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Research Progress on a Generative AI-Powered Clinical Reasoning Training Model for Rehabilitation Assessment

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ABSTRACT
Clinical reasoning competence is the core professional capability of rehabilitation therapists. Traditional training models are plagued by issues such as inadequate standardization, scalability challenges, and delayed feedback—problems that are particularly acute in private universities due to shortages of dual-qualified faculty and limited practical training resources. This paper proposes a "one-core, three-pillars" clinical reasoning training model for rehabilitation assessment based on generative AI, leveraging the open-source DeepSeek-R1 model as its technical foundation. Integrated into the practical teaching workflow of rehabilitation therapy programs, the model comprises three core functional modules: contradictory case generation, virtual supervisor inquiry, and competency profile diagnosis. A "three-dimension, six-index" evaluation system was constructed, and a longitudinal follow-up study was conducted to validate the model's effectiveness. The research findings aim to provide a low-cost, replicable AI-enabled solution for rehabilitation education in private universities, enrich the theoretical and practical framework of clinical reasoning training, and offer technical support for the standardized training of rehabilitation professionals in primary healthcare institutions.

KEYWORDS
Generative AI; Rehabilitation assessment; Clinical reasoning; Training model; Private universities

1 Introduction

Amid the advancing "Healthy China" strategy, China's rehabilitation medicine sector has entered a period of rapid development, imposing higher demands on the clinical reasoning abilities of rehabilitation professionals. As the core cognitive process through which rehabilitation therapists integrate assessment data and formulate personalized treatment plans, clinical reasoning serves as a critical bridge connecting theoretical knowledge to clinical practice, directly influencing rehabilitation outcomes and patient safety [1]. However, traditional clinical reasoning training models for rehabilitation assessment face numerous predicaments, failing to meet the talent development needs of the new era.

As key institutions for nurturing rehabilitation talent, private universities exhibit the unique duality of an application-oriented focus alongside resource constraints, rendering clinical reasoning training particularly challenging: The proportion of dual-qualified teachers (with both academic and clinical expertise) generally falls below 30%, restricting the quality of practical training guidance;Significant disparities in students' academic foundations create pressing demands for personalized training;

High-end educational resources such as virtual simulation systems require substantial investment (often in the millions), exceeding the financial capacity of most private universities [2]. Generative AI technology, centered on Large Language Models (LLMs), boasts robust capabilities in natural language interaction, case generation, and intelligent feedback, offering a novel approach to addressing these dilemmas.

Currently, generative AI tools such as ChatGPT-4 and DeepSeek-R1 have begun to penetrate medical education. Nevertheless, in the specialized field of rehabilitation assessment—characterized by its emphasis on "practical operation, interpersonal communication, and evidence-based practice" —relevant research remains in its nascent stages [3]. By systematically synthesizing domestic and international research findings, this paper summarizes the current state of generative AI applications in clinical reasoning training for rehabilitation assessment, highlights core innovations, and identifies existing gaps. Its purpose is to provide theoretical support and practical guidance for developing a low-cost, replicable training model tailored to private universities, thereby advancing the reform and high-quality development of rehabilitation education.

2 Evolution of Clinical Reasoning Training Research

Over decades of development, research on clinical reasoning training has evolved through three distinct phases, marked by innovations in educational philosophy and technological support, with notable differences in training models, technical infrastructure, and application outcomes.

2.1 Traditional Model Phase (1990s – 2010)

During this period, Problem-Based Learning (PBL) and Case-Based Learning (CBL) were the predominant paradigms, relying heavily on paper-based case materials and individual teachers' instructional experience [4]. Students engaged in group discussions around specific clinical cases, organizing their reasoning and formulating solutions under teacher guidance. While this model emphasized teacher-student interaction and experiential knowledge transfer—playing a pivotal role in early rehabilitation education—it suffered from inherent limitations:

Case resources were manually developed without standardized guidelines, leading to inconsistencies in training quality due to variations in teachers' case selection and instructional styles; Scalability was constrained by faculty numbers and classroom capacity, failing to accommodate the training needs of large student cohorts; Feedback depended primarily on post-session teacher reviews, resulting in delays that hindered the timely correction of cognitive biases in students' reasoning [5].

2.2 Virtual Simulation Phase (2010 – 2022)

Advancements in virtual simulation technology led to the adoption of Virtual Patient (VP) systems in clinical reasoning training. These systems simulated clinical scenarios via pre-programmed scripts, providing students with relatively realistic practical training environments [6]. This stage marked a transformation from "static cases" to "dynamic scenarios." Students could complete a series of clinical operations such as medical history collection, physical examination, and functional assessment through human-computer interaction, and adjust their reasoning directions based on system feedback. The advantages of virtual simulation systems included the ability to simulate rare cases and complex clinical situations, reduce practical training risks, and enable repeated use to improve the utilization rate of teaching resources [7]. However, their application in rehabilitation specialties faced significant drawbacks:

Interaction logic was confined to pre-set scripts, lacking flexibility to simulate dynamic changes in patient conditions or individual differences in clinical practice; Development and maintenance costs were prohibitive (often exceeding millions of yuan), placing them beyond the financial reach of most private universities; Feedback mechanisms focused primarily on the accuracy of operational steps, providing insufficient in-depth guidance on students' reasoning processes and failing to address the core goal of cultivating clinical reasoning competence [8].

2.3 Intelligent Enhancement Phase (2023 – Present)

The breakthrough development of generative AI has propelled clinical reasoning training into an era of intelligent enhancement. LLMs such as ChatGPT-4 and DeepSeek-R1 have demonstrated remarkable potential in clinical reasoning [9]. Compared to virtual simulation systems, generative AI offers greater interaction flexibility and knowledge generation capabilities, enabling real-time creation of personalized cases, targeted inquiries, and dynamic guidance of reasoning processes based on student input. In domains like acute case diagnosis, some LLMs have achieved reasoning capabilities comparable to human experts [10].

Research focus during this phase has shifted from "scenario simulation" to "cognitive empowerment," with three core advantages: Diverse and personalized case generation: Cases of varying types and difficulty levels can be generated to align with training objectives, meeting differentiated learning needs; Timely and in-depth feedback: Real-time responses to students' reasoning processes, with hierarchical questioning to deepen critical thinking; Cost controllability: Lightweight modifications based on open-source models lower the threshold for technological application [11].

Nonetheless, research on generative AI in rehabilitation assessment remains exploratory. A key challenge lies in adapting to the specialty's emphasis on "practical operation, communication, and evidence-based practice" to develop scientifically sound and effective training models [12].

3 Current Status of Generative AI Applications in Rehabilitation Education

3.1 Foreign Research Status and Characteristics

Foreign research on generative AI in rehabilitation education has advanced earlier, forming distinct characteristics across three key dimensions: tool application, specialty-specific exploration, and evaluation system development.

In terms of instrumental applications, generative AI primarily supports structured tasks. Studies indicate that ChatGPT-4 achieves an "advanced level" of accuracy in assisting report writing and decision-making in speech-language pathology, enabling rapid generation of standardized assessment reports and preliminary treatment recommendations to significantly improve training efficiency[13]. However, its performance in unstructured tasks—such as personalized treatment plan development, patient motivation enhancement, and cultural adaptation—is only "intermediate, "

reflecting its strength in rule-based structured tasks but limitations in addressing the "artistic" elements of rehabilitation assessment (e.g., humanistic care and adaptive communication)[14].

In specialty-specific exploration, AI application research has expanded across rehabilitation subspecialties. Birol et al. evaluated ChatGPT's performance in six core rehabilitation activities, finding that over two-thirds of clinical teachers and students endorsed its utility in document processing and educational material development. However, its adoption in direct service scenarios (e. g., bedside assessment and patient communication) remained below 20% [15]. Privacy protection and cultural adaptation are major barriers to clinical application: variations in medical regulations and cultural contexts across regions make it difficult for general-purpose AI models to fully adapt to diverse clinical settings [16].

In evaluation systems, significant gaps persist. Most current studies focus on comparing the accuracy of AI outputs against expert conclusions to validate utility, while neglecting multi-dimensional assessment of "reasoning process quality"[17]. The core goal of clinical reasoning training is to foster students' critical thinking and evidence-based decision-making, requiring attention to dimensions such as logical coherence, evidence integration, and reflective depth. Existing evaluation methods fail to meet the demand for "thinking visualization" in rehabilitation assessment education [18].

3.2 Domestic Research Status and Gaps

Domestic research primarily concentrates on medical diagnosis, with relatively limited exploration of generative AI in rehabilitation assessment. Key gaps exist in three areas: specialty depth, evaluation methods, and cost adaptability.

In specialty depth, most studies utilize general-purpose AI models without customization for rehabilitation assessment's unique requirements. Rehabilitation assessment involves specialized knowledge and tools (e.g:Brunnstrom Staging, Ashworth Scale, Fugl-Meyer Assessment), for which general AI models lack targeted training. This results in cases with insufficient professionalism and reasoning guidance of limited precision [19]. In contrast, AI models in medical diagnosis have undergone specialized training in disease diagnostic criteria and differential diagnosis, yielding more impactful applications [20].

In evaluation methods, domestic studies predominantly employ summative post-training assessments (e.g., pre-post test score comparisons) to measure effectiveness, lacking dynamic evaluation of the training process [21]. Clinical reasoning development is a gradual process that requires "embedded" competency diagnosis during daily practice to identify cognitive weaknesses and provide timely targeted guidance. Existing methods fail to capture dynamic changes in students' reasoning, limiting support for personalized training [22].

In cost adaptability, no lightweight solutions tailored to private universities have been proposed. Most domestic research relies on commercial AI models or high-cost customized development, which are unaffordable for private universities facing weak practical training infrastructure and limited funding [23]. Developing a low-cost, replicable generative AI training model is therefore a critical gap to address [24].

3.3 Special Needs of Rehabilitation Education in Private Universities

The application-oriented focus and resource constraints of private universities shape unique requirements for generative AI training models:

Personalized training for diverse student backgrounds: Private university students exhibit wide variations in academic foundations and learning abilities. Traditional "one-size-fits-all" models are inadequate, demanding intelligent solutions that dynamically adjust training difficulty based on individual proficiency [25].

Intelligent supervision to compensate for faculty shortages: The low proportion of dual-qualified teachers hinders personalized guidance during practice. Students' reasoning errors often go uncorrected, necessitating AI-powered virtual supervisors to provide "one-on-one" real-time feedback [26].

Sustained competency development for post-graduation adaptation: Private university graduates typically face a one-year gap between graduation and professional certification, during which clinical reasoning skills may deteriorate. Training must prioritize transferable, long-lasting cognitive abilities over rote knowledge memorization [27].

Low-cost solutions for limited resources: Private universities cannot afford high-investment resources like virtual simulation systems. Lightweight AI modifications based on open-source technology are urgently needed to improve training quality while controlling costs [28].

4 Conclusion

Generative AI technology offers an innovative pathway for clinical reasoning training in rehabilitation assessment, effectively addressing key limitations of traditional models. Domestic and international research has highlighted its core strengths in case generation, intelligent feedback, and personalized guidance, yielding innovations such as

"contradiction-driven" training theory and the "three-dimension, six-index" evaluation system. However, current research faces multiple challenges—including the accuracy of specialty-specific knowledge, evaluation validity, and skill transferability—with a notable lack of adaptability studies tailored to private universities.

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