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RESEARCH ON THE ESTABLISHMENT OF AN INNOVATIVE EDUCATION SYSTEM FOR UNDERGRADUATE VOCATIONAL EDUCATION: DIFFERENCE ANALYSIS AND PATH EXPLORATION IN THE VUCA ERA

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Abstract

Background. With China's strong policy push toward undergraduate-level, type-based vocational education, undergraduate vocational education has emerged as a new institutional form bridging higher education and technical and vocational education and training (TVET). In the context of the VUCA (volatility, uncertainty, complexity, and ambiguity) era, building an innovative education system for this sector has become particularly critical.

Aim. This study aims to examine the positioning and innovation challenges of undergraduate vocational education by comparing it with non-university tertiary vocational education, and to explore pathways for developing an innovative undergraduate vocational education system.

Material and methods. Drawing on a comparative analytical approach, this paper analyzes undergraduate vocational education and non-university tertiary vocational education in terms of training objectives, curriculum design, pedagogical models, and evaluation mechanisms, with a focus on their capacity to cultivate innovative talent.

Results. The analysis reveals that undergraduate vocational education faces significant challenges in fostering innovation under existing institutional and instructional frameworks. To address these challenges, the study proposes the establishment of a curriculum and instructional system characterized by interdisciplinary integration and project-driven approaches, the strengthening of university–industry collaboration, the creation of an empowering practice-oriented teaching–learning ecosystem, and the development of a "triple-role" innovative faculty team.

Conclusions. These strategies are essential for enhancing the innovation capacity of undergraduate vocational education and for enabling it to respond effectively to the demands of rapid industrial change and technological transformation in the VUCA era.

Keywords: *undergraduate vocational education, innovative education, difference analysis, implementation path*

1. Introduction

China's 14th Five-Year Plan explicitly identifies "enhancing the adaptability of TVET" and "promoting the integration of TVET and general education" as key strategic tasks, thereby entrusting undergraduate vocational education with a new historical mission (The State Council, 2021). Undergraduate vocational education represents not only a higher-level stage of TVET but also a crucial means of meeting the growing demand for highly skilled, innovative professionals in the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) era marked by rapid technological iteration and industrial upgrading. The rise of the intelligent era requires stronger capabilities in innovation, interdisciplinary integration, and independent learning (World Economic Forum, 2020). The World Economic Forum's Future of Jobs Report 2023 predicts that by 2025, 85 million jobs worldwide will be replaced by technology, while 85% of emerging positions will demand digital and cross-disciplinary skills (World Economic Forum, 2023). Traditional non-university tertiary vocational education, which emphasizes operational skills, can no longer meet the demand for "on-site engineers" and "innovative application-oriented" professionals in areas such as advanced manufacturing and the digital economy (Wang & Chang, 2019). Therefore, building an innovative education system for undergraduate vocational education carries both practical and theoretical importance.

By early December 2024, the Ministry of Education had approved 51 undergraduate vocational universities, with an additional 32 publicly announced by local education authorities (Li, Wu, Dai, & Yang, 2025). Although undergraduate vocational education is developing rapidly, there is still insufficient discussion on how its innovative education differs from that of non-university tertiary vocational education, and what paths and methods can be used to build and implement an innovative education system that matches the mission of undergraduate vocational education.

2. Differences in Innovative Education between Undergraduate and Non-university Tertiary Vocational Education

Existing research generally suggests that the essential distinction between undergraduate vocational education and non-university tertiary vocational education lies in for the elevation of talent cultivation, rather than in categorical differences in education. Wu Xuemin points out that: "Undergraduate-level vocational education has multiple attributes. It has an external technical attribute, representing the rational inquiry into 'what it is,' and an internal value attribute, reflecting the practical pursuit of 'how to do it'" (Wu, 2020). Similarly, Yang Xinbin states: "General undergraduate education primarily cultivates academic talent, while other types and levels of education focus on application-oriented talent (engineering, technical, and skilled professionals). Within this framework, application-oriented undergraduate education develops engineers, undergraduate vocational education trains technical professionals, and junior and secondary vocational education prepares technical and skilled workers" (Yang, 2022). This paper argues that the first step should be to identify the specific role each type of education plays in cultivating innovative talent within the broader innovation ecosystem. Only after clarifying these differentiated roles can an appropriate cultivation system for innovative talent be designed.

2.1. Positioning Differences within the Innovation Ecosystem Chain

Innovation can be understood as a complete ecological chain. At the front end lies disruptive discovery, followed by principle innovation, technical method innovation, technology integration innovation, and, finally, technology application service innovation (Danilina & Rybachuk, 2022). The front end of this chain is closer to the cognitive exploration of the natural world, while the back end moves toward the human-made domain, that is, the artificial physical, chemical, biological, and social systems created and shaped by human activity and for human purposes (Zhang & Zhang, 2001).

Disruptive discovery refers to the redefinition or revelation of the world's fundamental operating laws from first principles. Such discoveries radically overturn and reconstruct existing theories, paradigms, or scientific concepts, bringing about profound changes in essential understanding (Kostoff, Boylan, & Simons, 2004). Principle innovation builds on disruptive discoveries, uncovering new fundamental principles or theories in fields such as science, engineering, or economics. These then form the basis of innovation, as exemplified by Frederick Taylor's scientific management theory or the thermoelectric effect that converts thermal energy into electricity (Currall, Frauenheim, Perry, & Hunter, 2015). Training for disruptive discovery and principle innovation is typically the mission of academic education (cultivating scientists). Technical method innovation uses newly discovered principles to design and develop products, technologies, or services, whether entirely novel or improved versions of existing products or technologies (Chatzitheodoridis, Capova, & Persson, 2018). This type of innovation corresponds to engineering education (cultivating engineers). Technology integration innovation, by contrast, brings together principles, theories, and methods from multiple fields to create new, composite solutions (Hu, Li, & Zhang, 2013). Technology application service innovation applies established principles, theories, or methods to previously unexplored domains to generate new solutions or discover new opportunities (Bloecher, Hunke, Alt, & Satzger, 2022). Training for technology integration and technology application service innovation falls within the scope of TVET (cultivating industrial workers and technical engineers).

Taken together, technology integration innovation, and technology application service innovation can be described as technology application innovation. Application innovation occupies the middle and back segments of the innovation chain, aligning more closely with industry and markets. It is also a critical link between engineering realization and commercial transformation. Non-university tertiary vocational education emphasizes technology application services, prioritizing technical execution while involving relatively less innovation. By contrast, undergraduate vocational education focuses on technology integration innovation, aiming to produce high-quality technical professionals who can identify needs and respond quickly at the industry front line, and carry out integrated innovation in product structure, design, and functionality.

2.2. Differences in Training Objectives

The primary goal of non-university tertiary vocational education is to cultivate talents in technical operation and execution, with standards centered on job-skill proficiency. For instance, positions such as equipment maintenance or process execution highlight task orientation, enabling graduates to enter the workforce quickly and perform competently. This model underscores the integration of work and study. Undergraduate vocational education, however, must progress beyond "technical execution" toward "technology integration innovation." Its core objective is to cultivate "on-site engineers" with strong career orientation and practical innovation capabilities. These graduates should be able to translate design drawings into construction plans, oversee construction quality, and provide technical support (Wu, 2021). Such roles demand advanced problem-solving, technological innovation, and interdisciplinary integration skills. This contrast is also evident in knowledge structures: non-university tertiary vocational education tends to follow a linear accumulation of knowledge, whereas undergraduate vocational education fosters a networked, interconnected knowledge framework.

2.3. Differences in Curriculum Systems

The curriculum of non-university tertiary vocational education is centered on "skill modules," emphasizing practicality and specificity. More than half of the coursework is typically devoted to hands-on training, with content focused on repetitive, standardized tasks (Jiang, 2017). In this system, theory is considered sufficient as long as it supports skill development. For example, an automotive inspection and maintenance program might include eight modules, such as engine disassembly and chassis maintenance, each corresponding directly to job-related tasks.

In contrast, an analysis of the first 15 pilot undergraduate vocational institutions shows that majors are concentrated in applied fields: Engineering (32 of 67 programs), Arts (11 of 67), and Management (10 of 67). These align closely with regional pillar industries such as electronic information, equipment manufacturing, and finance (Zhai, 2021). The curriculum design for undergraduate vocational education thus reflects strong professional relevance and adaptability. It must integrate cross-disciplinary knowledge, advanced technical skills, and the progressive development of innovative capabilities.

2.4. Differences in Pedagogical Models

Non-university tertiary vocational education largely adopts task-driven instruction, emphasizing skill acquisition through simulations and training exercises (Jiang, 2017). Undergraduate vocational education, however, prioritizes problem-driven learning. Students are expected to engage in comprehensive and creative projects in authentic or near-authentic settings, such as technical research or product development in partnership with enterprises (Barrett, Cashman, & Moore, 2019). Such experiences not only strengthen technical proficiency but also enhance students' capacity for innovative problem-solving.

2.5. Differences in Evaluation Systems

Evaluation in non-university tertiary vocational education is based primarily on skill assessments and vocational certification, with an emphasis on job adaptability. Undergraduate vocational education, however, must extend beyond skill assessment to evaluate students' innovation, research ability, and overall competence (Zhai, 2021). Its evaluation framework should include value-added, results-oriented indicators, such as patent applications, as well as multidimensional feedback from both enterprise mentors and community mentors. This approach assesses not only whether students complete tasks correctly, but also how effectively they perform them and whether they demonstrate innovation, providing a more comprehensive measure of their technological application and innovative capacity.

3. Challenges in Cultivating Innovative Talents in Undergraduate Vocational Education in the VUCA Era

As a core concept describing the characteristics of modern society, VUCA originated in U.S. leadership research in the 1980s. After the 2008 global financial crisis, Robert McDonald, then Chief Operating Officer of Procter & Gamble, introduced the concept into the business field (Chinese Academy of Educational Sciences, 2023). The VUCA Era refers to a social context marked by four attributes: Volatility, Uncertainty, Complexity, and Ambiguity. In this context, there is a growing consensus that education must shift from "knowledge transfer" to "competence cultivation," and that the education system must be able to respond quickly to industrial change. This environment places greater demands on the cultivation of innovative talents in TVET. The main challenges can be summarized as follows:

3.1. Instability and Uncertainty of the External Environment

The rapid pace of technological iteration, particularly the widespread application of artificial intelligence and intelligent manufacturing, has significantly shortened technology cycles. This raises the bar for the forward-looking design and adaptability of curriculum content. For instance, the rapid evolution of power battery technologies in new energy vehicles, from lithium iron phosphate to ternary lithium batteries and now to solid-state batteries, requires practitioners to update their core technical competencies roughly every three years. Such a pace poses a serious challenge for undergraduate vocational education to keep its curriculum content up to date.

3.2. Adaptability Challenges in the Education System

Lagging Curriculum Content and Limited Integration: The curriculum system is the core vehicle for talent cultivation, yet its pace of renewal falls far behind technological advances. On the one hand, textbook publication, course development, and the upgrading of training equipment are unable to keep up with rapid technological change. On the other hand, innovative thinking and integrative innovation skills have not been systematically embedded into competency graphs resulting in ineffective integration and weak support between students' innovative capacity and professional expertise.

Structural Deficiencies in Faculty Composition: Faculty are the most critical resource for innovation-oriented education, yet the current situation is troubling. Data shows that among 15 pilot undergraduate vocational institutions, only two explicitly required professional certification as a condition for full-time faculty recruitment in 2020 (Zhai, 2021). Teachers with cutting-edge industry experience and the ability to instruct across disciplines remain scarce, which limits the effectiveness of innovation education.

Weak Support from Practical Platforms: Innovation grows out of practice, but current practice platforms are severely lacking in both quantity and quality. Research reveals that the number of such platforms is grossly inadequate compared with student demand, "able to serve only a small portion of student activities." More importantly, their functions are limited: "supporting facilities are incomplete, with most platforms offering only consultation and office services, unable to meet full-chain incubation needs such as project roadshows, product demonstrations, and technical testing" (Chen, 2023). This has greatly constrained both the translation of students' innovative results into outcomes and the honing of their practical skills.

3.3. Students' Weak Adaptability to Complex Environments

Deficits in Innovative Thinking and Independent Inquiry: Shaped by the traditional "instruction–imitation" model, students are accustomed to passively receiving knowledge and skills. As a result, their critical thinking, initiative in problem discovery, and problem-solving awareness are underdeveloped (Chen, 2023).

Insufficient Career Transfer Capability and Sustainable Development Capacity: The VUCA era calls for professionals who can engage in lifelong learning and show resilience in the face of career transitions. Yet the current evaluation system places excessive emphasis on static skill assessments, neglecting the cultivation of methodological literacy, information literacy, and professional identity. Consequently, students struggle to adapt to technological iteration and job mobility, undermining both their immediate adaptability and long-term development potential.

4. Innovative Strategies for Undergraduate Vocational Education to Address Challenges

To tackle the above challenges, the undergraduate vocational education system must undergo top-level restructuring and model innovation, giving it distinct typological attributes and hierarchical characteristics. Its defining feature is to anchor technological application innovation as the foundation, pursue deep industry–education integration as the pathway, and set professional competence and sustainable innovation capacity as its core objectives. The system should highlight four core attributes – vocational orientation, academic rigor, practical applicability, and adaptability – thereby achieving a comprehensive paradigm shift from the traditional pedagogical model. Building such a system requires attention to the following four key areas.

4.1. Innovation in Curriculum Design: Creating an "Interdisciplinary + Project-Driven" Integrated Curriculum

The curriculum for undergraduate vocational programs must break free from the limitations of traditional disciplinary frameworks and establish an integrated system that combines interdisciplinarity with project-driven learning. Its hallmark is embedding technological innovation thinking and professional core competency cultivation throughout the entire curriculum, using projects as the main driver and strengthening practice-oriented learning.

First, the curriculum should adopt a multidimensional structure of "foundational theory courses + general technical courses + industry frontier modules + innovation projects running throughout." Foundational theory courses include general education, mathematics, and engineering, designed to instill an interdisciplinary mindset for innovation and consolidate theoretical foundations. General technical courses respond to technological transformations by incorporating AI, big data analytics, and the Internet of Things as cross-disciplinary platform courses. Industry frontier modules are tailored to regional industrial cluster needs, deliberately breaking down disciplinary boundaries. They may take the form of micro-majors or modules such as Intelligent Connected Vehicle Technology or Digital Cultural Tourism Creative Design, systematically cultivating students' capacity for technological integration and interdisciplinary problem-solving. Innovation project courses function as the "glue" that binds knowledge and skills together. Centered on real-world technical challenges or innovation projects from industry, they shift students from being mere "answerers" to becoming "questioners." In the process, students integrate what they have learned to progress through identifying problems, defining them, and ultimately applying multidisciplinary knowledge to solve complex issues.

Second, Deep Integration of Professional Studies with Innovation and Entrepreneurship: Achieving a Dual-Engine Approach. Specifically, modules such as design thinking, intellectual property management for innovation, and business model canvases can be embedded within specialized courses to promote the shift from product-centered to user-centered thinking. For example, a smart hardware course could incorporate product design thinking and patent application practices, while a renewable energy course might include case studies on technology commercialization. In this way, professional education achieves a deep integration of "learning by doing" and "learning through innovation."

Third, Establishing a Three-Dimensional Assessment and Feedback Mechanism. Process-based assessment: Use learning portfolios to record students' trajectories in innovation practice. Outcome-based assessment: Employ hard metrics such as the number of patents granted and competition awards to measure effectiveness. Long-term assessment: Conduct graduate tracking surveys (every 3–5 years) to examine the transfer of innovation capabilities.

Finally, Innovating Course Delivery: A "Dual-Mentor Collaboration + Virtual–Physical Integration" Model. Academic faculty and industry engineers co-design curricula and co-teach, creating an interactive three-dimension loop of "theoretical instruction + technical guidance + project-based practice." At the same time, digital tools such as virtual simulations and remote collaboration should be fully utilized to enable cross-scenario and cross-regional learning, thereby enhancing students' competence and innovation capacity in tackling real-world complex problems.

4.2. Implementation of Practical Instruction and Industry Collaboration: Building an Empowering Ecosystem

Practical instruction is the soul of innovation and entrepreneurship education at the undergraduate vocational level. Its defining feature lies in elevating industry collaboration from mere "resource dependency" to "strategic mutual embedding," and shifting the focus from "skills training" to "innovation empowerment." Such collaboration should not be limited to providing internships, but should instead permeate the entire talent cultivation process, fostering an open, collaborative ecosystem that supports the full cycle of training, innovation, competition, and incubation.

Co-building High-Level Industry–Education Integration Platforms: These platforms serve not only as practice venues for students but also as critical vehicles for skill accumulation, innovation incubation, and faculty development. By partnering with leading enterprises and "specialized, refined, distinctive, and innovative" firms, institutions can co-establish industrial colleges, technology transfer centers, and collaborative innovation hubs with mixed ownership structures. These platforms act as "on-campus laboratories" for undertaking real research and development (R&D) projects and addressing frontline technical challenges, enabling students to hone innovation capacity in authentic engineering environments and transition from "students" to "pre-engineers" during their studies.

Implementing an Innovation Achievement Certification and Credit Conversion System: Evaluation standards for innovation outcomes should be established. Students who participate in technology development, obtain patents, complete industry-sponsored projects, or win awards in recognized competitions can have these achievements verified and converted into innovation credits. Such credits may substitute for required course credits or serve as graduation project deliverables. This institutional mechanism provides formal recognition and incentives for students' innovation practices.

Adopting a Dual-Mentor, Project-Based Practice Model: From their sophomore year, students should be guided jointly by academic mentors and industry mentors, participating in real-world projects such as technology upgrades, process optimization, and product development (Euler, 2018). This approach goes beyond traditional internships, confronting students with genuine frontline challenges. Their innovation results are thus subjected directly to market evaluation and validation.

4.3. Faculty Development and Cultivation: Building a "Tri-Functional" Innovative Faculty Team

Faculty quality is the decisive factor shaping the outcomes of innovation education. Teachers in undergraduate vocational programs must embody the dual identity of scholar and engineer – capable of lecturing in the classroom while also tackling technical challenges on the workshop floor. Building such a faculty team requires diversified development pathways and robust evaluation mechanisms.

Implementing a Faculty Industry Experience Certification System: The current "dual-qualified" certification for vocational faculty often remains symbolic, driven more by administrative requirements than by institutional mechanisms. As a result, many teachers only gain cursory exposure to enterprises through short-term visits during winter or summer breaks. A more rigorous system should require faculty to accumulate at least six months of full-time industry practice, technical service, or innovation/R&D experience every three years. Outcomes such as enterprise project deliverables or technical solutions should become core criteria for promotion and appointment. In addition, just as research universities offer academic sabbaticals, undergraduate vocational institutions should provide dedicated "industry sabbaticals" for faculty.

Establishing a Dynamic Rotation of "Industry Mentors" and "Professional Mentors": High-level technical experts, chief technicians, and R&D managers from partner enterprises should be recruited as adjunct faculty to teach project-based courses and supervise graduation projects, bringing the latest technologies, cases, and management practices into classrooms. At the same time, faculty should be encouraged to engage in corporate technical problem-solving, innovation projects, professional training, and skill certification, thereby continuously enhancing their expertise and engineering practice capabilities.

Promoting Research-to-Instruction Feedback Loops: Unlike non-university tertiary vocational faculty profiles that emphasize skills while downplaying research, undergraduate vocational education should focus on applied research fields. Institutions must create conditions for integrating instruction and research, prioritizing applied research and its commercialization. Faculty should translate their research achievements into instructional practice by involving students in real-world projects, thus realizing a developmental cycle of "instructional reflection → research transformation → social service." Through this process, faculty evolve from knowledge transmitters into "innovation mentors," enriching instruction with research insights. A scientific and effective faculty development system will ultimately yield a "tri-functional" faculty team proficient in instruction, industry engagement, and applied research, ensuring the high-quality cultivation of vocational undergraduate talent.

4.4. Cultivating and Promoting an Innovation Culture: Fostering a "Dedication-in-Action" Ethos

Culture provides the fertile soil that nourishes innovative spirit. Undergraduate vocational institutions should cultivate a "Dedication-in-Action" innovation ethos – one that combines the precision and perseverance of craftsmanship with the courage and determination of innovation.

Systematic Branded Activities as Cultural Drivers: Institutions should regularly organize branded activities such as campus- and province-level technical innovation competitions (focused on process optimization and technological improvement), innovation project pitch days, and entrepreneur workshops. Awards such as the President's Innovation Prize or Star of Technical Invention should be established to honor faculty and student teams that excel in innovation practice, elevating them as campus role models and amplifying their exemplary influence.

Building a "Failure-Tolerant and Empowering" Support Mechanism: Seed funds and maker-support funds should be created to provide early-stage capital for promising ideas. Instructional evaluation systems should be reformed by introducing process-based assessment, ensuring that projects which fall short of expectations but demonstrate rigor and learning value are duly recognized. This approach maximizes protection for students' enthusiasm and risk-taking spirit.

Disclossure

The authors declare that this manuscript is an original work and has not been published previously, nor is it under consideration for publication elsewhere. All authors have approved the manuscript and agree with its submission to the journal.

Supplementary Materials

No supplementary materials are associated with this manuscript.

Author Contributions

Conceptualization, TONG Wanting and ZENG Xiuzhen; methodology, TONG Wanting; formal analysis, TONG Wanting; writing – original draft preparation, TONG Wanting; writing – review and editing, ZENG Xiuzhen. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

In preparing this manuscript, the author(s) used OpenAI ChatGPT solely for the purpose of English language editing and stylistic refinement. After using this tool, the author(s) reviewed and edited the content as necessary and take full responsibility for the accuracy, integrity, and substantive content of the publication.

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