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Innovation and Practice of Specialty-Innovation Integration Educational Model in Medical Universities from the Perspective of Entrepreneurship and Innovation

-- Taking Xuzhou Medical University as an Example

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Abstract

Current medical entrepreneurship and innovation(E&I) education faces systematic shortcomings, including a rigid curriculum, fragmented practice platforms, homogeneous faculty competencies, and a results-driven evaluation mechanism. Using Xuzhou Medical University as a case study, this research constructs a "Four-Phase Progressive" educational model (cognition → practice → innovation → entrepreneurship) grounded in constructivist learning theory and the Outcome-Based Education (OBE) approach. By redesigning interdisciplinary courses from "isolated" to "integrated" learning and establishing a competition-fueled innovation practice system that integrates contests with innovation, the study aims to explore innovative practices in medical E&I education. The findings offer a replicable theoretical paradigm and practical insights for bridging the gap between specialized medical training and E&I education.

Keywords

Specialty-innovation integration; medical universities; entrepreneurship and innovation(E&I) education.

1. Introduction

China's Education Modernisation 2035 Plan clearly set the strategic goal of "advancing the deep integration of innovation and entrepreneurship education with professional education," emphasizing "strengthening practice-oriented education and building an industry-education collaborative talent cultivation system." However, the *2022 National Employment Quality Report for College Graduates* released by the Ministry of Education reveals that the entrepreneurship rate among medical school graduates is only 1.2%, significantly lower than that of comprehensive universities (3.8%). This data reflects systemic shortcomings in the top-level design, curriculum integration, and practical pathways of medical E&I education.

Aligned with the "Healthy China 2030" initiative, the mission of medical education is shifting from the singular goal of disease treatment to the comprehensive promotion of lifelong health. This evolving landscape demands the cultivation of interdisciplinary talent proficient in both clinical practice and innovation competencies—necessitating a "specialty + E&I" integration model. Against this backdrop, Xuzhou Medical University—a leading institution under Jiangsu Province's Peak Plan for High-Level University Development—has actively pursued reforms in integrated E&I education since 2019. Anchored in constructivist learning theory and the OBE framework, the university has restructured its E&I ecosystem through a tripartite mechanism consisting of "competition-driven learning, interdisciplinary collaboration, and studio-based incubation." Leveraging six years of empirical data (2019–2024), this study adopts a mixed-methods approach, incorporating a Difference-in-Differences (DID) model and in-depth case analysis, to systematically examine the innovation mechanisms and implementation outcomes

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of medical E&I education. The results aim to provide transferable theoretical models and practical references for peer institutions seeking to enhance their own educational frameworks.

2. Current Status of E&I Education in Medical Universities

Although medical universities in China have made incremental progress in advancing E&I education, persistent structural challenges continue to impede its effectiveness. Based on a survey of 526 students from eight medical universities in Jiangsu Province (Table 1) and a comprehensive review of existing literature, this study identifies the following core challenges:

Table 1. Key challenges in E&I education at Medical Universities (N=526)

Dimension	Identified Problem	Percentage(%)
Curriculum System	Lack of E&I elements in professional courses	78.6
Practical Platform	Insufficient opportunities for real-world project	91.2
Faculty Team	Inadequate guidance in innovation/entrepreneurship	65.3
Evaluation Mechanism	Low commercialization rate of outcomes	82.4

2.1. Linearized Curriculum System

Traditional medical education remains heavily focused on disease diagnosis and treatment, with minimal integration of E&I elements. The survey reveals that 78.6% of students perceive a lack of innovative thinking cultivation in professional courses. For instance, in one university's Internal Medicine curriculum, only four credit hours are dedicated to "clinical technology innovation case studies," predominantly taught through lecture-based instruction. This transmission-based pedagogy is insufficient for cultivating critical thinking and problem-solving skills.

2.2. Fragmented Practical Platforms

A striking 91.2% of respondents cited limited access to real-world project experiences. Most institutions limit E&I practice to business plan drafting or simulated campus competitions, which lack alignment with clinical needs. For instance, at one representative university, only 23% of 112 E&I projects initiated over three years involved authentic medical scenarios.

2.3. Outcome-oriented Evaluation Mechanism

Current evaluation systems overly emphasize tangible deliverables such as competition awards and publications, while undervaluing the development of core competencies and procedural skills. Notably, 82.4% of students pointed out the low commercialization rate of project outcomes. For instance, among 68 patents generated at one institution over five years, only nine reached the stage of clinical application, underscoring a weak link between academic innovation and real-world implementation.

3. Theoretical Foundations and Model Construction

3.1. Theoretical Framework

In constructing a theoretical model for medical E&I education, we draw upon classical theories from the fields of pedagogy and science, aiming to strike a balance between theoretical frameworks and practical application.

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First, Experiential Learning Theory provides foundational support for the design of the educational pathway. As proposed by Kolb(1984), learning is a cyclical process comprising concrete experience, reflective observation, abstract conceptualization, and active experimentation. This theory is embedded in our "Four-Stage Progressive" training system. For instance, after engaging in virtual simulation experiments (concrete experience), students are guided through reflective case analysis, ultimately transforming identified issues into innovative project initiatives (active experimentation). This "learning by doing" approach not only consolidates professional knowledge but also fosters critical thinking.

Second, Constructivist Learning Theory underscores the social and contextual nature of knowledge. Vygotsky(1978) argued that learning should take place within social context, where collaboration and interaction serve as catalysts for cognitive development. Building on this perspective, we designed a "Medicine +" interdisciplinary course cluster. For instance, in the *Hospital Management* course, the curriculum integrates medical knowledge with information technology, requiring students to work in teams to complete hospital operations optimization projects. This approach breaks down traditional disciplinary boundaries, enabling students to naturally synthesize knowledge while addressing real-world challenges.

In addition, Complex Adaptive Systems Theory provides a macro-level perspective for the model. Holland(1995) posits that the adaptability of a system stems from the dynamic interplay between internal components and external environments. In the context of medical E&I education, we not only focus on reforming curriculum and pedagogy but also emphasize building a robust external support ecosystem. For example, through partnerships with local governments, we have established "innovation workshops" that integrate real-world demands from biomedical enterprises into instructional design. Simultaneously, elements of medical humanities education are embedded within practical learning experiences. This "internal-external coupling" enables the educational system to continuously adapt and optimize in response to policy shifts and evolving industry needs.

3.2. The "Four-Stage Progressive" Training System

In practice, we adopt a competency-oriented approach to construct a pyramid-shaped, four-stage training model—Cognition → Practice → Innovation → Entrepreneurship—that progresses from foundational learning to applied practice(see Table 2).

The first stage (Cognition) serves as the foundational layer, aiming to cultivate basic E&I literacy through curriculum reform-currently covering 92% of academic programs. Drawing from the "remembering and understanding" levels in Bloom's Taxonomy of Educational Objectives, we have introduced general education courses such as *Health Management*. These courses combine theoretical instruction in health risk assessment and behavioral intervention strategies with case-based teaching methods that guide students toward innovative application. For example, when analyzing a project on "Community Hypertension Patient Health Management," students work in teams to design a mobile-based health monitoring system that integrate dietary recommendations, exercise plans, and medication reminders. By simulating real-world community healthcare scenarios, students gain a systematic understanding of the entire process from data collection to intervention implementation. Surveys indicate that after adopting this model, students' ability to design health management solutions improved significantly, with the proportion of high-quality proposals rising from 24% to 58%.

The second stage (Practice) emphasizes hands-on skill development through competition-based learning, reflecting Dewey's theory of "Learning by Doing." Each year, the university organizes 32 academic competitions, among which the "*Enterprise Operation Simulation Competition*" is particularly representative. Students should optimize processes in a virtual business environment, balancing product and service quality with cost control and operational efficiency.

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The third stage (Innovation) focuses on real-world project training, leveraging the design thinking process—particularly its "empathize-define-ideate-prototype-test" cycle—as a core framework. Student teams in innovation studios are expected to identify problems from clinical settings and propose technical solutions. One such team developed an "Intelligent Infusion Monitoring System," which not only won the national invention patent but also obtained Class III medical device certification. This complete journey from problem identification to product development allows students to deeply experience the value of innovation.

The fourth stage (Entrepreneurship) concentrates on research commercialization. Based on the Timmons Model of Entrepreneurial Process—particularly its principles of opportunity recognition and resource integration—we have established co-operative practice bases with 12 top-tier (Class III A) hospitals. These partnerships provide authentic clinical settings where student teams can test and validate the feasibility of their projects. For instance, the "AI Pathology Diagnostic Platform" accumulated over 10,000 cases during its clinical trial phase, ultimately securing venture capital investment. This "academia-hospital-industry" tripartite synergy transforms entrepreneurship education from theoretical discourse into tangible outcomes.

Table 2. Four-Stage Progressive Training Framework

Tier	Phase	Educational format & content
1	Cognition	Curriculum reform + General education in E&I
2	Practice	Virtual simulation experiments + Skills-based competitions
3	Innovation	Research projects + Patent incubation
4	Entrepreneurship	Innovation hubs + Industry commercialization

4. Innovations in Practical Pathways

4.1. Interdisciplinary Curriculum Reconstruction: From "Isolation" to "Integration"

To address the disconnect between traditional medical education and E&I training, Xuzhou Medical University has developed a multi-tiered curriculum system based on the "Medical+" concept:

4.1.1. Modular Curriculum Cluster Development

Aligned with the "New Medical Science" initiative (Ministry of Education, 2020), the university integrated resources from clinical medicine, data science and management to create six course modules (see Table 1). For instance, the course I*ntroduction to Artificial Intelligence* includes three components: machine learning algorithms, medical image analysis, and ethical risk management. The course is co-taught by faculty from multiple colleges. Students are tasked with designing an AI-based diabetic retinopathy screening system, with three outstanding projects successfully implemented in community hospitals.

4.1.2. Project-based Teaching Reform

A problem-based learning (PBL) approach is adopted to immerse students in real-world clinical scenarios. In the course of *Operations Research in Health Management*, students are required to analyze and improve emergency department workflows at a specific Class III A hospital in Xuzhou. Through field research, data modelling, and cost analysis, their proposed "hierarchic healthcare + smart triage" model was adopted by the hospital, reducing patient wait times by 40%. This project-based model now covers 87% of the university's majors, with 92% of student participation.

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4.1.3. University–Industry Collaborative Courses

Partnering with 12 biomedical enterprises, the university co-designed the course *Innovative Design of Medical Products*. Industry mentors present real-world problems such as "Human-Machine Interface (HMI) Optimization for Portable Ventilators". Student teams conducted market research, prototype, and clinical testing, with six designs receiving corporate patents.

4.2. Competition-Driven Practice System: Promoting Innovation through Competitions-Integrated Education

4.2.1. Pyramid-Shaped Competition Ecosystem

The university has established a three-tiered competition ecosystem to drive innovation and entrepreneurship. At the university level, the foundational tier engages over 3,000 students annually, focusing on cultivating fundamental innovation awareness. The provincial level serves as the advancement tier, where outstanding teams are selected to participate in high-profile competitions such as China College Student Engineering Practice and Innovation Ability Competition, the iCAN International Contest of innovation, and the "Xuechuang Cup" National Student Entrepreneurship Simulation Competition. Over the past three years, students have garnered 61 provincial-level awards. At the national level—the elite tier—students have achieved remarkable success, winning 36 national awards and consistently breaking school records while attaining top rankings among independently chartered medical universities. Notably, the university made history in 2024 by hosting the "Xuechuang Cup" National Finals, becoming the first medical institution to organize this prestigious event.

4.2.2. Studio-Based Training Model

We have established 12 interdisciplinary studios—such as "Smart Healthcare" and "Health Management"—organized in a "mentor + graduate + undergraduate" hierarchy. This studio-based model supports a comprehensive "Curriculum–Studio–Competition" E&I education system. These innovation hubs actively guide students through participation in competitions listed on the National Undergraduate Competition Rankings and graduate-level innovation practice contests, reaching students from all colleges and disciplines. For example, students from the "TipDM Intelligent Innovation Studio" completed a cost analysis model for basic public health services, which was adopted by the Xuzhou Health Commission for financial planning, benefiting nearly 10 million residents.

5. Outcome Analysis and Empirical Validation

5.1. Quantitative Evaluation System: From "Subjective Experience" to "Data-Driven"

To scientifically assess the effectiveness of medical E&I education, this study developed a Medical Innovation Index (MII) comprising 4 primary dimensions and 12 secondary indicators (Table 3) with weights determined using the Analytic Hierarchy Process (AHP).

5.2. Difference-in-Differences (DID) Validation: Causal Effects of Educational Intervention

A three-year longitudinal study was conducted with 2,346 clinical medicine students, comparing an experimental group (participating in integrated E&I courses) with a control group (traditional instruction).

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Table 3. Evaluation System for E&I Competencies

Primary Dimension	Secondary Indicator	Weight
Knowledge Integration	1. Interdisciplinary knowledge application	0.12
	2. Clinical problem identification and analysis	0.10
	3. Understanding of medical ethics and regulations	0.08
Practical Innovation	4. Research project design and implementation	0.15
	5. Quality of academic competition achievements	0.13
	6. Prototyping and technical validation	0.12
Achievement conversion	7. Number of patents/software copyrights authorized	0.10
	8. Technology transfer or commercialization revenue	0.07
	9. Rate of real-world clinical application	0.06
Social Service	10. Duration of participation in primary care projects	0.05
	11. Contribution to public health problem-solving	0.04
	12. Social impact of medical public service	0.03

Table 4. Effects of E&I-Oriented Curriculum Reform

Indicator	Experimental Group Improvement	Control Group Improvement	Significance (p-value)
Innovation project participation rate	58%	22%	< 0.001
Competition award rate	41%	15%	< 0.01
Patent commercialization rate	19%	5%	< 0.05

Note: Hausman test confirmed the exclusion of endogeneity bias (χ^2 = 12.34, p = 0.15).

Further analysis revealed that students in the experimental group exhibited the most significant improvement in the “clinical problem identification and analysis” (+42.3%), particularly in specialties such as emergency and radiology. Overall, E&I project participation rose from 34% to 92%, with students winning 139 national-level awards in competitions such as *Internet+* and the *Challenge Cup.* The achievement conversion rate reached 20.9%, compared to the national average of 9.6% among medical schools. Notably, the *AI-based Pathological Diagnosis System* tripled the efficiency of lung cancer screening. Meanwhile, the graduate entrepreneurship rate increased from 1.2% to 3.8%, significantly exceeding the national average for medical institutions.

5.3. Quantitative Evaluation System: From “Subjective Experience” to “Data-Driven”

A follow-up survey was conducted among 486 program graduates (91% response rate). Results showed that 83.2% of participants were employed in top-tier hospitals or med-tech companies, significantly higher than the 64.5% employment rate for non-participants. Moreover, 76.4% of employers affirmed that these graduates possessed interdisciplinary problem-solving skills. The entrepreneurship rate reached 3.8%, compared to the national average of 1.2%, with one venture—the *Mobile Emergency Monitoring System*—generating annual revenue exceeding 10 million RMB.

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6. Conclusion and Future Expectations

Through six-year educational reform and multidimensional empirical analysis, this study demonstrates that the proposed Four-Stage Progressive Training Model (*Cognition → Practice → Innovation → Entrepreneurship*) effectively addresses the disconnect between E&I education and professional medical training. The findings confirm that the integrated model—featuring a "three-dimensional coordination" model (knowledge, skills, values) and a "four-stage progressive" pathway—effectively broke down disciplinary barriers and bridged the gap between education and industry, offering a replicable framework for "New Medical Sciences" initiatives.

Based on research findings and practical feedback, the following three-tiered recommendations are proposed: At the institutional level, efforts should focus on promoting interdisciplinary course clusters under the "Medicine + X" framework, establishing mutual recognition mechanisms for E&I credits across departments, and creating dedicated funding to strengthen faculty competencies in innovation and entrepreneurship. At the industry level, tertiary hospitals are encouraged to set up "Clinical Innovation Needs Pools" and form a closed-loop ecosystem that links problem identification, academic research, and enterprise commercialization. At the policy level, E&I education should be integrated into the core evaluation criteria for medical programs, and it is recommended that the National Health Commission establish "Medical Entrepreneurship & Innovation Demonstration Bases".

Despite these achievements, the current model's adaptability in specialized domains such as Traditional Chinese Medicine (TCM) and nursing remains to be validated. Future research should explore a "TCM-Western medicine integrated E&I education" pathway, establishing a decade-long graduate career database to assess long-term impact, and leveraging international initiatives—such as "Belt and Road" medical collaborations—to develop cross-border innovation co-training models (e.g., China-Africa telemedicine partnerships), thereby enhancing the model's global applicability.

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