Education Insights

Article

Research on the Dilemma of Scientific and Technological Innovation Training in Application-Oriented Undergraduate Colleges and the Optimization Path of "Three-Dimensional Coordination"

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Abstract: Scientific and technological innovation training serves as the cornerstone for cultivating applied undergraduate students' innovative capabilities. Current training systems face critical challenges including insufficient student motivation, inadequate faculty guidance, and institutional support gaps, which hinder the effectiveness of "specialization-innovation integration". This study proposes a three-dimensional collaborative optimization framework involving students, teachers, and institutions. By strengthening students' foundational competencies and motivational engagement, enhancing educators' industry-academia-research-application integration skills, and improving institutional incentive mechanisms with PDCA closed-loop management systems, we aim to systematically elevate training quality. This approach provides an actionable model for nurturing applied innovators who can drive the development of new productive forces.

Keywords: scientific and technological innovation training; integration of specialization and innovation; three-dimensional collaboration; PDCA cycle

Published: 16 September 2025

1. Introduction

In recent years, universities across China have actively introduced innovative talent development models that place strong emphasis on cultivating students' entrepreneurial and innovative capabilities within their academic training programs. These institutions have increasingly prioritized structured innovation training initiatives, providing dedicated resources, mentorship, and institutional support, while encouraging students to actively participate in various types of innovation competitions, research projects, and collaborative ventures both inside and outside the classroom. As a result, many high-quality and meaningful innovative technology projects have been independently developed by students, spanning multiple disciplines and application domains, thereby providing a multidimensional platform for showcasing their creative potential, problem-solving skills, and individual strengths [1].

2. Analysis of the Dilemma of Scientific and Technological Innovation Training in Application-Oriented Undergraduate Colleges

Applied undergraduate institutions have integrated scientific innovation training into their talent development systems, allocating resources to establish special funds and expand participation scales. Some schools have even achieved notable results in competitions. However, the overall training effectiveness remains far from fully realized, with core challenges concentrated across three dimensions: students, faculty, and institutions.

The root cause lies in the "disconnection between training, guidance, and management" [2].

2.1. Students Are Weak in Both Endogenous Motivation and Innovation Ability

Students' low engagement stems from ambiguous perceptions of training value, often viewing it as an extra burden or believing it has little relevance to credit acquisition, core curriculum learning, or future career development, leading to a lack of intrinsic motivation [3]. Meanwhile, influenced by traditional teaching models, students generally exhibit deficiencies in critical thinking, independent inquiry, and problem definition skills [4]. Specifically, they heavily rely on teachers during topic selection, struggling to propose innovative research directions; during the research process, constrained by insufficient knowledge application skills and technical practice capabilities, they fail to effectively explore new methods and technologies, ultimately resulting in research outcomes that lack both innovation and practicality.

2.2. Teachers' Effective Guidance and Investment Are Insufficient

Some instructors lack industry-aligned practical experience and cutting-edge technical insights, resulting in a significant disconnect between academic instruction and real-world applications. This gap often limits their ability to provide students with forward-looking guidance that emphasizes practical implementation, problem-solving strategies, and exposure to current industry trends [5]. Furthermore, teachers generally face heavy teaching loads, administrative duties, and research evaluation pressures, which compound the difficulty of providing effective mentorship. For example, excessive weekly class hours, coupled with project supervision responsibilities, make it challenging to ensure sustained, in-depth guidance for student projects. Consequently, mentorship often becomes superficial, fragmented, or inconsistent, failing to adequately address students' individualized learning goals and the development of advanced analytical, experimental, and problem-solving skills.

2.3. The Lack of Systematic Incentive and Management Mechanism of the School

The school's incentive mechanism suffers from imbalances, with resources and policies overwhelmingly favoring teachers while severely underfunding students and projects themselves. Key components like robust credit recognition, achievement awards, exemption credits, and high-quality project incubation support remain absent, failing to effectively motivate students or sustain teachers' engagement [6]. Management mechanisms also operate in a lax and inefficient state. Project selection processes feature vague evaluation criteria that prioritize feasibility over innovation and practical value, resulting in uneven research quality. The absence of process monitoring—lacking mid-term reviews, progress tracking, and dynamic feedback mechanisms—allows projects to become delayed, half-hearted, or deviate from objectives. The rigid evaluation system overemphasizes procedural documentation and competition awards, neglecting to assess the actual application value, technology transfer potential, or comprehensive skill development benefits of research outcomes. This approach makes it difficult to objectively measure the true effectiveness of training programs.

3. "Student-Teacher-School" Three-Dimensional Collaborative Optimization Path

To address the dilemmas described above, it is essential to construct a comprehensive three-dimensional coordination mechanism involving "students, teachers, and schools." This framework aims not only to integrate professional education and innovation training at multiple levels, but also to ensure systematic alignment between students' skill development, educators' guidance capabilities, and institutional support structures [7]. By fostering collaboration across these three dimensions, universities can create an environment that simultaneously promotes knowledge acquisition, practical application, and creative problem-solving, thereby enhancing the overall effectiveness and sustainability of scientific and technological innovation training programs.

3.1. Focus on Building a Dual-Driven Mechanism of Capacity Building and Motivation Stimulation

From the student perspective, systematic efforts should first be made to enhance students 'understanding of the value of scientific innovation training. Through initiatives like promotional events, showcasing outstanding achievements and exemplary cases, and organizing alumni experience sharing sessions, the core benefits can be clearly demonstrated its core benefits in boosting innovative capabilities, deepening knowledge application, enhancing employability, and supporting long-term career development. This approach helps correct misconceptions while igniting intrinsic motivation and goal-setting drive. Secondly, we must strengthen students' professional foundations and unlock their innovative potential. By deepening curriculum reforms, we should emphasize case-based teaching and project-oriented learning in core courses, encouraging students to proactively identify, analyze, and solve real-world problems through experiments, course design, and internships. For instance, in computer science education, integrating programming, data structures, and algorithms with practical scenarios like software development challenges and AI model optimization needs can guide students to explore technical implementation pathways, laying a solid foundation for participating in related innovation projects. Additionally, establishing innovation workshops and creative marathon activities specifically cultivates students' critical thinking habits and problem-definition capabilities.

3.2. Building a Guidance Model Integrating Industry, Education, Research and Application

The primary task in the teacher dimension is to enhance educators' "dual-competency" literacy. We should encourage and fund teachers to participate in corporate internships, engage deeply in cross-disciplinary research projects, and provide technical consulting services, thereby accumulating rich industrial experience and staying abreast of technological trends [8]. Establishing a school-enterprise collaborative mentor database by inviting industry engineers and technical experts as part-time mentors or organizing specialized lectures and workshops can effectively address the shortcomings of in-house faculty in practical guidance. Secondly, innovative mentoring models and sustained teacher commitment are essential. Actively promoting the integration of education and research, we should break down applied research projects assigned to teachers into subtopics suitable for undergraduate participation, or directly align course content with cutting-edge research issues and practical application needs, achieving organic integration of teaching, research, and innovation training.

3.3. Improve the System Incentive and Closed-Loop Management System

The core of the school-level framework lies in establishing a comprehensive incentive system and PDCA closed-loop management mechanism [9]. Developing robust incentive policies is crucial, requiring the creation of a dedicated "Student Scientific Innovation Achievement Recognition and Evaluation Guidelines". These guidelines should strongly link outstanding achievements—including high-quality papers, authorized patents, software copyrights, prototype systems, high-level competition awards, and practical commercialization—to academic credit transfers, scholarship evaluations, honorary title conferrals, and eligibility for excellence awards. A "Distinguished Mentor Award" should be established to recognize teachers who demonstrate substantial investment and exceptional mentoring effectiveness. The management system must strictly implement the PDCA cycle concept. During planning and project initiation phases, optimized application guidelines should establish evaluation criteria that balance innovation, applicability, and feasibility. This involves multi-stage review processes including formal submissions, expert blind reviews, and on-site presentations, with participation from industry experts to ensure rigorous quality control. In execution and monitoring phases, milestone-based process management should require regular progress reports and mid-term reviews. An online project management platform should enable real-time progress tracking and instant feedback, while strengthening mentors' supervision responsibilities. For evaluation and assessment phases, a diversified achievement evaluation system should be implemented. This includes assessing research standardization, technical implementation complexity, innovation level, quality metrics, application potential, and students' skill development demonstrated through projects. Third-party evaluations involving corporate representatives and peer experts should also be incorporated. During the feedback and improvement phase, the system analyzes project evaluation results to summarize successful experiences and existing issues. These findings are effectively fed back into subsequent rounds of project initiation standard adjustments, management policy optimizations, and resource allocation decisions, forming a closed-loop system for continuous improvement. The "Quality Report on Scientific and Technological Innovation Project Training" is regularly released to ensure transparent quality status.

4. The Future New Form of Scientific Innovation Training for College Students

To meet the strategic needs of supporting the development of new-quality productive forces and cultivating high-quality application-oriented innovative talents, college students' scientific and technological innovation training will be profoundly reformed and present a new future form of "integration of industry and education, digital intelligence empowerment, open co-creation， and value transformation".

4.1. Integrate Production and Education, and Do Real Questions

We will further deepen industry-education integration and collaborative talent development by strategically expanding partnerships with leading enterprises, specialized innovative companies, and top-tier research institutions. These partnerships are not limited to formal agreements but extend to joint research initiatives, technology transfer projects, and co-designed training programs, allowing students to engage directly with real industrial processes and challenges. Through the establishment of industrial colleges, joint laboratories, and collaborative innovation centers, students will gain structured opportunities to work on authentic industry problems, participate in cutting-edge R&D projects, and learn from professionals actively involved in the innovation ecosystem.

This approach ensures that theoretical knowledge acquired in the classroom is continuously reinforced through practical application, enabling students to develop problem-solving skills, critical thinking abilities, and cross-disciplinary collaboration experience. By engaging in project-based learning, internships, and mentorship from industry experts, students are better prepared to understand the complexities of modern industrial challenges, including technical constraints, market demands, and sustainability considerations. Moreover, incorporating real-world challenges into the training framework fosters a culture of creativity, resilience, and adaptability, equipping students with the competence to respond effectively to emerging technologies and rapidly evolving industrial environments. Ultimately, this comprehensive integration of industry and education transforms the learning experience, bridging the gap between academic study and professional practice, and producing graduates who are not only knowledgeable but also capable of immediate contribution to innovation-driven enterprises.

4.2. Intelligent Empowerment, Innovation Guidance

Secondly, we should actively embrace the empowerment of digital and intelligent technologies, making full use of online collaboration platforms, virtual simulation experiments, and AI-assisted tools to improve the overall efficiency and effectiveness of the training process [10]. By integrating these advanced technologies, students can participate in interactive, simulation-based learning environments that closely mimic real-world scenarios, allowing them to explore complex scientific and technological problems in a controlled yet realistic setting. Online platforms facilitate seamless communication and collaboration among students, mentors, and industry partners, enabling real-time feedback, resource sharing, and project coordination across different locations. AI-assisted tools can further personalize the learning experience by providing adaptive recommendations, automating routine tasks, and analyzing students' performance data to identify strengths and areas for improvement. Moreover, virtual simulations and digital laboratories allow students to experiment with innovative solutions without the constraints of physical resources, promoting creativity, iterative problem-solving, and risk-free trial-and-error learning. By adopting such digital and intelligent approaches, universities can expand access to high-quality learning resources, foster more flexible and inclusive collaboration methods, and ultimately cultivate students' technological literacy, innovative thinking, and readiness for future industrial challenges.

4.3. Open Co-Creation, Competition and Integration

Efforts should be made to build an open and shared innovation ecology that encourages collaboration and knowledge exchange across multiple levels of the educational and research ecosystem. Universities should actively promote the formation of interdisciplinary, cross-grade, and inter-school scientific and technological innovation teams, enabling students from diverse academic backgrounds to combine their expertise, perspectives, and problem-solving approaches. By organizing innovative competitions, hackathons, and academic forums with regional or industrial influence, institutions can provide platforms for students to test their ideas in competitive yet constructive environments, gain practical experience, and receive feedback from both peers and industry professionals. Furthermore, integrating these initiatives into the campus culture helps cultivate an environment where creativity, experimentation, and entrepreneurial thinking are normalized and encouraged. Such a culture fosters continuous engagement in innovation activities, strengthens collaborative networks among students, faculty, and external partners, and enhances the visibility of student achievements. Over time, this approach contributes to the development of a sustainable innovation ecosystem that not only supports academic growth but also encourages students to proactively pursue entrepreneurial ventures, technological experimentation, and cross-disciplinary research projects, ultimately preparing them to address complex challenges in rapidly evolving industrial and societal contexts.

4.4. Value Transformation, Promote Development

It is necessary to strengthen the transformation and application orientation of scientific and technological innovation training, ensuring that students' research outcomes can move beyond theoretical achievements to practical implementation. Establishing a smoother and more efficient transformation mechanism is essential, and this can be achieved by leveraging technology transfer offices, university science parks, incubators, and industry collaboration platforms to provide structured support throughout the process. Such mechanisms not only facilitate the commercialization and practical application of students' innovative projects, but also offer guidance on intellectual property management, regulatory compliance, and market feasibility assessment. Furthermore, integrating the actual application and transformation of students' outstanding scientific and technological achievements into the institutional evaluation and reward systems helps to incentivize meaningful innovation. By recognizing and rewarding projects that demonstrate tangible societal or industrial impact, universities can encourage students to focus on real-world problem-solving and entrepreneurial thinking. Ultimately, this approach effectively enhances the direct contribution of innovation training to regional economic growth, industrial development, and social progress, while simultaneously preparing students to navigate complex technological, managerial, and market challenges in their future professional careers.

5. Conclusions and Outlook

Scientific innovation project training serves as the core mechanism for applied undergraduate institutions to achieve "specialization-innovation integration" and enhance talent cultivation quality. It plays an irreplaceable role in forging students' innovative thinking, solving complex engineering and practical problems, fostering teamwork spirit, and improving employability. This study reveals three major challenges in current training systems: insufficient student intrinsic motivation and innovation capabilities, inadequate effective guidance from teachers, and lack of systematic institutional management. The core issue lies in the "disconnection between specialization and innovation". To address this, we propose a three-dimensional collaborative optimization path involving "students-teachers-universities", focusing on building a dual-driven mechanism of capability foundation and motivation stimulation for students, creating industry-academia-research-application integrated guidance models for teachers, and establishing support systems combining institutional incentives with PDCA closed-loop management for universities. This approach aims to break through key bottlenecks in "specialization-innovation integration", consolidate educational synergy, and provides an actionable solution for systematically enhancing the effectiveness of scientific innovation project training.

Through the continuous optimization of the "three-dimensional collaboration" path and the deepening of the integration of specialization and innovation, applied undergraduate scientific and technological innovation training is expected to become a fertile soil for breeding future outstanding engineers, technological innovators and entrepreneurs, and provide a solid and powerful talent support for the improvement of national scientific and technological innovation capacity and industrial transformation and upgrading.

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