



RESEARCH ARTICLE

Bridging the Gap: How Innovation and Entrepreneurship Education Prepares Medical Students for the Workforce

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ABSTRACT

As medical schools strive to prepare their students for complex problem solving and solution design, they are increasingly offering training in innovation and entrepreneurship (I&E). This study aims at bridging the gaps in existing research, instructional strategies, and best practices for instructing medical professionals in innovation and entrepreneurship. The incorporation of multidisciplinary knowledge and the necessity of a thorough integration between professional education and innovation and entrepreneurship education are some of these challenges. Additionally, the advancement of innovation and entrepreneurship education in a sustainable manner and the absence of an innovation and entrepreneurship education management system also pose significant challenges. We identified and analyzed sixty-four distinct publications. The articles covered a number of common topics, such as career planning and skill development ($n = 12$), innovation and entrepreneurial intention ($n = 34$), and diverse skills essential for the medical entrepreneur ($n = 18$). While most programs reported high levels of satisfaction, only a few demonstrated substantial results. Additionally, there weren't many instructional strategies employed to encourage physicians or trainees to pursue entrepreneurship. Seven educational themes—entrepreneurship, innovation, technology, healthcare systems, leadership, business of medicine, and greater adaptability—and two topics related to teaching methods—active learning and interdisciplinary teaching—were identified using thematic analysis and were mentioned in more than 55% of the programs. To address the new skills required by doctors due to healthcare developments, medical school I&E programs are rapidly expanding, though they remain small in comparison to class sizes. Despite descriptions, few programs have proven effective. To teach these approaches, teacher recruitment, growth, and compensation should be prioritized. This gap can be closed with the assistance of those engaged in educational planning.

INTRODUCTION

China's National Innovation and Entrepreneurship Training Program for College Students (I&E Program) began with 2010 "Ministry of Education policy recommendations". These ideas promoted higher education innovation and entrepreneurial education to develop students' practical skills and innovative attitude. Central South University submitted 16,300 projects to the ministries for approval in 2011 [1]. In reaction to new laws, the Chinese government placed medical education reform as a top priority. The newly established medical department emphasizes the importance of lifetime health as a proactive approach to preventing and treating illnesses, with a specific focus on medical education. Medical education should actively address the challenges and opportunities presented by the technological revolution, advancements in research, and industry changes. This will entail the creation of new fields of study such as digital medicine, transformational medicine, and intelligent medicine [2].

In 2021, the Hunan Province of China granted approval to a total of 11,394 Innovation & Entrepreneurship programs, which encompassed the participation of 49,451 students and incurred a financial expenditure of 87.15 million yuan. Central South University initiated a total of 1,731 programs, encompassing 432 medical programs, 391 innovative programs, and 41 entrepreneurial programs [3, 4]. The integration of medical humanities, engineering, and science should be employed to bolster a novel medical education model within the framework of the worldwide Industrial Revolution 4.0 [5].

In this context, Chinese medical education should strengthen the establishment and refinement of the medical education professional certification system, and the quality standard system of medical talent training with Chinese characteristics and international substantive equivalent, create "Chinese concept" and "Chinese standard", and constantly improve innovation and entrepreneurship education training quality and international competitiveness [6]. Quality education needs to support innovation and entrepreneurial education to train more creative and energetic talent to promote national development and education reform [7].

The new medical school system with Chinese characteristics has extensively incorporated the emerging new medical specialties of translational medicine and precision medicine, enabling it to adapt to the technological and life science revolutions in artificial intelligence and synthetic biology. We need medical innovators who can use transdisciplinary expertise to solve cutting-edge medical problems. In the context of new medical science, how to organically integrate innovation and entrepreneurial education with specializations in medical schools and universities is an important problem of Chinese medical education and teaching reform [8]. New education reforms have made it imperative to integrate mental health education with I&E education in universities and colleges [9]. As the country develops, talent requirements rise.

Innovation and entrepreneurship education in China has emphasized innovation more since inventive thinking is crucial for personal and professional success in the modern world. Students need innovation skills more than company startup skills. Entrepreneurship relies on innovation to create new businesses and technologies. Educational programs attempt to foster creative thinkers and problem solvers who can contribute to healthcare, technology, and other industries by focusing on innovation. This ensures that students can start their own businesses and contribute to innovative and growing companies. Innovative students are better prepared to adapt and lead in a changing global market.

Innovation and entrepreneurship challenge students' mental health. Students with high entrepreneurial psychological qualities are the foundation of entrepreneurship [10]. Innovative entrepreneurs should study, never stop improving, and have excellent professional knowledge and skills [11]. Both innovation and entrepreneurship and mental health education share values, academics, goals, content, and techniques.

This study is to assess research competence among undergraduate medical students who participated in the I&E Program. That addresses the medical education and innovation gap, which emphasizes the growing demand for healthcare innovation and the lack of methods to nurture it in medical school. This review was intended to answer three questions:

1. What are medical professionals' entrepreneurial education practices?
2. How does medical education relate to entrepreneurship, and does the I&E Program enhance medical students' entrepreneurial and research skills?
3. What innovation education models exist for medical professionals, and how satisfied are students with the I&E Program, including areas for improvement?

Knowing this information helps medical education decision makers adapt curricula to equip future health professionals.

METHODOLOGY

The study aims to concentrate its efforts on identifying the gaps in the literature directly related to medical education, with the ultimate goal of developing programs and/or research in this field. Rather than focusing on a particular facet of education, it chose to investigate the connection between entrepreneurship and education.

Search Strategy

On MEDLINE, Embase, WoS, AMED, Google Scholar, and PubMed, these terms were searched as keywords. All searches were conducted up to Jan 1, 2024. ((Innovation) AND (Entrepreneurship) AND (Medical Education) AND (China) OR (Thematic Analysis) OR (Skill Development) OR (Competency Enhancement) OR (Medical Entrepreneurs) OR (entrepreneurial skills)).

We mapped each term to a MeSH subject heading and then used the 'explode' function to include all related subheadings, thereby capturing any peculiarities across the databases. This allowed them to search for specific papers by using keywords and mapping the terms to synonyms in the various systems.

Inclusion and Exclusion Criteria

Many of the results that our search keywords produced had nothing to do with the subject of our interest. The following requirements have to be fulfilled for manuscripts to be considered for this review: It has to meet three requirements: (1) be a journal article; (2) encourage healthcare professionals to think creatively and entrepreneurially; and (3) have something to do with physicians or people pursuing medical education.

Papers that didn't fit the above-mentioned inclusion criteria were eliminated, including those that weren't on innovation or entrepreneurial education, healthcare or medicine and grey literature.

Data Extraction and Analysis

Following screening, 64 full-text papers were retained for qualitative analysis. To standardize the analysis of every document, an extraction tool was created in an Excel spreadsheet. After the

reviewers had completed full-text screening and gained some familiarity with the literature, the tool was created.

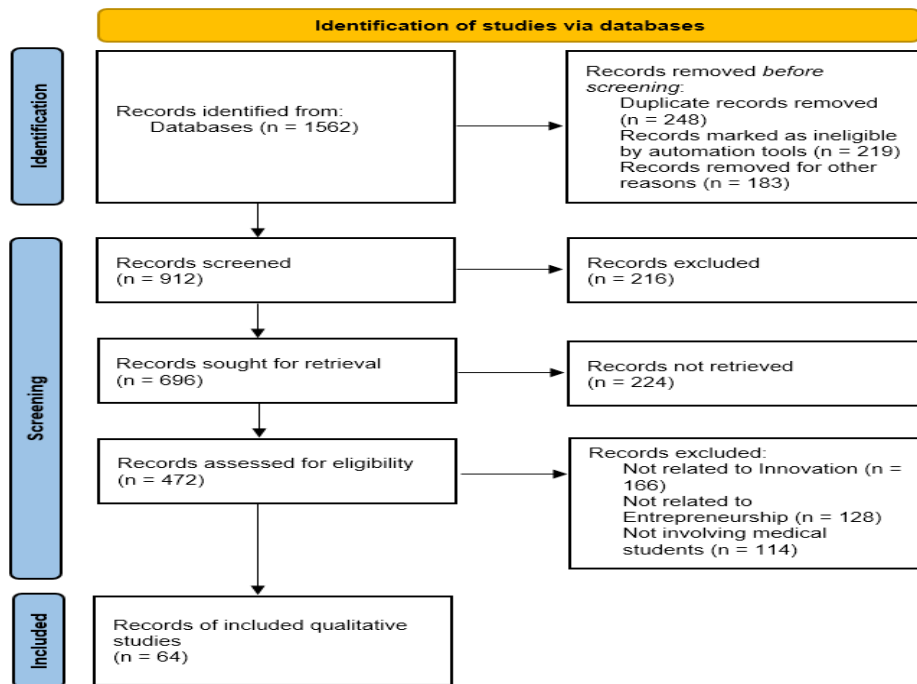


Figure 1. Flow diagram using PRISMA

The demographic data for each paper, the subjects and issues covered, and the views on innovation and entrepreneurship were among the domains for extraction. To determine the demographics, results, and resources covered in each educational innovation, additional analysis was done on papers that addressed particular innovations in education. These spreadsheet-formatted results served as the foundation for our PRISMA-formatted study (Figure 1).

RESULTS

Education for Innovation and Entrepreneurship in China

Medical schools and universities should develop innovative and entrepreneurial educational models in order to meet the needs of the modern world and societal advancement. Research on innovation and entrepreneurial education has had a significant positive impact on the field of medicine [12]. Researchers are conducting research on the reformation of teaching methods and curriculum, as well as the practical exploration of innovation and entrepreneurship activities among medical students, to provide a cutting-edge framework for teaching entrepreneurship in medical colleges. It is vital to establish a novel framework for teaching I&E.

The peculiarities and trends of the medical industry should guide the search for new teaching models and the establishment of new innovation and entrepreneurship education models. 1) Integrated course teaching style: To create an integrated course teaching mode, traditional medical courses must be blended with I&E education for undergraduate medical students. Students can learn about the philosophy and practice of I&E while gaining medical knowledge, and they can apply this information to the medical sector by naturally fusing courses in innovation and entrepreneurship with medical courses; 2) Practice-oriented teaching mode: The core curriculum of I&E education for medical undergraduates should incorporate practical teaching, and the curriculum itself should be

practice-oriented. Students can enhance their practical and innovative abilities by learning the techniques and skills of entrepreneurship and innovation through hands-on instruction; 3) Project-driven teaching style: Project-driven learning is necessary for medical undergraduates studying innovation and entrepreneurship, and it should be incorporated into the course's main curriculum [6].

Students can develop their creative thinking and collaborative skills while experiencing the innovation and entrepreneurship process in action through project-based learning. Medical science is naturally interwoven with other disciplines through innovative teaching methods, and cross-border collaboration between medical innovation and entrepreneurship is encouraged to enhance students' overall quality and capacity for creativity.

Nurturing entrepreneurial talent is essential to overcoming the middle-income trap and maintaining the growth of a thriving entrepreneurial sector [13]. In the meantime, since the late 1990s, the Chinese higher education system has grown significantly, much like its counterparts around the world. The gross enrollment rate hit a record high of 57.8% in 2021 [14]. The flowchart offers the steps and factors that must be taken into account in order to create and execute an efficient curriculum for innovation and entrepreneurship in Chinese medical schools (Figure 2).



Figure 2. A flow diagram of an effective innovation and entrepreneurship curriculum

A Thematic Study of Competency Improvement and Skill Development

Many students participating in the I&E Program have enhanced their academic performance, authored articles, filed patents, and achieved competition accolades. Their study has enhanced their theoretical research capabilities, clinical research skills, data analysis knowledge, in-lab procedures, experimental research skills, data analysis ability, entrepreneurship, communication, and teamwork. While 73.93% of student's express satisfaction with the I&E program, there are areas for improvement, including the inclusion of more robust practical elements, the provision of greater support, and the promotion of increased collaboration [15]. Moreover, the worldwide exposure to

entrepreneurship education and the proactive incorporation of these methods into fresh economic strategies aimed at generating employment opportunities in numerous countries have served as a source of inspiration for the Chinese government and universities [16].

In 2005, the International Labour Organisation, the Communist Youth League Central Committee, and the All-China Youth Federation worked together to encourage Chinese universities to adopt the KAB (Know About Business) Entrepreneurship Education (China) Programme in order to gain knowledge from global experiences. Subsequently, the KAB (China) Programme has had a significant impact on student practice, teacher preparation, and curricular development [17].

Furthermore, when evaluating candidates, Chinese hospitals and research organisations frequently give greater weight to medical students' achievements and laboratory experiences. This has led them to concentrate more on research pertaining to experimental programs in order to improve related skills and competitiveness in the job market. If medical education does not sufficiently encourage and train medical students in epidemiological research (26.60%) and entrepreneurship programs (9.57%), they may not be as knowledgeable or interested in these subjects [15]. By enrolling in an entrepreneurship course, students can acquire the fundamental theoretical information and abilities needed to establish a strong foundation for future entrepreneurial practice activities through the opportunity to enhance their learning. On the other hand, participating in entrepreneurship events and contests can help students retain what they have learned [18].

Qian et al. [19] brought up a number of initiatives, such as the entrepreneurship salon, which ignites the entrepreneurial spark in students and instructors by encouraging group brainstorming and the sharing of experiences in innovation and entrepreneurship. In conjunction with the students' individual specialisations, the workshop facilitates the design and implementation of health products.

Skill Development through Entrepreneurship Practices

Practice is an important component that influences entrepreneurial willingness and skills. It encourages the development of entrepreneurial skills. Jena [20] used random sampling to examine the thoughts, feelings, and actions of Indian college students on entrepreneurship education, and found that engaging in entrepreneurial activities significantly increased their intention to pursue entrepreneurship. The practice of entrepreneurship developed the spirit of entrepreneurship in addition to strengthening entrepreneurial abilities. Furthermore, it enhanced the inclination of prospective entrepreneurial students towards entrepreneurship. Based on the real-world experience of entrepreneurship education in China, Zhao et al. [21] thought that entrepreneurship education enhanced students' capacity for creativity and entrepreneurship and that this was a chance to further the growth of China's education sector. Wang et al. [22] studied the relationship between entrepreneurial education and other domains. The assessment of entrepreneurship education should follow formative and summative evaluation models because it is a dynamic educational system in which theoretical development and practical application occur simultaneously.

Competency enhancement through innovation and entrepreneurship education

Formal courses have been introduced by many Chinese medical schools to help students improve their abilities to address complicated problems. These design- and innovation-related initiatives come in a variety of shapes and sizes, and they frequently touch on entrepreneurship and innovation. Innovation and entrepreneurship have historically been fostered in business or product development-focused undergraduate programmes, but they are also commonly studied by graduate students in engineering, design and business. Further study is required to determine how innovation

and entrepreneurship courses complement medical courses and what kind of inspiration they may offer for future medical education, since these subjects have become ingrained in medical education. Without a question, physicians will be needed to assist in resolving present and upcoming issues within the healthcare system. Innovation and entrepreneurship education can offer pertinent information when physicians take the lead in creating products and finding answers to challenging issues [8].

Medical information education is an innovative method of delivering medical education. Providing a concise and accurate definition of medical innovation education is challenging. Medical innovation and entrepreneurship, as defined in the framework, refer to the capacity to effectively implement ideas. Competency models encompass a variety of skills, including structured medical problem solving, social orientation, needs analysis, and technical talents like financial analysis. This study employs an expansive interpretation of I&E education, defining it as the process of acquiring the skills to develop ideas and convert them into tangible objectives, such as projects or products. This method provides medical students with the fundamental knowledge and skills required to address intricate challenges in their future professions.

Promote the use of project-based learning. Every year, China Medical University distributes funds to build an "academic innovation project for college students" with the goal of promoting the development of innovation and entrepreneurship education at the institution. This project aims to provide students with the opportunity to engage in scientific research training during their free time, and to participate in the research projects of their respective teacher research groups. The project's objective is to provide students with the essential resources they need to become proficient in the most recent developments in their respective professions. Additionally, it intends to cultivate their own self-awareness and creativity through autonomous practice [12]. Furthermore, it is important to leverage student organizations to actively engage in business activities and foster creativity. China Medical University often directs students' associations to organize activities that are in line with their own characteristics. Promote innovation and entrepreneurial activity among each entrepreneurial team, taking into account their distinctive characteristics, with the "College of Science and Technology for College Students" taking the lead. Provide comprehensive and substantial financial assistance. This exercise utilizes the Project Leader system. The operational procedure encompasses event planning, instructor assessment, practical execution, summarization, and evaluation. Various activities can augment students' entrepreneurial aptitude and cultivate their self-directed learning and personal growth.

DISCUSSION

Mental health education is a critical component of helping college students develop their creative awareness and spiritual civilization. Incorporating innovation and entrepreneurship education has the potential to enhance college students' excitement for innovation while also providing real benefits for advancing economic development and scientific and technological progress [23]. Colleges and universities must integrate mental health education with innovation and entrepreneurship education for them to flourish. It is only possible to ensure the long-term growth of college talent's abilities in every way by building appropriate ideological ideals for them [24].

The entrepreneurial education (EE) curriculum comprehensively covers all students at comprehensive institutions. Zhang and He [25] highlighted a curriculum at Caltech, which features rich content and diverse teaching styles and has been in use for years. Their study demonstrated a positive relationship between overall satisfaction with the quality of entrepreneurship education and specific entrepreneurship courses. Three significant relationships emerged: 1) the content is closely

aligned with cutting-edge trends, 2) the content is closely integrated with professional knowledge, and 3) the teaching methods of entrepreneurship courses are varied. Updating course material to reflect current trends may contribute to increased student satisfaction with the quality of education.

The study uncovered several significant insights. The limited engagement with entrepreneurship courses in Chinese medical schools is due to multiple factors. These include fragmented curriculum structures, insufficient funding that poses significant hurdles for medical students aspiring to start their own ventures, the lack of supportive policies for medical entrepreneurship, and minimal teacher-student interaction that could enhance the educational experience. The study underscores the importance of creating a well-rounded and diverse curriculum for entrepreneurship education in Chinese medical schools, improving the visibility of students' entrepreneurial efforts, establishing a robust financial support system, and integrating key innovations into the educational framework.

When it comes to entrepreneurship, students frequently experience intense pressure and fear, which has a direct impact on the bravery and drive of business owners. After graduation, college students must fully transition from being students to social beings, and this requires them to undergo some internal changes due to the shift in their surroundings. The appearance of these unfavourable psychological feelings would adversely affect their day-to-day activities as well as their ability to innovate and grow their businesses [26]. The value of entrepreneurship education in predicting entrepreneurial behaviour is frequently evaluated by looking at students' aspirations to become entrepreneurs. Although most research has shown a positive correlation between the two, there are disagreements on the specifics of this correlation and whether or not teaching and learning methods are relevant [27].

The majority of students have no expectation that the I&E Programme will have an effect on their Mandatory assignments, despite the general consensus. More than half of the students think that taking part in the I&E Programme helps them study more in their necessary coursework. This may be explained by the fact that many undergraduates required courses include I&E education, and students understand the importance of their present career plans. A prior study found a significant overlap in important characteristics when looking at things from a professional and research perspective [28], which suggests that the research and the curriculum are closely related.

Their creative ideas can be developed into successful businesses or lab experiences with the help of the I&E Programme. Its goal is to develop highly skilled innovators who can fulfil the demands of creating a country that is focused on innovation [29, 30]. Under the direction of their instructors, it gives students the freedom to carry out independent research, programme design, execution, and analysis. The ability to translate ideas into actions is the broad definition of entrepreneurship competency according to the Entrepreneurship Competency Framework [31–35]. Numerous polls around the world indicate that integrating research into undergraduate medical education is viewed as a viable way to prepare future physician-scientists [36–40].

Since medical students, especially aspiring physicians, are on the front lines of accomplishing sustainable development goals, medical universities should be dedicated to training the next generation of physician-innovators [41, 42]. In order to enhance the growth of medical students, this study offers useful implications for pedagogical approaches and entrepreneurial learning in medical school. It is imperative that all parties involved, especially those affiliated with medical university faculties, acknowledge and concur that incorporating I&E into medical education presents a promising avenue for training future physicians to take on more responsibility for addressing social and public health issues [43].

Additionally, entrepreneurship education equips students to start their own businesses in the future by working together to create novel concepts, viewpoints, goods, and services [44]. In order to increase the quality of educational innovation and eventually have a beneficial impact on students who are directly involved in the interaction, this requires tight collaboration between teachers and students [45]. In this study, we employed the most generalisation of I&E in medical education.

Challenges and Limitations

The study examined innovation and entrepreneurship education changes in local scientific institutions in the changing environment of medical education, providing insights for educational reform. This study's difficulty is that reasonable execution is needed to prove these measures' efficacy. Innovation and entrepreneurship (I&E) competences from the I&E Program were assessed using specific abilities due to conceptual comprehension inconsistencies and questionnaire improvement limitations. Future research should include all entrepreneurship education stakeholders for a more complete assessment. Even though the study examined many system aspects in entrepreneurship education evaluation, it did not cover lecturer teamwork and coaching methods. Future research should include all method parameters for a fuller evaluation. This assessment may be incomplete and needs improvement. These constraints indicate the need for more inclusive research to improve medical school entrepreneurship education evaluation and implementation.

CONCLUSION

Innovation and Entrepreneurship (I&E) programmes in Chinese medical schools are rapidly evolving to meet the needs of changes in the healthcare industry. Further study of I&E education is needed to understand its possible incorporation into the basic medical school curriculum because these programmes aim to teach future doctors vital skills and information. To achieve this, I&E programmes should be more transparent and collaborative. Optimisation and growth will help medical schools implement I&E instruction. By including I&E in the medical curriculum, we can better train future doctors to lead in the complex healthcare system, improving patient care.

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