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The Status, Development And Future Of Graduate Clinical Education And Teacher Certification Programs

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Abstract:
The clinical medical teacher certification system serves as a cornerstone for enhancing the quality of medical education. This paper systematically reviews global advancements in graduate clinical education and teacher certification programs, highlighting critical challenges in China's clinical education system, including insufficient faculty professionalization (only 41.2% of teachers receive systematic pedagogical training), lagging technology integration (34.7% utilization rate of intelligent teaching systems), and unidimensional evaluation mechanisms. International experiences offer valuable insights: the U.S. ACGME's "Milestones Project" establishes a competency framework oriented toward six core competencies, the UK's GMC adopts a modular micro-credential system, and Japan's "three-dimensional competency certification model" integrates AI literacy and interdisciplinary collaboration. In China, the Clinical Medical Education Standards innovatively outlines a six-dimensional competency matrix encompassing teaching implementation and technology integration. Fudan University's "3D Smart Education Ecosystem" leverages educational data mining and blockchain technology to advance pedagogical practices. Future directions emphasize establishing an internationally recognized certification mechanism, integrating natural language processing (NLP) and machine learning to dynamically assess teaching cognition and behaviors, while blockchain ensures data privacy. Third-party certifications by organizations like WFME will enhance global comparability. The proposed "standard certification + intelligent diagnosis" dual-driven model provides an innovative pathway for transitioning from experience-based to competency-oriented medical education, aligning with the "Healthy China 2030" strategy and international standards for medical talent cultivation.

Keywords: clinical education; teacher certification

I. Introduction

The World Federation for Medical Education (World Federation for Medcical Education, WFME) emphasizes that accreditation of clinical teachers is a cornerstone of ensuring quality education[1]. Chinese Guidelines on Accelerating the Innovative Development of Medical Education clearly states that a certification system for clinical teachers teaching ability should be established[2]

Graduate clinical education is a core component of medical talent cultivation, and its quality directly impacts the level of healthcare services. Clinical doctors often take on the role of teachers in various settings, such as classroom teaching, graduate education, and academic exchanges. The teaching subjects and environments vary across different occasions, and thus, the teaching methods should also differ accordingly[3]. College education primarily focuses on enhancing learning abilities, providing students with more experiences, and nurturing and tapping into their potential. For graduate students, the teaching objective is to cultivate learners who mainly engage in scientific research, emphasizing the development of independent innovation and problem-solving skills. In todays higher education system, teacher professional development training mainly centers on improving the teaching capabilities of full-time undergraduate instructors at regular universities, which significantly differs from the special needs of clinical medical education. Although clinical physicians undertake classroom teaching tasks at institutions, their main educational practice areas are actually distributed

across outpatient clinics, wards, and operating rooms. The unique nature of these teaching environments necessitates that clinical physicians build dual professional competencies: not only systematically enhancing their theoretical knowledge of teaching but also deeply understanding the dynamic complexity of the clinical educational environment[4,5]. It is worth noting that in the existing teacher training system, the formation path of clinical physicians teaching philosophy and its influence mechanism on educational practice have been in a research blind spot for a long time —— there is neither a deep investigation into their teaching cognition system nor a systematic teaching ability cultivation mechanism[6]. At its core, the teaching philosophy inherent in clinical physicians not only determines the effectiveness of knowledge transmission during their mentoring process but also profoundly shapes medical students professional growth trajectories and career development potential through implicit dimensions such as teacher-student interaction models and clinical thinking cultivation methods. This dialectical relationship between teaching philosophy and practice is precisely the weak link in the current reform of medical education, which focuses on cultivating "dual-qualified" teachers, and it is also a key breakthrough for improving clinical teaching quality. Through graduate education and training, students can gain broader knowledge, deeper knowledge accumulation, and more specialized research content[7,8].

This paper systematically reviews the research progress of graduate clinical education and teacher certification programs at home and abroad, in order to provide reference for medical education reform.

II. The Core Position And Challenges Of Graduate Clinical Education

Global standards for clinical education

The authoritative institutions in the field of international medical education have always been dedicated to building a systematic theoretical framework and practical standards for clinical education. As a leader in global medical education reform, the Association for Medical Education International (AMEE) defined clinical education as "a dynamic educational process that integrates three dimensions—medical knowledge systems, professional skill modules, and ethical values of the profession—through the clinical practice setting" in its guiding document published in the Journal of Medical Education (Medical Education) as early as 1999[9]. This definition breaks through the limitations of traditional apprenticeship systems, constructing a three-dimensional training model that encompasses cognition, skills, and ethics. In the field of educational assessment, the Accreditation Committee for Graduate Medical Education (ACGME) in the United States innovatively developed the "Milestone Program" (Milestones Project). By establishing a three-dimensional assessment matrix (basic-intermediate-advanced) composed of six core competencies—patient care, medical knowledge, interpersonal communication, professional integrity, systems practice, and practice-based learning—the program has built a visual tracking system for the development of resident physician capabilities[10]. The system contains 268 specific evaluation indicators, and adopts the combination of formative evaluation and summative evaluation to realize the paradigm shift from input-oriented education to output-oriented education[11].

The field of medical education in Europe presents a different development path. The European Continuing Medical Education Accreditation Committee (EACCME) emphasizes the central role of contextualized learning (Context-based Learning) in the White Paper on Clinical Education in Europe[12]. This educational model constructs a three-tier situational framework of "clinical micro-environment-regional healthcare system-health policy environment." . It employs diverse teaching strategies such as standardized patient (SP) simulations, multidisciplinary team (MDT) on-site instruction, and immersive real medical scenarios to facilitate knowledge transfer and skill transformation in complex medical contexts. The latest neuroscience research in education confirms that contextual learning can increase knowledge retention by 42% and improve clinical decision-making accuracy by 28%[13].

The status quo of domestic clinical education

Chinese clinical medical education system is among the top in the world with the largest scale of education (covering 152 medical schools and training more than 120,000 medical students annually). However, structural contradictions in the faculty team need to be solved urgently[2]Based on empirical research from 32 "Double First-Class" medical schools (including 8 centrally-administered institutions, 17 provincial and ministerial co-built institutions, and 7 local key institutions), it is evident that there are significant shortcomings in the professional development of clinical faculty: —— Only 41.2% of teaching mentors have received systematic training in teaching skills (including course design, educational assessment, etc.), with less than 6% being national-level teaching masters[14]. In the education quality assessment system, the teaching concept of "student-centered" is not implemented enough, and the average score of the "student classroom participation" index (Likert 5 scale) is only 2.81±0.73, lower than the standard value of medical education (3.5 points)[15]. The modernization of educational technology lags behind, and the routine use rate of intelligent teaching systems (such as VR simulation diagnosis and AI-assisted medical record analysis) is only 34.7%, far lower than the average level of medical education institutions in OECD countries (68.2%)[16]. These data reveal that during the

expansion of clinical medical education in our country, there are systemic development bottlenecks in areas such as professionalization of faculty teams, innovation in teaching models, and empowerment through educational technology. There is an urgent need to achieve connotative development transformation through a "trinity" reform path (reconstruction of teacher development systems, innovation in educational evaluation mechanisms, and construction of smart teaching environments).

III. International Experience Of Teacher Certification Programs

American model: competency-based certification system

The American medical education system has innovated through the "Competency-Based Education (CBE) paradigm," establishing a professional development framework for medical educators that sets international benchmarks. The Association of American Medical Colleges (AAMC) revised the Core Competencies Framework for Medical Educators (Version 3) (Core Competencies for Medical Educators 3.0) in 2023, integrating theories from Learning Sciences (ILP) and Educational Neuroscience (EduNeuSci). This framework constructs a three-dimensional competency matrix (knowledge-skills-attitudes) across six domains: teaching implementation, educational assessment, curriculum design, academic research, career development, and systems leadership.[17]. The framework is vertically aligned with the six core competencies of the Accreditation Board for Postgraduate Medical Education (ACGME) (Patient Care, Medical Knowledge et al.) and has been incorporated into the faculty development module of the Global Standards for Medical Education (2025) by the International Federation for Medical Education (IIME).

As a practical model of the AAMC framework, Harvard Medical School (HMS)s "Clinical Educator Certification Program (CECP)" has established a "three-tier progressive" training system: (1) Contextual teaching skills development: requiring 120 hours of immersive simulation instruction (including high-fidelity OSCEs, standardized patient (SP) workshops, virtual anatomy labs, etc.), with 80 hours conducted using a blended model of case-based learning (CBL) and team-based learning (TBL); (2) Competency-based assessment system: implementing Entrustable Professional Activities (EPA)-oriented 360-degree formative assessment, which includes student evaluations (40%), peer reviews (30%), educational supervisor assessments (20%), and self-reflection (10%), focusing on eight microcompetencies such as "clinical reasoning teaching ability" and "professional competence transmission effectiveness."[18]; (3) Academic Teaching Transformation: Mandatory production of at least one teaching academic achievement (SoT), including: (1)educational data mining (EDM)-based teaching intervention studies (such as RCT trials on the impact of VR simulations on diagnostic thinking); (2) theoretical construction of course innovations (such as building a "cross-disciplinary EPA integration model"); (3) empirical research on educational policies (such as econometric analysis of teaching load and educational output). This certification system has achieved significant results: clinical teachers who participated in the certification (n=847) significantly outperformed non-certified teachers in indicators such as teaching academic productivity (0.78 articles per person/year), student critical thinking scores (increased by 23.5%), and integration of educational technology (79.2% usage rate of intelligent teaching systems) ($p<0.01$). Its experience has been adopted by institutions such as the Royal College of Physicians (RCPSC) and the General Medical Council (GMC), forming a closed-loop system of "competency standards-training pathways-effectiveness evaluation."[19].

European model: standardization and flexibility are equally important

The General Medical Council (GMC) of the UK has innovatively constructed a "modular micro-certification (Modular Micro-credentials)" system based on the "Competency-Based Education (CBE) 2.0" paradigm. Its "Clinical Tutoring Certification Scheme (Train the Trainer)" represents the cutting-edge practice in the professional development of medical educators. This system is grounded in adult learning theory (Andragogy), reflective practice theory, and competency-based education (CBE)[20]. A "3D dynamic certification model" has been constructed: capability dimension (teaching implementation, assessment design, career development), time dimension (short-term micro-certification, medium-term advanced certification, long-term expert certification), and space dimension (online learning community, offline training center, cross-institutional collaboration network)[21].

Asian Practices: Innovation in Japan and Singapore

The East Asian medical education system has developed a unique paradigm in the innovation of "Competency-Based Education (CBE)". The practices in Japan and Singapore represent the cutting-edge exploration of professional development for medical educators in Asia. Based on the "Basic Law for the Promotion of Medical Education in Japan (2022 Revision)", the Ministry of Education, Culture, Sports, Science and Technology has established the "Clinical Education Expert Certification (Clinical Education Specialist Certification)" system, which integrates educational cognitive science (Educational Neuroscience) and healthcare quality improvement (HQI) theories to form a "Three-Dimensional Competency Certification

Model": (1)Teaching Implementation (Simulation Pedagogy); (2)Interdisciplinary Collaboration (IPEC Competencies); (3)Technology Integration (Healthcare AI Literacy)[22, 23]. The system aligns strategically with the World Federation for Medical Education (WFME)s Global Minimum Essential Requirements for Medical Education (GMER), setting a benchmark in the Asian region. Based on the "Smart Educational Ecosystem (SEES)" theory, the National University of Singapore (NUS) has developed a "VR-AR-MR tri-modal integration" teaching system and launched the "TeachMed" platform, integrating virtual reality (VR) surgical simulation with real-time instructional feedback[24].

IV. Exploration And Practice Of Chinese Teacher Certification Program

Policy-driven system construction

Based on the "Healthy China 2030" Plan Outline and the strategic deployment of "China Education Modernization 2035," the Ministry of Education and the National Health Commission jointly issued the "Chinese Clinical Medical Education Standards (2022 Edition)" (CMEST 2022), which establishes a "five-in-one" quality assurance system. For the first time, it includes the "Clinical Teacher Teaching Competency Certification" (Teaching Competency Certification, TCC) as a core indicator for evaluating tertiary Class A hospitals (with a weight of ≥5%).[25] The standard innovatively introduces the concept of "Outcomes-Based Education (OBE)," referencing international medical education accreditation standards (such as ACGME, IIME), to construct a competency matrix covering six domains (teaching implementation, curriculum design, assessment innovation, technology integration, academic research, and career development). This aligns vertically with the "Content and Standards for Standardized Training of Resident Physicians." As a pioneer in CMEST 2022, Peking Union Medical College (PUMC) has developed a "three-stage progressive" training system based on adult learning theory (Andragogy) and educational neuroscience (EduNeuSci), creating the "Clinical Educator Competency Model" (comprising 12 micro-capabilities)[26].

Technology innovation enables the certification system

Fudan Universitys Zhongshan Hospital (ZS-Hospital) has developed the "3D Intelligent Education Ecosystem (3D-SEES)" based on the "Digital Development Strategy for Chinese Medical Education (2025-2035)." The core component, the "Clinical Teaching Intelligent Management System (CTIMS v2.0)," integrates Educational Data Mining (EDM), Blockchain Technology (Blockchain), and Predictive Analytics (Predictive Analytics), forming a closed loop of "data collection-intelligent analysis-decision support." The research findings provide a "Chinese solution" for the global digital transformation of medical education, particularly in areas such as educational equity at the grassroots level, teaching analysis in complex scenarios, and educational data governance. These areas exhibit significant theoretical originality and practical guidance, with relevant technical indicators (such as prediction accuracy of 89.3%) reaching international leading levels[27].

V. Key Issues And Countermeasures Of Teacher Certification Program

Existing challenges

In existing research, there is less attention paid to evaluating teacher certification programs and other perspectives, lacking depth; when assessing teacher competence, only the perspectives of students and teachers are considered, with little evaluation from the angles of administrators, patients, and their families, resulting in a lack of multidimensional evaluation mechanisms and limited breadth of research; in constructing teacher development plans, only small sample cross-validated methods and conceptual validity methods are used for empirical studies, or no empirical studies have been conducted yet, lacking persuasiveness and credibility, and there is a lack of application of digital research tools, with the current adoption rate of VR/AR tools in certification being less than 20%[19]. In terms of research subject selection, most studies focus on clinical nursing teachers and resident training instructors, with fewer involving general practitioners, pharmacists, and dentists. Research on clinical practice teachers is relatively scarce, leading to an uneven distribution of research subjects. In terms of research methods, most studies follow the research systems in competency fields abroad, drawing on their construction processes, with few adopting innovative methods such as fuzzy comprehensive evaluation or object element analysis.

Systemic solutions

Constructing a national-level certification framework, drawing on the six core competencies of ACGME in the United States, establish a three-dimensional standard of "teaching scholarship-clinical competence-technology application"; innovate incentive mechanisms, incorporating certification outcomes into hospital performance evaluations and physician regular assessments; deeply integrate technology, developing a "metaverse clinical teaching platform" to support hybrid certification scenarios. This system innovatively achieves a three-dimensional linkage of "standards-incentives-technology," effectively promoting the transformation of clinical medical education in China from experience-based to competency-based through a

capability certification ecosystem that covers the entire career cycle of physicians, providing high-quality talent support for the implementation of the Healthy China strategy.

VI. Future Development Direction

Drawing on the Global Medical Educator Certification (Global Educator Certification) of the International Foundation for Medical Education and Research Promotion (FAIMER), a cross-border mutual recognition mechanism will be established[28]. By establishing a unified framework of competency standards and evaluation processes, we promote international recognition and mobility of medical education faculty qualifications. On this basis, we integrate learning analytics technology to build a multi-dimensional teacher competency development system: using natural language processing (NLP) techniques to conduct semantic analysis and cognitive depth assessment of teaching reflection logs, quantifying teachers critical thinking levels; leveraging machine learning algorithms to establish competency diagnostic models, which analyze teaching behavior data, academic output, and training records to intelligently identify professional development bottlenecks and generate personalized pathways for skill enhancement[29]. The final result is a dynamically updated digital profile of teacher capabilities. This dual-driven model of "standard certification + intelligent diagnosis" not only ensures the international comparability of core competencies for medical educators but also achieves precise support for the development of teacher certification programs through technological empowerment, providing an innovative solution for building an open and collaborative global community of medical education.

In the process of advancing cross-border certification mechanisms, it is necessary to simultaneously establish a privacy protection system that covers the entire data lifecycle. Based on international standards such as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA), teacher competency profiles involving teaching behavior data, academic achievements, and training records should be encrypted at different levels and desensitized. Blockchain technology can be used to achieve distributed ledger storage and authorized access tracing[30]. At the same time, authoritative institutions such as the World Federation for Medical Education (WFME) are invited to act as independent third parties to conduct periodic audits on the technical reliability of the certification system, the fairness of the evaluation process, and data governance compliance. The international certification reports they issue can serve as authoritative endorsements for cross-border mutual recognition and continuously optimize the certification standards through dynamic quality monitoring. This dual safeguard mechanism of "technical protection + institutional constraints" not only enhances the international credibility of certification results but also effectively balances the tension between data sharing needs for teacher professional development and the protection of personal information rights, laying the foundation for building a secure and trustworthy global network of mutual recognition among medical educators.

VII. Summary

The teacher certification program, as a core strategy to address the bottleneck in clinical education quality, provides an innovative breakthrough for the reform of medical education in China by systematically integrating international certification standards and intelligent assessment technologies. In terms of practical implementation, it can deeply draw on the mature framework of the "Global Medical Educator Certification" by the International Foundation for the Advancement of Medical Education (FAIMER) to construct a competency standards map for clinical educators that fits Chinas national conditions. At the same time, it relies on learning analytics technology to establish a dynamic evaluation system: using natural language processing (NLP) to model cognitive levels of teaching reflections, and employing machine learning algorithms to analyze teacher-student interaction patterns in teaching videos. By combining academic influence and clinical mentoring data, it generates multidimensional competency profiles, achieving a transformation from experience-based judgments to evidence-driven assessment paradigms. This system ensures the traceability and privacy security of certification data through blockchain technology and introduces third-party institutions such as the World Federation for Medical Education (WFME) to conduct international certifications, ensuring global comparability of assessment results while leveraging intelligent diagnostic systems to provide personalized development plans for teachers. This certification system, which integrates international experience and technological empowerment, not only significantly enhances the professional level of clinical faculty but also establishes a closed loop for talent quality assurance, contributing to the "Healthy China 2030" strategy with global impact. The competitive power of medical education will eventually achieve the strategic connection between clinical education quality and international standards for medical talent training.

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