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EXPLORATION OF INDUSTRY-EDUCATION INTEGRATION MODEL FOR MEDICAL-ENGINEERING TALENT DEVELOPMENT IN THE CONTEXT OF DIGITAL LIVELIHOOD

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Abstract: This study explores innovative industry-education integration models for cultivating medical-engineering talents in higher education institutions within the context of digital livelihood. It analyzes both the current demands for talent driven by the upgrading of digital social services and the emerging trends in medical-engineering convergence, highlighting existing challenges and opportunities in talent development in this respect. Furthermore, drawing on successful experiences, this study suggests a new insight into industry-education collaboration model aimed at cultivating interdisciplinary talents in medical-engineering integration. Through theoretical teaching and practical training, the article integrates the three main entities of higher education institutions, hospitals, and enterprises to achieve integration in disciplines, curriculum, and platforms. Finally, the article details innovative strategies and specific implementation paths, including the construction of an interdisciplinary teaching system and a project-driven workshop practice system.
Keywords: Digital livelihood; Medical-engineering talents; Industry-education integration; Workshops

1 INTRODUCTION

With the wave of digital technology sweeping across the globe, the concept of "digital livelihood" has evolved into a profound social reality, actively reshaping service delivery models and patient care experiences in the healthcare sector [1]. Against this backdrop, the medical industry is undergoing an unprecedented digital transformation. The widespread application of emerging technologies such as smart medical care, telemedicine, and AI-assisted diagnosis has greatly improved medical efficiency and quality [2,3]. However, these changes also pose substantial talent challenges. The accelerated digitalization and informatization of healthcare demand new competency in areas such as medical device R&D and health management, fueling an urgent need for innovative, interdisciplinary professionals with cross-domain expertise [4]. Therefore, digital transformation has not only reshaped the medical industry, but also put forward higher requirements for the knowledge structure and ability quality of medical-engineering talents.

In early 2025, the *Reform Plan for Adjustment and Optimization of Disciplines and Majors in General Higher Education* explicitly required increased proportions of basic science and foundational medical majors, with a focus on cultivating cross-disciplinary "Medicine + X" specialties. The plan also explicitly advocates for "medical-engineering integration" and "medical-physics integration" in interdisciplinary development. The education sector further underscores the construction of "New Medical Sciences," calling for universities to cultivate innovative talents equipped with interdisciplinary competencies spanning medicine, engineering, and management [5]. This study primarily addresses the cultivation of medical-engineering talents under the digital livelihood paradigm, emphasizing industry-education collaboration as an essential modality.

2 NECESSITY OF MEDICAL-ENGINEERING TALENT CULTIVATION BASED ON INDUSTRY-EDUCATION INTEGRATION

The extensive application of digital technologies, such as big data, artificial intelligence, and the Internet of Things, has profoundly transformed hospital diagnosis, management, and service models. This process intensifies the integration of medicine and engineering, shifting the demand from mere technical operators to innovative, problem-solving talents capable of addressing complex challenges [3]. During the process of building and operating smart systems, hospitals are increasingly in urgent need of medical-engineering interdisciplinary professionals. Such talents need to be proficient in medical business processes, data analysis, system development and other digital skills. Specifically, there is an urgent need for digitally proficient interdisciplinary talent with expertise in both medical knowledge and engineering technology to support hospital informatization, R&D of smart devices, and data management[3]. However, hospitals have higher expectations for colleges and universities since the existing medical-engineering professionals have shortcomings in the application of digital technologies and practical skills.

Although universities have established a series of models for the training of medical-engineering talents, these models still exhibit significant limitations owing to their traditional orientation[6-8], including rigid disciplinary boundaries with a disconnection among medicine, engineering, and management curricula; course content lagged behind the latest smart healthcare, inadequate practices; and homogeneous evaluation systems. Students lack opportunities to apply their knowledge in real medical contexts, being unable to bridge theory with complex and variable clinical practices. Thus, it is difficult to meet the urgent needs of the medical industry in the digital age for innovative, interdisciplinary, and application-oriented medical-engineering talents[5]. Therefore, universities are in urgent need of reform in their training model for medical-engineering talents[4,9].

Reforming the training model for medical-engineering talent in universities focuses on two key areas: first, the insufficient emphasis on practical application courses, leading to poor integration of theory and practice, second, a lack of deep understanding of industry needs due to the limited engagement with hospitals and enterprises, which negatively affects graduates who lack clinical experience. This situation hampers the ability of university-trained medical-engineering talent to adapt to the demands of the local job market. To address these challenges, fostering collaboration between universities, hospitals, and industry players has become essential. By adopting innovative formats such as workshops and mentorship programs, universities can engage frontline hospital experts and industry managers in curriculum design and practical training, enabling students to understand real-world industry needs and develop problem-solving capabilities.

3 CASE STUDIES OF THE UNIVERSITY-HOSPITAL-INDUSTRY MODEL

With the promotion of the digital livelihood strategy, the interdisciplinary integration of medicine and engineering has become the core driving force for the innovative development of the healthcare sector. All institutions, referring to universities, hospitals and enterprises across the country, are actively exploring new models of collaborative education and have formed distinctive cooperation cases.

3.1 Focusing on Children's Health with the Cross-Innovation of Medicine and Engineering

As a leading pediatric medical institution in China, Nanjing Children's Hospital has actively expanded its cooperation with domestic and international universities in recent years. In addition, it has established a multi-tier, high-level platform for the integration of medicine and engineering. In March 2025, the Children's Hospital of Nanjing Medical University and Nanjing Tech University jointly established the "Center for Medical-Engineering Interdisciplinary Innovation"[10]. The center focuses on addressing engineering and technical challenges in the field of children's health, promoting the research, development, research, development and translation and translation of smart medical equipment by aligning clinical needs with universities' scientific research strengths. Its mission is to advance children's health through the “cross-innovation of medicine and engineering.” Cutting-edge cross-disciplinary research projects are being carried out, leveraging advanced technologies such as artificial intelligence to build digital healthcare services which are more intelligent and efficient.

3.2 Leveraging Large Models as a Catalyst to Drive Both Scientific Research and Education

The Interdisciplinary Institute for Medical Engineering of Fuzhou University is a model of medical-engineering integration in Fujian Province [11]. It is affiliated with the School of Artificial Intelligence and focuses on biomedical materials, medical big data and intelligent medical devices to build a whole-process innovation ecosystem spanning data, algorithm and application. In terms of talent cultivation, the institute has adopted a dual-driven model of "scientific research + teaching". This model attracts students from diverse disciplines such as medicine, computer science, and bioengineering to participate in research, thereby enhancing their abilities in areas such as data analysis and engineering practice. Moreover, it combines clinical cases with algorithm training to foster the deep integration of medicine and informatics. This approach not only accelerates the translation of scientific research outcomes but also provides students with a comprehensive development pathway from theory to practice.

3.3 Building a Closed-Loop of Industry-Academia-Research Application Driven by Clinical Demands

The medical-engineering integration project between Guangdong University of Technology and ShenShan Medical Center is a representative of the "Artificial Intelligence + Healthcare" application scenario in Guangdong Province. It focuses on joint research in areas such as smart medical big data platforms, and surgical robot development. Regarding the development of talents, the project has implemented a "mutual mentorship program", where hospital experts, and university professors jointly mentor graduate students. Students participate in the entire process, from market research to product implementation.

In summary, it is evident that the Nanjing model emphasizes international cooperation and specialized focus, and the Fuzhou model highlights data-driven and multidisciplinary integration while the Guangdong model leverages clinical needs to facilitate rapid industrial transformation. These experiences collectively point toward a future trend: medical-engineering talent development has to break down disciplinary barriers to establish a tripartite collaborative ecosystem involving universities, hospitals, and industry.

4 INNOVATIVE STRATEGIES FOR CULTIVATING MEDICAL-ENGINEERING TALENTS UNDER THE INDUSTRY-EDUCATION INTEGRATION MODEL

This study, based on current teaching practices and field research, proposes innovative strategies for cultivating medical-engineering talents under the industry-education integration model. These strategies incorporate more practical platforms oriented towards medical-engineering integration, including key elements such as an interdisciplinary teaching system, and a practical project-driven "workshop" in teaching platform. These strategies provide new insights for cultivating medical-engineering talents within the context of digital livelihoods.

4.1 Developing an Interdisciplinary Teaching System Emphasizing Both Theory and Practice

4.1.1 Reconstruction of curriculum

To ensure that medical-engineering talent cultivation adheres to the teaching philosophy of "equal emphasis on theory and practice", and to deeply integrate resources from universities, hospitals, and enterprises, this study establishes a three-dimensional, clearly defined teaching management framework. This framework, comprised of a teaching management committee composed of faculty leaders, and core experts from partner hospitals and enterprises, is responsible for strategic decision-making, resource coordination, and quality assurance, ensuring the alignment of talent development with advanced industrial demands.

In terms of curriculum management and implementation, the position of "Curriculum Group Leader" serves as the central hub. It is held by a "dual-qualified" faculty member with both strong academic credentials and extensive industry experience. Acting in a dual-responsibility role, this leader oversees the development and reform of the theoretical framework as well as the overall planning and quality assurance of practical instruction. Two types of executive roles operate under this structure. The first is the "Theoretical Course Leader," responsible for updating course content, innovating teaching methods, and delivering theoretical instruction. The second is the "Practical Project Mentor," typically an enterprise engineer or a senior hospital technician, who translates real-world industrial projects into teaching cases and guides students through hands-on tasks. This management model, characterized by top-level leadership from the committee, coordinated oversight by the curriculum group leader, and the parallel implementation of theory and practice, achieves a refined division between management and curriculum while embedding industrial resources from hospitals and enterprises throughout the teaching process. Meanwhile, this creates a new paradigm of collaborative education that seamlessly integrates theoretical instruction with practical training, and simultaneously enhances disciplinary knowledge and industry capabilities. This provides a solid organizational foundation for cultivating high-quality interdisciplinary medical-engineering professionals who meet the demands of digital livelihood development.

In terms of the curriculum design, the primary objective is to build a solid foundation of interdisciplinary knowledge of medicine and engineering. The curriculum design moves beyond the mere juxtaposition of traditional courses, establishing instead a matrix-based instructional framework that emphasizes disciplinary integration. This system enables students from diverse academic backgrounds not only to master the core knowledge of their respective fields but also to grasp the underlying logic of related disciplines, thereby enhancing their capacity for collaborative innovation. The curriculum design encompasses three primary components.

First, clinical medicine courses are central to laying a solid medical foundation. Rather than teaching students how to merely "operate" medical systems, this component of the curriculum emphasizes the fundamentals of medical education, systematically covering core subjects such as human anatomy, pathophysiology, clinical diagnostics, internal medicine, and surgery. Its purpose is to provide students with a thorough understanding of the biological basis of disease, the logic and processes of clinical diagnosis and treatment, and the rigorous scientific rationale underpinning medical practices. Only with such a foundation can students accurately recognize clinical challenges and correctly interpret the significance of medical data in subsequent engineering practice, thereby helping to bridge the gap between technological innovation and clinical needs.

Secondly, the course of information management and information systems aims to develop competencies in digital healthcare management. This component focuses on the organization and operation of healthcare institutions, with core courses including healthcare information system architecture, hospital management processes, health information standards and interoperability, and medical data security and privacy protection. It seeks to cultivate students' understanding of institutional operations, data flow pathways, and the strategic significance of information technology development from the perspectives of managers and system planners. In this way, graduates are expected to serve as bridges connecting clinical needs with technological implementation, ensuring that smart healthcare systems are not only technically feasible but also efficient, compliant, and sustainable from a management standpoint.

Finally, artificial intelligence courses will serve as a driving force for the innovative application of cutting-edge technologies. This component equips students with technical methodologies for addressing complex healthcare challenges. Core knowledge includes machine learning and deep learning theory, data mining and preprocessing, computer vision, and natural language processing. It emphasizes algorithmic principles, model development, and engineering implementation, with the aim of cultivating students' ability to leverage AI for processing large-scale, multimodal healthcare data, such as medical imaging, electronic medical records, and genomic data.

In summary, the design of the teaching content establishes a coherent knowledge chain that progresses from the source of medicine, to the management core, and finally to the technological frontier through the integration of three domains: clinical medicine (problem definition), information management (process planning), and artificial intelligence (solution development). This structure ensures that all students, regardless of their disciplinary background, acquire a systematic understanding of smart healthcare within an interdisciplinary learning environment. It lays a solid knowledge foundation for future collaborative innovation in industry-education integration and addresses the developmental needs of the healthcare sector in the era of digital livelihood.

4.1.2 Innovation in teaching methods

a. To enhance learning outcomes, hybrid teaching is implemented by establishing interdisciplinary workshops and conducting theme-based competitions. The workshops focus on themes such as the development of hospital information platforms, the operation of smart medical devices, and medical data analysis. The themed competition on digital healthcare is based on real-world project proposals corresponding to different topics provided by hospitals or enterprises. This competition is expected to enhance teaching quality and provide benefits for both instructors and students.

b. Project-based learning is adopted as an instructional method. This approach involves establishing a cross-college mentoring group that integrates expertise in “medicine, management and AI”. The mentoring system primarily focuses on supervising students' graduation projects, and improving their professional competencies. Each student is paired with a mentor from a hospital or enterprise. Through one-on-one guidance, students are expected to acquire relevant industry skills and strengthen their professional development. In addition, colleges and universities collaborate with enterprises to jointly develop courses. Enterprise mentors primarily concentrate on revising the design of practical application courses to address the current and practical needs of the industry.

Based on this model of industry-education integration, cultivating medical–engineering professionals provides an effective means to address the urgent demand for interdisciplinary expertise in the context of digital public welfare. Furthermore, it plays a vital role in supporting the digital transformation of hospitals and enhancing the quality of medical service.

4.2 Construction of a Workshop-Driven Practical Teaching Platform

This model proposes a practical teaching system that takes the "workshop" as its core vehicle, aiming to deepen the integration of industry and education to transform the traditional static practice platform into a dynamic teaching process. More specifically, this system is no longer confined to treating on-campus simulation laboratories and off-campus practice bases as separate entities. Instead, these resources are reconceptualized as "resource libraries" and "training grounds" that support the operation of diverse workshops. Through a series of carefully designed workshop projects, students are encouraged to engage in active exploration, collaboration, and innovation in real or highly simulated contexts, thereby enhancing their understanding, skills, and professional competence.

4.2.1 On-campus simulation workshops

These workshops aim to strengthen students’ foundational knowledge and provide simulated practice opportunities. The on-campus Smart Healthcare Simulation Laboratory serves as the primary venue for foundational and integrative workshops. By leveraging its core functional modules, a series of themed, task-oriented workshops will be designed.

a.HIS System Full-Process Simulation Workshop. Students assume roles such as doctors, nurses, pharmacists, and cashiers to complete the entire virtual patient journey, from admission to discharge, within a simulated hospital information system. The workshop is designed to deepen students’ understanding of data flow logic and the collaborative relationships among different business modules, while cultivating their systematic thinking and process optimization skills.

b. Electronic Medical Record Data Mining and Assisted Diagnosis Workshop. Using de-identified clinical data provided by the Medical Big Data Analysis Center, students will utilize tools such as Python and R to complete the entire process of data cleaning, feature engineering, and model building (e.g., disease prediction models). The workshop concludes with a project defense, requiring students to not only present algorithmic results but also interpret their clinical implications, cultivating their data science literacy and interdisciplinary communication skills.

c. Smart Healthcare Application Prototype Design Workshop. This workshop addresses specific clinical pain points (e.g., medication adherence management for the elderly and remote monitoring of chronic disease patients). Students work in small groups to conduct needs analysis, functional design, UI/UX prototyping, and ultimately present their work in a virtual simulation environment. This workshop aims to inspire students' innovative thinking, enhance their competencies in product design and user-centered approaches.

In summary, these on-campus workshops are jointly organized by the course leader and the course coordinator. In addition, industry engineers and clinicians are regularly invited as guest instructors to deliver tutorials, ensuring both cutting-edge content and industry relevance.

4.2.2 Off-campus practical workshops

This workshop aims to dive into scenarios and solve real problems. Off-campus practice bases serve as an extension of our practical workshops at a more advanced level. It integrate internships with project-based learning, where students are expected to participate as “quasi-employees” in authentic work scenarios and address challenging cases from companies or hospitals. Upon entering the hospital internship base, students will take part in a 4-6 week Smart Project Operations and Maintenance for Tertiary Hospitals Workshop. Guided by in-house IT engineers, they will engage in specific operations and maintenance tasks, such as collecting user feedback and designing optimization solutions for a newly launched mobile nursing system, or analyzing and optimizing data center storage performance bottlenecks. Students will conduct on-site investigations, diagnose problems, develop solutions, and submit formal reports to the hospital's IT department. Their findings will provide valuable reference for hospital decision-making.

4.2.3 A closed-loop and collaborative workshop system

This study establishes a complete practical teaching closed-loop through a step-by-step design consisting of "on-campus simulation workshops" and "off-campus practical workshops". In the on-campus practical workshops, students acquire fundamental skills and project methodologies, which serve as a prerequisite for entry into the off-campus workshops. In the off-campus stage, they apply this knowledge to address complex and authentic problems. The emerging challenges and insights generated in this process, in turn, drive the continuous iteration and updating of on-campus workshop content. This workshop-based model of practical teaching not only achieves efficient integration of educational and industrial resources, but more importantly, it transforms students from passive recipients of knowledge into active problem solvers. By fostering stronger intrinsic learning motivation and enhancing learning outcomes, it effectively cultivates the core competencies required of interdisciplinary medical-engineering talents in the era of digital healthcare and public welfare.

5 CONCLUSION

In the context of digital livelihood, there is a growing demand for interdisciplinary medical-engineering professionals in the era of digital transformation. It has become imperative for universities to introduce innovations in talent development models to address pressing societal needs. Through industry-university integration, higher education institutions can better allocate resources, optimize training programs, enhance students' practical and innovative capacities, and cultivate a workforce that supports the upgrading of digital healthcare and welfare services. This project aims to advance the medical-engineering talent development model in higher education. Based on the industry-university integration framework, it enriches both teaching and practice systems, promotes interdisciplinary curriculum design and diversified management approaches, and establishes workshop-driven practice platforms that effectively integrate theory with practice.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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