

Reform and Practice of the Talent Training System for Chemical Engineering Majors Under the Guidance of a Comprehensive Engineering Perspective

Liying Guo, Haiyue Wang, Rongrong Zheng, Xiaohui Song

School of Petroleum and Chemical Engineering, Shenyang University of Technology, Liaoyang 111003, China

Copyright: © 2026 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The transformation and upgrading of Liaoning's petrochemical industry urgently requires applied chemical engineering professionals with a systems engineering mindset and practical innovation capabilities. Addressing challenges in local universities' chemical engineering programs—including insufficient student professional identity, outdated curriculum frameworks, fragmented engineering practice training, and inadequate value-oriented education—this study adopts the chemical engineering curriculum at Shenyang University of Technology's School of Petrochemical Engineering as a framework. By integrating a holistic engineering perspective with outcome-based education (OBE) principles, aligning new engineering education initiatives with ideological-political education requirements, and establishing an integrated talent development model featuring “reverse design, tiered education, continuous practical engagement, competition-integrated teaching, and comprehensive ideological education,” the research implements six key reforms: restructuring curricula, developing interdisciplinary new engineering course platforms, creating seamless four-year practical progression chains, enhancing competition-driven learning mechanisms, building dual-qualified teaching teams, and fully embedding ideological-political elements into courses. These measures effectively address students' engineering competency gaps, improve talent-industry alignment, and provide a replicable model for revitalizing regional petrochemical industries and advancing the substantive development of undergraduate chemical engineering programs.

Keywords: Broad engineering perspective; OBE; New engineering education; Chemical engineering major; Talent development; Industry–education integration

Online publication: October 26, 2026

1. Introduction

The petrochemical industry is a pillar sector of Liaoning Province, with its refining capacity accounting for one-fifth of the national total. However, during the industry's transition toward refinement, greening, and intelligentization, there is a significant shortage of high-quality frontline engineering professionals. The School of Petrochemical Engineering at Shenyang University of Technology offers programs in Chemical Engineering

and Technology, Applied Chemistry, and Polymer Materials and Engineering, two of which are national first-class undergraduate programs and one is a provincial first-class program, with its educational focus dedicated to serving Liaoning's petrochemical industry^[1].

The current traditional talent cultivation model for the chemical industry exhibits significant shortcomings: societal biases lead to weak professional identity among students, with a notable rate of major changes; curriculum content updates lag, and new engineering elements such as digital chemistry, green safety, and intelligent simulation are inadequately integrated; practical teaching relies predominantly on verification experiments, while corporate internships are often limited by safety constraints, resulting in a lack of hands-on experience that hinders the development of comprehensive engineering thinking; educational efforts focus primarily on knowledge transmission, lacking systematic emphasis on engineering ethics, craftsmanship spirit, and national commitment^[2-4].

China introduced the concept of "Big Engineering Vision" in 1996, yet most universities have remained confined to theoretical research without establishing a comprehensive implementation framework covering the entire talent development process. This study adopts the Big Engineering Vision as an overarching guideline, integrates the Objectives-Based Education (OBE) principles from engineering education accreditation, and focuses on four core educational objectives—engineering design, innovative practice, professional competence, and national commitment^[5-7]—to drive systematic reforms in chemical engineering education. At the theoretical level, it refines implementation pathways for the Big Engineering Vision in regional undergraduate chemical engineering programs, combines OBE, new engineering education approaches, and curriculum-based ideological education to enrich the theoretical framework for applied engineering talent cultivation^[8-10]. Practically, it addresses challenges such as gaps in engineering practice, low professional identification, and superficial industry-academia collaboration by establishing a tiered, iterative training system^[11,12]. These innovations can be fully implemented across three major chemical engineering programs at the university, promoted nationwide among chemical engineering institutions in Liaoning Province, and serve as a replicable model for similar institutions. Industrially, they cultivate application-oriented professionals tailored for positions in fine chemicals, polymer materials, and intelligent chemical technologies, driving the refined, green, and intelligent transformation of Liaoning's petrochemical sector^[13-15].

2. The core issues in current talent cultivation for the chemical engineering field

Based on the actual educational practices of our college's chemical engineering programs and industry research, we have identified four key issues that hinder the improvement of talent cultivation quality.

2.1. Insufficient professional identity among students and poor student retention rate

Society holds a one-sided and negative perception of the chemical industry, while both parents and students exhibit misconceptions regarding the professional value of this field. During their academic years, a significant number of students in Chemical Engineering and Technology programs switch majors or leave the program, with few choosing to transfer into related fields. Students generally lack a strong commitment to pursuing a long-term career in the petrochemical industry and demonstrate insufficient learning initiative.

2.2. The training program is out of sync with the needs of the new engineering industry

The existing curriculum system primarily focuses on traditional chemical engineering theories, lacking cutting-

edge topics such as digital chemistry, AI-driven chemical engineering, green and low-carbon technologies, and safety and environmental protection. There is insufficient interdisciplinary integration, and the course design fails to meet the comprehensive competency requirements of enterprise positions. Moreover, the relationships between graduation criteria, course objectives, and teaching content remain unclear, with no established mechanism for continuous improvement.

2.3. The training system for engineering practice skills is fragmented

Practical teaching primarily relies on classroom verification experiments, with a low proportion of comprehensive and design-oriented projects; factory internships are short, focusing more on observation than hands-on practice; the components of experiments, course designs, corporate internships, and innovation/entrepreneurship competitions operate in isolation, failing to form a cohesive four-year engineering competency training framework; resources for virtual simulation and school-enterprise training bases are not fully integrated.

2.4. The comprehensive collaborative education mechanism remains inadequate

The faculty team's engineering practice background requires enhancement, and the "dual-qualified, dual-skilled" structure still needs optimization; course-based ideological education remains fragmented, with ideological elements and professional knowledge integrated mechanically, while engineering ethics, industry mission, and craftsmanship spirit have not been systematically integrated into the entire teaching process; there is insufficient synergy among classroom instruction, competitions, research activities, and corporate internships as part of the second-stage educational framework.

3. The overall framework for reforming talent cultivation under the guidance of a comprehensive engineering perspective

3.1. Overall approach to reform

We adopt a comprehensive engineering perspective to coordinate the entire talent cultivation process, adhering to the OBE principles of "student-centeredness, outcome orientation, and continuous improvement," and building upon our university's distinctive educational features of "solid foundation, emphasis on practice, pursuit of innovation, and high quality." Reforms are advanced simultaneously across six dimensions—curriculum design, course structure, practical teaching, competition-based education, faculty development, and ideological and political education integrated into courses—to establish a closed-loop educational system. This approach involves determining training objectives and graduation competency requirements based on regional industrial needs, developing tiered course modules, delivering instruction through diverse practical platforms, refining teaching content using multi-dimensional assessment feedback, and establishing a sustainable improvement mechanism.

3.2. Core objectives of the reform

With the core mission of cultivating applied chemical engineering professionals who achieve comprehensive development in moral, intellectual, physical, aesthetic, and labor education, while possessing systematic engineering thinking, innovative design capabilities, strong engineering ethics, and a sense of national commitment, the institution focuses on establishing a first-class chemical engineering program cluster with

distinctive new engineering characteristics. It has developed a robust curriculum and practical training system aligned with engineering education accreditation standards, continuously supplying frontline technical talent for the fine chemicals, polymer science, and intelligent chemistry sectors to Liaoning's petrochemical industry, thereby empowering regional industrial transformation and upgrading.

3.3. Six key implementation paths for core reforms

(1) OBE Reverse Reconstruction Talent Development Program

Based on multidimensional survey data from enterprises, graduates, and current students, the training program is revised in a reverse manner; secondary indicators for graduation requirements are refined, and the competency support points corresponding to each course are clearly defined; new engineering disciplines such as green chemistry, intelligent simulation, safety and environmental protection, and digitalization are integrated into the curriculum structure; an annual course achievement evaluation mechanism is established, and the teaching syllabus is dynamically adjusted by incorporating feedback from enterprises, competition results, and student assessment data to achieve closed-loop optimization of teaching quality.

(2) Establish a three-stage interdisciplinary curriculum platform for new engineering disciplines

The program adopts a tiered structure of “2 years of foundational training – 1 year of specialized training – 1 year of personalized, distinctive training”: the foundational phase strengthens general knowledge in mathematics, physics, chemistry, and engineering; the specialized phase offers core courses in chemical processes, equipment, and materials; the personalized phase establishes an interdisciplinary course selection platform covering energy chemistry, fine chemicals, and advanced polymer materials, incorporating specializations in AI empowerment, low-carbon environmental protection, and workplace safety. Students independently select courses based on their career aspirations, enabling tailored education.

(3) Establishing a progressive engineering practice system spanning four years without interruption

The program integrates four key practical platforms: basic laboratories, on-campus training centers, industry-academia internship bases, and faculty research platforms, forming a comprehensive practice chain that spans “basic experiments – integrated process design – chemical engineering training – corporate internships – scientific research innovation.” Lower-year students develop operational skills through basic experiments; mid-to-higher-year students engage in comprehensive design of unit equipment and full-process technologies; while senior-year students enhance their engineering proficiency by utilizing virtual simulation systems, participating in corporate field internships, and working on faculty-led research projects. Practical engineering courses account for over 30% of the total curriculum hours at the college, supported by integrated virtual-real training facilities covering distillation, polymerization, crude oil processing, and microchannel reactions, thereby addressing limitations in hands-on enterprise experience.

(4) Establish a competition-integrated education mechanism that promotes learning through competitions and fosters holistic development.

Integrate chemical engineering design competitions, chemical engineering principles competitions, and innovation and entrepreneurship contests into regular teaching programs, transforming competition projects into comprehensive experiments and course design topics; leverage these competitions to encourage students to independently conduct literature reviews, collaborate in teams, and optimize process designs, thereby bridging the gap between theoretical knowledge and real-world engineering challenges; organize faculty and student participation in academic competitions at universities both within and outside the province to broaden engineering perspectives while simultaneously enhancing innovative thinking and teamwork skills.

- (5) Combining talent recruitment with professional development to build a dual-qualified teaching team that integrates full-time and part-time faculty members.

Internally, a mentorship system for young teachers has been established to support faculty members in conducting postdoctoral research and industry training at enterprises, while enhancing the long-term mechanism for cultivating professional ethics and teaching standards. Externally, versatile technical professionals with frontline industrial experience have been recruited; senior engineers from companies such as Liaoyang Petrochemical and Liaoning Aoke Group have been appointed as instructors for off-campus internships and course design projects, forming a collaborative teaching team comprising full-time university faculty and part-time industry experts.

- (6) Promote the deep integration of ideological and political education into curriculum across all educational domains.

Establish a joint teaching research group comprising specialized course instructors and ideological and political education teachers to systematically identify ideological and political elements within chemical engineering courses, ensuring comprehensive integration of such elements throughout the curriculum. Utilize major petrochemical projects as case studies to foster students' sense of national identity; leverage topics related to green chemistry and workplace safety to emphasize engineering ethics and ecological responsibility; employ examples of process optimization and product development to cultivate a spirit of excellence; and collaborate with career planning courses to guide students in establishing roots at Liaoning Petrochemical's grassroots level while developing sound employment values.

4. Outcomes of the reform and key innovations

4.1. Outcomes of the reform

The college's chemical engineering programs leverage the National Petrochemical Engineering Practice Education Center and five provincial-level teaching platforms to advance talent development reforms. During project implementation, they collaborated with leading provincial petrochemical enterprises such as Liaoyang Petrochemical and Aoke Group, establishing joint laboratories and stable off-campus internship bases, thereby creating a robust platform for university-industry collaborative education. Moving beyond fragmented curriculum approaches, the program integrates four core educational philosophies—comprehensive engineering perspective, OBE (Outcomes-Based Education) certification, new engineering disciplines, and ideological and political education embedded in courses—coordinating the entire talent cultivation process to build an integrated, closed-loop, and sustainable talent development system.

In practical education, the program has established a progressive hands-on curriculum spanning all four years of university study, integrating four major on-campus practice platforms. By adopting a blended teaching model that combines virtual simulations with offline practical training, it addresses the shortage of practical resources for corporate internships while systematically cultivating students' engineering mindset and enhancing their core competencies in solving complex chemical engineering problems. Through systematic development, the program has achieved comprehensive outcomes: designing talent cultivation plans and corresponding teaching syllabi aligned with new engineering education principles; establishing interdisciplinary course systems for emerging engineering fields; compiling tiered practical guides and collections of ideological education cases for chemical engineering courses; developing replicable competition-integrated teaching models and standardized dual-qualified faculty development frameworks; publishing

multiple educational reform papers; securing numerous university- and provincial-level teaching innovation projects; and winning various teaching achievement awards—all supported by both practical implementation results and theoretical research foundations. These reforms benefit multiple stakeholders across the institution, directly benefiting over 2,000 undergraduate students annually in all chemical engineering programs. The program also shares standardized reform paradigms with provincial universities offering chemical engineering programs and disseminates its experiences through academic journals and national teaching conferences, serving as a reference model for chemical engineering program development at regional applied universities nationwide.

Through comprehensive evaluation utilizing multiple channels—including questionnaire surveys, academic performance data analysis, and corporate visits and follow-ups—the reform has demonstrated remarkable educational outcomes. At the student level, professional identity has steadily strengthened, the attrition rate due to major changes has been effectively reduced, while engineering design proficiency, awards won in academic competitions, employment alignment rates, and corporate satisfaction have all seen significant improvement, equipping students with the comprehensive ability to address complex chemical engineering challenges independently. Among faculty members, teaching capabilities in engineering practice instruction and curriculum-based ideological education have been substantially enhanced, resulting in the establishment of a stable, high-quality teaching team with outstanding pedagogical expertise. From a regional development perspective, this reform has created a distinctive talent cultivation model tailored to Liaoning's petrochemical industry, addressing the shortage of applied technical professionals in the sector, strongly supporting regional petrochemical industrial upgrading, continuously enhancing the industry influence and enrollment appeal of the university's chemical engineering program, and contributing to high-quality local economic development.

4.2. Reform, innovation, and distinctiveness

The reform achieves multidimensional innovation by deeply integrating four core educational philosophies: a comprehensive engineering perspective, OBE (Outcomes-Based Education) accreditation in engineering education, new engineering disciplines, and curriculum-based ideological education, thereby establishing an integrated closed-loop talent development system. It employs a three-stage tiered training approach complemented by an interdisciplinary elective platform, incorporating elements of green, intelligent, and safe chemical engineering to balance standardized training with personalized development. A four-year coherent practical training framework is developed, leveraging diverse virtual and physical practice platforms to address the shortcomings of corporate internships and foster systems engineering thinking. Six key components—classroom instruction, academic competitions, research projects, corporate internships, curriculum-based ideological education, and faculty development—are interconnected, forming a comprehensive collaborative education model spanning teaching, competitions, research, and industry engagement. This reform package is tailored to the resource capabilities of local undergraduate institutions, featuring low implementation costs and accessibility barriers, making it suitable for replication and promotion across applied chemistry programs at universities serving regional industries nationwide.

5. Conclusion

To address the high-quality development needs of Liaoning's petrochemical industry and tackle prominent

challenges such as insufficient engineering mindset in chemical engineering education, gaps in practical training, and fragmented value-oriented guidance, this study adopts a comprehensive engineering perspective as its core framework while integrating outcome-based education (OBE) principles. It implements systematic teaching reforms across six dimensions—curriculum design, instructional structures, practical training, competition-driven learning, faculty development, and ideological education integration—to establish a tiered, industry-academia collaborative model for cultivating applied chemical engineering professionals. Leveraging established first-class program foundations, enhanced training platforms, and regional petrochemical resources, the initiative creates a continuous improvement mechanism that effectively enhances students' engineering practice skills, innovative design capabilities, and professional competence, ensuring a sustained supply of high-caliber engineers to the industry. Future efforts will monitor reform outcomes, dynamically refine curricula and practical training systems based on feedback from enterprises and graduates, and continuously improve the talent cultivation paradigm under the big engineering perspective, providing actionable insights for enhancing local undergraduate chemical engineering programs in the era of new engineering education.

Funding

Research project on undergraduate teaching reform in general higher education institutions, Liaoning Provincial Department of Education, “Exploration and Practice of Talent Training Models for Chemical Engineering Majors Under the Perspective of Engineering (Project No.: 2025YBXM1310)”

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Wang K, Guo L, Wang L, et al., 2025, Reform and Exploration of Innovative Talent Cultivation Models for Polymer Materials and Engineering Majors under the New Engineering Education Framework. *Educational Theory and Research*, 3: 127–129.
- [2] Guo L, Zheng R, Song X, et al., 2024, Research on the Reform of Ideological and Political Education in Chemical Engineering Courses from the Perspective of Holistic Education. *Education World*, 6(7): 241–242.
- [3] Li P, 2011, The Comprehensive Engineering Perspective and the Pathways for Engineering Education Reform in China. *Higher Engineering Education Research*, 3: 1–3.
- [4] Zhu J, 2023, Innovation in Classroom Teaching Models for Chemical Engineering Majors under Engineering Education Accreditation. *Guangzhou Chemical Industry*, 51(11): 145–147.
- [5] Zhou L, Wu J, 2024, Research on Countermeasures for Deep Integration of Party Building and Discipline Development in Universities during the New Development Stage. *China Higher Education*, (21): 56–58.
- [6] Zheng X, Tian S, 2023, The Current Status and Optimization Strategies for Extending Comprehensive Strict Party Governance in Universities to the Grassroots Level. *Journal of National Academy of Educational Administration*, (6): 78–83.
- [7] Huang X, Li L, 2024, Practical Pathways and Innovative Mechanisms of Party Building Leading Technological Innovation in Engineering Universities. *Higher Engineering Education Research*, (3): 167–171.

- [8] Qin P, Ying F, Liu J, 2026, Exploration and Practice of Talent Cultivation Models for Computer Science Programs at Local Undergraduate Universities Based on OBE. *Journal of Liupanshui Normal University*, 38(4): 44–55.
- [9] Sun R, Wang Z, Liu X, 2026, Innovative Approaches to Integrating Ideological and Political Education into Practical Courses for Materials Science Majors under the Framework of New Engineering Education and Engineering Accreditation. *Higher Education Journal*, 12(20): 179–183.
- [10] Wei B, Wang Z, Liu L, 2025, Exploration of Ideological and Political Education in Practical Courses—Guided by the Cultivation of Craftsmanship Spirit. *Computer Knowledge and Technology*, 21(10): 157–160.
- [11] Yang Y, Liu J, Han Y, et al., 2025, Construction and Exploration of a Practical Teaching System for Collaborative Talent Cultivation between Universities and Enterprises in Application-Oriented Institutions: A Case Study of Dalian Ocean University. *China Journal of Multimedia and Network Teaching (First Ten Days Issue)*, (10): 132–135.
- [12] Chen Y, 2025, Innovation Research on Three-Level Progressive Practical Teaching in International Business Programs at Higher Vocational Colleges Enhanced by Artificial Intelligence. *Public Relations World*, (18): 105–107.
- [13] Li C, Sun X, 2022, Research on Enhancing the Supply of Vocational and Technical Skills Personnel in Regional Petrochemical Industries: A Case Study of Panjin City. *Inner Mongolia Science, Technology and Economy*, (10): 29–30.
- [14] Chen L, Wang H, Ai C, 2014, Cultivation of “Double High” Talents under the Background of Industrial Transformation and Upgrading. *Vocational Education*, (36): 32–34.
- [15] Dai L, 2026, Experiences and Methods of Teaching Reform in Introduction Courses at Local Applied Universities Under the OBE Concept. *Journal of Longyan University*, 44(1): 104–109.

Publisher’s note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.