Article

Research and Exploration of Undergraduate Innovation and Entrepreneurship Education Oriented toward Industry-Innovation Integration

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Abstract: The integration of industry and innovation has fundamentally endowed university innovation and entrepreneurship education with new contemporary connotations, constructing a highly virtuous closed-loop system. Within this dynamic framework, education and teaching actively lead technological innovation, technological innovation seamlessly integrates with industrial innovation, and industrial innovation subsequently feeds back into the continuous improvement of education and teaching methodologies. This synergistic approach provides a robust new path and strategic thinking for modern universities aiming to cultivate science and technology-oriented innovative and entrepreneurial talents equipped for future challenges. Based on a comprehensive review of the current research status of innovation and entrepreneurship education in domestic higher education institutions, this paper systematically analyzes the critical importance of implementing such educational paradigms. Furthermore, it rigorously examines the practical difficulties and structural bottlenecks currently faced by academic institutions. To address these multifaceted challenges, this study innovatively proposes a comprehensive full-chain and whole-process talent cultivation model. This advanced framework is primarily guided by science-popularization-based education and teaching principles, strategically taking technological innovation projects as the core practical carrier, and ultimately aiming at the successful industrialization of technological achievements. The overarching purpose of this research is to significantly promote the overall quality and operational efficiency of university students' innovation and entrepreneurship education, thereby realizing the systematic and sustainable cultivation of highly adaptable, compound innovative, and entrepreneurial talents for the global economy.

Keywords: industry-innovation integration; entrepreneurship education; technological innovation; industrial innovation; science popularization; talent cultivation

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1. Introduction

The profound integration of science and technology (S&T) innovation and industrial innovation constitutes the core characteristic of the high-efficiency and high-quality development of new quality productive forces [1, 2]. Consequently, high-quality S&T supply and the effective commercialization of scientific and technological achievements serve as pivotal trajectories for achieving this integration. Promoting the systematic alignment and organic fusion of S&T and industrial innovation chains is an imperative requirement for enhancing the global competitiveness, influence, and leadership of China's modernized industrial system. Central to both S&T and industrial innovation is the cultivation of a robust innovative talent pool, with a particular emphasis on nurturing young innovative talents. As the frontline for talent development, Higher Education Institutions (HEIs) shoulder a critical historical mission and national responsibility. It is essential for HEIs to implement the strategies of invigorating the nation through science

and education, strengthening the country through human capital, and driving development through innovation. This requires a coordinated reform of the mechanisms governing education, S&T, and talent, while fostering a synergistic linkage between scientific research and pedagogical cultivation. By aligning with industrial trends and leveraging S&T innovation to empower talent cultivation, HEIs provide indispensable educational, technological, and human capital support for the construction of a Chinese-style modernized industrial system.

2. The Significance of Innovation and Entrepreneurship Education in HEIs

Currently, the Chinese economy is undergoing a structural transition from a traditional industry-led model to an innovation-driven paradigm, wherein science and technology (S&T) innovation occupies a central, commanding position. The sustainable development of the national economy fundamentally depends on industrial innovation and upgrading; at this stage, the deep integration of S&T and industrial innovation is particularly critical [1].

Higher education institutions (HEIs) play a vital role within the national S&T and industrial innovation systems, occupying an irreplaceable position in the cultivation and supply of young innovative talents [3, 4]. Therefore, within the context of industry-innovation integration, higher education must strengthen innovation and entrepreneurship education (IEE). This involves unlocking the innovative potential of students and enhancing their practical entrepreneurial capabilities. It is necessary to cultivate the knowledge base, international perspective, practical skills, and psychological resilience required for IEE to meet the practical demands of industrial innovation.

The primacy of talent is closely linked to the flourishing of science popularization. Talent gravitates toward meaningful endeavors, and such endeavors prosper through talent. The realization of S&T self-reliance and self-strengthening depends primarily on high-level innovative S&T personnel, while every phase of scientific research is inextricably linked to science popularization. Serving both socio-educational and economic functions, science popularization aims to enhance national comprehensive strength and cultivate diversified talent. Improving the scientific literacy of university students is the foundation for bolstering their S&T innovation capabilities. Science popularization not only optimizes human resource quality but also significantly promotes the overall elevation of national S&T innovation capacity [2].

The primacy of innovation through S&T is emphasized by achieving breakthroughs in key core technologies and fostering the growth of strategic emerging industries [3]. Significant achievements have been reached in fields such as crewed spaceflight, lunar and Mars exploration, deep-sea and deep-earth sensing, supercomputing, satellite navigation, quantum information, nuclear power technology, large aircraft manufacturing, and biomedicine, propelling China into the ranks of innovative nations. Promoting the popularization of S&T resources and achieving the deep integration of scientific research and outreach can both accelerate the S&T innovation process and disseminate its achievements to the public.

The primacy of industry through entrepreneurship highlights entrepreneurial activity as a vital catalyst for industrial development, upgrading, and innovation. Entrepreneurship not only injects new growth points into industrial sectors but also drives technological progress and market expansion, thereby enhancing core industrial competitiveness. Specifically, S&T-based entrepreneurship effectively facilitates industrial transformation and enhances market adaptability to meet evolving demands. By introducing and nurturing talent through an industry-demand-oriented approach, a precise alignment between human capital and industrial needs can be achieved. As HEIs are the primary engines of talent supply, they represent the critical nexus where industry, technology, and talent converge. The implementation path for IEE under the framework of industry-innovation integration is realized through the "Triple Helix" model, as illustrated in Figure 1.

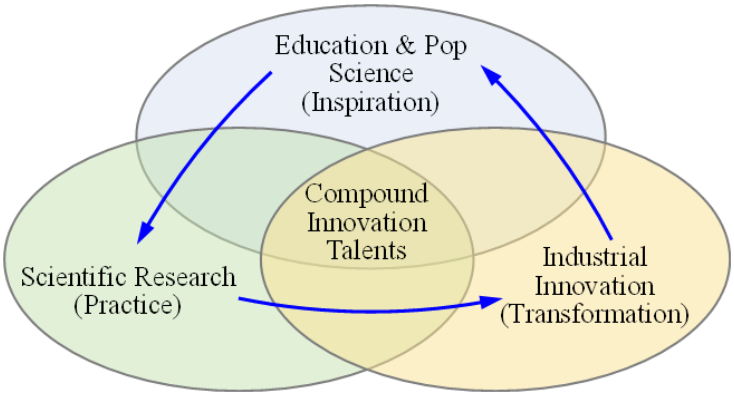

Figure 1. The "Triple Helix" Model of IEE within the Framework of Industry-Innovation Integration

3. Current Status and Challenges of IEE in HEIs

In 2015, the State Council issued the Implementation Opinions on Deepening the Reform of Innovation and Entrepreneurship Education in Higher Education Institutions, explicitly proposing the establishment of a comprehensive Innovation and Entrepreneurship Education (IEE) system that integrates "theoretical teaching with autonomous learning, and practical exploration with guidance and support." This marked the beginning of a phase of deepened development for IEE at the national level [5, 6]. However, after more than a decade of educational practice, higher education institutions must still accelerate the integrated reform of education, science and technology (S&T), and talent mechanisms to inject new momentum into traditional higher education through the development of new quality productive forces. In the process of promoting the organic combination of teaching and research—and the deep integration of research with industry—it is necessary not only to incorporate S&T achievements into pedagogical practice but also to drive the commercialization of S&T achievements into tangible, applicable productive forces. By leveraging the depth and breadth of industrial development to stimulate the vitality of S&T innovation, higher education institutions can achieve a "sympathetic resonance" and mutual promotion between technology and industry. Ultimately, this cultivates new quality productive forces and transforms these resources into educational assets that "feed back" into teaching, continuously nurturing innovative and entrepreneurial talents for national development.

Despite the new mandates for constructing new quality productive forces, existing talent cultivation models in higher education institutions still face several critical issues, primarily manifested in the following four dimensions:

Decoupling of IEE from Industrial Demand: Student-led S&T innovation activities are often out of sync with the actual needs of the industry. There is a significant time lag in the transmission of industrial requirements to higher education institutions, and discrepancies exist in how both parties perceive the same technical needs. Consequently, S&T achievements in universities struggle to be effectively translated into industrial applications [7].

Misalignment between Innovation Activities and Student Career Planning: Due to limited research capacity, insufficient practical experience, and a lack of clear career planning, students often engage in S&T activities blindly [8]. Furthermore, their limited understanding of industrial realities often leads to a sense of helplessness, a lack of "research confidence," and a fear of "trial and error," which ultimately stifles their enthusiasm and initiative.

Insufficient Conversion of Faculty Research into Pedagogical Resources: Driven by research-oriented targets, faculty members tend to focus on the research process itself. They often lack a deep understanding of how S&T innovation can facilitate talent cultivation and lack the motivation to timely transform research outcomes into teaching content, making it difficult to effectively guide students in innovation activities.

Isolated Institutional Silos among Education, Research, and Industry: Higher education institutions have been slow to integrate frontier issues from the S&T and industrial sectors into their talent cultivation systems. The linear compartmentalization of disciplines, majors, and curricula ensures that traditional teaching models remain dominant. This limits the development of students' innovative thinking and practical skills, resulting in a gap between the talent produced and actual societal demand [8].

4. Research Approach for Undergraduate IEE Based on Industry-Innovation Integration

The core of "Science Popularization-style" IEE lies in utilizing the engaging, widespread, and intuitive nature of science communication to mitigate the "fear of difficulty" that undergraduates often experience in the early stages of research due to lack of experience. By translating sophisticated research results into accessible science popularization resources, this model provides a "zero-threshold" pedagogical assurance. This allows students to build research confidence through subtle immersion, encouraging them to embrace trial-and-error and exploration [9]. This approach not only facilitates effective knowledge penetration but, more importantly, constructs a smooth transition path from interest-driven engagement to professional specialization, enabling IEE to reach a broader student population.

This paper proposes a new model for undergraduate IEE that utilizes industry-innovation integration as the vehicle and science popularization-style IEE as the method to drive the commercialization of university S&T achievements. The model adheres to the core tenet of talent cultivation while guiding students to be bold in their attempts and innovations. The specific research framework, as illustrated in Figure 2, is described as follows:

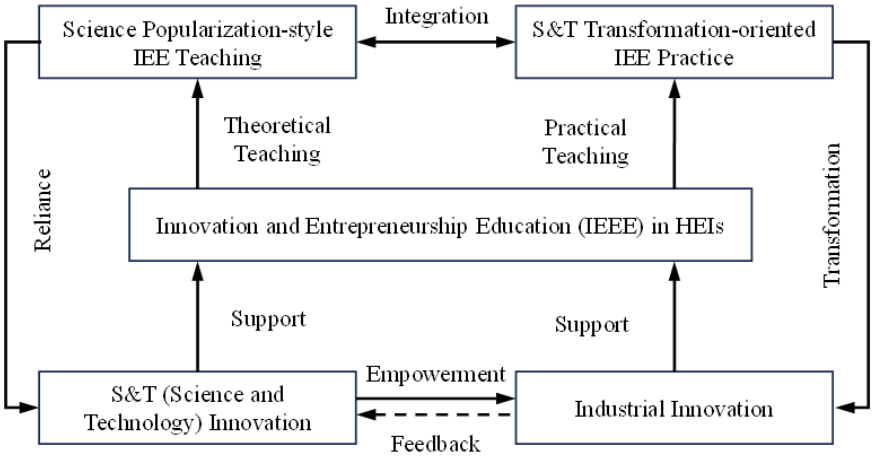

Figure 2. The Research Framework for IEE Based on Industry-Innovation Integration

Constructing an IEE model centered on industry-innovation integration and developing a science popularization-based pedagogical system. This involves breaking the barriers between university S&T and industry. By using science popularization-style teaching, students can understand industrial needs; these needs, in turn, drive university research, while research outcomes "feed back" into education. This creates a "Science Popularization -- Research -- Industry" three-dimensional linkage for talent cultivation. By leveraging the intuitive, foundational, and personalized characteristics of science popularization, HEIs can build an IEE practice system rooted in aesthetic and general education, expanded through specialized training activities.

Implementing the "Competency-Career" Empowerment Growth Plan. IEE should be integrated into the entire life cycle of a student's career development, moving from blind experimentation to precision planning. This requires a dual focus on professional

competency and innovative literacy. To address student pain points regarding inexperience and lack of confidence, a hierarchical and progressive practical training system should be established. By introducing industrial mentorship and aligning with sector-specific job requirements, a "stepped" growth path—from cognitive internships to real-world project execution—can be designed. Through immersive industrial experiences and retrospective analysis, students develop research confidence and resilience, making IEE a powerful engine for career advancement.

Optimizing the Development of IEE Faculty Teams [10, 11]. This involves assembling a comprehensive "Triple-Teacher" team (theoretical lecturers, academic researchers, and practical mentors) with solid theoretical foundations, outstanding academic abilities, and rich practical experience. This diversification of teaching staff meets the multifaceted development needs of students. Furthermore, an incentive mechanism for "research-teaching reciprocity" should be established to shift the focus from "research over teaching" to a genuine integration of science and education, providing faculty with new evaluation metrics and developmental impetus.

Exploring the Formation of Industry-Education Innovation Alliances. To dissolve resource barriers between HEIs, research institutes, and enterprises, the disciplinary and curricular systems must be restructured. This includes setting up interdisciplinary modules and promoting a compound cultivation model. Through deep institutional binding, a high-efficiency cycle of educational resources, research outcomes, and industrial demand can be achieved, ultimately producing compound talents characterized by social adaptability and innovative competitiveness.

To effectively eliminate the "isolated silos" between education, research, and industry, a deeply coupled collaborative mechanism must be established. By forming an Industry-Education Innovation Alliance, HEIs can bridge resource gaps with research institutes and enterprises. In this ecosystem, faculty research is promptly converted into teaching materials, and frontline industrial needs evolve directly into student research projects. This creates a virtuous cycle where pedagogical leadership drives S&T innovation, and industrial innovation, in turn, nourishes education. This deep alignment of interests and resource sharing ensures that the cultivated talent precisely meets the practical demands of both society and industry.

5. Practical Measures for IEE Based on Industry-Innovation Integration

The "Industry-Innovation Integration" model constructed in this study follows a progressive development logic. The core elements of each phase in the full-chain talent cultivation process are detailed in Table 1. During the Enlightenment Phase, innovation awareness is activated through science popularization-driven general education courses and seminars showcasing frontier industrial trends. In the Advanced Research Phase, students join research camps or labs to engage in technical problem-solving based on actual industrial needs under the guidance of academic mentors, thereby enhancing their practical research capabilities. Finally, in the Transformation Phase, integrated campus-enterprise platforms and professional mentorship facilitate the transition of research outcomes to the industrial sector, achieving a closed-loop conversion from conceptualization to commercial operation.

Table 1. Core Elements of the Full-Chain Talent Cultivation Process

Cultivation Phase	Pedagogical Implementation	Primary Objective	Supportive Human Capital
Science Popularization Enlightenment	Utilizing industrial cases in courses such as	Mitigating "research anxiety" and sparking	Theoretical Lecturer Team

	Foundations of IEE Theory and Literacy.	interest in industrial technologies.	
Research Training	Guiding students in specific research projects via laboratories and innovation project databases.	Developing systematic thinking and core technical problem-solving skills.	Academic Faculty Team
Industrial Transformation	Utilizing the "Pilot IEE" Training Camp and Makerspaces to bridge industrial needs and capital.	Achieving productization of research outcomes and incubating student startups.	Practical Mentor Team

By adopting industry-innovation integration as the vehicle, science popularization-style pedagogy as the driver, S&T innovation projects as the pathway, and the commercialization of S&T achievements as the objective, the university facilitates innovation and entrepreneurship activities for undergraduates. Students are guided to deeply align with industrial demands during the S&T innovation process. Through the development of a science popularization-based IEE curriculum, S&T talent training camps, and industry-integration research, a new "industry-innovation integration" model for undergraduate cultivation is constructed, effectively merging disciplinary innovation with professional education. The specific measures are as follows:

Establishing Industry-University-Research (IUR) alignment teams based on disciplinary development to proactively "go global" and interface with the industrial sector. Through field research and symposia, a series of S&T innovation projects suitable for student participation are identified from the enterprise side. This has led to the preliminary establishment of an Industrial Demand Innovation Project Database, providing a solid foundation and clear objectives for the IEE pedagogical system. By employing diverse methods such as site visits, project matching, and specialized training, the university has interfaced with over 100 enterprises, creating a preliminary demand library and effectively bridging the communication gap between HEIs and industry.

Developing a science popularization-based IEE curricular system that integrates S&T innovation projects into teaching and consolidates diverse outreach resources to create flagship courses. Relying on general science education, the model encourages students to participate in S&T projects, providing "zero-threshold" pedagogical assurance for the budding of innovative consciousness [12]. The teaching process identifies student interests to precisely match them with S&T projects, thereby systematically cultivating their practical IEE capabilities. Led by the Foundations of Innovation and Entrepreneurship Theory and Literacy (a general and aesthetic education course) and supplemented by specialized S&T training, the curriculum is continuously optimized using industrial research findings and high-quality internal and external resources. Currently, an average of five sessions per year are held, covering over 500 participants across various levels—from pre-school science popularization to undergraduate and postgraduate innovation—effectively attracting students from all majors and completing the cultivation chain from scientific enlightenment to innovative practice.

Consolidating hardware platform resources and tapping into the potential of laboratory assets to ensure a "barrier-free" enhancement of students' S&T skills. By leveraging university facilities and equipment while expanding access to corporate hardware, the university has built an integrated school-enterprise IEE practice platform. This enhances the quality and impact of the curriculum while providing essential physical support for high-quality science outreach and S&T projects. Based on the Xiamen University "Science Popularization--Technology--Entrepreneurship" Three-Dimensional

Education Maker Space, the platform features dedicated studio space and a complete institutional framework (including organizational structure, management regulations, and operational workflows). This ensures the long-term, orderly implementation of projects and achieves the full-cycle integration of science popularization, S&T innovation, and entrepreneurship education.

Assembling a comprehensive IEE mentor team comprising "theoretical lecturers, academic researchers, and practical mentors." By integrating human resources from administration, research, and engineering, and employing a strategy of "inviting in and reaching out," the university has enhanced the overall quality of its mentorship. The inclusion of corporate mentors and connections with venture capital firms provide "zero-worry" support for student entrepreneurs. By hosting the Xiamen University trials of the China International College Students' Innovation Competition, the university has incubated projects across campus, recruiting over 200 comprehensive mentors with solid theoretical foundations and rich practical experience [13]. With more than five online training sessions held annually, the pedagogical content is significantly enriched to meet the diverse developmental needs of students.

Establishing undergraduate IEE training camps to attract students who have completed science popularization-based courses, focusing on S&T innovation services to conduct social research, internships, and entrepreneurial practice [4, 14]. This effectively bridges the gap between HEI education and the industrial sector. Using academic competitions as a catalyst, the university provides serial training and "zero-distance" support for students to drive the commercialization of research results through competition participation. The annual "Navigator IEE" Talent Special Training Camp selects interested undergraduates from various majors. Through a mutual selection process, students are matched with research groups for scientific training. The university organizes over five social practice activities related to science popularization and IEE annually, having incubated five student-led startups to date, thereby achieving the effective conversion of research outcomes into industrial innovation.

Based on the practical application of the industry-innovation integration model, Xiamen University has achieved significant breakthroughs in talent cultivation quality [9, 12]. Regarding the scale effect, annual science popularization and IEE training have reached over 1,000 participants, attracting students from diverse disciplines. In terms of results commercialization, the model has facilitated engagement with over 100 enterprises and the incubation of five student startups, directly serving socio-economic development through S&T innovation. Furthermore, the 100+ national and provincial awards won by students in S&T competitions demonstrate the model's excellence in enhancing systemic thinking, creative cognition, and team leadership.

6. Conclusion

This paper explores a novel talent cultivation model for innovation and entrepreneurship education (IEE) in higher education, proposing a full-chain, whole-process training scheme driven by science popularization-style pedagogy, channeled through science and technology (S&T) innovation projects, and aimed at the commercialization of S&T achievements. This model represents a pioneering effort to introduce science popularization concepts into IEE, organically integrating talent development with S&T and industrial innovation. Through science outreach, the cultivation of foundational S&T capabilities becomes more "visualized" and "popularized," while alignment with industrial demand guides students toward a deep integration of theory and practice.

Relevant practical measures have resulted in 10 sessions of science popularization and IEE training and 6 course offerings, covering over 1,000 students and forming a full-cycle path from scientific enlightenment to innovative practice. With over 10 S&T teams incubated annually and partnerships with over 100 enterprises, a preliminary collaborative industry-university-research (IUR) nurturing network has been established. Students have secured over 100 national and provincial awards, with five startups

successfully incubated, achieving the effective transformation of ideas into tangible results. Under this model, students are empowered to act with clear objectives, ensuring that their learning is applicable, productive, and effective. They gradually enhance their abilities to solve practical problems, their systemic and creative thinking, their S&T innovation capacity, and their leadership and communication skills. Simultaneously, the model guides students in expanding their career horizons, allowing them to grow into pioneers of S&T self-reliance, drivers of industrial upgrading, and creators of societal job opportunities. Practical evidence confirms that this model yields significant outcomes in talent cultivation and possesses high potential for replicability and scalability.

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