An Innovative Study on the Dual Integration of Science & Education and Industry & Education in Application-Oriented Universities

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Abstract: Under the backdrop of emerging engineering education and industrial transformation, provincial application-oriented universities urgently need to address the dual challenges of the separation between scientific research and education and the disconnection between industry and education. This research focuses on the dual-integration model of "scientific-education and industry-education," systematically exploring its mechanism for empowering innovation in undergraduate education. By clarifying the theoretical connotations and logical relationships between scientific-education integration and industry-education integration, the study provides an in-depth analysis of the core challenges faced by provincial application-oriented universities in advancing this dual integration. It constructs a four-in-one innovation mechanism model comprising the motivation mechanism, collaboration mechanism, guarantee mechanism, and evaluation mechanism. Furthermore, it proposes multiple pathways for practical innovation, including strengthening top-level design, co-establishing substantive platforms, restructuring the curriculum system, developing a dual-qualified teaching faculty, and building an intelligent evaluation system. The research offers a systematic theoretical framework and practical solutions for provincial application-oriented universities to deepen the reform of undergraduate education and innovate talent cultivation systems through the dual-integration model.

Keywords: Application-Oriented Universities; Integration of Scientific Research and Education; Industry-Education Integration; Innovation Mechanism; Undergraduate Education

1. Introduction

The new round of technological revolution and industrial transformation is profoundly reshaping the global economic landscape and the structure of talent demand. China is currently in a critical period of transition from “Made in China” to “Created in China.” The construction of a modern economic system urgently requires a large number of applied talents with solid theoretical knowledge, outstanding practical abilities, innovative spirit, and the capacity to solve complex engineering problems. As the backbone of mass higher education, provincial applied universities play a crucial role, and the quality and adaptability of their talent cultivation directly impact the effectiveness of regional innovation systems and industrial competitiveness.

However, studies indicate that a considerable number of provincial applied universities remain constrained by their existing development trajectories, failing to effectively break through traditional paradigms in undergraduate education reform. Internally, a “disconnect” between research and teaching persists, whereby cutting-edge scientific achievements by faculty are seldom translated into high-quality teaching resources. Undergraduate students rarely have opportunities to engage in substantive research activities, resulting in insufficient cultivation of innovative thinking [1]. Externally, a “barrier” exists between universities and industry, leading to a mismatch between talent cultivation programs and actual enterprise needs. Practical teaching components are often weak or nominal, and there is a shortage of “dual-qualified” teachers with both academic and industry expertise. Consequently, graduates lack strong practical skills and job adaptability [2]. These two issues are intertwined, forming a negative cycle that significantly undermines the core competitiveness of applied undergraduate education. Therefore, breaking away from traditional models and promoting the deep integration and synergistic evolution of research-education integration and industry-education integration has become a strategic pivot for provincial applied universities to address developmental challenges and empower innovation in undergraduate education. The dual integration is not a mere juxtaposition of the two but requires the organic unity and benign ecosystem of research activities, industrial development, and teaching processes. This study aims to systematically elucidate the internal mechanism through which dual integration empowers undergraduate education, construct its innovation framework, and explore feasible implementation pathways, holding significant theoretical value and urgent practical relevance.

2. Theoretical Connotation and Logical Connections of Dual Integration

2.1 Definition of Core Concepts

Integration of Research and Education: This refers to the organic unity and mutual promotion of scientific research and teaching activities. Its core lies in breaking down the barriers between knowledge creation and knowledge dissemination, achieving research-based teaching and teaching-informed research. It is characterized by: incorporating cutting-edge research findings, scientific methods, and research thinking into the curriculum system and classroom instruction; opening research platforms and projects to undergraduate students and promoting research-based learning; and cultivating students' innovative mindset and capabilities through research projects [3].

Industry-Education Integration: This denotes the deep alignment and synergistic development of the industrial chain and the educational chain. Its goal is to achieve structural alignment between the supply side of talent cultivation and the demand side of industry. It transcends traditional superficial cooperation such as internships and recruitment, emphasizing the joint planning and design of training objectives and programs, co-development of curricula and teaching resources, co-implementation of the teaching process, and co-evaluation of training quality by higher education institutions and industry enterprises. This forms a community characterized by co-cultivation of talents, co-management of processes, sharing of outcomes, and shared responsibility [4].

2.2 The Intrinsic Logic and Correlation Model of Dual Integration

The integration of research and education and the integration of industry and education are not isolated concepts. Instead, they share a profound and dialectically unified logical connection, jointly serving as twin engines empowering innovation in undergraduate education, as illustrated in Figure 1.

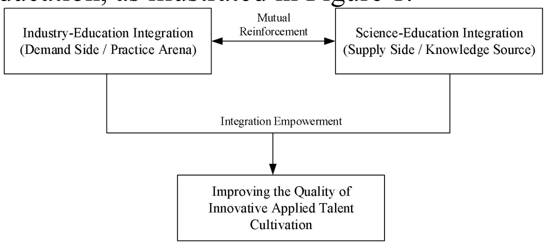

Figure 1. Model of the Logical Connection between Research-Education Integration and Industry-Education Integration

Industry-Education Integration provides demand traction and practical fertile ground for Research-Education Integration. The real technical challenges and market demands raised by the industry provide direction for application-oriented research in universities, ensuring the practical value and socio-economic benefits of research work. Simultaneously, the real production environments, cases, and projects offered by enterprises provide an excellent practical arena for research-based teaching activities, enabling theoretical knowledge to be applied, tested, and deepened in real-world contexts.

Research-Education Integration injects knowledge vitality and an innovation core into Industry-Education Integration. Through continuous scientific research, universities generate new knowledge and technologies, serving as a source of innovation for enterprise technological advancement and transformation, thereby elevating the level of Industry-Education Integration from mere talent recruitment cooperation to collaborative innovation. Furthermore, students cultivated through Research-Education Integration, equipped with research literacy and innovative potential, are better able to adapt to and lead future technological transformations in industries, providing long-term human resource security and intellectual support for partner enterprises.

3. Analysis of the Current Status and Issues of Dual Integration in Provincial Applied Universities

3.1 Research-Education Integration: The Schism between "Detached" Research and Teaching

Imbalance in the Guiding Role of Evaluation Systems: Presently, the faculty assessment and promotion systems in most provincial universities continue to disproportionately emphasize quantifiable research metrics—such as competitive research grants, publications in indexed journals like SCI/SSCI, and research funding—while offering insufficient recognition and incentives for teaching commitment, achievements in pedagogical innovation, and curriculum development. This incentivizes faculty to rationally prioritize efforts toward easily measurable research outputs, leaving them with little motivation or time to integrate research findings into teaching materials [5].

Ineffective Channels for Translating Research Resources into Instruction: While many institutions host high-quality research platforms, including various key laboratories and engineering centers, these facilities are primarily dedicated to postgraduate training and faculty-led research. Access for undergraduates, particularly those in their early years of study, remains severely limited. Furthermore, systematic mechanisms for converting research outcomes into teaching cases, experimental modules, or simulation software are underdeveloped. A prevalent issue is the prioritization of infrastructure establishment over resource sharing and its subsequent application in teaching.

According to the 2022 Compilation of Statistics on Science and Technology in Higher Education Institutions, the revenue generated from the commercialization of R&D results at local universities amounted to only 7.53 billion yuan, representing approximately 28.5% of the national total for higher education institutions. This highlights a broader deficiency in the application and translation of research outcomes, including their adaptation for educational purposes. Additionally, a survey conducted by the National Academy of Education Sciences targeting applied universities revealed that only 36.8% of faculty respondents systematically incorporate their research findings into lesson plans and classroom instruction. Concurrent data indicates that the participation rate of undergraduates from local applied universities in faculty research projects has consistently remained below 35%.

3.2 Industry-Education Integration: Superficial Cooperation and Institutional Deficiencies

Insufficient Depth and Stability of Cooperation: University-enterprise collaborations are predominantly concentrated at superficial levels, such as internship placements, recruitment seminars, and special lectures. Progress in deeper-level areas, including jointly developing training standards, co-constructing specialized courses and laboratories, and collaborative technology research and development, remains limited. Due to a lack of clear mechanisms for benefit-sharing and stable policy expectations, enterprises generally lack endogenous motivation to participate in talent cultivation. Consequently, cooperative relationships are easily affected by market fluctuations [6].

Structural Shortage of Dual-Qualified Teaching Staff: "Dual-qualified" teachers possessing both solid theoretical knowledge and rich engineering practical experience are crucial for achieving industry-education integration. However, most regular faculty members in universities transition directly "from campus to campus," lacking frontline work experience in enterprises. Meanwhile, recruiting high-level technical talent from industry often encounters institutional barriers related to public establishment quotas, professional title evaluation systems, and salary structures.

Disconnect between Practical Teaching Systems and Industry Realities: The design of experimental, practical training, and internship components often lags behind the development of industrial technologies, featuring outdated content that is disconnected from real production processes and technical standards in enterprises. Some graduation internships suffer from a "laissez-faire" phenomenon, where students cannot access core business activities, significantly diminishing the effectiveness of practical skill development.

According to a MyCOS Research Institute survey of major partner enterprises, satisfaction with cooperation from undergraduate universities is only 68%, significantly lower than the 83% satisfaction rate with vocational colleges. Among the main obstacles cited, the mismatch between talent cultivation and organizational needs accounted for as high as 77%. Furthermore, data from the Department of Development Planning of the Ministry of Education shows that as of 2022, dual-qualified teachers accounted for approximately 27.5% of full-time faculty in national regular undergraduate institutions. Although this proportion has increased annually, it still falls short of the requirements for deepening industry-education integration.

4. Mechanism Construction of Dual Integration Empowering Undergraduate Education Innovation

To address the aforementioned systemic challenges, a four-in-one enabling model (as illustrated in Figure 2), integrating dynamic, collaborative, guarantee, and evaluation mechanisms, is constructed to drive the dual integration from concept to practice.

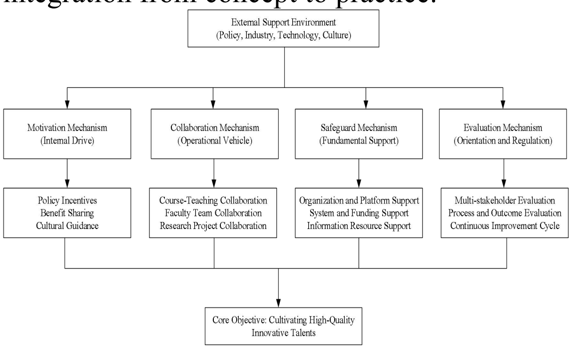

Figure 2. Systematic Model of the Dual Integration Mechanism Empowering Undergraduate Education Innovation

4.1 Deepening the Dynamic Mechanism to Stimulate Endogenous Motivation for Multi-Stakeholder Participation

Policy and Interest Dual-Wheel Drive: Provincial governments and education authorities should establish dedicated funds and performance evaluation indicators for dual integration. Core metrics, such as the effectiveness of modern industrial college development, the rate of scientific and technological achievement transformation, and the proportion of dual-qualified teachers, should be incorporated into the university assessment system to strengthen policy guidance [7]. Simultaneously, a market-oriented benefit-sharing mechanism must be established to clarify rules regarding intellectual property ownership and profit distribution in university-enterprise collaborations. For instance, the experience of Zhengzhou University of Science and Technology can be referenced. Through professional operation via a provincial-level technology transfer demonstration institution, a patent titled "An Industrial Robot" was successfully transformed within an enterprise, generating economic benefits. This initiative significantly enhanced the participation motivation of both the university and the enterprise [7].

Cultural Guidance and Conceptual Integration: Foster an educational atmosphere within the university that promotes innovation through practice. Initiatives such as establishing awards for research-education and industry-education collaborative innovation can enhance the recognition and acceptance of dual integration among faculty and students. For example, Huanghuai University promotes the integration of professional education and industrial development by transforming enterprise technical standards into curriculum modules, thereby cultivating an educational culture characterized by "Five Dimensions and Three Integrations".

4.2 Optimizing the Collaborative Mechanism to Build a "Teaching-Research-Industry" Symbiotic System

Curriculum and Platform Synergy: Construct a reverse design pathway of "industry demand – competency objectives – curriculum system" and integrate real-world projects into curriculum development. For instance, Changzhou University has restructured the integrated cultivation process for industry-education integration by adding new interdisciplinary majors and cross-disciplinary micro-programs. Simultaneously, leveraging a three-tier platform system (foundational experimental platforms –industry training platforms – innovation research platforms) achieves the interconnection of the education chain and the industry chain. For example, at Huanghuai University, through facilities like a pilot-scale fermentation workshop and an intelligent greenhouse, students participate in enterprise projects in the role of engineer assistants [7].

Faculty and Project Synergy: Implement a dual-appointment system and an open research project mechanism, encouraging enterprise engineers to serve as industry professors and facilitating faculty members to undertake temporary positions in enterprises. For example, the School of Science at Inner Mongolia University of Science and Technology has significantly enhanced students' practical abilities by transforming industrial technologies into virtual experimental resources, thereby promoting the feedback of faculty research into teaching. Furthermore, opening both industry-sponsored (horizontal) and government-sponsored (vertical) research projects to students forms a closed-loop driven by "research projects-teaching transformation-industrial application."

4.3 Refining Safeguard Mechanisms: Constructing Institutionalized and Digitalized Support Systems

Organizational and Institutional Safeguards: Establishing entity-type industry colleges and collaborative innovation centers helps break down disciplinary barriers. For instance, Zhengzhou University of Science and Technology has partnered with industrial parks to co-build innovation incubation platforms, forming a collaborative network covering fields such as smart manufacturing and artificial intelligence. Institutionally, supporting policies covering areas such as program development and faculty teams must be introduced. For example, Changzhou University has implemented over 30 institutional documents to comprehensively safeguard the practice of industry-academia integration [7].

Resource and Information Safeguards: Building a digital management platform enables intelligent resource matching. For instance, Changzhou University has independently developed a student competency attainment platform and an industry-academia resource collaborative adaptation platform, utilizing AI technology to empower the entire process of industry-academia integration.

4.4 Innovating Evaluation Mechanisms to Form a Closed Loop for Sustainable Improvement

Multi-Stakeholder Evaluation: Incorporate entities such as enterprises, industries, and third-party organizations to construct a "quadripartite evaluation system," focusing on socialized indicators such as graduate career development and the value of scientific and technological achievements transformation [8].

Balanced Evaluation of Process and Outcomes: Combine quantitative performance indicators (e.g., number of patents transformed, project participation rate) with qualitative assessments (e.g., innovative capability, engineering literacy) to establish a PDCA (Plan-Do-Check-Act) cycle of evaluation–feedback–improvement. For example, Huanghuai University has implemented a research supervisor evaluation system that includes the rate of transformation of scientific research result in supervisor assessments, thereby achieving continuous improvement.

5. Practical Pathways for Dual Integration to Empower Innovation in Undergraduate Education

5.1 Strengthen Top-Level Design and Refine the Institutional Guarantee System

Universities should elevate dual integration to the level of institutional development strategy, formulating special development plans and action plans. The core lies in improving supporting institutions, systematically revising key regulations covering teaching management, research evaluation, personnel appointments, and financial asset management to dismantle institutional and systemic barriers that hinder dual integration. For instance, clearly incorporating outcomes such as faculty participation in industry-sponsored (horizontal) projects, co-development of courses, and supervision of enterprise-based practical training into criteria for professional promotion and performance assessment, and establishing a dedicated professorial track for teaching excellence. These measures aim to stimulate faculty participation motivation from an institutional root.

5.2 Co-Construct Entity-Based Platforms to Promote Deep Resource Integration

Moving beyond loose cooperation models, the focus should be on building entity-based operational platforms, such as modern industrial colleges, future technology schools, and collaborative innovation centers. These platforms should adopt a board-based governance model, granting them greater autonomy in areas like program establishment, curriculum development, faculty appointment, and fund utilization. Platform development must concentrate on regional leading industries and strategic emerging industries, introducing authentic enterprise production environments, R&D projects, and technical standards. The goal is to create a trinity resource support system comprising on-campus practical training bases, enterprise internship bases, and collaborative innovation platforms. This achieves the organic linkage of the education chain and talent chain with the industry chain and innovation chain [9].

5.3 Restructure the Curriculum System and Deepen Teaching Model Reform

With the core objective of cultivating students' ability to solve complex engineering problems and innovative thinking, comprehensively advance curriculum reform based on projects and authentic contexts. Systematically transform real-world enterprise cases, technical challenges, and faculty's cutting-edge research findings into project banks, case libraries, and course modules, promoting project-based learning (PBL) throughout the entire talent cultivation process. Simultaneously, actively introduce advanced engineering education models such as CDIO (Conceive-Design-Implement-Operate), driving the transformation of classroom teaching from knowledge transmission to competency building. This enables students to integrate knowledge and skills while solving practical problems [10].

5.4 Cultivating a High-Level Dual-Qualified Faculty and Opening Two-Way Talent Flow Channels

Implement a faculty development strategy that combines external recruitment and internal cultivation to facilitate two-way mobility. On one hand, vigorously recruit engineers and technical experts from enterprises who possess both profound theoretical knowledge and rich practical experience, and design dedicated career development pathways for them. On the other hand, establish a regularized mechanism for faculty to gain practical experience in enterprises—through initiatives such as "visiting engineer" programs—to ensure that full-time faculty accumulate no less than six months of frontline enterprise experience every five years. By forming joint supervisory teams consisting of on-campus supervisors and enterprise mentors to co-guide students in capstone projects, discipline competitions, and innovation and entrepreneurship initiatives, the complementary strengths and overall capability enhancement of the faculty can be achieved [11].

5.5 Building an Intelligent Evaluation System to Achieve Data-Driven Continuous Improvement

Leverage information technologies such as big data and artificial intelligence to construct a dual-integration quality monitoring and intelligent evaluation platform. This platform should be capable of dynamically collecting whole-process data on talent cultivation, graduate career development, enterprise satisfaction, and the transformation of scientific and technological achievements. Through data modeling and analysis, it should provide precise profiling and early warnings regarding the effectiveness of dual integration, forming a closed-loop management cycle of monitoring-assessment-feedback-improvement. The evaluation results should be released regularly and serve as the core basis for dynamic program adjustment, optimization of training plans, and precise resource allocation. This ensures that the practice of dual integration continuously optimizes around its core objective of enhancing the quality of talent cultivation.

6. Conclusion

In summary, dual integration constitutes a rich and organic whole. Research-education integration provides the knowledge and innovation source for industry-education integration, while industry-education integration offers the demand orientation and practical field for research-education integration. The two reinforce and symbiotically evolve with each other. Promoting dual integration cannot rely on piecemeal reforms but requires systematic mechanism construction. The four-in-one model proposed in this study—comprising dynamic, collaborative, safeguard, and evaluation mechanisms—offers a viable action framework for higher education institutions. The successful implementation of dual integration depends on robust practical pathways. It necessitates coordinated efforts across five dimensions: top-level design, platform construction, curriculum restructuring, faculty development, and intelligent evaluation, thereby transforming systemic advantages into tangible outcomes in talent cultivation.

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