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Exploration and Practice of Digital Construction Teaching Reform of "Analysis and Synthesis of Chemical Engineering Process" Course Under OBE Concept

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Abstract: With the in-depth advancement of engineering education accreditation, traditional teaching mode of "Analysis and Synthesis of Chemical Engineering Process" course has been difficult to meet the demands of cultivating chemical engineering talents in new times. Based on Outcome-Based Education (OBE) concept and combined with digital technology, the teaching reform and practice of this course were deeply discussed. A student-centered and ability cultivation-oriented teaching system was constructed by optimizing teaching contents, introducing mind maps, adopting composite teaching modes, and applying process simulation software such as Aspen Plus. This practice shown that abilities of students in engineering practice, problem-solving, and autonomous learning were significantly enhanced by the integration of digital construction and OBE concept, which provides new ideas for the teaching reform of chemical engineering-related professional courses.

Keywords: OBE Concept; Analysis and Synthesis of Chemical Engineering Process; Digital Construction; Teaching Reform; Engineering Education Accreditation

1. Introduction

"Analysis and Synthesis of Chemical Engineering Process" is a core course for the major of chemical engineering and technology, aiming to cultivate abilities of students to solve complex chemical engineering problems by applying ideas and methods of systems engineering. However, traditional teaching mode generally has four problems that need to be solved urgently: (1) teaching contents are overly focused on theoretical derivation and disconnected from practical engineering applications, (2) teaching methods are mainly based on lectures of teachers, and the participation of students is low, (3) practical links are weak, and engineering practice ability cultivation of students is insufficient, and (4) evaluation methods are single and difficult to comprehensively reflect the learning effect [1]. With the advancement of "New Engineering" construction and the implementation of engineering education accreditation standards, Outcome-Based Education (OBE) concept has become one of important directions of teaching reform [2]. Meanwhile, the rapid development of digital technology has also provided new tools and platforms for the construction of this course [3].

Relevant scholars have carried out a series of studies in this field. OBE concept was first proposed by Spady [4], emphasizing that education should focus on abilities that students can ultimately demonstrate. This concept also emphasizes that learning outcomes of students should be the orientation, ensuring that students have the ability to solve complex engineering problems through the reverse design of curriculum system. Based on the engineering education accreditation standards, Jin *et al.* [5] proposed reform measures such as optimizing teaching contents and assessment methods around OBE concept, introducing mind maps, and adopting composite teaching modes. Zhang *et al.* [6] explored the teaching mode reform centered on engineering cases and focused on cultivating abilities of students to design/develop and solve problems, integrating OBE concept throughout the design and teaching process of this course. Feng *et al.* [7] suggested that during the teaching period of chemical engineering professional courses, information technology means should be fully utilized. Centering on OBE and engineering education concepts, production-education integration as well as ideological and political education in courses

should be integrated into teaching. However, in-depth exploration is still needed in aspects such as the construction of digital teaching resources and the application of virtual simulation technology.

By deeply integrating OBE concept with digital teaching methods, comprehensive abilities of students can be enhanced in this work through optimizing teaching design, introducing modern tools, and composite teaching methods. The teaching reform pathway exploration of "Analysis and Synthesis of Chemical Engineering Process" course has important theoretical and practical value for improving the quality of talent cultivation in chemical engineering-related majors.

2. OBE Concept and Curriculum Objective Design

2.1 Connotation and Core of OBE Concept

OBE concept involves the interpretation and solution of four aspects, *i.e.*, learning outcomes, learning significance, learning process, and learning evaluation. First, what are the learning outcomes? It is necessary to clarify the objectives of each course and the ability requirements that students should achieve upon graduation. Second, why are these achievements needed? It is necessary to clarify the necessity of these abilities for personal development and social demands. From the perspective of "Analysis and Synthesis of Chemical Engineering Process", it is necessary to align with demands of chemical industry and engineering certification standards. Thirdly, how can we help students achieve results? Effective teaching strategies can be designed to help students achieve their goals by optimizing teaching methods and resources. Fourth, how to evaluate the achievement degree of outcomes? A scientific evaluation system or assessment & feedback mechanism can be established to verify the achievement degree of outcomes. By integrating above four aspects, it can be ensured that students have the ability to solve complex engineering problems upon the completion of this course or after graduation.

2.2 Course Objective Design

In view of this, three course objectives were designed, including mastering systematic analysis methods of chemical processes (objective 1), possessing the ability of process design and optimization (objective 2), and being proficient in using modern tools such as Aspen Plus (objective 3). Corresponding graduation requirements were to enhance the ability of problem research, the ability to design/develop solutions, and the ability to use modern tools, respectively. Corresponding assessment methods were regular assignments & final exams, computer practice & course reports, and software simulation & engineering major assignments, respectively. It should be pointed out that the support strength of objectives 1 and 2 should be high, while that of objective 3 should be medium. Teaching contents and methods were constantly modified through achievement degree analysis of course objectives.

2.3 Reconstruction of Course Contents

For the reconstruction of course contents, breaking limitations of traditional textbook chapters and reconstructing teaching contents in accordance with the logic of "basic theory - method tools - engineering application" are necessary. Among them, basic module focuses on the learning of modeling and simulation methods for process systems. Method module focuses on the study of contents such as pinch point technology, heat exchange network synthesis, and separation sequence synthesis. Application module focuses on the study of case analyses about typical chemical processes.

2.4 Course Evaluation

A three-dimensional evaluation system was established in this course. Process evaluation mainly based on classroom performance, regular homework, and other assessments accounts for 40%. Practical evaluation mainly based on software operation, experimental reports, and other assessments accounts for 30%. Summative evaluation mainly based on final exams, course designs, and other assessments accounts for 30%.

3. Specific Measures for Digital Teaching Reform

3.1 Construction of Intelligent Teaching Platform

A smart teaching platform was constructed by building online resource library, mobile learning terminal, and intelligent management system. In addition, an online course platform including teaching videos, animated demonstrations, and virtual simulations was also built. A mobile

application that supports learning at any time was developed, and subsequently functions such as learning behavior analysis and intelligent question answering were realized. Taking the intelligent teaching platform as the carrier, the efficiency about theoretical knowledge learning and practical skill cultivation of students in this course was enhanced.

3.2 Teaching Content Optimization: From Textbooks to Engineering Cases

Traditional teaching is mostly theoretical, and it is difficult for students to apply knowledge to solve practical problems in chemical production. Through digital teaching reform, typical engineering cases (such as heat exchange network optimization and separation sequence synthesis) were used as the carrier of course contents, and software such as Aspen Plus was used to simulate and analyze for enhance the practical ability of students [8]. Three cases were used as examples. Case 1: In the teaching of "heat exchange network synthesis by pinch point technology", the influence of various minimum heat transfer temperature differences on the system energy efficiency was demonstrated through Aspen Energy Analyzer, guiding students to propose optimization schemes. Case 2: In the teaching of "separation sequence synthesis", the ordered intuitive inference method was adopted to design the separation process, and its economy and feasibility were verified through software. Case 3: In the teaching of "steady-state simulation for process systems", knowledge points such as sequential module method, equation oriented method, and simultaneous module method were associated through mind maps to enhance logical thinking and autonomous learning abilities of students.

3.3 Composite Teaching Modes

A blended teaching model of "online self-study + offline in-depth discussion" was adopted in this course, teaching quality of course and students' learning efficiency of students were improved through diversified teaching methods such as problem-oriented, heuristic, and discussion-based approaches. For online learning, platforms such as Chaoxing and Rain Classroom were used to provide MOOC videos and simulation software tutorials. Students completed the learning of basic knowledge, including previewing and reviewing through online platforms. For offline classrooms, difficult points and key teaching were focused on, and in-depth teaching activities such as case studies and software practical operations were carried out by teachers. For example, "engage in idle theorizing" of students was solved by combining the sequential module method with Aspen simulation through the case of ethylbenzene dehydrogenation. For the major engineering assignment, group training was conducted, and tasks such as the simulation of methanol distillation from natural gas were completed, which cultivated teamwork and innovation abilities of students, thereby consolidating the learning outcomes.

3.4 Deep Integration of Aspen Plus Software

Aspen Plus is a commonly used chemical simulation tool/software. A three-level practical training system of "basic operations - process simulation - optimization design", *i.e.*, mastering basic operations of software (basic level), completing typical process simulations (improvement level), and conducting process optimization design (innovation level), was constructed. In addition, three aspects of application were focused on and broken through in teaching activities. For process simulation, the issue of setting and convergence of fracture flow streams was explained through the case of ethylbenzene dehydrogenation. For energy efficiency optimization, corresponding energy-saving schemes were proposed based on pinch point analysis and evaluation of heat exchange network by Aspen Energy Analyzer. For the combination of virtual and real lessons, micro-lesson videos were recorded to assist in after-class exercises, reinforcing and consolidating the knowledge points and software operation skills that students learned, and making up for the deficiency of insufficient class hours.

4. Effectiveness of Teaching Reform

Remarkable reform results were achieved through two rounds of teaching practice. Comprehensive abilities of students were effectively enhanced. The achievement rate of course objectives increased by approximately 15%, and 90% of students can independently complete the process simulation and optimization tasks. The learning enthusiasm of students was effectively enhanced. The team-based model of major engineering assignments stimulated subjective initiative of students. The ability of graduates to apply simulation software

in enterprises related to this industry was recognized.

5. Conclusion

Based on OBE concept, a new teaching model for "Analysis and Synthesis of Chemical Engineering Process" course was constructed, through systematic exploration and practice of teaching reform, achieving remarkable results. Remarkable course reconstruction results were achieved. Outstanding achievements were made in the innovative application of digital teaching methods. Advantages of composite teaching mode were verified. This diversified assessment system is more scientific and reasonable. Teaching practice shows that the experience summarized in the exploration and practice of digital construction teaching reform of "Analysis and Synthesis of Chemical Engineering Process" course under OBE concept can provide useful references for the teaching reform of other engineering courses. With the in-depth development of educational informatization and the continuous advancement of engineering education accreditation, the teaching reform of this course will continue to deepen and improve.

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