

Exploration of a New Industry-Education Integration and Collaborative Talent Cultivation Mode for “Mechanical Basis of Chemical Equipment”

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Abstract:

Under the dual imperatives of emerging engineering education initiatives and the cultivation of applied talents, Mechanical Basis of Chemical Equipment—a core course that bridges theoretical knowledge and engineering practice for chemical-related disciplines—urgently requires pedagogical reform. Aiming at the problems in traditional teaching such as the disconnection between theory and practice, outdated curriculum content compared with industrial development, and a single evaluation system, this paper proposes a “four-in-one” integrated model of industry–education collaboration tailored to Yulin University’s institutional mission of “rooted in Yulin, serving the local community” and leveraging the region’s strengths in the energy and chemical sectors. This paper proposes a “four-in-one” new mode of industry–education integration and collaborative talent cultivation, combined with Yulin University’s school-running orientation of “based in Yulin and serving the local area” and the advantages of the regional energy and chemical industry. The model advances talent development through four synergistic pathways: reconstructing the curriculum system to reflect current industrial standards; innovating teaching methodologies to enhance engagement and applicability; co-constructing practical training platforms with industry partners, and refining evaluation mechanisms to better measure competency and readiness for professional roles. By aligning course content precisely with industrial demands and ensuring students’ practical competencies match job requirements, this approach provides robust support for cultivating high-quality, application-oriented professionals capable of driving the high-quality development of the regional energy and chemical industry.

Keywords:

Mechanical Basis of Chemical Equipment, Industry-education Integration, Collaborative Talent Cultivation

1. Introduction

With the transformation of China's energy and chemical industry towards high-endization, intelligence, and greenization, especially as Yulin is a national energy and chemical base, industrial clusters such as coal chemical industry and chlor-alkali chemical industry continue to expand. The demand for high-quality applied talents mastering core skills such as chemical equipment principles, design, operation, and maintenance is increasingly urgent [1]. As a basic course for the Chemical Engineering and Technology major, "Mechanical Basis of Chemical Equipment" integrates theoretical and engineering practical characteristics, and is a key carrier for cultivating students' engineering thinking, practical abilities, and innovative awareness [2]. However, under the traditional teaching mode, the course has many drawbacks: the teaching content focuses on theoretical derivation, which is disconnected from the actual production scenarios of enterprises; the practical link is weak, experimental equipment is updated slowly, and students lack training in hands-on operation and engineering problem-solving abilities; the teaching team lacks sufficient engineering practice experience, making it difficult to accurately meet industrial technical needs; the assessment method is single, making it difficult to comprehensively evaluate students' comprehensive literacy.

As an applied undergraduate university located in the core area of energy and chemical industry, Yulin University has always adhered to the school-running philosophy of "based in Yulin and serving the local area". In recent years, it has actively promoted the construction of the Modern Coal Chemical Industry College, and deepened industry-education integration through ways such as school-enterprise co-construction of courses, co-compilation of textbooks, and introduction of enterprise experts to teach [3]. Against this background, taking the course "Mechanical Basis of Chemical Equipment" as the entry point to explore a new mode of industry-education integration and collaborative talent cultivation in line with regional industrial characteristics can not only improve the quality of course teaching, but also transport more adaptable professional talents for the regional energy and chemical industry, realizing a virtuous interaction between education and industry.

2. Course Introduction

The course "Mechanical Basis of Chemical Equipment" in our college is offered for the Chemical Engineering and Technology major, with a total of 54 class hours, including 48 class hours of theoretical teaching and 6 class hours of practical teaching. The theoretical teaching content mainly covers traditional chapters such as basic engineering mechanics, chemical equipment materials, and vessel design; the practical teaching includes 2 confirmatory experiments and 2 weeks of course design. In recent years, the university has gradually promoted teaching reform, introduced multimedia teaching methods, and adopted case teaching for some chapters. However, the overall teaching mode is still constrained by the traditional lecture-based method, and the depth of industry-education integration is insufficient.

Relying on regional industrial advantages, Yulin University has established cooperative relations with enterprises such as Shaanxi Jingyi Chemical Industry and China Coal Yulin Energy and Chemical Industry, and invited enterprise experts to participate in curriculum teaching guidance. However, most of these cooperations remain at a shallow level, and a normalized and systematic collaborative talent

cultivation mechanism has not been formed. There is still a large gap between course teaching and the actual needs of enterprises.

3. Current Status of Course Teaching

Outdated curriculum content, disconnected from industrial needs. The current course textbooks still focus on traditional chemical equipment theories, lacking targeted explanations of characteristic equipment in Yulin's energy and chemical industry (such as large-scale coal chemical towers), and failing to integrate industry hot issues such as equipment energy-saving optimization and safety and environmental protection under the background of carbon peaking and carbon neutrality. Most of the teaching cases are general-purpose, which are disconnected from real problems encountered in enterprise production such as equipment selection, fault diagnosis, maintenance, and overhaul. Students find it difficult to connect theoretical knowledge with industrial practice.

Weak practical teaching links and insufficient engineering training. On the one hand, the practical teaching content is mainly composed of confirmatory experiments, with a low proportion of design-oriented and comprehensive experiments, which cannot cultivate students' innovative design abilities; on the other hand, the number of on-campus training equipment is limited and the technology is relatively backward, making it difficult to simulate large-scale and intelligent production scenarios of enterprises. However, due to high safety risks and heavy production tasks, real enterprise production sites are difficult to accept a large number of students for training, resulting in poor training effects on students' practical abilities.

Single assessment and evaluation system, making it difficult to comprehensively evaluate students' abilities. The current course assessment still mainly relies on the final written exam (accounting for 70%), and the usual performance (including homework and experimental reports) accounts for 30%. The assessment focuses on the memory of theoretical knowledge, ignoring the evaluation of students' practical operation abilities, engineering problem-solving abilities, and teamwork abilities. This single evaluation method cannot objectively reflect students' comprehensive literacy, nor can it guide students to attach importance to the cultivation of practical abilities.

4. Construction of a New Industry-Education Integration and Collaborative Talent Cultivation Mode

Combined with Yulin University's school-running orientation, regional industrial characteristics, and the current status of course teaching, a "four-in-one" new mode of industry-education integration and collaborative talent cultivation is constructed, which includes "modular reconstruction of the curriculum system, project-based innovation of teaching modes, virtual-real integrated construction of practical platforms, and diversified improvement of evaluation mechanisms", so as to realize the full-chain connection between industrial needs and talent cultivation.

Guided by the equipment technology needs of Yulin's energy and chemical industry (coal chemical industry, chlor-alkali chemical industry, etc.), we cooperate with local leading enterprises such as Shaanxi Jingyi Chemical Industry and China Coal Yulin Energy and Chemical Industry to fully integrate enterprise real projects, technical standards, and engineering cases into all links of course teaching [4]. Following the principles of "sufficient theory, emphasis on practice, and priority to innovation", we break the constraints of the disciplinary system of traditional courses, construct a

teaching system centered on engineering competence cultivation, and realize the integration of teaching, learning, doing, and researching.

4.1. Align with industrial needs and optimize content structure

Streamline traditional theoretical derivation content, retain essential knowledge points such as the basics of chemical equipment materials, core formulas for vessel strength calculation, and equipment sealing principles, and focus on the practical and applied explanation of theoretical knowledge to lay a foundation for subsequent practical links [5].

Incorporate characteristic content of Yulin's energy and chemical industry, and add sub-modules such as "Special Topics on Key Coal Chemical Equipment" and "Safety and Environmental Protection of Chemical Equipment". Invite enterprise experts to teach the structural characteristics, operating conditions, and maintenance points of commonly used equipment in local enterprises such as coal tar hydrogenation reactors, large-scale distillation towers, and heat exchangers; combined with actual enterprise cases, analyze industry hot issues such as energy-saving optimization technology of chemical equipment under the background of carbon peaking and carbon neutrality, and the selection and design of tail gas treatment equipment.

4.2. Innovate teaching modes and stimulate learning initiative

Adopt a "project-driven + virtual-real integration" teaching mode, integrate course knowledge points into specific project tasks, and realize the organic connection between theoretical teaching and practical teaching [6].

Taking real projects of energy and chemical enterprises as carriers, such as "Design of Heat Exchangers in a Certain Coal Chemical Enterprise", decompose the course content into multiple sub-tasks, and guide students to complete project research, scheme design, theoretical calculation, simulation analysis, achievement display and other links in groups. In the teaching process, teachers and enterprise experts provide joint guidance to help students solve theoretical and technical problems encountered in project implementation, and cultivate students' teamwork abilities and engineering problem-solving abilities [7].

Utilize the on-campus virtual simulation laboratory to develop a virtual simulation teaching system for chemical equipment, simulating scenarios such as operation, fault diagnosis, and maintenance of large-scale chemical equipment, such as start-stop operation of heat exchangers and emergency treatment of reactor overpressure. Allow students to conduct safe and repeated practical training in a virtual environment, making up for the shortage of real training sites.

4.3. Integrate school-enterprise resources and strengthen competence training

Adhere to the principle of "co-construction on campus and sharing off-campus", and jointly build a virtual-real integrated practical teaching platform with enterprises to provide students with a comprehensive practical training environment.

Relying on the Modern Coal Chemical Industry College of Yulin University, upgrade the existing process equipment training center, add a coal chemical equipment exhibition area, introduce decommissioned equipment such as heat exchangers and reactors for students' disassembly, assembly, and mapping training; cooperate with enterprises to develop a virtual simulation teaching platform for

chemical equipment, covering multiple modules such as equipment design, operation, and fault diagnosis, realizing the complementarity between virtual training and real operation.

Deepen cooperation with enterprises such as Shaanxi Jingyi Chemical Industry and China Coal Yulin Energy and Chemical Industry, co-build stable off-campus practical teaching bases, sign long-term cooperation agreements, clarify the responsibilities and obligations of both parties in student training, teacher training, project cooperation, etc., and realize the seamless connection between “classroom” and “job”.

4.4. Improve the evaluation mechanism in a diversified way

Break the traditional single assessment mode, and establish a diversified evaluation system based on “process evaluation as the mainstay, result evaluation as the supplement, and combination of quantitative evaluation and qualitative evaluation”, so as to comprehensively evaluate students’ mastery of theoretical knowledge, practical operation abilities, innovative abilities, and teamwork abilities [8].

Incorporate students’ classroom performance, completion of project tasks, quality of experimental reports, classroom test results, group tasks, etc., into the evaluation scope. Construct an evaluation subject system of “teacher evaluation + student mutual evaluation” [9]. Teachers mainly evaluate students’ mastery of theoretical knowledge and on-campus practical performance; student mutual evaluation mainly focuses on teamwork, communication and expression abilities in the process of project cooperation, so as to ensure the objectivity and comprehensiveness of evaluation results.

Adjust the weight of each evaluation link: the proportion of the final written exam is reduced to 60%, and the usual performance (including classroom performance and homework) accounts for 40%. Through weight adjustment, guide students to attach importance to the cultivation of practical abilities, and realize the goal of “promoting learning and practice through assessment”.

5. Conclusions

The construction and implementation of the new industry-education integration and collaborative talent cultivation mode for the course “Mechanical Basis of Chemical Equipment” is an important measure for our college to implement the goal of applied talent training and serve the development of the regional energy and chemical industry. Through the “four-in-one” joint efforts of modular reconstruction of the curriculum system, project-based innovation of teaching modes, virtual-real integrated construction of practical platforms, and diversified improvement of evaluation mechanisms, this mode effectively solves the core problems in traditional teaching such as the disconnection between theory and practice and a single evaluation system, and realizes the accurate alignment between teaching content and industrial needs, as well as the in-depth adaptation between practical abilities and job requirements.

It is believed that through continuous exploration and practice, this mode will provide strong support for cultivating more high-quality applied talents adapting to the high-quality development of the regional energy and chemical industry, and also provide replicable and promotable experience for the teaching reform of engineering courses in similar universities.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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