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Exploration of Teaching Reform Strategies for the "Principles of Chemical Engineering" Course Based on the OBE Concept

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Abstract: Against the backdrop of "New Engineering," how to strengthen students' abilities in independent analysis, critical thinking, and innovative problem-solving while imparting traditional engineering knowledge has become a crucial issue for engineering universities in cultivating applied, interdisciplinary, and innovative chemical engineering talents. This paper expounds on the necessity of engineering education reform, outlines the importance of the "Principles of Chemical Engineering" course, and analyzes the problems existing in its teaching. Guided by the OBE (Outcome-Based Education) concept, the paper constructs the CDIO teaching model, focuses on three aspects, teaching content, teaching methods, and teaching evaluation, and explores teaching reform strategies for the "Principles of Chemical Engineering" course. It aims to provide a reference for optimizing the teaching model of chemical engineering-related courses.

Keywords: OBE concept; Principles of chemical engineering course; Teaching reform; Strategies

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1. Introduction

In February 2017, the Department of Higher Education of the Ministry of Education issued the "Notice on Carrying Out Research and Practice on 'New Engineering'." The notice points out that at the current stage, China needs to deepen the concept of engineering education to proactively respond to the new round of scientific and technological revolution and industrial transformation, serve the needs of national strategies and regional development, accelerate the development of "New Engineering," explore and form a world-class engineering education system with Chinese characteristics, and promote China's transformation from a large country in engineering education to a powerful one. OBE emphasizes designing teaching with final learning outcomes as the orientation, while CDIO focuses on the full-cycle practical training in engineering education. In the teaching of "Principles of Chemical Engineering", the basis for the integration of OBE and CDIO lies in their joint commitment to improving students' comprehensive literacy and professional capabilities in the field of chemical engineering, to meet the demand of the chemical industry for innovative and practical talents. To implement the spirit of "transformation," there is an urgent need to carry out teaching reform on the "Principles of Chemical Engineering" course. This reform should strengthen the connection between theoretical knowledge and practical application, and improve students' ability to use theoretical knowledge to solve complex practical engineering problems. The ultimate goal is to achieve the cultivation of high-quality applied talents and better serve the rapid development of the regional economy under the new normal [1].

2. Problems in the teaching of the "Chemical Engineering Principles" course

At present, the "Chemical Engineering Principles" course in the chemical engineering discipline system still has many problems in cultivating talents for the "Emerging Engineering Education" initiative.

2.1. Disconnection between course theory and engineering practice

The theoretical knowledge of the course is delivered solely through teachers' in-class lectures, resulting in a single teaching method and a lack of intuitive teaching tools. The practical segment mainly relies on chemical engineering principles and experiments, and there is a gap between the experimental operations that students participate in and actual engineering projects [2]. Teachers and schools fully rely on exam results to evaluate students' engineering capabilities [3]. Since students' understanding of engineering concepts comes entirely from teachers' explanations in class, they have little exposure to real engineering practice in the course, leading to a lack of awareness of engineering concepts.

2.2. Teaching model neglects the cultivation of engineering competence

In terms of the course model, students' learning process lacks interaction, and they have no concept of team collaboration. In the course evaluation system, only exam scores are considered, while the assessment of engineering competence is ignored, making the evaluation system overly simplistic. These problems in the educational process are far from meeting the training requirements for "Emerging Engineering Education" talents and urgently need to be studied and addressed [4]. Currently, engineering education focuses on the inculcation of knowledge points, lacking the cultivation of the ability to transform knowledge into practical application and the training of innovative capabilities. Therefore, against the backdrop of the new era, higher education institutions should reform the course teaching and evaluation system based on national policies and concepts, combined with modern information technology.

3. Teaching reform strategies for the "Principles of Chemical Engineering" course based on the OBE concept

3.1. Reconstructing the teaching content system in accordance with the OBE educational concept

In accordance with the OBE reverse design principle, the core knowledge that students need to master is identified. Teachers should start from the talent training program for chemistry majors, conduct research on and decompose the demands of job groups in the chemical engineering industry, and clarify the learning outcomes that students need to achieve based on the nature of the "Principles of Chemical Engineering" course [5].

Firstly, based on the corresponding relationship between job groups and students' learning outcomes, the course learning outcome objectives are defined: students should be able to proficiently master basic principles such as fluid flow, heat transfer, and mass transfer, and apply these principles to conduct calculations for chemical unit operations, equipment selection, and process flow design; they should also be able to analyze and solve common engineering problems in chemical production processes, and possess certain engineering practical capabilities and innovative thinking. Based on the course teaching content, teachers can refine the above-mentioned learning outcomes and formulate specific knowledge and skill objectives. For example, students should be able to accurately calculate parameters such as Reynolds number and heat transfer coefficient, and design the specifications and operating parameters of equipment like distillation columns and heat exchangers according to given conditions [6].

Secondly, teachers can reconstruct the teaching system of the "Principles of Chemical Engineering" course and develop modular teaching content based on the four stages of CDIO (Conceive, Design, Implement, Operate). In the Conceiving stage, real project cases from the chemical engineering industry are selected and transformed into project-based learning tasks, such as chemical product synthesis projects. These projects require students to learn and construct a knowledge framework, and put forward personal ideas from the perspectives of feasibility, technology, and solutions. In the Design stage, teachers organize project exploration activities, guiding students to combine the knowledge they have learned with project requirements to carry out process design and equipment selection exploration; through in-depth thinking and exploration, students can gain a deeper understanding of the application value of principles such as mass transfer and heat transfer [7]. In the Implementing stage, students use simulation experiments or hands-on experiments to verify the feasibility of the design scheme, and with the help of result feedback from virtual simulation software, they promptly identify and solve problems, optimize the operation process, and exercise their ability to solve practical problems. In the Operating stage, students are required to maintain and improve the project, reflect the complete project implementation process in project reports and technical documents, which helps cultivate their engineering management and teamwork abilities and further enables them to master the entire process of chemical production.

3.2. Optimizing course teaching methods driven by the CDIO model

Under the guidance of OBE (outcome-based education), teachers can apply the CDIO engineering education model and combine it with traditional teaching methods.

Firstly, innovatively apply the project-driven teaching method. Teachers can design a series of "Principles of Chemical Engineering" projects, and the implementation of this method runs through three links: pre-class, in-class, and post-class [8]. Before class, teachers prepare materials while students search for relevant information, and they work together to determine the project theme; during class, teachers explain the content of project tasks, adopt a group cooperation approach to organize students in in-class exploration activities, arrange groups to take turns presenting their ideas, and provide comments on each group's performance; after class, teachers conduct Q&A sessions to address unresolved issues from the class, help students adjust and improve the project content, and appropriately extend and expand knowledge related to the project. For example, with "designing a shell-and-tube heat exchanger" as the project theme, student teams need to complete the entire process from project conception (determining design tasks, equipment types, etc.), design (detailed design calculation methods, heat transfer rate equations, heat balance calculations, etc.), implementation (building an experimental model or completing virtual simulation operations) to operation (monitoring operation effects and conducting optimization adjustments).

Secondly, the case teaching method is applied innovatively: teachers should integrate the course content with chemical production cases, such as the crude oil distillation process in large-scale petrochemical enterprises and the drug synthesis and purification process in pharmaceutical enterprises, and design a series of case exploration topics [9]. In teaching, first, in accordance with the OBE concept, put forward learning outcome-related questions about the cases, such as "analyze the energy-saving measures in the heat transfer link of this process and propose improvement plans based on the knowledge of chemical engineering principles". Then, use the CDIO model to guide students in analyzing the cases, covering the process from conceiving the process principles, designing improvement plans, implementing plan simulation or experimental verification to operating the implementation and evaluation of the plans [10]. Through case teaching, students can gain a deep understanding of the application of chemical engineering principles in actual production, while developing their ability to analyze and solve problems, enabling them to gradually achieve the expected learning outcomes.

3.3. Focus on students' learning outcomes and reconstruct the teaching evaluation system

The OBE (Outcome-Based Education) concept emphasizes student-centeredness. Teachers should focus on evaluating students' performance throughout the learning process and establish a diversified evaluation system [11]. To objectively record and assess students' process-based learning performance, teachers should design self-evaluation and peer-evaluation sessions. They may also invite professionals from enterprises or other teachers to evaluate students in aspects such as their understanding of theoretical knowledge, calculation proficiency, experimental operation skills, and teamwork performance, so as to conduct a comprehensive assessment of students' learning abilities and learning outcomes [12]. During the implementation of the project, students can independently comment on their personal gains, team contributions, and existing shortcomings. Meanwhile, group members can provide feedback on each other's knowledge application, communication skills, and work performance. All this data is uniformly submitted to teachers for review. Guided by the OBE outcome-oriented principle, teachers should refine the evaluation criteria and establish an evaluation index system covering three dimensions: knowledge, ability, and literacy. This system aims to assess students' mastery of the theoretical knowledge of Chemical Engineering Principles, their innovative ability, communication skills, and teamwork ability demonstrated in the process of discussing project solutions, as well as their awareness of concepts such as green environmental protection, engineering safety, and scientific rigor reflected in their literacy performance. By building a comprehensive evaluation index, an "evaluation-feedback-incentive" mechanism is formed to encourage students to continuously strive for better learning outcomes [13].

4. Achievements of project implementation

4.1. Enhanced the integration of theory and practice

Traditional Chemical Engineering Principles classes are usually limited to in-class lectures, where students are mostly engaged in absorbing theoretical knowledge and lack opportunities to connect knowledge with engineering practice [14]. After reconstructing the teaching model under the OBE concept, real projects are organically integrated into the curriculum design and practice. This enables students to understand and apply curriculum knowledge through project analysis and practice, strengthens the connection between theoretical learning and experimental design, and helps students gain an in-depth understanding of abstract knowledge in practice. Thus, it makes up for the deficiency in integrating theory and practice in traditional classrooms.

4.2. Significantly improved students' learning initiative

In traditional teaching, students are in a passive learning position and show low enthusiasm for participating in in-class exploration. By establishing and implementing the OBE-CDIO teaching model, the central role of students in project-based learning and case analysis is highlighted, allowing them to truly experience the entire practical process of a project and stimulating their interest in learning. Additionally, with the integration of a diversified evaluation system, students' learning processes and outcomes can be recorded, which reflects their learning performance and achievement levels in project participation. This further inspires students' enthusiasm for innovative thinking and problem-solving, and enhances their initiative to participate in classroom activities.

4.3. Fully aligning teaching content with industry needs

The content of traditional Chemical Engineering Principles courses often lags behind the development of the chemical industry [15]. By implementing teaching reforms guided by the Outcome-Based Education (OBE) concept, we can base our efforts on the latest needs of the chemical industry, select cases of new processes and technologies from the industry, and transform them into curriculum teaching projects. This allows students to access industry-related content corresponding to the course theories, helping them understand industry needs and fostering engineering and technical talents who can adapt to the development requirements of the industry.

5. Conclusion

To sum up, centering on the OBE educational concept, adopting a reverse design approach, determining course teaching objectives based on industry needs, and designing students' learning outcome objectives to promote the teaching reform of the Chemical Engineering Principles course are conducive to advancing the update and development of the course teaching system and enhancing the comprehensiveness and practicality of teaching activities. Therefore, teachers should adhere to the outcome-based education concept, continuously pay attention to and understand the needs of the chemical industry, decompose the teaching objectives of the Chemical Engineering Principles course in a targeted manner, and design learning outcome objectives essential for students' future employment and development. In the implementation process, by integrating the CDIO (Conceive, Design, Implement, Operate) engineering education model and following the framework of conception, design, implementation, and operation, a curriculum system that integrates core knowledge modules with chemical engineering stages should be established. This system should balance students' knowledge acquisition and practical ability cultivation, enabling them to learn knowledge purposefully and solve problems in the process of analyzing and addressing project cases, thereby improving the overall teaching effectiveness of the course.

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References

[1] Wang L, 2024, Exploration on the Teaching Reform Approaches of the "Principles of Chemical Engineering" Course Under the Background of Emerging Engineering Education. Contemporary Chemical Industry Research, 2024(23): 140–142.

[2] Wang Z, Qi J, Su W, et al., 2024, Reflective Teaching and Practice of the "Principles of Chemical Engineering" Course. Tianjin Chemical Industry, 38(5): 131–133.

[3] Niu F, Cao Z, Zhang Y, et al., 2024, Teaching Reform and Practice of "Principles of Chemical Engineering" Under the Background of First-Class Course Construction. Chemical Enterprise Management, 2024(23): 30–34.

[4] Wu Q, Yang W, Bai L, et al., 2024, Construction and Practice of Offline "Principles of Chemical Engineering" Courses Under the Application-Oriented Talent Training Model. Chemical Engineering & Equipment, 2024(6): 158–160 + 164.

[5] Wang Y, Gu X, Li L, 2024, Research on the Evaluation of Course Objective Achievement of "Principles of Chemical Engineering Experiment" Based on the OBE Concept. Anhui Chemical Industry, 50(2): 193–196.

[6] Liu H, Han Y, Hou C, et al., 2024, Teaching Design of "Principles of Chemical Engineering" Course Design and Evaluation of Course Objective Achievement Based on the OBE Concept. Tianjin Chemical Industry, 38(2): 153–156.

[7] Yuan F, Chen Z, Hu J, et al., 2024, Teaching Reform and Practice Based on "OBE + BOPPPS + Ideological and Political Education in Courses"—A Case Study of the "Principles of Chemical Engineering" Course. Education and Teaching Forum, 2024(13): 65–68.

[8] Liu C, Zheng Y, Zhang S, et al., 2024, Teaching Reform of the "Principles of Chemical Engineering" Course for the Cultivation of Top-Notch Innovative Talents. Contemporary Chemical Industry Research, 2024(6): 126–128.

[9] Liu J, Tan X, Peng G, et al., 2023, Research on the Teaching Reform of "Principles of Chemical Engineering" Based on the OBE Concept. Guangzhou Chemical Industry, 51(6): 158–160.

[10] Zhang H, Yu T, Fang F, et al., 2023, Teaching Reform of "Principles of Chemical Engineering" Under the Application-Oriented Talent Training Model. Guangzhou Chemical Industry, 51(2): 304–305 + 308.

[11] Meng X, Zhang J, Zhuang S, et al., 2022, Exploration and Practice of a Three-Dimensional Teaching Model for the "Principles of Chemical Engineering" Course Focusing on Cultivating Students' Ability to Solve Complex Engineering Problems. Higher Education in Chemical Engineering, 39(5): 84–90 + 143.

[12] Ma Z, Yin X, Liu Y, et al., 2022, Research on the Teaching Reform of "Principles of Chemical Engineering" Based on the CDIO Education Model and "Double Carbon-Emerging Engineering Education". Guangdong Chemical Industry, 49(10): 213–215.

[13] Li Q, Zhang Y, Huang Q, 2022, Reform and Practice of the "Principles of Chemical Engineering" Course in Colleges and Universities Based on the OBE Concept. Journal of Hubei University of Education, 39(2): 83–88.

[14] Zhang Y, Yuan J, 2020, Research on the Teaching Reform of "Principles of Chemical Engineering" Based on the CDIO Concept. Shandong Chemical Industry, 49(18): 159–160 + 163.

[15] Wang J, Li J, Liu J, et al., 2020, Practice and Effect of Teaching Reform in Project Design of "Principles of Chemical Engineering". Chinese Journal of Chemical Education (Chinese & English), 41(18): 34–38.