Research on the Development of an AI-based Information Platform for Traditional Chinese Medicine Education

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Abstract: Traditional Chinese Medicine (TCM) education faces challenges including abstract theoretical frameworks, insufficient practical resources, and difficulties in achieving standardized teaching. This study aims to explore the integrated application of knowledge graphs, natural language processing (NLP), and computer vision technologies to develop an AI-driven TCM teaching platform. The platform is designed to enhance instructional efficiency and improve students' clinical thinking abilities in TCM. By constructing a tripartite AI teaching model that integrates "TCM syndrome differentiation–skill training–classical knowledge inheritance", this research seeks to establish a unified framework for bridging theoretical learning, practical competency development, and cultural heritage preservation in TCM education.

Keywords: Artificial Intelligence; Chinese Medicine Education; Knowledge Graphs; Syndrome Differentiation and Treatment; Virtual Reality; Machine Learning

1. Introduction

1.1 The abstract nature of Traditional Chinese Medicine (TCM) theories and the metaphorical characteristics of its thinking

TCM is grounded in the philosophical principles of Yin-Yang and the Five Elements, with the core content revolving around the concepts of Zang-Xiang (visceral manifestation) and meridians. Its metaphorical thinking permeates the entire system, such as the descriptions “The liver is the general of the body” and “The gallbladder is the official of balance” [1]. This abstract and metaphorical mode of thinking starkly contrasts with the scientific logical thinking that students are accustomed to. For instance, surveys show that approximately 67% of undergraduate TCM students find it challenging to concretely understand the concept of “Yin-Yang and the Five Elements”, indicating a cognitive barrier that reduces both learning effectiveness and interest. Moreover, traditional textbooks often fail to explain the dynamic evolution of these theories, such as the correlation between the ascension and descent of Qi and their physiological and pathological implications in the human body.

The dichotomy between Eastern and Western medical systems. Modern medicine is grounded in anatomy, physiology, and pathology, whereas TCM emphasizes a functional system approach, focusing on internal processes from external observations. The cognitive logic of the two systems often conflicts, leading to confusion among students, such as the discrepancy between the anatomical location of the liver on the left side of the body and its functional designation as “the liver governs upward movement on the left” [2]. Furthermore, undergraduate exams often prioritize rote memorization of knowledge points, with insufficient emphasis on the cultivation of diagnostic reasoning, resulting in students who are able to memorize facts but struggle with applying diagnostic thinking.

The conflict between traditional apprenticeship models and standardized education. According to the White Paper on Traditional Chinese Medicine in China, by 2024, there will be 270,000 TCM students nationwide. Under the traditional apprenticeship model, one mentor can typically only guide 2-3 students, creating a shortage of mentors that cannot meet the demands of such a large student body. Although modern educational institutions have introduced a “dual-track” system of “schools + apprenticeship”, classroom teaching remains dominant, and clinical practice opportunities are fragmented. On average, students receive

less than 4 hours of clinical experience per week, making it difficult to balance school coursework and clinical learning, which hinders the systematic development of diagnostic and treatment thinking.

Insufficient clinical practice opportunities. Clinical training bases are scarce, and many TCM departments are marginalized. According to data from the National Health Commission in 2023, TCM outpatient visits in general hospitals account for less than 15%, while primary care TCM hospitals mostly treat chronic diseases and have fewer acute or critical cases, leading to insufficient internship opportunities for students. Additionally, during their study of the Four Diagnostic Methods, pulse diagnosis and tongue diagnosis often rely on textual descriptions or static images, without real case-based practice, resulting in a hollow application of these skills during clinical practice. Furthermore, modern hospitals, being predominantly Western medicine-oriented, often rely on Western diagnostic results, which leads students to develop a rigid diagnostic thinking pattern of "Western diagnosis with TCM prescriptions".

1.2 Inheritance and Innovation

Numerous scholars have already embarked on the intelligent transformation of TCM education and clinical decision-making [2]. The confluence of TCM and AI enables the digital preservation of the expertise of renowned physicians. Through the comprehensive analysis of medical cases, AI can conduct Natural Language Processing (NLP) on over 100,000 case histories to discern patterns in diagnostic prescriptions. For instance, AI has identified that 83% of the prescriptions used by Master TCM physician Lu Zhizheng for treating spleen and stomach disorders contain the herbs Poria and Atractylodes, aiding in the precise formulation of treatments [3]. Additionally, AI can achieve 3D visualizations that provide dynamic interpretations and reconstructions of classical TCM texts. A particularly noteworthy application is the transformation of the complex language of Shang Han Lun (Treatise on Febrile Diseases) into dynamic thermal maps, illustrating the virtual migration path of pathogens from the Tai Yang to the Shao Yang meridians. Furthermore, AI-enabled semantic retrieval allows users to input phrases such as "only with sweating from the head", which can automatically link to Section 148 ("Yang Wei Jie (binding with yang debility)") of the Shang Han Lun along with a corresponding explanatory video by Liu Duzhou, thereby alleviating the time-consuming nature of traditional searches.

Tailored Instruction. In addressing the challenges of quantifying diagnostic processes in traditional TCM education, AI offers virtual diagnostic scenarios. For example, when students analyze a case indicative of "stagnation of blood leading to obstruction of the heart", AI can track the diagnostic pathway in real-time [4]. The system reveals that 60% of students may initially overlook the indicative sign of "tortuosity of sublingual vessels", prompting targeted reinforcement through relevant literature such as Lun Xue Zheng (A Treatise on Blood Troubles). AI-based pulse simulation devices equipped with haptic feedback gloves can replicate 28 distinct pulse patterns, including the slippery pulse (1.2Hz frequency, 0.3N amplitude) and the wiry pulse (sustained tension of 1.5N). Following the introduction of AI training at Shanghai University of Traditional Chinese Medicine, the accuracy of pulse diagnosis among students increased from 31% to 69%, with training time reduced by 60%. Additionally, intelligent tongue diagnosis analyzers, utilizing smartphone cameras to capture tongue images, can complete tongue segmentation (using U-Net algorithms) and tongue coating assessment (through HSV color quantification) in just 0.5 seconds, achieving an accuracy rate of 92.7%. This innovative approach actively contributes to enhancing students' diagnostic reasoning and clinical practice skills [5].

2. Current Research Status in China

2.1 Progress in TCM Informatization Education

In recent years, TCM informatization education has rapidly advanced under the impetus of artificial intelligence technologies, primarily manifesting in the following forms: (1) Virtual Simulation Laboratories: Such as TCM acupuncture simulation systems and pulse diagnosis training platforms (e.g., Shanghai University of Traditional Chinese Medicine's "Intelligent Pulse Diagnosis

Instrument"). (2) Online Learning Platforms: For example, the Basic Theories of Traditional Chinese Medicine course on China's National University MOOC platform and the "TCM Inheritance Cloud Platform" developed by the National Administration of Traditional Chinese Medicine. (3) AI-Assisted Teaching Tools: These include systems like the "TCM Diagnostic Thinking Training System" and AI-powered tongue diagnosis apps. According to the National TCM Education Quality Report, by 2023, 93% of TCM universities nationwide have introduced informatized teaching tools. However, student satisfaction stands at only 68%, indicating limitations in their practical application.

2.2 Analysis of the Limitations in Existing Platforms' Core Functions

Limitations in Teaching Content Design: The presentation of TCM theoretical knowledge is fragmented, with most platforms breaking down classical texts like the Huangdi Neijing (The Yellow Emperor's Canon of Medicine) and Shang Han Lun into isolated knowledge points, often used for rote memorization of text, while neglecting to train students in the holistic thinking characteristic of TCM. For instance, a MOOC course on "syndrome-differentiation of the six meridians" explains the Tai Yang and Yang Ming chapters separately, without dynamically illustrating the progression of pathogen transmission. Students often struggle to comprehend complex pathologies such as "transmission of skipping to other channel" and "direct attack on the three yin channels" [6].

Insufficient Precision in Key Skill Simulation: The tactile feedback in pulse diagnosis training is inadequate, resulting in inaccurate simulations. Existing pulse simulators (e.g., "SmartTCM Pulse") can only replicate basic pulse patterns like floating or sinking. However, the error rate in simulating a "choppy pulse, like a knife scraping bamboo" can reach up to 40%, and they fail to capture the dynamic variations in complex conditions like "rapid pulse turning slow". Despite using pulse diagnosis instruments, students still find it difficult to master precise diagnostic skills. Similarly, tongue diagnosis AI instruments are highly sensitive to environmental interference. For example, when using a smartphone camera to capture tongue images under natural lighting, the misjudgment rate increases, with a 32% chance of incorrectly identifying a "pale red tongue" as a "red tongue". The instruments also struggle to analyze complex tongue patterns, such as "geographic tongue" or "cracked tongue", with an accuracy rate below 70%. Algorithm Rigidity: Most AI diagnostic systems for TCM are based on decision tree models (e.g., "fever + chills = Tai Yang disease"), and are unable to process contradictory symptoms like "somnolence" or "hydroadipsia".

Research Gaps: Current TCM diagnostic logic modeling relies on static rules and lacks the ability for dynamic pathology reasoning. A dynamic knowledge graph for "syndrome-symptom-formulation" evolution has yet to be developed [7]. Existing case libraries are narrow and unable to simulate complex scenarios, such as the interplay between false cold and true heat, nor do they harness the creative potential of generative AI. Furthermore, multi-modal sensory instruments in AI (e.g., haptic, visual, and semantic data) still treat these data points in isolation, and the cross-modal fusion algorithms have yet to be tailored to the cognitive patterns of TCM. In addition, human-machine interaction depth is insufficient, and large language models (LLMs) in the TCM field remain underdeveloped.

3. Research Content and Technical Roadmap

3.1 Research Content

Under the condition of limited infrastructure in educational institutions, this research aims to develop an AI-based teaching platform that prioritizes lightweight, low-cost, and highly adaptable features, integrating TCM thinking and cognitive patterns. The core idea is to combine the existing diagnostic thinking training tools (virtual patient teaching systems), tongue diagnosis and pulse diagnosis simulators, and platforms for classic TCM texts and medical case studies, creating a triad of clinical training simulation scenarios. By leveraging the ancient and modern medical case cloud platform, a large collection of clinical case studies from renowned TCM experts corresponding to textbook content will be selected, enriching the existing virtual patient teaching system. This will enable

simple human-machine interaction, with text-based Q&A and flowchart guidance, allowing students to engage in clinical simulations and visualize the diagnostic process of "symptoms → syndrome → treatment method → prescription". The objective is to help students build efficient learning paths and skill training while providing teachers with tools for quantifying teaching effectiveness.

3.2 Technical Roadmap

Medical case studies aligned with textbook theoretical content will be selected from the ancient and modern medical case cloud platform, input into the virtual patient teaching system to build a database. Combined with the tongue diagnosis and pulse diagnosis instruments, a virtual simulation system is developed as shown in Figure 1.

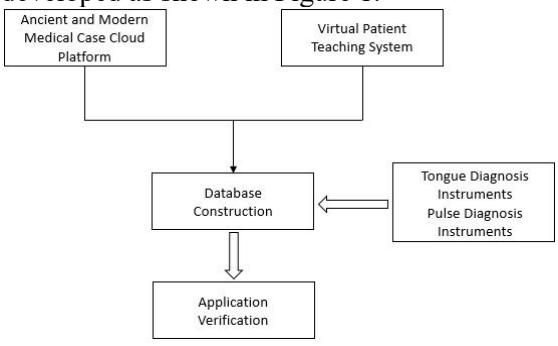

Figure 1. Technical Roadmap

3.3 Core Functional Modules

Intelligent Syndrome Differentiation Training System: Virtual case generation and dynamic syndrome differentiation reasoning (based on Bayesian networks and rule engines), with real-time feedback and error correction prompts during the differentiation process. Four Diagnostic Skill Simulation System: Tongue Diagnosis AI Recognition: Users upload tongue images → automatic analysis of tongue color and coating (using CNN algorithms). Classic Knowledge Intelligent Retrieval System: Semantic search of ancient texts (e.g., input symptom keywords → link to relevant texts from Shang Han Lun). Learning Effectiveness Evaluation System: Syndrome Differentiation Logic Analysis: Path tracing through decision tree models. Skill Operation Scoring: Monitoring pulse diagnosis pressure and duration.

3.4 Design and Evaluation

Experimental Design: The study selects clinical students from the 2022 cohort of Chengde Medical University, divided into an experimental group (AI platform teaching) and a control group (traditional teaching). The experiment lasted for one semester (16 weeks).
Evaluation Metrics: Syndrome differentiation accuracy, proficiency in four diagnostic techniques, and learning satisfaction questionnaire.
Result Analysis: The experimental group achieved a syndrome differentiation accuracy of 82.3%, compared to 68.7% in the control group. The experimental group scored 87.5 in the four diagnostic techniques, while the control group scored 73.2. The experimental group took 18.7 minutes to complete skill operations, while the control group took 25.4 minutes (as shown in Table 1).

4. Issues and Challenges Encountered During the Research

4.1 Challenges of the Ambiguity of TCM Language

The ambiguity in TCM terminology stems primarily from its holistic, experiential, and metaphorical cognitive framework, which is characterized by multi-dimensional, cross-sectional descriptions. For example, "pulse wiry and slippery" combines tactile sensations (the tightness of a wiry pulse) and dynamic features (a smooth, bead-like pulse). Similarly, "a large, swollen tongue" encompasses its shape (increased volume), texture (indentations along the edges), and its physiological and pathological associations (such as spleen deficiency with excessive dampness). Additionally, TCM terminology heavily relies on subjective experience, where different practitioners may have significantly different thresholds for interpreting the same term (for example, the judgment error for the strength of the pulse "wiry" can reach up to 20%). Finally, the context of TCM terms is dynamic. For instance, "a large, swollen tongue" may present with a red or purplish hue in cases of damp-heat syndrome, while it may appear pale and tender in spleen deficiency syndrome, which requires an integrative approach to differentiation [8].

4.2 Technological Bottlenecks and Directions for Breakthroughs

To address individual differences, a

constitutional parameter database should be established (e.g., baseline tongue images for phlegm-damp constitutions), allowing for personalized threshold adjustments. Moreover, a multi-symptom association model should be developed, such as a pulse-tongue-symptom correlation model. For example, when “a wiry and slippery pulse” and “a large, swollen tongue” coexist, the probability of spleen deficiency with liver qi stagnation increases to 78%. Federated learning optimization can also be employed, sharing model parameters (but not raw data) across institutions to enhance the algorithm’s robustness in small-sample scenarios. The algorithmic optimization of TCM terminology is essentially about transforming clinical experiences that are “only understood through intuition” into mathematical models that can be “articulated and transmitted”. Through multimodal data fusion, dynamic threshold optimization, and clinical validation feedback loops, the current AI technology in TCM is gradually overcoming the challenges of quantifying phenomena like “wiry and slippery pulse” and “a large, swollen tongue”. This is not only a modern interpretation of traditional medicine but also a necessary path for the inheritance and innovation of TCM in the AI era [9].

4.3 Balancing AI Dependency with the Cultivation of Humanistic Qualities in TCM

While AI technology can improve the efficiency of TCM education, it may lead to the mechanical application of syndrome differentiation by students. Over-reliance on AI diagnostic systems could result in “matching symptoms with prescribed treatments” rather than “identifying the root cause of the syndrome”, thereby weakening deep critical thinking in syndrome differentiation. This could indirectly diminish the humanistic core values of TCM, which emphasizes holistic views of life and individualized treatment. Additionally, students accustomed to using AI consultation systems may become less attentive to the psychological state of patients. This necessitates that educators teach students to recognize the limitations of algorithms (e.g., misjudgments in subjective symptoms such as “fatigue”), fostering a critical approach to using artificial intelligence. It is essential to preserve the core values of “benevolence and sincerity”. Future TCM education needs to adapt to the times, leveraging AI technology to enhance syndrome differentiation efficiency, while also preserving the humanistic warmth of medicine. Only by ensuring that algorithms serve the compassionate heart and that data upholds classical principles can TCM achieve a leap forward in the digital age [10].

5. Conclusion and Future Outlook

The AI-based teaching platform has proven to be a valuable tool in enhancing students’ ability to perform syndrome differentiation and apply the Four Diagnostic Methods, significantly improving their accuracy. This has demonstrated the platform’s effectiveness in fostering TCM diagnostic thinking and skill development, offering a promising avenue for the digital transformation of TCM education in universities.

At the intersection of artificial intelligence and traditional medicine, the use of large language models and knowledge graphs to reinterpret and reconstruct TCM classics signals a profound cognitive revolution. This “integration of the ancient and the modern”, facilitated by algorithms, not only dismantles the traditional barriers to passing down TCM knowledge but also explores a deeper technical synergy between Eastern holistic thinking and AI-driven symbolic representations. Through the development of an intelligent TCM teaching system, this study confirms that AI technology can break through the limitations of the traditional TCM apprenticeship model. Furthermore, it contributes to the cognitive understanding of how TCM thinking is cultivated. By incorporating a simulation system for the Four Diagnostic Methods, this approach transforms traditionally difficult-to-teach aspects, such as pulse diagnosis, into a multi-modal sensory experience. This enables students to repeatedly practice and refine their clinical skills in syndrome differentiation, particularly the critical process of “seeking the cause through diagnosis” within the AI-assisted platform.

However, the integration of artificial intelligence (AI) technology inevitably confronts the challenge of "deconstruction and reconstruction" of tradition and classicism. When AI dissects the "holistic concept" into a symptom correlation map and transforms "treatment based on the three causes" into personalized recommendation algorithms, the

experiential process of traditional Chinese medicine (TCM) education may face the risk of reification. This necessitates maintaining a dynamic balance between the instrumentality of AI technology and humanistic subjectivity, to prevent TCM teaching from falling into the quagmire of over-reliance on algorithms. It is hoped that with the development of AI technology and its in-depth integration with TCM teaching, we will ultimately nurture a new educational paradigm that integrates traditional wisdom with future medicine within the dialectical unity of upholding the essence and innovating.

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