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Research on Innovation and Entrepreneurship Ability Cultivation of Vocational Undergraduates from the Perspective of Science and Education Integration

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Abstract: Against the backdrop of building a strong education nation and implementing innovation-driven development strategies, vocational undergraduate education serves as the pinnacle of modern vocational education systems, bearing the core mission of cultivating high-quality technical, interdisciplinary, and innovative talents. The integration of science and education follows a fundamental logic where research informs teaching practices, teaching supports scientific research, and innovation drives talent development. This approach provides crucial pathways to address current challenges in vocational undergraduate innovation and entrepreneurship education, such as overemphasis on technical skills at the expense of innovation, simulation-focused training overshadowing practical application, and theoretical knowledge neglecting real-world translation. Starting from the positioning of vocational undergraduate institutions and the connotation of innovation and entrepreneurship capabilities, this study analyzes the intrinsic mechanisms of science-education integration in fostering innovation and entrepreneurship. It identifies existing issues in current vocational undergraduate education, including conceptual cognitive biases, fragmented curriculum systems, insufficient platform support, imbalanced faculty structures, and inefficient technology transfer. The research constructs a five-in-one cultivation framework encompassing conceptual guidance, curriculum restructuring, platform support, faculty empowerment, and institutional safeguards, while proposing targeted implementation strategies to provide theoretical foundations and practical references for vocational undergraduate institutions to deepen science-education integration and enhance students' innovation capabilities.

Keywords: science and education integration; vocational undergraduate education; innovation and entrepreneurship; talent cultivation; industry-education integration

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1. Introduction

With the implementation of key national strategic documents—including the policy guidance on advancing modern vocational education and the long-term planning framework for national education development—the vocational undergraduate education sector has transitioned into a stage characterized by enhanced quality, structural optimization, and systemic coherence [1]. The pedagogical emphasis has evolved beyond foundational skill acquisition to encompass advanced technical proficiency, adaptive problem-solving, and original solution design. This evolution directly responds to dynamic socioeconomic imperatives, particularly the accelerating pace of industrial transformation, widespread adoption of intelligent manufacturing systems, and the nationwide commitment to sustainable and low-carbon development pathways. Within this context, innovation and entrepreneurship capacities are no longer peripheral competencies but constitute central pillars of vocational graduates' professional identity and labor market readiness. These capabilities function as an essential integrative mechanism—linking curricular delivery with real-world technological challenges, bridging academic instruction with enterprise-driven R&D

priorities, and aligning graduate attributes with evolving occupational standards across high-value sectors such as advanced equipment manufacturing, digital services, and green energy infrastructure.

Presently, certain vocational undergraduate institutions continue to rely heavily on traditional pedagogical frameworks inherited from earlier-tier vocational programs, leading to several persistent structural gaps: first, innovation and entrepreneurship education remains largely compartmentalized from discipline-specific coursework, limiting contextual relevance and applied depth; second, it is frequently decoupled from authentic scientific inquiry and applied research activities, thereby constraining students' exposure to iterative experimentation, evidence-based reasoning, and technology validation processes; third, curricular content often lacks timely calibration against emerging industry requirements, resulting in misalignment between graduate outputs and employer expectations for agile, cross-functional talent. In contrast, the systematic integration of scientific research resources into undergraduate education offers a robust pathway toward resolving these disconnects. By embedding students in faculty-led applied research initiatives, co-developing industry-sponsored prototyping projects, and utilizing university-enterprise joint laboratories as experiential learning environments, institutions can foster cognitive flexibility, technical resilience, and venture-oriented mindset development. This integrated model advances a cohesive educational paradigm where teaching, research engagement, innovation practice, and entrepreneurial application operate synergistically—thereby strengthening the institutional capacity to produce technically grounded, creatively confident, and socially responsive dual-innovation professionals.

2. Core Concepts and Theoretical Foundations

2.1. Definition of Core Concepts

Vocational Undergraduate Education represents a strategically positioned tier within China's diversified higher education system, explicitly designed to bridge the gap between academic rigor and industrial relevance. It is distinguished by its dual emphasis on professional specialization and applied learning, grounded in advanced academic standards that meet national occupational qualification frameworks and industry competency benchmarks. This educational model prioritizes high-end manufacturing, strategic emerging industries, modern services, and digital economy sectors, cultivating bachelor-degree-holding technical professionals who integrate deep theoretical understanding with hands-on expertise. Graduates are expected to demonstrate not only mastery of domain-specific technologies but also robust analytical reasoning, adaptive learning capacity, ethical judgment in professional practice, and sustained potential for career progression and lifelong upskilling. The integration of science and education constitutes a systemic pedagogical paradigm wherein scientific research activities are deliberately embedded into curriculum design, teaching delivery, and student assessment [2]. Through structured research-informed learning experiences—such as undergraduate thesis projects, industry-coordinated R&D tasks, and faculty-mentored innovation labs—students develop critical inquiry habits, evidence-based decision-making skills, and the ability to translate theoretical knowledge into practical solutions. This integration fosters a virtuous cycle: research enriches teaching content and methods, while teaching cultivates future researchers and innovators, collectively advancing the quality, relevance, and social impact of vocational higher education.

Innovation and Entrepreneurship Competencies of Vocational Undergraduate Students encompass a multidimensional capability set that extends beyond conventional technical proficiency. These competencies are systematically developed through integrated curricula, project-based learning, cross-disciplinary collaboration, and real-world engagement with enterprises and innovation ecosystems. Students cultivate technological innovation thinking by critically analyzing production constraints, identifying inefficiencies, and proposing evidence-supported improvements in

equipment operation, process optimization, or service delivery models. Their problem-solving abilities are honed through iterative design challenges, failure analysis exercises, and scenario-based simulations aligned with frontline operational contexts. Project development capabilities include requirements elicitation, feasibility assessment, prototyping, testing, documentation, and stakeholder communication—skills reinforced via capstone projects co-supervised by industry mentors. Entrepreneurial practice skills involve opportunity recognition, business model conceptualization, resource mobilization strategies, and risk-aware implementation planning. Teamwork competencies are strengthened through collaborative engineering tasks, interdisciplinary innovation competitions, and simulated startup incubation experiences. Collectively, these competencies empower students to drive technical improvement, lead process innovation, facilitate technology transfer from lab to factory floor, and execute entrepreneurial initiatives with social responsibility and sustainable orientation.

2.2. Theoretical Basis

Competency-Based Education Theory centers on the systematic development of students' core competencies through authentic, context-rich learning experiences [3, 4]. It prioritizes task-driven pedagogical strategies—such as applied research projects, simulated professional challenges, and structured industry internships—to foster the internalization of disciplinary knowledge and transferable skills. When integrated with scientific education, this approach supports the progressive transformation of theoretical understanding and technical proficiency into tangible innovation capacity and entrepreneurial mindset, thereby directly supporting the mission of vocational undergraduate programs to produce highly adaptable, practice-oriented talent. Collaborative Education Theory emphasizes systemic synergy across higher education institutions, enterprises, scientific research organizations, and public sector stakeholders. This coordination enables structural alignment among teaching systems, workforce development pathways, technological innovation processes, and industrial value chains. Scientific-educational integration serves as a foundational platform for such collaboration, facilitating seamless linkages across teaching, research, innovation, production, and real-world application. Outcome-Based Education Theory adopts final learning outcomes as the central organizing principle for curriculum design, instructional delivery, and assessment architecture. By anchoring all educational activities to clearly defined, measurable competencies, it ensures coherence and accountability; scientific-educational integration further enhances this framework by generating empirically grounded innovations and practice-informed entrepreneurial initiatives that inform continuous improvement in pedagogical approaches.

3. The Intrinsic Mechanism of Science and Education Integration in Empowering Innovation and Entrepreneurship Competency Development for Vocational Undergraduate Programs

3.1. Goal Alignment: Alignment of Values in Science-Education Integration and Innovation-Entrepreneurship Cultivation

Vocational undergraduate programs are strategically designed to cultivate high-level technical personnel who possess not only robust disciplinary knowledge but also advanced practical competencies, adaptive problem-solving abilities, and a strong orientation toward real-world application. The integration of science and education serves as a pedagogical framework that systematically bridges theoretical understanding with experimental inquiry, technological practice, and innovation-driven learning experiences. This integration fosters cognitive flexibility, encourages evidence-based reasoning, and strengthens the capacity to translate scientific principles into tangible solutions [5]. Both paradigms—vocational undergraduate education and science-education integration—share a foundational commitment to developing talents who are application-oriented, innovation-capable, and proficient in interdisciplinary synthesis. Their convergence is further reinforced by common emphases on experiential learning, industry-relevant

curriculum design, authentic assessment methods, and collaborative project-based instruction. Such deep value alignment establishes a coherent conceptual and operational foundation for synergistic implementation, enabling sustained enhancement of innovation and entrepreneurship competency development across diverse vocational domains.

3.2. Resource Interoperability: Scientific Research Resources Provide Support for Innovation and Entrepreneurship Cultivation

Scientific research projects, research platforms, technological achievements, and faculty teams constitute a rich reservoir of pedagogical assets that can be systematically integrated into innovation and entrepreneurship education at the vocational undergraduate level [6]. These resources serve multiple interrelated functions: research projects provide authentic, problem-based learning contexts; research platforms offer hands-on experimental and prototyping environments; technological achievements supply real-world case studies and commercially viable project ideas; and faculty members—many of whom possess industry experience and active R&D engagement—act as knowledgeable mentors and incubation facilitators. Such integration directly mitigates persistent challenges including fragmented curricular design, limited access to applied learning infrastructure, insufficient mentorship continuity, and weak alignment between academic training and market-driven innovation demands.

3.3. Capability Progression: Scientific Research Practice Drives Upgrading of Innovation and Entrepreneurship Competencies

Through sustained, hands-on engagement across the full lifecycle of scientific research—including problem identification, experimental design, data acquisition and analysis, prototype development, validation of technological breakthroughs, and real-world application through technology transfer—students systematically cultivate a robust set of integrated competencies. This experiential learning pathway fosters advanced innovative thinking grounded in empirical rigor, strengthens independent research and development capabilities, refines technical execution and interdisciplinary collaboration skills, and deepens entrepreneurial literacy including opportunity recognition, resource mobilization, risk assessment, and value creation [7]. As a result, learners undergo a demonstrable capability progression: evolving from foundational skill operators who execute predefined tasks, to autonomous technological innovators capable of conceiving and realizing novel solutions, and ultimately to entrepreneurial pioneers who initiate, lead, and scale innovation-driven ventures with societal and economic impact.

3.4. Industrial Alignment: Integration of Science and Education to Facilitate Technology Transfer Channels

The integration of science and education establishes a robust industry-education collaboration platform that systematically bridges academic research with real-world industrial requirements. This synergy enables student-led innovation and entrepreneurship projects to advance through well-defined stages—from initial ideation and feasibility analysis, to structured research and development, rigorous prototyping and validation, pilot-scale testing, and ultimately scalable implementation and industrial application. By embedding market intelligence, user-centered design principles, and lifecycle cost-benefit assessment throughout the innovation pipeline, this model ensures that technological outputs are not only scientifically sound but also commercially viable and socially applicable. Furthermore, it strengthens institutional capacity for technology transfer by cultivating interdisciplinary competencies, fostering joint supervision mechanisms between academia and industry, and supporting intellectual property management frameworks aligned with national innovation strategies.

4. Practical Challenges in Cultivating Innovation and Entrepreneurship Competencies among Vocational Undergraduate Students

4.1. Conceptual Cognitive Bias: Disconnection between Science and Education Integration and Innovation-Entrepreneurship Education

A persistent conceptual cognitive bias undermines the effective cultivation of innovation and entrepreneurship competencies among vocational undergraduate students. Some institutions exhibit an ambiguous understanding of the distinctive positioning and mission of vocational undergraduate education, continuing to emphasize narrow technical proficiency at the expense of higher-order cognitive capacities such as critical thinking, integrative problem-solving, and creative application. The integration of science and education is frequently misinterpreted as merely facilitating research project acquisition or funding success, rather than serving as a pedagogical strategy to deepen disciplinary understanding and foster evidence-informed practice. Consequently, innovation and entrepreneurship education often remains confined to isolated elective modules or extracurricular activities, failing to become embedded across core curricula, laboratory instruction, capstone projects, and faculty mentoring practices. Curriculum design reflects structural fragmentation: specialized innovation content is seldom systematically aligned with scientific literacy development or discipline-specific research training. Entrepreneurship courses tend to rely heavily on generic theoretical frameworks and case studies detached from students' professional domains and ongoing research contexts. Teaching materials frequently omit up-to-date industrial applications, emerging technological paradigms, and evolving market dynamics, while lacking dedicated instructional components on foundational research methodologies, human-centered design thinking, intellectual property navigation, and translational pathways from prototype to practice. This systemic absence of a coherent, vertically integrated curriculum framework—unifying specialization, research engagement, and innovation practice—significantly constrains the holistic development of adaptive, context-responsive entrepreneurial capabilities.

4.2. Weak Platform Support: Insufficient Integration of Scientific Research with Innovation and Entrepreneurship Platforms

Research platforms within higher education institutions are predominantly designed to support faculty-led projects and remain largely unavailable to undergraduate and graduate students, thereby limiting early exposure to authentic scientific inquiry [8]. Innovation and entrepreneurship platforms frequently emphasize theoretical simulation exercises rather than immersive, project-based learning grounded in real-world technological challenges; they lack robust mechanisms for transforming research outcomes into viable prototypes, intellectual property, or market-ready solutions, and insufficiently integrate industrial technology roadmaps, testing facilities, or supply-chain resources. University-industry collaborative platforms often operate as formalized memoranda of understanding without substantive resource sharing, joint supervision, or co-developed curricula—resulting in fragmented engagement rather than integrated innovation ecosystems. A persistent structural imbalance exists in faculty composition: there is a marked scarcity of educators who simultaneously hold advanced academic credentials and substantial industry R&D experience, while the majority possess either purely disciplinary expertise or applied technical training without demonstrable research output or hands-on innovation leadership. The functional silos among research mentors, entrepreneurship coaches, and industry practitioners impede the formation of cohesive, cross-sectoral mentorship teams capable of guiding holistic student development. Moreover, institutional performance evaluation systems continue to assign minimal weight to teaching innovation, research-integrated pedagogy, and student venture mentoring—undermining faculty incentives to invest time and effort in these critical dimensions of talent cultivation.

4.3. Ineffective Technology Transfer: Lack of a Mechanism for Integrating Competition, Innovation, Research, and Production

A persistent challenge in higher education innovation ecosystems is the limited progression of student-led initiatives beyond contest-based engagement, where

participation metrics and award outcomes often overshadow sustained research development and real-world implementation. This gap reflects systemic deficiencies in institutional infrastructure for technology transfer, including underdeveloped pathways for converting academic research outputs into scalable prototypes, viable products, or commercially relevant services. Supporting mechanisms—such as dedicated translational funding streams, structured industry-academia collaboration frameworks, standardized intellectual property management protocols, and professionalized incubation support—are frequently fragmented or inconsistently applied across institutions. Furthermore, insufficient linkage between university research laboratories, regional industrial clusters, and market validation platforms impedes the formation of a robust innovation value chain. The prevailing evaluation paradigms exacerbate this disconnect: student assessments continue to privilege summative knowledge verification through standardized examinations and discrete skill demonstrations, while underrepresenting longitudinal indicators such as hypothesis-driven inquiry, iterative prototyping, interdisciplinary teamwork, patent disclosures, startup formation, or community-impact documentation. Similarly, faculty performance reviews disproportionately weight peer-reviewed publication volume and journal impact factors, with minimal recognition for pedagogical innovation, curriculum co-design with industry partners, mentorship of student ventures, or contributions to regional economic development—factors essential for cultivating talent capable of bridging scientific discovery, technological application, and entrepreneurial execution.

5. Construction of Vocational Undergraduate Innovation and Entrepreneurship Competency Cultivation System from the Perspective of Science-Education Integration

Centered on the deep integration of scientific advancement and educational practice, this framework builds upon the distinctive positioning of vocational undergraduate education to systematically cultivate innovation and entrepreneurship competencies [9]. It establishes a holistic 'five-in-one' cultivation system comprising conceptual guidance that aligns pedagogical philosophy with national development needs, curriculum restructuring that embeds real-world problem-solving, interdisciplinary project-based learning, and digital literacy across disciplines, platform support through university-industry-research collaboration bases, maker spaces, and incubation centers, faculty empowerment via dual-teacher capability development, industry immersion, and applied research incentives, and mechanism guarantee through policy alignment, quality assurance protocols, dynamic evaluation metrics, and sustainable resource allocation—ensuring comprehensive, all-dimensional, and whole-process talent development.

5.1. Conceptual Guidance: Establishing an Educational Philosophy Integrating Science, Education, Innovation, and Industry

Clarifying educational positioning requires a deliberate alignment of vocational undergraduate education with the evolving demands of modern industry and technological advancement. This entails sustaining a balanced integration of professional competence, research-oriented inquiry, and innovation-driven practice, ensuring that science-education synergy is not peripheral but foundational to institutional mission and pedagogical design. Skill proficiency must be advanced not merely through technical training but through active engagement in scientific research, applied problem-solving, and iterative prototyping—processes that cultivate analytical rigor and adaptive expertise. Educational value is further demonstrated when students translate theoretical understanding into tangible outcomes via entrepreneurship, technology transfer, and solution-oriented innovation projects. Strengthening top-level design involves formulating coherent, cross-functional policies that explicitly support science-education integration and innovation-led curricular development. Such policies must facilitate seamless coordination among teaching units, research laboratories, incubation platforms, and industry partners, while systematically dismantling administrative and disciplinary

silos. A unified institutional ecosystem emerges only when governance structures, resource allocation mechanisms, and performance evaluation frameworks are all calibrated to reinforce interdisciplinary collaboration. Furthermore, ideological guidance—understood here as the cultivation of ethical responsibility, societal awareness, and professional integrity—is embedded organically through the consistent promotion of craftsmanship ethos, critical thinking, resilience in experimentation, and an entrepreneurial mindset across all learning experiences, thereby achieving integrated development of values, knowledge, and capabilities.

5.2. Curriculum Restructuring: Building an Integrated Course System for Science Education, Innovation, and Industry

Hierarchical Curriculum Design establishes a coherent, progressive four-tiered framework comprising Foundation Level, Intermediate Level, Innovation Level, and Entrepreneurship Level. At the Foundation Level, students engage with foundational courses in innovation literacy, entrepreneurial mindset development, and systematic research methodology—including literature review strategies, experimental design principles, and data interpretation fundamentals. The Intermediate Level bridges disciplinary knowledge with applied competencies by embedding authentic research tasks, case-based problem solving, and laboratory or field-based inquiry into core professional coursework. The Innovation Level centers on student-led scientific research projects, prototype development, patent awareness training, and participation in university-industry joint laboratories or innovation incubators. The Entrepreneurship Level cultivates capabilities in technology valuation, intellectual property management, business model canvas application, market feasibility analysis, and startup operations [8]. Reverse Integration of Scientific Research Content systematically infuses current research themes, industry-validated technical standards, and real-world engineering challenges directly into subject-specific syllabi—enabling the co-development of distinctive 'Research + Specialty + Innovation' teaching materials and modular learning units that align pedagogy with evolving scientific frontiers and industrial practice. Interdisciplinary Curriculum Development responds to strategic national priorities in high-end manufacturing, intelligent systems, biotechnology, and green energy by designing cross-domain courses—such as 'AI for Materials Science' or 'Policy-Economics of Renewable Energy Systems'—that dismantle traditional academic silos and foster integrative thinking, systems analysis, and transdisciplinary solution design.

5.3. Platform Support: Establishing a Practice Platform for Integration of Science Education, Innovation, and Production

Open access to research platforms enables students to engage directly with advanced scientific infrastructure, including key national laboratories, provincial and ministerial-level engineering research centers, and regional technology innovation hubs. This structured access supports active involvement in ongoing research projects and applied technical development, fostering the systematic cultivation of problem-solving acumen, experimental rigor, and innovation capacity through sustained, supervised practice [9]. The upgraded innovation and entrepreneurship incubation hub functions as an integrated ecosystem that unifies research and development, specialized skills training, early-stage venture incubation, and market-oriented commercialization pathways. It strategically leverages enterprise-provided resources—such as industry-standard equipment, mentorship from technical professionals, and real-time market feedback—as well as validated academic research outputs to deliver end-to-end support for student-led projects, from conceptualization and prototyping to validation and pilot deployment. Furthermore, the industry-education-research collaboration platform establishes formalized partnerships with leading enterprises and public research institutes to co-found modern industrial colleges and joint innovation centers. These entities systematically translate authentic industrial pain points and frontier scientific questions into curriculum-integrated, project-based learning experiences—ensuring that student

innovation is grounded in real-world relevance, methodological authenticity, and implementable outcomes.

5.4. Faculty Empowerment: Building a Dual-Qualified Mentor Team

Teacher competency enhancement constitutes a strategic priority, requiring systematic, practice-oriented professional development initiatives that strengthen research capabilities, deepen expertise in innovation and entrepreneurship guidance, and foster authentic industry-education integration. These programs emphasize experiential learning through structured corporate internships, collaborative industry-led research projects, and applied pedagogical design workshops, thereby cultivating educators who seamlessly integrate research, teaching, and innovation functions. Mentor team development advances beyond individual capacity building by establishing interdisciplinary, functionally diverse mentor teams composed of in-house research mentors, discipline-specific subject matter experts, experienced industry practitioners, and certified entrepreneurship advisors. Such teams operate through coordinated supervision models, joint project design, and shared assessment frameworks to ensure holistic student development in research practice and innovative problem-solving. Incentive mechanism optimization aligns institutional evaluation systems with these strategic goals by formally incorporating outcomes related to research-based education delivery, quality of student innovation mentoring, and successful technology transfer activities into faculty workload allocation, promotion criteria, and annual performance reviews—thereby reinforcing sustained engagement and long-term commitment to educational innovation.

5.5. Mechanism Guarantee: Improving the Operational Mechanism for Integration of Science, Education, Innovation, and Production

A robust collaborative management mechanism is essential to align institutional priorities and operational practices across science, education, innovation, and production domains. This entails the formal establishment of a dedicated Leading Group for Science-Education Integration and Innovation-Entrepreneurship Education, empowered with cross-departmental authority to harmonize curriculum development, research planning, talent cultivation pathways, and industry engagement strategies. Such coordination actively dismantles structural silos that traditionally separate classroom instruction, laboratory research, student-led innovation projects, and university-industry collaborative ventures [10, 11]. Complementing this governance structure, a systematic technology transfer mechanism operates as a staged relay system—guiding scientific discoveries through successive phases of validation, prototype development, entrepreneurial incubation, and scalable industrial application. This process is underpinned by integrated support services encompassing seed funding allocation, targeted policy incentives, streamlined intellectual property management protocols, and facilitated market entry channels. Furthermore, a multi-dimensional evaluation system has been institutionalized to reflect the complexity of integrated development goals: for students, assessment now integrates knowledge mastery, active research participation, hands-on innovative practice, and tangible entrepreneurial outcomes; for faculty, performance metrics holistically weigh teaching effectiveness, scholarly output, pedagogical influence on student capability development, and demonstrable contributions to technology transfer and societal application.

6. Implementation Pathways for Cultivating Innovation and Entrepreneurship Competencies in Vocational Undergraduate Education from the Perspective of Science-Education Integration

6.1. Deepening Conceptual Integration to Promote Transformation of Educational Models

University-wide professional development initiatives on science-education integration and innovation-entrepreneurship education are essential to align faculty understanding, consolidate institutional vision, and establish shared pedagogical goals.

This strategic alignment facilitates a paradigm shift from conventional, isolated skill transmission toward a holistic educational philosophy that positions technical proficiency as the foundational layer, innovation capacity as the central developmental axis, and entrepreneurial mindset as the forward-looking orientation guiding curriculum design and delivery [11]. To institutionalize this transformation, science-education integration and innovation-entrepreneurship competencies must be explicitly embedded across all levels of academic governance—including institutional talent development frameworks, program-level curriculum standards, and semester-level teaching plans—ensuring coherence, continuity, and accountability. Curriculum optimization requires moving beyond superficial thematic overlap to achieve substantive integration of teaching, applied research, and real-world innovation practice. This entails co-developing discipline-specific courses and institutionally authored teaching materials grounded in authentic scientific inquiry, emerging industrial applications, and student-led entrepreneurship projects. The incorporation of intelligent digital learning platforms, simulation tools, and data-rich case repositories further strengthens curriculum responsiveness and experiential authenticity. Pedagogical innovation is advanced through sustained implementation of project-based learning, problem-based instruction, and research-informed teaching strategies, wherein classroom activities are systematically anchored in live scientific investigations, industry-defined challenges, and interdisciplinary innovation tasks—thereby cultivating students' analytical agility, solution-oriented thinking, and adaptive creativity through sustained, scaffolded inquiry.

6.2. Integration of Platform Resources to Strengthen Support for Practical Education

We will enhance connectivity among campus research platforms, training centers, and innovation bases to achieve equipment sharing, resource pooling, and collaborative project development across disciplinary boundaries. By deepening industry-academia partnerships, we will systematically integrate corporate R&D centers, production facilities, and entrepreneurial resources into the curriculum delivery framework, thereby creating authentic practice environments characterized by real-world scenarios, authentic projects grounded in current industrial demands, and rigorous, competency-based evaluations aligned with professional standards. Leveraging initiatives such as the 'Internet+' College Students Innovation and Entrepreneurship Competition, the Challenge Cup National Academic Science and Technology Competition for College Students, and vocational college innovation competitions, we will institutionalize competition-based learning pathways that foster iterative design thinking, cross-functional teamwork, and evidence-informed problem solving. To build a robust faculty team with integrated teaching, research, and practice capabilities, we will implement a dual-qualified teacher training program, annually selecting educators for immersive research workshops, structured industry internships, and certified innovation mentorship programs to strengthen pedagogical agility and domain expertise. We will expand mentor recruitment channels by inviting corporate technical experts, research institute specialists, and accomplished entrepreneurs as adjunct mentors to enrich our faculty roster with diverse professional perspectives. A comprehensive mentor evaluation and incentive mechanism will be established, offering preferential treatment in academic promotions, recognition awards, and targeted funding support for outstanding mentors, thereby reinforcing sustained engagement and excellence in practice-oriented education [11].

6.3. Facilitate Conversion Channels to Promote the Implementation of Innovative Outcomes

To strengthen the translation of academic innovation into tangible societal and economic value, a dedicated Science-Education Integration Innovation and Entrepreneurship Incubation Fund should be formally established within the institutional framework [2]. This fund must provide comprehensive support—including seed funding, subsidized co-working spaces, mentorship networks, and tailored policy guidance—to high-potential student-led projects demonstrating technical feasibility, market relevance, and social utility. Concurrently, university-based Intellectual Property Service Stations should be institutionalized to deliver end-to-end assistance in patent landscaping,

provisional and formal patent filing, freedom-to-operate analysis, licensing strategy development, and early-stage technology valuation. Furthermore, robust university-enterprise collaboration platforms—leveraging digital matching algorithms and sector-specific industry liaison officers—must be deployed to align student innovations with real-world industrial challenges, supply chain opportunities, and regional development priorities, thereby fostering demand-driven innovation ecosystems. Evaluation systems require fundamental recalibration: for students, a credit-based management model should systematically recognize research engagement, prototype development, field testing, intellectual property creation, and successful technology transfer as integral components of academic progression—reducing overreliance on traditional written examinations. For faculty, performance appraisal criteria must foreground demonstrable contributions to pedagogical innovation, student mentorship in applied research, and measurable impact from knowledge transfer activities, rather than privileging quantitative publication outputs alone. Systematic longitudinal assessment of science-education integration outcomes—using mixed-methods indicators including project survival rates, IP generation metrics, startup formation, and employer feedback—enables evidence-informed iterative refinement of policies, resource allocation, and capacity-building initiatives.

7. Conclusion and Prospects

As the highest tier of contemporary vocational education systems, vocational undergraduate education plays a pivotal role in preparing graduates for rapidly evolving socioeconomic landscapes characterized by industrial upgrading, intelligent transformation, and the imperatives of green and sustainable development. To fulfill this mandate, it is essential to systematically cultivate robust innovation and entrepreneurship capabilities among students—not as ancillary competencies, but as core learning outcomes integrated across disciplinary boundaries and experiential modalities. Presently, innovation education at this level confronts interconnected challenges spanning epistemological foundations—such as fragmented conceptual frameworks that fail to reconcile technical proficiency with creative problem-solving—curricular structures that often prioritize procedural knowledge over iterative design thinking, infrastructural limitations in research-practice integration platforms, uneven faculty capacity for mentoring innovation-oriented projects, and institutional mechanisms that lack incentives for cross-sectoral collaboration or longitudinal assessment of innovation competencies. A more effective paradigm emerges when scientific research, pedagogical practice, and innovation cultivation operate synergistically: research informs authentic, context-rich learning experiences; pedagogy scaffolds the translation of theoretical insights into applied solutions; and industry-academia co-creation enables real-world validation and refinement of student-generated ideas. Implementing a comprehensive 'five-in-one' cultivation system—comprising coherent conceptual guidance, adaptive curriculum restructuring grounded in competency-based progression, scalable platform infrastructure supporting prototyping and incubation, sustained faculty professional development focused on innovation mentorship, and responsive institutional policies ensuring resource allocation, governance flexibility, and accountability—provides a robust foundation for systemic advancement. Further strengthening this framework requires deepening alignment between educational aims and societal needs, optimizing course sequencing to scaffold innovation literacy progressively, consolidating shared physical and digital platform resources, building interdisciplinary faculty teams with dual expertise in domain knowledge and innovation methodology, streamlining pathways for translating student projects into viable applications, and refining multi-dimensional evaluation systems that capture process, product, and impact dimensions of innovation.

Looking ahead, the intensifying convergence of digital technologies—including artificial intelligence, immersive simulation, cloud-based collaborative tools, and data analytics—with vocational education will fundamentally reshape how innovation is taught, practiced, and assessed. This digital integration will accelerate the evolution of

science-education-research synergy toward greater digital fluency, deeper interdisciplinary synthesis (e.g., merging mechatronics with human-centered design or environmental science with circular economy principles), tighter coupling with industrial value chains, and expanded opportunities for transnational knowledge exchange and co-development. Vocational undergraduate institutions must therefore proactively advance strategic integration across scientific inquiry, pedagogical innovation, entrepreneurial application, and industrial deployment. This entails piloting AI-augmented learning environments that personalize innovation project support, developing hybrid curricula where research modules directly feed into capstone innovation challenges co-defined with industry partners, establishing translational support units to assist in intellectual property navigation and prototype commercialization, and cultivating cohorts of technically adept, ethically grounded, and socially responsive innovators equipped to address complex, real-world challenges. Such efforts not only elevate the quality and relevance of vocational education but also reinforce its indispensable contribution to national and global capacities in education, science, technology, and talent development.

References

1. Y. W. Li, H. F. Zhang, T. Y. Zhang, L. Han, X. L. Sun, X. M. Zhang, and X. Sun, "Exploration and practice of cultivating innovative talents in pharmaceutical specialty based on deep integration of industry–university–research," *Journal of Chemical Education*, vol. 101, no. 8, pp. 3126–3134, 2024.
2. J. Qian and X. Y. Zhang, "Exploring Practical Education Reform in Vocational Colleges under Industry-Education Integration: A Model of Tripartite-Chain Synergy and Four-Dimensional Advancement," *Advanced Electromagnetics*, vol. 15, no. 3, pp. 8049–8067, 2026.
3. J. Kong, J. Feng, Q. Zhang, T. Su, and X. Jin, "Design and Practice of New Engineering Innovation Education for Automation Majors," *Frontiers in Educational Innovation and Research*, vol. 2, no. 1, pp. 20–32, 2026.
4. L. Ruth, E. McGowan, T. Masciangioli, F. Wood-Black, and P. Anastas, Eds., *Exploring Opportunities in Green Chemistry and Engineering Education: A Workshop Summary to the Chemical Sciences Roundtable*, 2007.
5. Y. Yang, M. S. Rasul, and M. Omar, "A systematic review on the challenges and pathways for the integration of open education and vocational education in China," *Multidisciplinary Journal for Education, Social and Technological Sciences*, vol. 11, no. 1, pp. 72–98, 2024.
6. L. Mordhorst and T. Jenert, "Curricular integration of academic and vocational education: a theory-based empirical typology of dual study programmes in Germany," *Higher Education*, vol. 85, no. 6, pp. 1257–1279, 2023.
7. L. Ding, "Research on the Collaborative Education Path and Strategy in Vocational Colleges for the Integration of Science and Industry Education," *International Journal of Educational Curriculum Management and Research*, 2025.
8. M. N. Berulava, "The integration of general and vocational education," *Russian Education & Society*, vol. 34, no. 6, pp. 7–13, 1992.
9. F. Huang, "Exploring a new model of undergraduate vocational education," *Vocation, Technology & Education*, vol. 2, no. 1, p. e3, 2025.
10. I. Farran and I. Nunez, "Converging pathways: New approaches to integrate vocational education training and higher education," *Journal of Vocational Education & Training*, vol. 77, no. 4, pp. 1147–1165, 2025.
11. M. C. Wu, M. Marsono, and F. Khasanah, "Advancing vocational student's self-efficacy through integration STEM (science technology engineering and mathematics) education," in *2nd International Conference on Vocational Education and Training (ICOVET 2018)*, Atlantis Press, Jan. 2019, pp. 126–129.

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