

Exploration of the Application Methods of Artificial Intelligence-Assisted Teaching in the Training of Master's and Doctoral Students in Traditional Chinese Medicine

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Abstract: With the rapid development of artificial intelligence technology, its application in medical education provides a new development path for the training of master's and doctoral students in traditional Chinese medicine. This paper analyzes the characteristics of high-level talent cultivation in traditional Chinese medicine and the demand for the intervention of artificial intelligence, and explores its application methods in theoretical teaching, clinical practical training, scientific research training, and cultivation management. Artificial intelligence can promote personalized learning, syndrome differentiation thinking training, scientific research efficiency improvement, and optimization of cultivation quality evaluation through technologies such as knowledge graphs, generative large models, virtual cases, and data analysis. At the same time, the paper points out that the application of artificial intelligence still faces risks such as knowledge distortion, algorithmic bias, academic integrity, data security, and over-reliance. In the future, the principle of "enhancement rather than replacement" should be upheld, and the construction of specialized knowledge bases, the cultivation of artificial intelligence literacy, and standardized governance should be strengthened to promote the deep integration of artificial intelligence with the training patterns of Traditional Chinese Medicine graduate students.

1. Introduction

In recent years, artificial intelligence (AI) has developed rapidly and has been widely applied in the field of medical education, mainly including intelligent tutoring systems, personalized learning, virtual patient simulation, clinical skills training, medical imaging teaching, and automated teaching evaluation ^[1]. In recent years, generative AI represented by Chat Generative Pre-trained Transformer (ChatGPT) has been further used for medical knowledge question answering, case

analysis, and clinical reasoning training, promoting the development of medical education models toward intelligence and personalization ^[2]. In particular, the rise of large language models has fundamentally rewritten the goals and methods of medical teaching and learning. It can not only serve as a personalized tutor and simulated patient for dialogue training, but also drives the transformation of the teaching model toward a "teacher-machine-student" triadic structure ^[3,4]. However, this technology also brings severe challenges such as knowledge hallucination, algorithmic bias, and academic integrity, and the academic community therefore advocates treating AI as a fundamental tool of medicine rather than a subsidiary course, integrating it into the training system as early as possible, and gradually incorporating it into an internationally consensual digital health competency framework ^[5].

TCM graduate education aims to cultivate high-level medical talent with both clinical syndrome differentiation ability and research innovation literacy. Although its training process continues the tradition of mentorship and classics education, it faces problems such as the difficulty of quantifying dialectical thinking, the uneven distribution of high-quality clinical preceptorship resources, and insufficient training in research methods ^[6]. AI has tremendous potential for intervention in the theoretical instruction, clinical demonstration, research training, and management evaluation involved in the training of master's and doctoral students in traditional Chinese medicine. For example, using natural language processing technology to analyze ancient Chinese medicine texts can assist in building knowledge graphs and solve the problem of classical theories being obscure and difficult to understand; simulating the diagnostic reasoning of renowned senior Chinese medicine practitioners through multimodal large models can provide students with standardized clinical thinking training scenarios and make up for the shortage of clinical apprenticeship resources.

2. Characteristics of TCM Master's and Doctoral Student Training and the Space for AI Intervention

The training system for master's and doctoral students in Traditional Chinese Medicine (TCM) exhibits significant disciplinary particularity, with its core differences manifested in three dimensions: training objectives, clinical competency construction, and research paradigms. This determines that AI intervention must be localized and adapted based on TCM ontology, rather than being a simple transfer of general medical education solutions ^[7,8]. First, in terms of training objectives, advanced TCM education aims to cultivate composite talents who possess both profound clinical syndrome differentiation abilities and independent research innovation capabilities. This requires TCM graduate students not only to master modern medical evidence evaluation methods, but also to have a solid theoretical foundation in TCM and the ability to perform syndrome differentiation and treatment, enabling them to accurately analyze disease patterns using TCM thinking and achieve effective integration of theoretical knowledge with clinical practice. Second, the acquisition of clinical competencies is highly dependent on the transmission of tacit knowledge. TCM syndrome differentiation and treatment is a pattern recognition process based on relational thinking. Its core knowledge is often implicit in mentor-apprentice clinical shadowing, medical case reflections, and individualized diagnostic and therapeutic intuition, and it is characterized by substantial individual variability and non-standardization^[9]. This differs fundamentally in epistemological terms from the evidence-based structure of Western medicine, which is based on isolated etiological factors and standardized laboratory indicators, making it difficult for traditional standardized teaching to fully cover the complexity of TCM clinical thinking. Furthermore, research training faces the challenge of processing multi-source heterogeneous data. TCM research needs to integrate multimodal data such as ancient texts and literature, clinical medical cases, syndrome

evolution, and Chinese herbal formulas. These data have the characteristics of high dimensionality, nonlinearity, and semantic ambiguity, placing higher demands on researchers' data mining and methodological literacy^[10].

In light of this, the application space of AI in TCM graduate education can be reconstructed into four deeply integrated levels: First, in the teaching of classical theory, knowledge graph technology is used to assist in building a structured knowledge system, enabling personalized guidance and in-depth logical analysis; Second, in clinical thinking training, through the objectification technology of tongue and pulse diagnosis and virtual simulated medical cases, implicit four-diagnosis information is transformed into quantifiable teaching resources, strengthening dialectical logic training; Third, in research training, natural language processing and machine learning algorithms are introduced to support data mining, evidence synthesis, and automated writing for massive medical cases, improving the efficiency of processing complex clinical data; Fourth, at the training management level, a learning situation analysis model based on multimodal data is established to achieve dynamic quality evaluation of graduate students' clinical competence and research potential. This layered adaptive strategy both respects the epistemological premises of traditional Chinese medicine and fully leverages the advantages of digital and intelligent technologies in knowledge representation and pattern recognition, providing a new paradigm for the cultivation of high-level traditional Chinese medicine talents.

3. Main Application Methods of AI-Assisted Teaching

3.1 Theoretical Teaching and Knowledge Construction

Graduate education in Traditional Chinese Medicine (TCM) emphasizes both the systematic study of classical TCM theories and the mastery of modern medicine and scientific research methods. However, different research directions lead to significant differences among students in terms of knowledge structure and learning needs. The introduction of AI provides a new pathway to address the lack of personalized support in traditional teaching, and it can primarily promote innovation in the theoretical teaching model for TCM graduate students through AI literacy cultivation and intelligent learning support.

First, AI literacy should be incorporated into the training system for TCM graduate students. Most TCM graduate students possess the ability to use AI tools for knowledge acquisition, literature analysis, and research assistance, and can become effective "users" of AI; a small number of graduate students with an interdisciplinary foundation can further leverage the cognitive characteristic of "categorization by analogy" in TCM, explore the integrated application of AI technology and the TCM theoretical system, and grow into "transformers" in the AI field. Many medical education practitioners have proposed that medical education should regard generative AI literacy as one of the core competencies of future medical talents, with emphasis on cultivating students' ability to understand, evaluate, and standardize the application of AI outputs^[11]. Related studies also show that medical students have widely used ChatGPT to assist their learning, but at the same time they are concerned about information accuracy and model bias, suggesting that AI education should emphasize critical use rather than simple tool training^[12].

Second, generative AI can serve as a personalized learning assistant to promote the construction of theoretical knowledge in traditional Chinese medicine. Large language models can explain complex concepts through dialogue, provide immediate feedback, and adjust teaching content according to learners' levels. Studies have shown that ChatGPT has been applied in medical education in scenarios such as personalized learning support, knowledge explanation, and learning feedback, and its advantage lies in its ability to provide a continuous interactive learning experience^[13]. For example, in the teaching of Chinese medicine classics, graduate students can use AI to

conduct interpretation of passages, theoretical comparisons, and analysis of medical cases around works such as the Huangdi Neijing and Shanghan Lun; in the stage of research training, models can be used to assist in constructing a knowledge framework in a disease domain, sorting out research hotspots, and forming literature reading paths. Similar application models have been explored in medical graduate education, where generative AI is used for clinical reasoning training, simulated case discussions, and research design assistance.

3.2 Clinical Practical Training and Syndrome Differentiation Thinking Training

Clinical competency training is a core component of the cultivation of master's and doctoral students in Traditional Chinese Medicine (TCM), and it is also an important direction for AI application. AI can enhance the quality of graduate training through two aspects: the objectification of the four diagnostic methods' information and intelligent clinical training. First, AI helps promote the objectification of TCM four diagnostic methods teaching. Traditional TCM diagnostic and treatment experience has strong tacit characteristics, and information such as tongue images and pulse conditions is difficult to quantify and standardize. In recent years, tongue image recognition technology based on computer vision has been applied to the extraction of features such as tongue color, tongue shape, and coating nature, providing a visualized and quantitative basis for tongue diagnosis teaching. For example, Lin et al. used deep learning methods to establish a tongue image analysis model, achieving tongue body segmentation and automatic recognition of tongue image features, providing technical support for the objectification research of TCM tongue diagnosis [14]. In addition, some studies have utilized AI to perform feature extraction and classification of pulse signals, thereby improving the reproducibility of pulse diagnosis information acquisition and analysis [15]. These technologies do not replace physicians' experience, but rather transform the experiential knowledge in traditional diagnosis and treatment into observable and comparable data, thus assisting teachers in conducting clinical demonstrations and skill feedback.

On the other hand, generative AI and virtual patient systems can provide new teaching scenarios for TCM clinical reasoning training. Existing studies have shown that large language models can simulate patient communication, generate case scenarios, and provide immediate feedback in medical clinical reasoning training. For example, Lee et al. compared the performance of ChatGPT and medical students in clinical reasoning tasks and found that large language models reached a level close to that of medical students in some diagnostic reasoning steps, suggesting their potential to assist medical training [15]. In the field of TCM education, it is possible to further integrate the four diagnostic information of inspection, auscultation and olfaction, inquiry, and palpation to construct a virtual medical case system that includes tasks of symptom collection, syndrome differentiation analysis, and treatment based on syndrome differentiation. For example, multi-round consultation training can be conducted for typical cases such as "stomachache" and "insomnia," with the system prompting for missing information, pattern differentiation deviations, and issues in prescription reasoning, thereby enhancing the repeatability and safety of clinical thinking training.

3.3 Research Skills Training

Research capability refers to the comprehensive ability of an individual or team to identify problems, analyze problems, and solve problems in scientific research, and to innovatively propose new theories, new methods, and new technologies. The cultivation of research capability is likewise a necessary component of the education of master's and doctoral students in Traditional Chinese Medicine (TCM), running through the entire process of their training^[16]. For master's and doctoral students in TCM, under the "dual-track integration" training model, research time is severely insufficient. In addition, there is a methodological gap between the knowledge system of TCM

disciplines and modern research paradigms, making the dilemma in cultivating their research capability prominent, with widespread difficulties in evidence synthesis, method selection, and writing. AI, especially generative AI, can provide extensive support for the entire research process [17-18].

In the evidence synthesis stage, machine learning tools can be used for title and abstract screening in systematic reviews [19]. Automated workflows for evidence synthesis are also advancing, and language models can even assist in risk of bias assessment for randomized controlled trials [20]. In the methods training stage, researchers can use large models to check study design in accordance with reporting checklists such as STROBE. Traditional Chinese medicine research often involves medical case mining, prescription pattern analysis, and syndrome association analysis, and AI happens to be adept at handling such multi-source heterogeneous data [21], so it can serve as a training vehicle for research methods. At the level of writing and research guidance, graduate students are a high-frequency group of AI users. Interview studies show [22] that tools such as ChatGPT may assist with literature organization, draft generation, and terminology standardization, but may also weaken independent critical thinking and alter the supervisory relationship; meanwhile, cross-sectional evidence suggests that generative AI use is closely related to graduate students' research progress [23].

The academic community remains divided on the role of AI in academic writing, necessitating a balance between its efficiency value and integrity risks, and an exploration of graduate advising assistant design bounded by academic integrity [24]. For Traditional Chinese Medicine graduate students, writing assistance should also cover Traditional Chinese Medicine terminology expression and literature management, and instructors need to clarify which stages allow tool intervention.

3.4 Personalized Training Management and Quality Evaluation

The AI application in the training management stage is still in the exploratory phase, but it has already shown application potential in areas such as academic performance analysis, personalized training, and evaluation assistance. AI can collect process data from graduate course learning, research training, and clinical practice through learning platforms, form dynamic competency profiles, identify learning difficulties and competency shortcomings, and provide a basis for optimizing training programs. For example, Ouyang et al. constructed an educational support system that integrates AI prediction models with learning analytics, predicts learning performance by analyzing students' learning process data, and helps teachers implement precise interventions through visual feedback. Quasi-experimental studies show that the system can improve students' learning engagement, collaborative performance, and learning satisfaction, demonstrating the feasibility of AI-driven learning analytics in personalized cultivation [25].

In terms of assessment and evaluation, generative AI has begun to be applied to question generation, automated feedback, and formative assessment. Kung et al. found that ChatGPT demonstrated a relatively high level of answering ability on the United States Medical Licensing Examination, suggesting that large language models have the potential to assist medical education evaluation and learning feedback [3]. On this basis, AI can be further extended to preliminary screening, format compliance checking, and assisted review of research proposals, mid-term examinations, and dissertations, thereby improving the efficiency of training management and enabling supervisors to devote more energy to academic guidance and research innovation [26]. For the TCM postgraduate training system that combines mentorship cultivation with large-scale education, the data analysis and evaluation support provided by AI helps alleviate the contradiction between insufficient mentorship guidance resources and the growing demand for student training, and thus has high application value [27]. However, for high-stakes evaluation scenarios such as

postgraduate admissions, milestone assessments, and degree evaluations, it is still necessary to pay attention to issues such as data security, evaluation fairness, and model bias.

3.5 Comparison of Main Application Methods of AI-Assisted Teaching

According to the different stages of AI-assisted teaching and training, the main application scenarios, main carriers, application value, and evidence status of different training stages are summarized in Table 1, providing a reference for clinical AI-assisted teaching.

Table 1. Main Applications of AI-Assisted Teaching in the Training of Master's and Doctoral Students in Traditional Chinese Medicine

Training Component	Main Application Scenarios	Technical Tools	Application Value and Evidence Status
Theoretical Teaching and Knowledge Construction	AI literacy development; personalized tutoring; course resource generation	Large language model–based Q&A; intelligent tutoring systems; intelligent question banks	Supports knowledge acquisition, conceptual understanding, and self-directed learning; applications have been reported in medical education, while evidence in TCM settings remains limited.
Clinical Training and Syndrome Differentiation Reasoning	Objective demonstration of the four diagnostic methods; virtual case training; syndrome differentiation dialogue simulation	Tongue image recognition; pulse signal analysis; large language model–based virtual patients	Improves the visualization and repeatability of clinical skills training; technically feasible, but evidence on educational effectiveness remains limited.
Research Capacity Training	Literature retrieval and evidence synthesis; data analysis; research design and academic writing support	Literature screening tools; machine-learning models; generative AI writing assistants	Preliminary empirical evidence is available and suggests improved research efficiency, but academic integrity and the cultivation of critical thinking require attention.
Training Management and Quality Evaluation	Learning analytics; competency profiling; formative self-assessment; review assistance	Learning analytics systems; intelligent test generation; automated feedback	Still at an exploratory stage; may improve training management, but high-stakes assessment requires safeguards for fairness, privacy, and security.

4. Risks and Coping Strategies of AI-Assisted Cultivation of Traditional Chinese Medicine Graduate Students

While AI enhances the efficiency of cultivating TCM graduate students, it may also bring risks such as cognitive dependence, knowledge distortion, academic integrity, and data governance. Since the cultivation of TCM talent particularly emphasizes understanding of classics, pattern differentiation thinking, clinical embodied experience, and mentor-apprentice transmission, the intervention of AI should not merely pursue teaching efficiency, but should pay more attention to whether the core competencies of graduate students are preserved and strengthened.

First, we should prevent the weakening of dialectical thinking and clinical judgment caused by AI dependence. Generative AI can quickly provide diagnostic and treatment recommendations and answers to questions, but if learners long-term directly accept model outputs without independent analysis, they are prone to automation bias, that is, developing excessive trust in AI results, thereby reducing the awareness of active verification and independent judgment. Nguyen pointed out that medical learners, due to limited clinical experience, may be more susceptible to automation bias, so AI education should simultaneously strengthen result verification and critical thinking training ^[28].

For graduate students of traditional Chinese medicine, syndrome differentiation and treatment involves the comprehensive analysis of the four diagnostic methods, analysis of pathogenesis, and holistic judgment, and model-generated syndromes or prescriptions should even less be directly regarded as standard answers. Therefore, a teaching process of "independent syndrome differentiation—AI assistance—comparative reflection—mentor feedback" can be adopted, so that AI assumes the functions of prompting, verification, and feedback, rather than replacing graduate students in completing the process of syndrome differentiation.

Second, attention should be paid to the reliability of generated content and the issue of adaptation to traditional Chinese medicine knowledge. Large language models can generate fluent but factually incorrect content, and phenomena such as fabricated references and erroneous diagnostic and treatment recommendations may occur. A review on graduate medical education pointed out that generative AI carries risks such as inaccurate information, overreliance, and bias, and it should not be used as the sole source of information in important clinical and academic scenarios ^[29]. Traditional Chinese medicine knowledge also has characteristics such as differences in meaning between ancient and modern times, synonyms in terminology, complex versions of classics, and strong interconnectedness of the theoretical system, so general models may produce problems such as misquotation of classical original texts, confusion of syndrome concepts, or detachment from the context of syndrome differentiation. Therefore, priority should be given to building a specialized knowledge base for traditional Chinese medicine based on authoritative textbooks, classic ancient texts, clinical guidelines, and standardized terminology, and establishing a quality control mechanism of "model generation—source verification—expert review" through retrieval-augmented generation, source attribution, and teacher review.

Third, the boundaries for the use of AI in research training and academic writing should be clearly defined. Generative AI can assist with literature organization, language polishing, formatting, and preliminary feedback, but if it is used to replace research design, data interpretation, and the formation of core viewpoints, it may weaken graduate students' independent research capacity and give rise to issues of originality and attribution of responsibility. Existing research in medical education has pointed out that improper use of AI may lead to fabricated citations, a lack of critical analysis, and risks to academic integrity, making it necessary for educational institutions to formulate clear usage guidelines ^[30]. Current research on medical graduate education also recommends that authors should bear ultimate responsibility for academic content produced using generative AI and that the use of AI should be appropriately disclosed ^[29]. Therefore, graded usage rules can be established for the training of Traditional Chinese Medicine graduate students: AI may be allowed for literature retrieval assistance, language optimization, and format checking; used cautiously for research design and data interpretation; should not replace graduate students in completing the core content of their theses; and AI usage should be disclosed in accordance with the requirements of schools, journals, and degree management.

5. Conclusion

In conclusion, artificial intelligence provides new approaches to the education and training of master's and doctoral students in Traditional Chinese Medicine (TCM), offering support in theoretical learning, clinical training, research development, and quality assessment. Technologies such as knowledge graphs, generative large language models, virtual clinical cases, and data analytics can facilitate personalized learning, strengthen syndrome differentiation and clinical reasoning, and improve research efficiency^[31]. However, their application also entails risks, including inaccurate knowledge, algorithmic bias, academic integrity concerns, data security issues, and excessive dependence on AI. Therefore, the principle of "augmentation rather than replacement"

should be upheld. Efforts should focus on developing authoritative TCM-specific knowledge bases, enhancing AI literacy, and strengthening standardized governance, while promoting the deep integration of AI into postgraduate TCM education under the guidance of educators.

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