

Editorial

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Medical education embraces new transformative opportunities

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Abstract: With the development of technologies such as artificial intelligence (AI), big data, and virtual reality, medical education is facing significant reform opportunities. The fourth-generation medical education reform emphasizes interdisciplinary cooperation, focuses on health rather than just disease treatment, and uses AI technology to enhance the quality of education. The reform requires cooperation from multiple parties, including government top-level design, optimization of medical school organizational structures, and the cultivation of medical students' sense of responsibility and mission. The goal is to build a fair and efficient health service system.

Introduction

The ongoing scientific and technological revolution, particularly the rapid advancement of artificial intelligence (AI), big data, and virtual reality technologies, presents both significant challenges and unprecedented opportunities for transforming traditional medical education. Over the past century, medical education has evolved and matured systematically, progressing from its initial focus on foundational medical knowledge acquisition and clinical skill development to its current emphasis on cultivating comprehensive competencies in medical students. Nevertheless, with the emergence of global health challenges coupled with the new paradigm of technology-driven healthcare, medical education is pressing for a more fundamental and comprehensive reformation.

Persistent challenges in medical education development

The evolution of medical education follows a distinct historical trajectory. The publication of the *Flexner Report* in the

United States in 1910 marked the inception of modern medical education, followed by three significant transformational phases spanning over 110 years: the first-generation reform emphasized scientific foundations and the scientificization and standardization of medical education [1]; the second-generation reform introduced problem-based learning and curriculum integration, promoting student-centered approaches and encouraging collaborative and self-directed learning for problem-solving [2–4]; the third-generation reform adopted a health system perspective with competency-based frameworks, emphasizing medical education-practice alignment, technological integration, leadership development, and educational equity [5].

As a crucial arena for cultivating future medical talents, medical education confronts multiple challenges, including rapid technological advancement, demographic transitions, healthcare policy evolution, and climate change impacts on public health. Additional complexities also arise from disparities in socioeconomic development and inconsistencies in medical education advancement across regions.

While the three generations of medical education reforms have progressively shifted from traditional teacher-centered, didactic approaches toward student-centered, discussion-based, and competency-oriented methodologies, limitations persist. For instance, the third-generation reform, though progressive, maintains a disease-centric focus while emphasizing the aim of “strengthening the health system”; even with the introduction of “interprofessional education” concepts, development remains largely confined within institutional boundaries and the internal dynamics between healthcare and educational systems [4].

The content of medical education materials often lags behind advances in medical science, and the integration of emerging disciplines and insufficient attention is given to emerging and interdisciplinary knowledge integration, potentially limiting students' access to cutting-edge developments. The educational process overemphasizes knowledge assessment while inadequately developing non-cognitive competencies such as critical thinking, innovation, and practical skills. Furthermore, the comprehensive evaluation system remains underdeveloped, with excessive focus on

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examination performance at the expense of nurturing individual aptitudes, interests, and talents, thereby constraining the cultivation of talents with diverse professional capabilities [5].

In October 2016, the Central Committee of the Communist Party of China and the State Council launched the “Healthy China 2030” initiative, outlining the goals and tasks for the construction of a healthy China. The 19th National Congress of the Communist Party of China proposed the major strategic decision to deploy the Healthy China strategy, establishing a prevention-oriented framework promoting healthy lifestyles and disease control. This strategic direction provides a comprehensive blueprint for developing an integrated, lifecycle-based health service system aimed at achieving universal health. The increasing healthcare service demands and public health requirements have catalyzed medical education reforms and paradigmatic shifts. Technological advancement, particularly in AI, has facilitated cross-disciplinary knowledge integration, redefined disciplinary boundaries, and accelerated interdisciplinary convergence. AI technologies have revolutionized medical knowledge generation and dissemination, updated methods of knowledge obtainment, and transformed pedagogical approaches, which will fundamentally restructure the frameworks of academic institutions.

Adaptations in medical education to meet transforming health demands

The advancement of medical disciplines and medical education exhibits a synergistic relationship of mutual enhancement. The implementation of the Healthy China strategy has catalyzed the emergence of a new fourth-generation medical education reform, building upon the foundations established by previous generations. This new paradigm emphasizes a holistic approach to human health beyond disease treatment, advocating for interdisciplinary collaboration and the integration of AI to address increasingly complex health challenges [6].

Contemporary healthcare delivery has expanded beyond traditional therapeutic interventions to encompass disease prevention, health promotion, and comprehensive life-cycle health management. The expanding healthcare market and evolving public health needs necessitate a transformation in medical education, one that not only requires attention to physical health but also to psychological well-being, social adaptation, and environmental health determinants, while reinforcing

public health services and community health education initiatives.

In response to the complexities of modern disease patterns, diverse health needs, and advancing medical technologies, medical education is increasingly emphasizing interdisciplinary collaboration. Educational approaches that span across disciplines and industries, characterized by boundary crossing, multidisciplinary fusion, and knowledge integration, will help cultivate medical professionals with comprehensive perspectives and multidimensional problem-solving capabilities. This trend is evidenced in China’s current medical education framework through the development of “Medicine+X” interdisciplinary programs and related curricula innovations [7].

Nowadays, the integration across disciplines, professions, and industries has facilitated the evolution from memorization-based and integrated learning approaches to transformative learning paradigms. The traditional sequential model of learning for students has shifted from obtaining basic knowledge in classrooms before clinical exposure, to getting into touch with patients at an earlier stage. This transformation not only enables immediate knowledge application in the clinical scenario, but also enhances critical thinking through clinical case analysis, fostering life-long learning through evidence-based practice and literature engagement.

Medical education is being revolutionized through the incorporation of emerging technologies, including virtual reality, augmented reality, mixed reality, simulation technologies, big data, and AI. These innovations provide learners with more accessible knowledge acquisition pathways and personalized learning experiences. At the same time, the educational focus has shifted toward competency-based practices, emphasizing the development of critical thinking, innovation, leadership, communication, and teamwork skills, alongside technological competency in both medical and information technologies for medical students. Assessment methods have evolved from singular knowledge-based evaluations to comprehensive competency assessments encompassing clinical skills, teamwork, ethical decision-making, communication proficiency, and research innovation.

Collaborative imperatives for advancing medical education reform

The implementation of the next-generation medical education reform requires careful consideration of strategic

approaches. The fourth-generation reform, emerging from the evolution of previous reforms and accelerated technological advancement, emphasizes three core principles: population health orientation, interdisciplinary fusion and integration, and comprehensive AI adoption [7]. This necessitates in-depth investigation into the fundamental concepts of fourth-generation medical education, clarifying reform objectives and frameworks, and developing forward-looking strategic plans. Governmental entities must strengthen their oversight through enhanced top-level design, optimizing mechanisms that facilitate collaboration between healthcare and educational institutions, improving clinical instruction quality, and developing robust regulatory frameworks. Additionally, establishing comprehensive quality assurance systems is essential to ensure effective reform implementation.

Medical institutions should further optimize organizational structures; innovate relevant management systems; establish interdisciplinary research centers to promote knowledge integration and innovation; develop normative and efficient organizational frameworks to enable rapid resource allocation and dynamic team formation and adjustment, in order to accommodate to the rapidly changing demands of scientific research and education; implement flexible administrative systems for personnel, research, and educational management, and create diverse faculty cultivation and development programs; reform research evaluation systems to recognize collaborative efforts, interdisciplinary achievements, and societal impact, and encourage the transformation of research results [7].

As medical practice expands beyond treatment to encompass prevention, rehabilitation, and health management, medical education must cultivate professionals with a strong sense of responsibility as health guardians and commitment to public health advancement. This transformation requires the dissolution of traditional disciplinary boundaries, integration of medical education with information technology, biological sciences, social sciences, and psychology, as well as development of multidisciplinary educational models. As boundary crossing, multidisciplinary fusion, and knowledge integration become important trends in the reform and development of contemporary higher education, it is urgent to create an innovative curriculum system accordingly.

To adapt to the rapidly changing medical environment and the continuous updating of medical education content, medical institutions should keep up in educational program adjustment, incorporating emerging health and disease knowledge, advanced medical technologies

and research developments, cross-cultural communication skills and global health perspectives to cultivate students' adaptability and foresight. Meanwhile, practical learning should be enhanced through bedside teaching, clinical practice, and technological methods such as simulated patients and virtual reality operations. In addition, the accelerated popularization of AI requires us to accept and learn AI technologies, strengthen the construction of smart campuses, and provide students with personalized, customized learning platforms.

Clarifying the core concepts and practical paths of the fourth-generation medical education reform, and helping health education administrators, faculty and students renew notions to actively respond to changes, is crucial for achieving the objectives of the "Healthy China" strategy and advancing global health and education equity. This endeavor requires coordinated societal effort to embrace and promote the fourth generation of medical education reform, in order to lay the foundation for a more equitable, efficient, and humanized medical healthcare system.

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