Research on the Mechanism of Industry-Education Integration and Collaborative Education for the Cultivation of Application-Oriented Talents in the Applied Chemistry Major at Kashi University

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Abstract. As a typical integration of science and engineering, the Applied Chemistry major is crucial for cultivating application-oriented talents via industry-education integration and collaborative education. Taking Kashi University (China's westernmost university) as a case, this study explores its Applied Chemistry program. Through multi-dimensional reforms (curriculum optimization, application-oriented teaching innovation, faculty practical capacity improvement, experimental platform upgrading, school-enterprise cooperation, and students' practical skill enhancement), the industry-education integration and collaborative education model effectively connects students' theory with practice, cultivates high-quality application-oriented talents, and promotes regional chemical industry development.

Keywords: Industry-Education Integration; Collaborative Education; Cultivation of Application-Oriented Talents; Applied Chemistry Major

1 Introduction

In November 2015, the Ministry of Education, in conjunction with the National Development and Reform Commission and the Ministry of Finance, jointly promulgated the "Guiding Opinions on Promoting Certain Local Ordinary Undergraduate Institutions to Transition to Application-Oriented Institutions." This pivotal initiative marked the official commencement of the transformation of local undergraduate colleges toward application-oriented education, prompting numerous universities to embark on the exploration of novel training paradigms [1-4].

In Dec 2017, the State Council's Notice emphasized deepening industry-education integration to link the educational chain, talent pipeline, industrial framework and innovation processes. With the Ministry of Education's new engineering initiative, applied chemistry (a key interdisciplinary field) faces opportunities and challenges; industry-education integration becomes a focus of higher education reform to align teaching with industry and meet societal talent demands [5-7].

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In Apr 2019, Tianjin University launched its New Engineering Construction Plan 2.0, shifting from advocacy/strategic design to practical implementation and quality improvement.

In Oct 2019, the National Development and Reform Commission and 6 departments stressed industry-education integration in the National Implementation Plan, regarding it as a strategy for education, talent, industry and economic development. Ministry of Education's Wu Yan noted it as a basic way for university-enterprise collaboration to improve talent training quality [8,9]. Many Chinese universities have since implemented industry-education integrated applied talent programs, with relevant outcome analyses [10-13].

As an application-oriented discipline, applied chemistry is closely linked to multiple industries. Amid technological and industrial transformation, its reform under the "new engineering" philosophy focuses on enhancing knowledge application, strengthening industry ties and optimizing collaborative education to align talent training with emerging technologies, industries and business models.

Kashi University, a modern comprehensive university in China's westernmost region, plays an irreplaceable role in Xinjiang's basic education, social stability and economic development. Established in 2011, its applied chemistry program enrolls over 100 students annually and has cultivated more than 1,000 professionals in a decade, contributing to China's and Xinjiang's applied chemistry-related industries.

With China's rapid economic growth and industrial transformation, the chemical sector demands more high-quality application-oriented talents. For Kashi University in southern Xinjiang, a key reform challenge is how its applied chemistry program meets this demand, requiring an application-centered orientation adjustment. Industry-education integration and collaborative education are crucial for enhancing students' practical skills, innovation and professional competence.

This study explores effective pathways and mechanisms for industry-education integration and collaborative training in the program, aiming to provide a reference for building a scientific application-oriented talent cultivation system.

2 Global and Domestic Practices in Applied Talent Cultivation

2.1 International Practices

Germany and the UK are typical examples of international applied talent cultivation. Germany adopts a tripartite governance system of "university autonomy-government supervision-social participation": universities manage personnel, develop curricula and conduct international exchanges; the government regulates macroscopically through funding and quality assessment; society participates in talent selection, demand forecasting and cultivation, forming a closed-loop. For faculty, a "dual-qualified" mechanism is implemented, with enterprise experts undertaking practical teaching if faculty are unqualified. Curricula are co-constructed by universities (professional knowledge) and enterprises (skills training via external centers); 60%-70% of teaching is enterprise-based, 30%-40% on campus, with outcomes evaluated by third parties.

The UK adopts a market-oriented model. The government conducts performance-based funding assessment via intermediaries; universities adopt corporate governance with trustee boards dominated by external directors. Education competition is promoted by removing enrollment caps and prioritizing tuition fees. Faculty are selected under "academic-industry-teaching" standards with industry experience; new teachers receive pre-service training, and a "dual-mentor" model is adopted (on-campus mentors for theory, enterprise experts for skills). A triadic cultivation model (flexible academic system, demand alignment, alternating work-study) is established, with pathways including full-time and "sandwich" modes. Universities and enterprises co-develop segmented curricula (e.g., "1+2+1"), requiring enterprises to manage students as quasi-employees with ≥45 weeks of practical training. Talent demand is matched via industry research, with a three-dimensional quality monitoring system (enterprise, mentor, student self-assessments) to deepen industry-education integration.

2.2 Domestic Practices

Since 2016, Guangdong Province has promoted the transformation of higher education institutions toward applied talent cultivation via policy guidance, pilot programs and systemic reforms. Adopting a top-down and pilot-first approach, it focuses on faculty, talent and discipline reforms: a "dual-qualified and dual-capable" teacher training system is implemented, with delegated professional title evaluation and bidirectional university-enterprise talent exchanges; government-enterprise joint education and communication platforms are built to align curricula with industrial demands; new major evaluation and dynamic program adjustment are enforced, and industry colleges are established to integrate talent cultivation, technological services and achievement transfer.

Since 2015, Zhejiang Province has advanced applied talent cultivation through policy leadership, pilot demonstrations and systemic reforms. It emphasizes top-level design, selects demonstration institutions, delegates professional title evaluation and introduces social service-oriented titles to elevate applied talent development. Enrollment plans are adjusted to expand its scale; the "Five One Batch" project (alliances, bases, enterprises, engineering and talent projects) is launched to build mixed-ownership industrial colleges. Discipline structures are optimized by linking industrial, innovation and discipline chains, forming a "policy-driven, pilot breakthroughs, deep industry-education embedding" pathway.

Both provinces promote applied talent cultivation through policies (e.g., applied university transformation opinions) and pilot-first strategies (e.g., dynamic program adjustment). Professional title reform (Zhejiang's social service titles, Guangdong's bidirectional talent mobility) incentivizes faculty participation. However, challenges such as disciplinary conceptual biases remain, requiring further efforts to remove institutional and cultural barriers.

3 Mechanism for Cultivating Application-Oriented Talents through Industry-Education Integration and Collaborative Training

3.1 Construction of Collaborative Training Model

Industry-education integration is crucial for contemporary application-oriented education, enabling resource sharing, complementary advantages, and synergy among the educational chain, talent development, industrial framework, and innovation pathways. Its paradigms include school-enterprise alliances, talent cultivation frameworks, co-constructed entities, achievement transformation, technology development, and resource sharing, among which the collaborative training model is pivotal. Based on the Kashi region's characteristics and existing industry-education integration models, a collaborative training model involving universities, enterprises, and research institutions has been constructed for the applied chemistry program (Figure 1). In this model, universities and enterprises jointly establish practical teaching bases (enterprises provide internships and production environments), while universities and research institutions offer cutting-edge research outcomes and technical solutions to address enterprise challenges, collectively formulating talent cultivation plans, optimizing resource allocation, and improving efficiency.

With Kashi University's deepened collaboration with relevant enterprises and research institutions, its collaborative talent training program is being revised. Guided by production needs and engineering education accreditation standards, aligned with new chemical engineering discipline construction, universities and enterprises will jointly design professional talent development objectives, establish cultivation standards, define graduation requirements, and develop a comprehensive talent cultivation program and curriculum system, ensuring talent development matches local industrial demands.

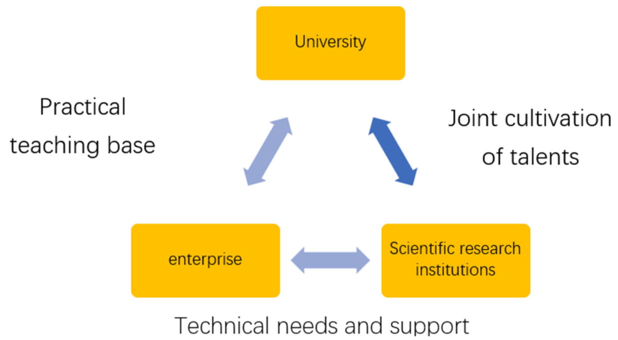

Fig. 1. Collaborative Training Model of the Applied Chemistry Program at Kashi University

3.2 Curriculum Design and Teaching Reform

Curriculum design and teaching reform are vital to the collaborative training model. Based on the Outcome-Based Education (OBE) philosophy, the existing curriculum system is evaluated and optimized, focusing on applicability and practicality-comprehensive, design-oriented experimental projects are added to professional course experiments, while demonstrative and verification experiments are reduced. Kashi University's applied chemistry program totals 2,590 teaching hours: 968 for general education (excluding comprehensive quality courses), 1,570 for professional courses (including electives), and 52 for practical classes. It also includes 39 weeks of practical training (distinct from general/professional course experiments), with an 18-week professional internship in the seventh semester. This allows students to engage in enterprise production environments, enhancing practical skills and bridging the gap between theory and practice (Figures 2 and 3).

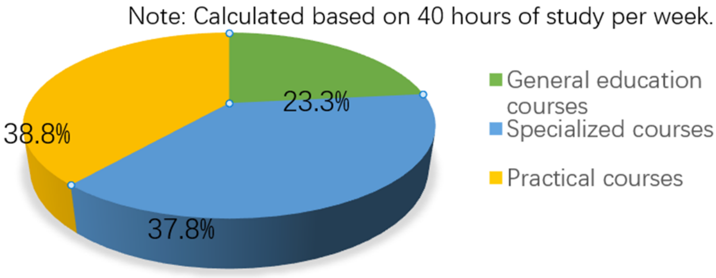

Fig. 2. Structure of course types in the Applied Chemistry program at Kashgar University

It is imperative to strengthen curriculum-industry ties by integrating enterprise case studies and cutting-edge technologies to align course content with real-world demands. Adapting to Kashi's industrial characteristics, the applied chemistry program's compulsory courses add "Natural Products and Chemistry," broadening students' understanding of Xinjiang's characteristic natural mineral and medicinal resources and fostering recognition of local enterprises. Given Kashi's renowned Uyghur-style cuisine popular among domestic and international tourists, the program's electives include "Food Chemistry," enabling students to explore the scientific principles behind local specialty dishes and equipping them to work as technicians in local small food processing enterprises, supporting the regional goal of cultivating application-oriented talents. Additionally, Kashi University promotes teaching method reform, adopting project-based and case-based teaching that integrates faculty research projects and student innovation initiatives to foster students' creative thinking and practical skills, enriching the educational experience and meeting industrial needs.

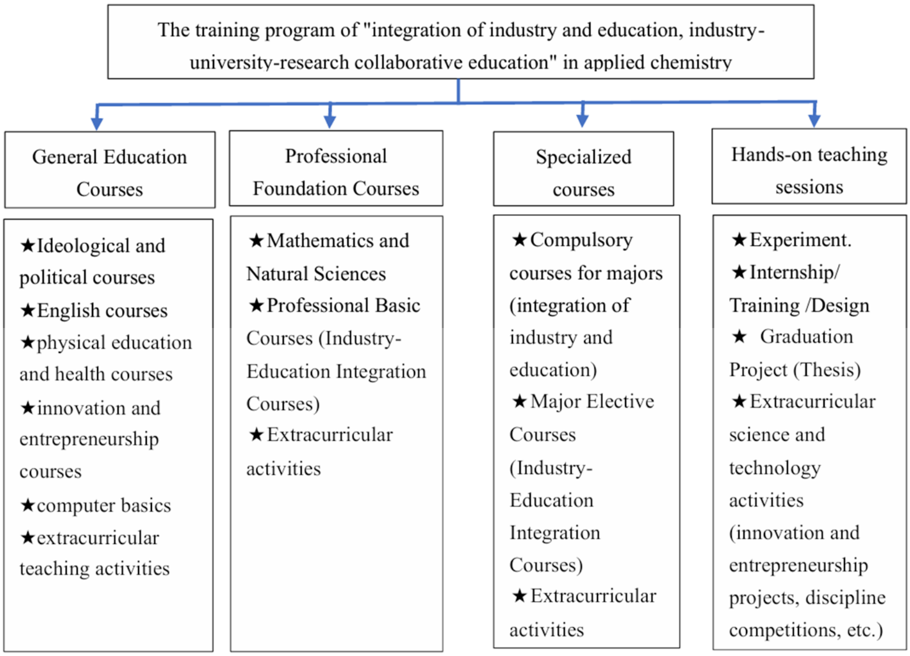

Fig. 3. The training program of "integration of industry and education, industry-university-research collaborative education" in applied chemistry

3.3 Practical Teaching and Laboratory Platform Development

Practical instruction constitutes a vital element in the nurturing of talent within the applied chemistry program. To better accommodate the training of application-oriented professionals, Kashi University is refining its practical teaching framework and advancing the development of laboratory platforms, thereby establishing a multi-tiered practical teaching system. This initiative emphasizes an increased focus on integrated design and research-oriented experiments, building upon foundational experiments found in courses such as General Chemistry and Chemical Engineering Principles. The innovative research-oriented experiments leverage platforms associated with the university's innovation projects as well as faculty research initiatives, actively encouraging faculty members to involve second- and third-year undergraduates in their project teams. In response to the actual teaching environment, faculty are also establishing specialized innovation studios. Furthermore, considerable efforts are being dedicated to enhancing the informatization of laboratory facilities; for instance, a virtual simulation experiment platform has been introduced in the "Chemical Engineering Principles" course to augment the efficiency and effectiveness of laboratory instruction. In addition, collaborative partnerships with enterprises are being forged to jointly develop practical teaching bases that immerse students in authentic production environments and provide valuable internship opportunities. This endeavor significantly enhances their practical skills and professional competencies. The construction of the practical teaching cultivation system at Kashi University is depicted in Figure 4.

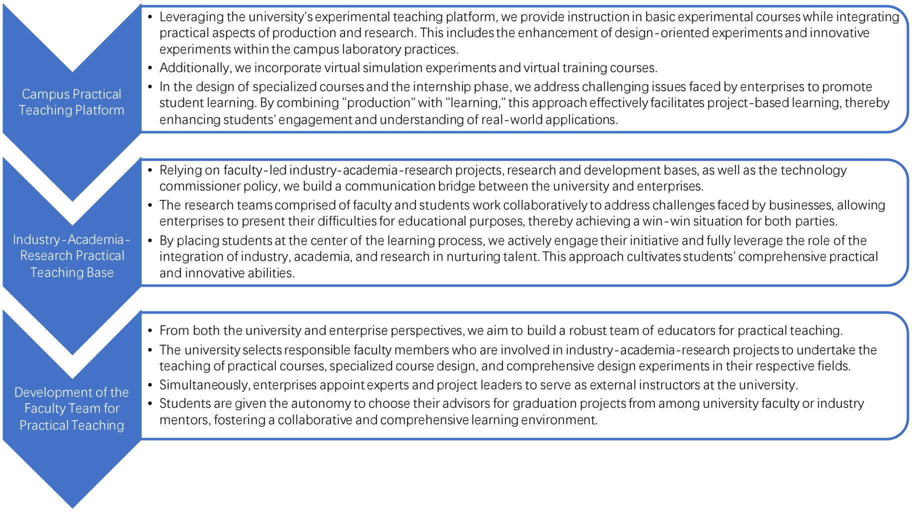

Fig. 4. Development of the Practical Teaching and Training System for the Applied Chemistry Program at Kashi University

3.4 Faculty Development and Management

A strong faculty team is fundamental to the collaborative education model. Faculty collaborative talent cultivation capabilities can be enhanced through three key approaches: training integrating industry experience and academic scholarship, advanced degrees (PhDs/postdoctoral qualifications) with practical training, and involvement in relevant industrial activities [14]. Kashi University prioritizes faculty development and management, focusing on improving their professional and practical competencies. To boost research capabilities, it promotes faculty participation in research projects and industry-academic partnerships, linking research outcomes to teaching effectiveness and performance. For practical teaching skills, the university encourages faculty to take enterprise internships/temporary assignments to refine abilities and understand industry dynamics, and is establishing a comprehensive evaluation and incentive system to stimulate enthusiasm and innovation.

Located in southern Xinjiang, Kashi University faces challenges in faculty quantity, qualifications, and practical engineering expertise. To address this, the applied chemistry program leverages its characteristics and adopts three strategies: recruiting outstanding domestic/international PhDs and professors, engaging “silver-age teachers” (retired faculty from prestigious universities), and collaborating with enterprises to hire senior industry professionals as external advisors. These industry mentors provide student internship training and periodic university lectures, enhancing both faculty and student practical competencies.

In the past two years, the program has recruited 2 silver-age professors, 2 full-time PhD faculty, 2 jointly trained doctoral educators (3 with substantial industry experience), and 2 enterprise-based industry mentors, significantly improving its application-oriented talent cultivation capacity and quality. The current faculty structure is shown in Figure 5.

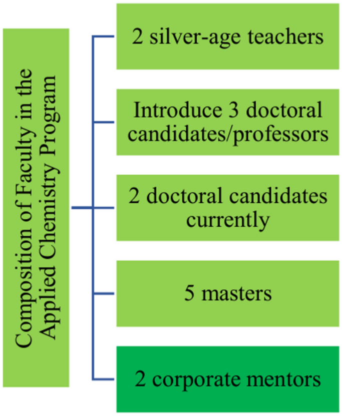

Fig. 5. Current Faculty Structure of the Applied Chemistry Program at Kashi University

3.5 Collaboration Between Universities and Enterprises and Integration of Industry, Academia, and Research

In the context of the new era, collaboration between universities and enterprises, along with the integration of industry, academia, and research, has become a crucial pathway for promoting technological innovation and industrial upgrading. First and foremost, Kashi University engages in discussions with enterprises to clarify collaborative goals and needs, ensuring that both parties share a common vision. Subsequently, the university selects enterprises and institutions that possess both technical capabilities and a willingness to cooperate, thereby establishing a solid foundation for partnership.

The co-construction of research and development (R&D) platforms fosters technological innovation. Project-driven collaborations deepen cooperation for mutual benefits; the talent exchange and training mechanism (e.g., expert exchanges, student internships) improves human resource quality. Emphasis is placed on research outcome conversion and benefit sharing to ensure market application of collaborative results. Formal cooperation agreements clarify responsibilities for standardized operation, and regular collaboration effectiveness assessments enable dynamic strategy adjustments for sustainable development.

These initiatives have significantly advanced partner enterprises' technological progress and industrial upgrading, while enhancing Kashi University's social service capability and influence. As per this model (Fig.6), Kashi University and Kashi Kunlun Uyghur Pharmaceutical Co., Ltd. jointly established the Key Laboratory of Chemical Resources of Characteristic Medicinal and Edible Plants of Xinjiang Uyghur Autonomous Region in August 2014. Focusing on Xinjiang's (especially southern Xinjiang's) characteristic medicinal and edible plants, the laboratory researches arid highland plant resource sustainable utilization, traditional Chinese medicine modernization, and active component separation, purification, structural modification and efficacy evaluation. High-level R&D on Xinjiang's diverse medicinal plant resources promotes regional socio-economic development. Serving southern and whole Xinjiang, it has become a key regional research base for natural medicinal resources and a training ground for talents in drug analysis, natural product R&D, quality testing and monitoring. Kashi University also signed a cooperation agreement with Kaitian Environmental Protection Technology Co., Ltd., jointly cultivating applied talents via an internship base that provides practical training for over 100 students annually.

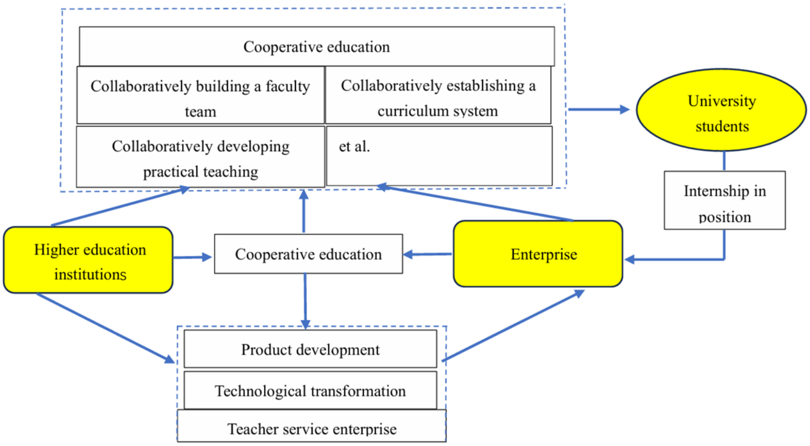

Fig. 6. Collaborative education model integrating industry and education

3.6 Cultivation of Student Innovation and Practical Abilities

Cultivating students' innovation and practical capabilities is the core of the collaborative education model. Multiple approaches are adopted, including curriculum reform, strengthened practical teaching, and innovation and entrepreneurship education. Students are encouraged to participate in research projects and innovation competitions to enhance research abilities and innovative thinking. A comprehensive practical teaching system is established, with improved management and assessment of practical components to ensure students acquire solid practical skills and professional qualities.

University-enterprise collaboration provides a platform for students to transform theoretical knowledge into practical skills. Enterprises offer advanced production equipment, rich practical experience and real vocational environments, helping students understand industry dynamics and demands. Through participating in enterprise actual projects, students gain firsthand experience in product development, production management and other key processes, fostering their innovative thinking and problem-solving abilities.

Industry-academia-research integration effectively links scientific research, technological development and business operations. It accelerates scientific achievement conversion and improves talent cultivation quality: universities leverage research strengths to solve enterprise technological challenges, while using enterprise practical platforms to cultivate students' innovative awareness and practical skills.

3.7 Establishment of Evaluation and Feedback Mechanisms

Establishing evaluation and feedback mechanisms is crucial for the effective operation of the collaborative education model. Kashi University's applied chemistry program has developed a comprehensive system to supervise and assess the entire talent cultivation process. Feedback is collected via student evaluations, faculty assessments and enterprise evaluations to timely identify issues and make improvements. An incentive and accountability mechanism is also established to reward outstanding students and faculty, and provide guidance for those in need. To enhance evaluation credibility, the introduction of professional third-party evaluation agencies for objective assessments of industry-academia-research collaboration projects is under consideration.

4 Outcomes and Conclusion

The industry-education integration and collaborative education model significantly improves students' experimental skills, problem-solving abilities and innovative capacities, facilitating their rapid adaptation to job requirements. Deepened university-enterprise cooperation broadens students' employment channels, increasing employment rates, improving job quality, and enhancing both student job satisfaction and enterprise recognition. University-enterprise collaboration achieves positive results in research partnerships and technological achievement conversion, realizing mutual benefits and promoting regional economic development. Based on the above research, the following conclusions are drawn:

(1) The industry-education integrated talent cultivation mechanism for applied chemistry is long-term and complex, requiring continuous exploration, innovation, and strengthened collaboration among schools, enterprises and research institutions.

(2) Such collaboration is crucial to improving applied chemistry talent cultivation quality and deepening social services.

(3) Future efforts should focus on deepening and expanding university-enterprise cooperation, optimizing talent cultivation models, and boosting regional economic development.

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