limited class hours, scattered knowledge points, and the emphasis on theoretical teaching with experimental teaching as a supplement in the "Fuel Cell Technology" course. The teacher-centered "cramming" teaching mode reduces students' understanding of fuel cell classification, composition, working principles, etc. The related fuel cell disassembly and assembly instructional videos are dull, and simply lecturing on knowledge points is difficult to stimulate students' interest in learning.

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3. Introduction to the PBL+ blended teaching mode

3.1. PBL teaching method

Problem-based learning (PBL) is a teaching method that focuses on using problems as the basis for instruction. Unlike traditional teacher-centered approaches, PBL places students at the center of learning and uses problems as a foundation. Under the guidance of teachers, students engage in group discussions to independently gather information, identify and solve problems. This instructional model aims to cultivate students' abilities for self-directed learning and innovation. This teaching method fully utilizes the guiding role of problems in the learning process.

The PBL teaching method specifically includes six steps: analyzing project cases, identifying core issues, formulating analysis plans, exploring answers to questions, exchanging and discussing results, and adjusting content based on feedback. Through analysis, it can be determined that the key to PBL lies in whether the selected teaching cases can stimulate students' interest in learning, whether the problems discovered by students through cases are relevant to course instruction, and whether the formulated research plans are comprehensive. This requires teachers to timely understand the content of student discussions and adjust the direction of discussion during the teaching process.

In conclusion, the PBL teaching method can stimulate students' interest in learning and improve their analytical, problem-solving, and knowledge application abilities. However, implementing the PBL teaching method in actual teaching may require more time. Due to the tight schedule and heavy workload of the "Fuel Cell Technology" course, it is difficult to solely rely on the PBL teaching method to complete relevant instruction.

3.2. Blended online and offline teaching mode

The blended learning model combines online learning and traditional classroom teaching, allowing teachers to take the lead while also reflecting students' autonomy, resulting in better teaching outcomes. Compared to traditional teaching methods, the blended learning model offers a wider range of learning resources and enables differentiated instruction anytime and anywhere. It utilizes fragmented time effectively and caters to individual students' needs by using on-demand videos, replayed videos, online questioning, etc., for different levels of understanding. The learning mode of pre-learning and post-review saves valuable class time for teachers.

3.3. Feasibility of PBL+ blended online and offline teaching

With the promotion of fuel cell market applications, there are more classic cases and hot topics related to fuel cells. The goal of the "Fuel Cell Technology" course is for students to understand the bottlenecks in fuel cell market applications, analyze fuel cell safety and economic usage methods, and ultimately propose safe methods for using fuel cells and improving their endurance. Based on PBL blended teaching with online and offline components, a flipped classroom approach is adopted. Starting from several key cases such as the "Lin Zhiying" Tesla car accident hot topic and the potential market value of "Upp" fuel cell power banks, students take the lead in analyzing potential knowledge about fuel cells in these cases. The teacher asks questions to assist in planning discussion directions, while students use problem-based learning methods to explore autonomously, thereby increasing their interest in learning. The blended teaching mode combines online and offline components which compensates for the longer duration of PBL teaching method. It also allows personalized instruction based on individual needs and differentiated teaching to achieve timely feedback on student learning outcomes.

4. Reform method based on PBL+Blended teaching

Based on the above discussion, it is believed that the PBL+online and offline blended teaching mode can effectively solve the problems of limited teaching time and heavy teaching tasks in the "Fuel Cell Technology" course. The application of the PBL+online and offline blended teaching mode in "Fuel Cell Technology" includes four stages: pre-class, in-class, post-class, and feedback.

4.1. Pre-class Designing Teaching Cases based on PBL

Before conducting the course teaching, overall combing of the knowledge points of "Fuel Cell

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Technology" course should be done. Select PBL classic cases based on the course content and current hot topics. Use classic cases as a guide to integrate all teaching contents of this course. Taking Lin Zhiying's Tesla car accident as an example, combined with the characteristics of "Fuel Cell Technology" course, guide students to discuss the current development of the automotive industry, explore the differences between two types of vehicle power systems, and introduce the advantages and disadvantages of fuel cells and lithium batteries to strengthen students' confidence in learning and improving fuel cell technology. Compare and analyze performance parameters between Mirai and Tesla Model S, allowing students to consider from a consumer perspective which one they would prioritize if purchasing a car. Combine teaching cases to find suitable instructional videos for "Fuel Cell Technology" on platforms such as Xuexi Online and MOOCs, design instructional calendars, plan online video playback content and playback time.

4.2. Traditional Teaching and Flipped Classroom during Class

Combining the traditional teaching model with teacher-led and student-led approaches, as well as the innovative flipped classroom model[3,4], we fully utilize the advantages of smart classrooms. By using multimedia to play videos on the development of fuel cells, students can witness the transition from large volume to small volume, from low energy storage to high energy storage, and from complex and expensive structures to simple and affordable ones. This visual impact helps explain the economic trends in fuel cell development and increases students' interest in studying and researching fuel cells. We encourage students to form groups and consult literature materials in a flipped classroom format, integrating big data analysis on current market shares of different types of fuel cell vehicles for discussions on their performance drawbacks. Additionally, we provide fuel cell models and assembly videos so that students can demonstrate their understanding of battery structure by assembling them themselves, enhancing their learning experience.

4.3. Online Clarification and Enrichment of Case Library after Class

After the classroom teaching is over, teachers can use Learning Pass to push relevant learning videos and post exercises to students, in order to timely consolidate the knowledge points taught in class. Firstly, by pushing post-class exercises to students through Learning Pass, we can test the effectiveness of classroom teaching and identify weak areas in student's understanding. Based on the test results, we can focus on completing video tutorials for further learning. Secondly, through Learning Pass, we can encourage students to share case studies related to "Fuel Cell Technology" course and update the teacher's case study library.

4.4. Combining Online and Offline Methods to Achieve Timely Feedback

Traditional teaching methods often rely on students providing feedback through answering questions and participating in classroom interactions. However, this type of feedback is often scattered and not suitable for shy or introverted students[5]. The lack of timely feedback on teaching effectiveness seriously reduces the quality of instruction. In order to address this issue, the "Fuel Cell Technology" course innovatively combines Rain Classroom with Learning Passto achieve in-class and out-of-class teaching feedback. During class, Rain Classroom is used for attendance taking, in-class testing, and random questioning. This teaching model not only saves time but also increases fairness in the student questioning process. At the same time, using Rain Classroom's bullet screen function allows students to ask questions anonymously or publicly during the teaching process, enabling real-time assessment of instructional effectiveness. Outside of class, Learning Passis utilized for answering questions and collecting student opinions and suggestions on the course delivery process. It also collects data on student attendance and conducts analysis to assess out-of-class instructional effectiveness. By using Rain Classroom and Learning Pass, not only are students provided with a good avenue for learning feedback but it also provides convenient conditions for improving instruction in this course.

5. Assessment methods during the process and the effect of educational reform

To address the issues of a single assessment method and lack of process evaluation in traditional course learning, this course adopts a PBL+ blended teaching model that combines online and offline instruction. While enriching the teaching mode, it incorporates online video lectures, participation in discussions, and supplementary teaching case studies as well as offline analysis of cases and independent

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learning activities for assessment purposes. This approach aims to cultivate students' comprehensive qualities and abilities. The specific composition of regular grades is shown in Table 1.

Table 1: Composition of regular grades for PBL+ blended courses combining online and offline components.

Number	Project	Specific content	Weightage of Grades/%
1	Online teaching	Complete the course videos, PPT presentations, and additional reading materials assigned by the teacher for learning.	30
2	Offline teaching	Attendance in class, the effectiveness of classroom listening, and random questioning.	30
3	Online and offline discussions	Students are required to participate in case analysis discussions and evaluate each other.	10
4	Online homework	Evaluate the completion of unit quizzes and supplementary teaching case studies after class, based on factors such as grades and number of completions.	20
5	Offline homework	Completion status of offline projects	10

The teaching approach of the "Fuel Cell Technology" course is shown in Figure 1. This course incorporates current hot topics and classic teaching cases throughout the entire teaching process. It innovatively combines the traditional teacher-led and student-led teaching models with the flipped classroom model to stimulate students' interest in learning. The introduction of current hot topics enlivens the atmosphere in the "Fuel Cell Technology" classroom; students' self-learning abilities are improved through watching instructional videos provided by teachers; real-time feedback online and offline improves students' learning outcomes. According to surveys and interviews, 90% of students expressed satisfaction with the reformed teaching model.

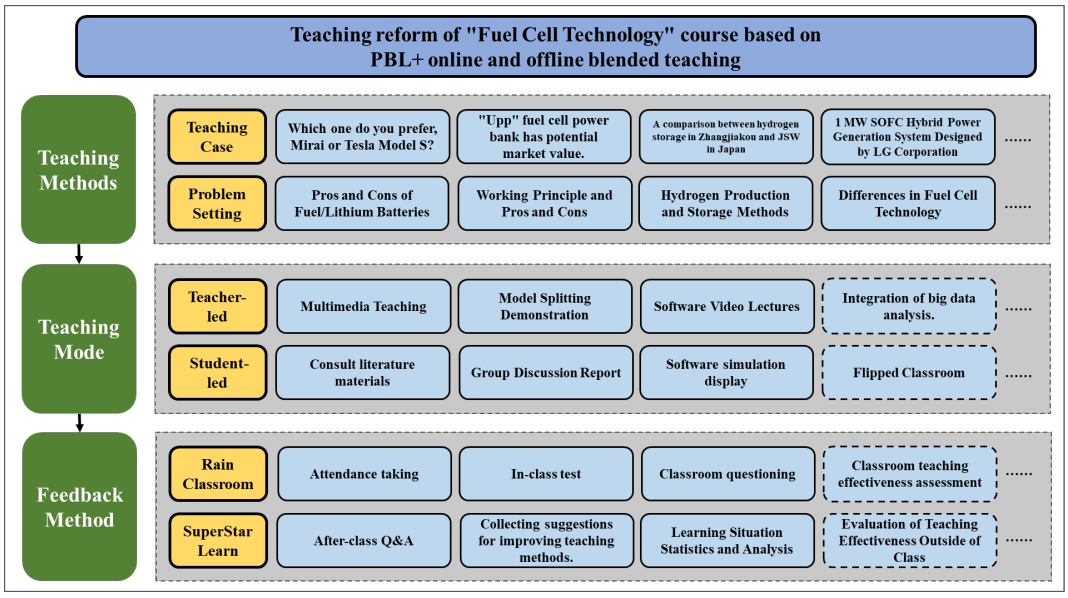

Figure 1: Overall Teaching Approach for the Course

6. Conclusion and outlook

The teaching reform this time has achieved certain success and played a positive role in cultivating students' knowledge of fuel cells and their ability to handle practical problems. However, there are still some issues that need improvement. Teaching cases based on current events have a better effect on stimulating students' interest in learning, but the timeliness of these cases is poor, requiring constant updates to the case library. The design of flipped classrooms can enhance students' self-learning abilities,

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but the scope of student discussions is too broad, necessitating continuous expansion of teachers' knowledge reserves. This course reform has laid the foundation for teaching method reforms in other professional courses.

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