`Research on the Reform of Experimental Practice Teaching in Fine Chemical Engineering Based on the OBE Concept

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Abstract: This study focuses on the pain points of experimental practice teaching in the fine chemical major based on the core of Outcome-Based Education (OBE), following the closed-loop logic of "defining outputs - achieving outputs - evaluating and improving". The reform exploration is carried out from four dimensions: curriculum system reconfiguration, teaching mode innovation, evaluation system optimization, and guarantee mechanism improvement. By aligning with industry talent demands, strengthening practical ability cultivation, and constructing a diversified evaluation system, the aim is to solve problems such as the disconnection between teaching content and the industry, insufficient student initiative, and single evaluation methods in traditional teaching. A replicable new model of fine chemical experimental teaching is formed, providing a reference for the practice teaching reform of chemical engineering majors in local universities under the background of new engineering disciplines.

Keywords: Outcome-Based Education (OBE); Fine Chemical; Experimental Practice Teaching; Teaching Reform; New Engineering Discipline

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1.Introduction

1.1 Research Background

As the fine chemical industry undergoes a transformation towards high-end, green, and intelligent development, the industry's demand for talents has shifted from the traditional operational type to the innovative and engineering application types. However, there are three major pain points in the experimental practice teaching of fine chemical specialties in local universities at present: First, the teaching content lags behind the development of the industry, with a high proportion of verification experiments, and insufficient design, comprehensive, and innovative experiments, making it difficult to support students' ability to solve complex engineering problems; Second, the teaching model is centered on teachers, with students passively participating, lacking opportunities for independent exploration and teamwork, which contradicts the core principle of "student-centered" in OBE; Third, the evaluation system focuses on outcome assessment, ignoring process evaluation, and is unable to effectively feedback teaching effects, making it difficult to achieve the core goal of "continuous improvement" in OBE [1].

1.2 Research Significance

(1)Theoretical Significance: To enrich the application research of OBE in the experimental teaching of chemical engineering specialties, to improve the theoretical system of practical teaching in fine chemical specialties, and to provide theoretical support for the reform of new engineering practice teaching.

(2)Practical Significance: To solve the problem of disconnection between fine chemical experimental teaching in local universities and industrial demands, to enhance students' engineering practice ability, innovative thinking, and professional quality, to help graduates quickly adapt to industry positions, and to promote the deep development of industry-academia integration.

2.Core Connotation and Reform Logic of OBE Concept

2.1 Core Connotation of OBE Concept

OBE (Outcome-Based Education) is outcome-oriented education [2], its core is "student-centered, outcome-oriented, and continuous improvement". The implementation logic revolves around four core questions: What are the learning outcomes we want students to achieve? Why do we want students to achieve such outcomes? How can we effectively help students achieve the expected outcomes? How can we prove that students have achieved the outcomes?

Based on the characteristics of fine chemical specialties, the core learning outcomes should cover four dimensions: First, solid professional knowledge, mastering core theories such as unit operations in fine chemicals, chemical synthesis, and quality inspection; second, strong engineering practice ability, being able to independently complete experimental design, operation, data analysis, and problem-solving; third, innovative thinking and research literacy, having the preliminary ability to explore new methods and develop new products; fourth, professional quality and safety awareness, familiar with industry norms, environmental protection requirements, and safety production standards.

2.2 Reform Logic

This research is guided by the OBE concept and follows the reform logic of "reverse design, forward implementation, and closed-loop improvement":

(1)Reverse Design: Based on the job requirements and graduation requirements of the industry, clearly define the core learning outcomes of the experimental teaching stage, and thereby reverse the goals, content, and methods of the experimental courses.

(2)Forward Implementation: Focusing on the core learning outcomes, restructure the curriculum system, innovate teaching models, and optimize teaching resources to ensure that teaching activities are precisely matched with the outcome goals.

(3)Closed-loop Improvement: Build a multi-dimensional evaluation system, combine process evaluation and result evaluation, comprehensively assess the achievement degree of learning outcomes, continuously optimize teaching links based on evaluation feedback, and form a "design - implementation - evaluation - improvement" virtuous cycle.

3.Current Situation and Problems of Experimental Practice Teaching in Fine Chemical Specialties

3.1 Disconnection between Teaching Content and Industrial Requirements

The current experimental content is mostly dominated by classic verification experiments, accounting for over 60%, focusing on basic operational skills training, lacking experimental projects related to the cutting-edge technologies in the fine chemical industry (such as green synthesis, intelligent detection, and functional chemical product development). At the same time, the experimental projects do not sufficiently connect with the actual production and R&D scenarios of enterprises, and do not fully consider the industry's requirements for core capabilities such as "process optimization, cost control, and environmental compliance", resulting in students being unable to quickly adapt to job positions after graduation.

3.2 The teaching mode is monotonous, and students' initiative is insufficient.

The traditional experimental teaching adopts a one-way mode of "teacher's explanation - student's imitation - submission of reports", where students lack the space to independently design experimental plans and choose experimental routes. The pre-experiment preparation stage is merely formalistic, and students merely mechanically memorize the operation steps without deeply understanding the experimental principles and design logic; during the experiment, the goal is to complete tasks, lacking exploration of abnormal phenomena and problem-solving thinking, making it difficult to cultivate innovative consciousness and autonomous learning ability.

3.3 The evaluation system is not complete, and the feedback and improvement mechanism is lacking.

The current evaluation mainly focuses on end-of-term assessment, with the proportion of experimental reports exceeding 70%. The assessment content mainly focuses on the correctness of experimental results, ignoring the operational norms, the rationality of the design of the experiment, the depth of data analysis, and the team collaboration performance. At the same time, there is a lack of systematic assessment of the achievement of learning outcomes, and the evaluation results are only used for scoring, not for analyzing teaching shortcomings and optimizing teaching plans, which cannot meet the core requirements of OBE "continuous improvement".

3.4 Insufficient support from teachers and teaching resources

Some teachers lack first-line work experience in enterprises and have weak engineering practice abilities, making it difficult to effectively guide students to carry out comprehensive and innovative experiments; the depth of school-enterprise cooperation is insufficient, and the internship bases mainly consist of visiting and learning, leaving students without opportunities to operate hands-on and participate in practical projects; the construction of virtual simulation experiment resources is lagging behind, unable to meet the practical teaching needs in complex working conditions and high-risk scenarios, and not matching the industry characteristics of fine chemicals as "high risk and high investment".

4.Experimental Practice Teaching Reform Path Based on OBE Concept

4.1 Reverse Design: Clarify Core Learning Outcomes, Reconstruct Curriculum System

(1)Anchor Outcomes Goals: Through research on industry leading enterprises, tracking feedback from graduates, and expert argumentation, clarify the "experimental design, process optimization, quality control, and safety and environmental protection" four core capabilities that graduates of the fine chemical major need to possess, and refine them into measurable and evaluable learning outcome indicators. For example, "having the ability to design green synthesis processes" can be refined into "able to design 2 or more synthesis routes based on raw material characteristics and product requirements, and be able to optimize process parameters to reduce energy consumption by more than 10%".

(2)Reconstruct Curriculum System: Reconstruct the experimental course system according to the four levels of "foundation - comprehensive - innovation - application":

Foundation layer: Retain necessary unit operations and basic synthesis experiments, strengthen core operational skills, and adjust the proportion to 30%;

Comprehensive layer: Offer comprehensive experiments such as "Fine Chemical Synthesis and Detection" and "Chemical Process Optimization", integrating multiple disciplines of knowledge, with a proportion of 40%;

Innovation layer: Introduce the "research feedback teaching" model, converting teacher's research projects into experimental projects, such as the preparation of nano catalysts and the development of functional surfactants, with a proportion of 20%;

Application layer: Connect with actual enterprise needs, carry out "real problem real operation" project-based experiments, such as the development of cosmetic preservatives customized by a certain enterprise, and the optimization of coating aid formulas, with a proportion of 10%.

(3)Optimize Course Content: Delete outdated and repetitive verification experiments, add cutting-edge content such as green chemistry, intelligent equipment, and bio-based chemicals; increase the proportion of design and inquiry experiments to over 50%, integrating industrial requirements such as safety and environmental protection, cost control, and quality traceability.

4.2 Innovative Teaching Mode: Centered on students, strengthen practical ability cultivation

(1)Implement Project-Based Learning (PBL): Drive with real fine chemical projects, divide students into 3-5 person groups, and carry out teaching according to the process of "project initiation - scheme design - experiment implementation - results presentation - reflection and improvement" [3]. For example, with the project titled "Optimization of Surface Active Agents in a Laundry Liquid", students are required to independently conduct literature research, design a compounding plan, carry out experiments, analyze performance data, and finally produce a project report and defend it. The role of the teacher shifts from "instructor" to "guide", focusing on guiding the design of the plan, problem-solving, and teamwork.

(2)Implement the "Three Integration" teaching model: Promote "Research into the Laboratory, Enterprises into the Classroom, and Achievements into Teaching". Invite enterprise engineers to give special lectures, sharing production line cases and technical problems; organize students to enter enterprise training bases to participate in actual production processes and project research; Transform the teacher's research achievements into experimental teaching projects, allowing students to come into contact with cutting-edge technologies and cultivate research thinking.

(3)Integrate virtual simulation and real-world teaching: Build a "Virtual Simulation + Real-World Operation" mixed teaching model. For high-risk and high-cost experiments (such as high-temperature and high-pressure reactions, synthesis of toxic chemicals), use virtual simulation technology for preview and operation training to reduce safety risks; For core unit operations and process optimization, rely on the school's training center and enterprise internship bases to conduct real-world hands-on training, achieving "Virtual Simulation as a Foundation, Real-World Operation for Deepening" complementary teaching.

(4)Adopt multi-teacher co-teaching model: Form a teaching team consisting of school professional teachers, enterprise engineers, and researchers, using team teaching, special lectures, and joint guidance to conduct teaching throughout the project process, enhancing the professionalism and practicality of teaching.

4.3 Build a diversified evaluation system: Focus on achievement attainment, achieving closed-loop improvement

(1)Establish a combination of process and final evaluation system: Adjust the evaluation weight to "60% process evaluation + 40% final evaluation". Process evaluation covers pre-reading reports (10%), scheme design (10%), experimental operation (20%), teamwork (10%), data processing and analysis (10%); Final evaluation mainly consists of experimental reports, project defense, and practical operation assessment.

(2)Develop multi-dimensional evaluation indicators: Focus on core learning outcomes, designing "Knowledge Mastery - Ability Achievement - Quality Enhancement" three-dimensional evaluation indicators. For example, the evaluation dimension of experimental operation includes standard operation, safety awareness, and abnormal handling; the evaluation dimension of scheme design includes rationality, innovation, and feasibility; the evaluation dimension of quality includes teamwork, communication expression, and environmental awareness.

(3)Introduce multiple evaluation entities: Use a combination of "Teacher Evaluation + Student Self-evaluation + Enterprise Evaluation". Teacher evaluation focuses on the experimental process and outcome quality; student self-evaluation focuses on teamwork and contribution; enterprise evaluation evaluates students participating in enterprise projects, from job fit, practical ability, etc., to ensure the comprehensiveness and objectivity of the evaluation.

(4)Establish an assessment and improvement mechanism for achievement attainment: At the end of each semester, statistically analyze the attainment degree of each learning outcome indicator, and for unattained indicators, improve through holding teaching seminars, optimizing teaching content, and adjusting teaching methods. For example, if the "Process Optimization Ability" attainment degree is low, additional training on process simulation software operation can be added, and enterprise engineers can provide special guidance on process optimization [4].

4.4 Improve the guarantee mechanism: Strengthen the support of teachers and resources

(1)Strengthen the construction of the teaching team: Establish a "Dual-Teacher" training mechanism, requiring teachers to spend at least 3 months on enterprise assignment each year, participating in enterprise production and research projects; regularly organize teachers to participate in training on OBE concepts, advanced technologies in fine chemical engineering, and experimental teaching methods; appoint senior enterprise engineers and experts from research institutes as part-time teachers to enrich the teaching team.

(2)Deepen the integration of education and industry: Cooperate with leading enterprises in the industry to establish internship and training bases, sign long-term cooperation agreements, and clearly define the responsibilities and obligations of enterprises in receiving students for internships and participating in teaching; jointly formulate teaching plans and develop experimental projects, achieving "synchronization of teaching content with industrial demands and alignment of teaching evaluation with job standards".

(3)Optimize the allocation of teaching resources: Increase investment in the experimental and training center, purchase advanced fine chemical experimental equipment, virtual simulation software and testing instruments; build a shared resource library for schools and enterprises, integrate enterprise cases, industry standards, and cutting-edge technical literature, providing students with rich learning materials.

(4)Establish an expenditure guarantee mechanism: Set up a special fund for experimental teaching reform, used for experimental project development, teacher training, virtual simulation resource construction, and enterprise cooperation, ensuring the implementation of reform measures.

5.Reform Implementation Effects and Reflections

5.1 Implementation Effects

(1)Significant improvement in students' abilities: After the reform, students' operational norms, scheme design abilities, and problem-solving abilities have significantly improved. The number of awards won in national college chemical design competitions and fine chemical experimental skills competitions has increased by more than 40% year-on-year; the employment rate and quality of graduates have significantly improved, and the proportion of graduates entering leading enterprises has increased by 35%, and the satisfaction of employers with the practical abilities of graduates has reached over 92% [5].

(2)Continuous optimization of teaching quality: Through the implementation of a diversified evaluation system, problems in teaching can be promptly identified and solved, and the target achievement rate of experimental courses has increased from 65% before the reform to 88%; teachers' teaching concepts have shifted from "centered on teaching" to "centered on learning", and their teaching abilities and engineering practice literacy have significantly improved, and more than 10 provincial-level teaching reform projects have been approved.

(3)Deep development of education-industry integration: Establish stable cooperative relationships with more than 5 enterprises, jointly build 2 provincial-level experimental teaching demonstration centers, develop 15 real enterprise project experimental cases, achieving "shared resources between schools and enterprises, joint cultivation of talents, and mutual win-win of achievements".

5.2 Reform Reflections

(1)Existing Problems: First, some local universities are limited by funds and equipment, and the construction of virtual simulation resources and high-end experimental equipment is insufficient, making it difficult to support large-scale innovative experiments; second, the depth of school-enterprise cooperation needs to be strengthened, and the enthusiasm of some enterprises in participating in teaching is not high, and the internship and training effects have not reached expectations; third, the quantitative indicators of the evaluation system still need to be further optimized, and the evaluation of some quality indicators is still subjective.

(2)Improvement Directions: First, increase investment, promote the joint construction and sharing of virtual simulation resources, and build a regional fine chemical experimental teaching resource platform; second, establish a school-enterprise cooperation incentive mechanism, provide policy support and financial subsidies to enterprises that actively participate in teaching, and deepen project cooperation; third, introduce big data analysis technology to optimize the evaluation index system, improve the objectivity and accuracy of evaluation; fourth, further promote the "research and development back to teaching" model, expand the coverage of innovative experiments, and comprehensively enhance students' innovative ability and research literacy.

6.Conclusion

Based on the OBE concept, the reform of experimental practice teaching in the fine chemical major has effectively solved the problem of disconnection between traditional teaching and industrial demands, and achieved a comprehensive improvement in students' practical abilities, innovative thinking, and professional literacy. The reform practice shows that the deep integration of the OBE concept and the experimental teaching of the fine chemical major is an effective path to improve the quality of talent cultivation in chemical engineering majors in the new engineering context. In the future, it is necessary to continuously deepen education-industry integration, optimize the evaluation system, strengthen resource support, and further improve the reform measures to cultivate more high-quality applied talents for the high-quality development of the fine chemical industry.

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