

Construction and Practice of the Three-Tier Linkage Teaching Model for the Oilfield Chemistry Major

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Abstract: As oil and gas resource development expands into deep-layer, deep-sea, and unconventional domains, there is an increasingly urgent demand for high-quality, application-oriented talents in the field of oilfield chemistry. Traditional teaching models exhibit significant deficiencies in bridging theory with practice and fostering students' innovative capabilities. Based on the pedagogical reform practices at Xi'an Shiyou University, this paper proposes and constructs a "Triple-Linkage" teaching model integrated via "Disciplinary Competitions, School-Enterprise Platforms, and Professional Experiments." It systematically elaborates on the theoretical foundations, construction pathways, implementation mechanisms, and practical outcomes of this model. Evidence from practice demonstrates that this approach effectively enhances students' practical skills and innovative literacy, creating a virtuous cycle characterized by "promoting learning through competition, driving education through industry-led engagement, and consolidating fundamentals through experimentation." This model provides a scalable paradigm for teaching reforms in oilfield chemistry-related majors.

Keywords: Oilfield Chemistry; Triple-Linkage; Teaching Model; Disciplinary Competitions; School-Enterprise Cooperation; Professional Experiments.

1. Introduction

Against the dual backdrop of the accelerated global energy structure transition and the continuous iteration of oil and gas exploration and development technologies, Oilfield Applied Chemistry, as a key discipline supporting the efficient development of oil and gas resources, is facing unprecedented technical challenges and talent demands. On the one hand, the large-scale development of deep, deep-sea and unconventional oil and gas resources has imposed higher requirements on high-end chemicals such as chemical oil displacement agents, intelligent drilling fluids and environmentally friendly fracturing fluids. On the other hand, the in-depth advancement of the green and low-carbon development philosophy has also set new standards for the environmental compatibility and sustainability of oilfield chemical technologies[1]. This trend not only drives the continuous expansion of the disciplinary frontiers, but also raises higher expectations for the engineering practice capabilities, systems thinking abilities and innovation capabilities of professional talents[2].

However, the current teaching model of the Oilfield Applied Chemistry major still exhibits a significant lag. In terms of curriculum design, teaching content overemphasizes the systematic impartation of fundamental theories, while cutting-edge disciplinary knowledge and the latest technological advances in the industry are difficult to be effectively integrated into classroom teaching, resulting in a structural mismatch between what students learn and what the industry requires. In the aspect of practical teaching, most experimental projects are confirmatory experiments where students follow pre-determined procedures[3]. The lack of comprehensive, design-oriented and innovative training makes it difficult to cultivate students' ability to independently solve complex engineering problems[4]. At the level of industry-university collaboration, most partnerships remain at the agreement level, lacking long-term operational mechanisms and in-depth

integration. Students can hardly access real engineering sites and engage in real-world projects, leading to an unbridgeable gap between theoretical teaching and engineering practice. The superposition of these issues severely restricts the coordinated development of students' engineering practice capabilities and innovative literacy, and fails to meet the industry's urgent demand for high-quality applied talents[5].

Faced with the aforementioned challenges, drawing on long-accumulated experience in teaching reform and based on the cutting-edge demands of the industry, we actively explore and systematically construct a three-tier linkage teaching model of "Disciplinary Competitions-Industry-University Platforms-Professional Experiments". Driven by disciplinary competitions, this model stimulates students' innovative awareness and competitive spirit. Supported by industry-university joint platforms, it bridges the "last mile" between classroom teaching and engineering practice. Based on professional experiments, it establishes a progressive and systematic training system for practical capabilities. The three components are organically integrated and operate in synergy, aiming to break down the barriers between traditional teaching segments, achieve deep integration of theoretical teaching and engineering practice, and promote the transformation of talent cultivation from "knowledge transmission" to "competence construction". This model will continuously deliver high-quality applied talents with solid theoretical foundations and outstanding practical capabilities to sustain the high-quality development of the oil and gas industry.

2. Connotation and Construction of the Three-Tier Linkage Teaching Model

2.1. Model connotation

The "Three-Tier Linkage" Teaching Model "Three-Tier Linkage" Teaching Model is a systematic teaching framework formed in the teaching reform practice of the Oilfield Applied Chemistry major. This model takes "Disciplinary

Competitions – Industry-University Platforms – Professional Experiments" as its three core dimensions. The three components are not only relatively independent with distinct functions, but also mutually supportive and synergistically advanced, jointly forming a teaching closed loop with unified objectives, coherent content and efficient operation.

As the first dimension of the model, disciplinary competitions take high-level disciplinary competitions as the carrier and focus on real-world engineering problems in the field of oilfield chemistry[6]. By organizing students to participate in high-profile events such as the China International College Students' Innovation Competition, the "Challenge Cup" National College Students' Extracurricular Academic and Scientific Works Competition, and the National College Students' Energy Conservation and Emission Reduction Social Practice and Science and Technology Competition, we guide students to stimulate innovative awareness, exercise systems thinking and enhance teamwork capabilities in the process of solving practical problems. Competitions are not only a platform for students to demonstrate their capabilities, but also a critical link connecting classroom teaching and engineering practice.

As the second dimension of the model, industry-university platforms build a bridge for students to access real engineering scenarios by relying on industry-university co-constructed laboratories and industry-university-research cooperation bases[7]. Through industry-university joint platforms such as the Kai Pu Oil and Gas Stimulation Technology Research Institute, we introduce real enterprise projects, technical challenges and engineering standards, enabling students to understand theoretical knowledge, master technical specifications and cultivate professional literacy in actual production environments. The platforms also serve as the implementation carrier for the dual-mentorship system, under which university faculty and enterprise engineers jointly guide students through the entire process from scheme design to engineering practice.

As the third dimension of the model, professional experiments focus on consolidating the foundation and systematically improving students' practical capabilities. By reconstructing the experimental teaching content, we establish a three-level progressive experimental system of "Basic - Comprehensive - Innovative": Basic experiments strengthen fundamental skills and standardized operations; Comprehensive exercises train the ability to integrate and apply multiple knowledge points; Innovative experiments encourage students to independently select topics, design experiments and conduct investigations, cultivating their scientific thinking and original innovation capabilities[8].

The core of the Three-Tier Linkage Teaching Model Three-Tier Linkage Teaching Model lies in synergy and closed-loop operation. At the objective level, the three components collectively serve the core goal of "cultivating students' ability to solve complex engineering problems". At the content level, competition topics originate from actual enterprise demands, and experimental projects are transformed based on competition outcomes and platform cases. At the operational mechanism level, a virtuous cycle of "Enterprises propose problems → Competitions provide solutions → Experiments verify results → Achievements feed back to industry" has been formed. Through the organic integration of the three components, the teaching effects of "learning promoted by competitions, teaching driven by

industry, and foundations consolidated by experiments" are truly realized, advancing the deep integration of theoretical teaching and engineering practice.

2.2. Construction Pathways

(1) Demand-Driven Competition Design: Achieving Precise Alignment Between Competition Content and Industry Demands

The educational value of disciplinary competitions depends on the degree of alignment between competition topics and engineering practice. To this end, the project team has systematically designed a demand-driven competition topic selection mechanism. Through industry-university joint platforms, we collect practical technical challenges faced by enterprises in fields such as fracturing fluid optimization, oil displacement agent development and wastewater treatment, and transform them into competition topics with engineering backgrounds. For example, targeting the synergistic optimization problem of drag reduction performance and flowback fluid treatment in shale gas fracturing processes, we set the competition topic "Self-Cleaning Shale Gas Fracturing Fluids"; addressing the urgent demand for intelligent chemical agents in the field of enhanced oil recovery (EOR), we set the topic "Molecular Design of Intelligent Oil Displacement Agents". All competition topics are jointly reviewed by enterprise technical experts and university faculty to ensure they possess both academic challenge and compliance with engineering practice standards, making disciplinary competitions a genuine bridge connecting classroom theory and field practice.

(2) Deepening Cooperation through Industry-University Co-Constructed Platforms: Establishing a Collaborative Education Mechanism for Industry-Education Integration

Industry-university joint platforms are the key carrier to bridge the "last mile" between university teaching and enterprise practice. Relying on industry-university co-constructed platforms such as the Kai Pu Oil and Gas Stimulation Technology Research Institute, the project team has explored and established a dual-mentorship system collaborative education mechanism. In the operation of the platforms, university faculty are responsible for theoretical guidance and academic standards, while enterprise engineers take charge of engineering practice and industry standards. Both parties jointly guide students through the entire process from technical research and scheme design to experimental verification. Enterprises not only provide real project cases and experimental sites, but also regularly send technical backbones to teach on campus, participate in competition judging and guide graduation projects, enabling students to access cutting-edge industry trends, understand engineering logic and familiarize themselves with enterprise processes during their studies. In addition, the platforms also undertake the function of teaching resource transformation, developing actual enterprise cases into teaching projects to feed back into classroom teaching and the construction of experimental systems.

(3) Reconstruction and Upgrading of the Experimental System: Establishing a Systematic and Progressive Training System for Practical Capabilities

Professional experiments are the cornerstone of cultivating students' practical capabilities. The project team has carried out a systematic reconstruction of the traditional experimental teaching system and established a new three-level progressive

experimental teaching paradigm of "Basic – Comprehensive – Innovative". At the basic experimental level, we strengthen training in basic skills such as standardized operation of experimental instruments and synthesis and characterization of chemical agents. At the comprehensive experimental level, we design comprehensive experimental projects covering the complete chain of "Oilfield Chemical Agent Synthesis – Performance Evaluation – Field Simulation Application", such as the experiment "Construction and Comprehensive Performance Evaluation of Fracturing Fluid Systems", which requires students to comprehensively apply knowledge from multiple courses to complete full-process operations from formula design to performance testing. At the innovative experimental level, we set up open-ended research topics and encourage students to independently select topics, design experimental schemes and conduct exploratory research. Through this three-level progressive design, students' practical capabilities have achieved a stepwise improvement from "being able to operate" to "being able to design" and further to "being able to innovate".

3. Implementation Mechanisms

To ensure the efficient operation of the Three-Tier Linkage Teaching Model, the project team has established a closed-loop operation mechanism of "Enterprises propose problems → Competitions provide solutions → Experiments verify results → Achievements feed back to industry", achieving dynamic alignment between teaching content and industry development.

(1) Enterprises Propose Problems: Demand-Driven Source Design

The industry-university joint teaching and research office regularly organizes "technical demand matchmaking meetings", where enterprise technical experts release practical technical challenges encountered in production. The university faculty team conducts pedagogical transformation of these topics to form competition questions suitable for students' ability levels, ensuring that competition content originates from real field sites and serves actual demands[9].

(2) Competitions Provide Solutions: Innovative Practice of Competition-Driven Learning

Under the dual guidance of university faculty and enterprise engineers, student teams conduct literature research, scheme design, experimental verification and achievement presentation around the competition topics[10]. The competition process not only exercises students' innovative thinking and teamwork capabilities, but also deepens their understanding and application of professional knowledge in the process of solving real-world problems.

(3) Experiments Verify Results: Technical Support for Achievement Implementation

Outstanding schemes generated in competitions are further verified and optimized based on industry-university co-constructed laboratories and professional experimental platforms. For example, targeting the competition scheme of "Self-Cleaning Shale Gas Fracturing Fluids", students complete formula optimization, performance evaluation and simulated application tests in the laboratory to ensure the feasibility and reliability of the scheme.

(4) Achievements Feed Back to Industry: Value Closed-Loop of Industry-Education Integration

Verified outstanding achievements are fed back to enterprise production practice through industry-university

cooperation channels, forming a value chain of "Teaching Achievements → Productivity Transformation". Meanwhile, competition achievements and experimental data are developed into teaching cases and fed back into classroom teaching and experimental teaching, realizing the continuous accumulation and iterative optimization of teaching resources.

4. Conclusion

The "Disciplinary Competitions - Industry-University Platforms - Professional Experiments" Three-Tier Linkage Teaching Model is an important exploration in the teaching reform of the Oilfield Chemistry program. Through the systematic integration of teaching resources, the establishment of a collaborative education mechanism, and the introduction of cutting-edge technical means, this model has effectively addressed key issues in traditional teaching, such as the disconnection between theory and practice and insufficient cultivation of innovative capabilities. In the future, the project team will further optimize the operation mechanism and expand its promotion scope, providing more exemplary reform pathways for talent training in Oilfield Chemistry and related disciplines.

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