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Clinical Critical Thinking in Medical Education: Research Progress and Cultivation Strategies

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Abstract

Critical thinking is widely regarded as one of the core competencies in medical education and constitutes an important cornerstone for medical students to make scientific decisions and ensure clinical safety. In recent years, with the transformation of medical education concepts and the increasing complexity of the clinical environment, the cultivation of critical thinking has become a key link in the competency education system for medical students. Based on a systematic review of domestic and foreign literature, this article comprehensively reviews the research progress of clinical critical thinking from four dimensions: concept evolution, assessment tools, influencing factors, and training paths. The research results show that the essence of critical thinking lies in rational analysis, reflective judgment and evidence integration, while its effective cultivation depends on the collaborative transformation of inquiry-based teaching, diversified assessment systems and educational culture. In the future, longitudinal tracking research and intelligent assessment should be strengthened to promote a profound transformation of medical education from knowledge-oriented to thinking-oriented.

Keywords

Critical Thinking; Medical Students; Teaching Methods; Cultivation Pathways.

1. Introduction

Critical thinking ability is one of the core capabilities in medical education and serves as the foundation for medical students to make scientific decisions, avoid diagnosis and treatment risks, and ensure clinical safety. As early as 1999, the International Council for Medical Education Guidance clearly pointed out in its "Minimum Essential Requirements for Global Medical Education" that critical thinking is one of the seven core abilities that medical graduates should possess[1].

In recent years, with the increasing complexity and diversity of clinical practice, critical thinking ability has been regarded as the "second stethoscope" for doctors to deal with uncertainties, analyze complex conditions and make scientific judgments. Research shows that approximately 20% of errors in clinical decision-making are related to thinking biases, and systematic critical thinking training can significantly reduce the misdiagnosis rate [2]. Furthermore, The Lancet and the British Medical Journal (BMJ) have repeatedly pointed out that traditional medical education overly emphasizes knowledge imparting while neglecting thinking training, resulting in medical students lacking effective analytical and reasoning abilities when facing complex clinical scenarios [3].

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From the "Undergraduate Medical Education Standards - Clinical Medicine Major (Trial)" in 2008 [4] to the "Opinions on Deepening the Synergy between Medical Education and Medical Education and Further Promoting the Reform and Development of Medical Education" issued by The General Office of the State Council in 2017 [5], China has explicitly stated that critical thinking should be incorporated into the competency-oriented training system. However, at present, critical thinking still has problems such as the disconnection between theory and practice, an imperfect assessment system, and a single teaching strategy.

Therefore, systematically sorting out the theoretical evolution, assessment tools, influencing factors and cultivation paths of critical thinking is of great significance for promoting the reform of medical education in China and enhancing the comprehensive clinical decision-making ability of medical students.

2. Theoretical Evolution of the Conceptual Framework and Clinical Connotation

The concept of critical thinking can be traced back to Dewey's "reflective thinking" theory, which emphasizes that individuals should form beliefs through rational reflection and logical judgment when facing problems [6]. Subsequently, Facione proposed in the "Delphi Report" that critical thinking is a "purposeful, self-regulating judgment process", and established a two-dimensional model that encompasses six core skills: explanation, analysis, reasoning, evaluation, explanation, and self-regulation [7]. This model not only emphasizes the logic and systematicness of cognitive skills, but also highlights the role of emotional tendencies (such as openness, truth-seeking, and self-confidence) in the formation process of critical thinking, thus becoming an important theoretical framework for medical education research.

After entering the 21st century, scholars began to explore the concept of "Clinical Contextual Critical Thinking (CCCT)", believing that critical thinking should be embedded in specific clinical contexts. It is reflected in the dynamic reasoning and decision-making ability of doctors when facing uncertainty, ambiguity and multiple information [8]. For instance, in its revised training standards in 2020, the Accreditation Board for Nursing Education (ACEN) in the United States defined clinical critical thinking as a "comprehensive thinking mode that integrates clinical evidence, ethical judgment, and patient values" [9].

In the Chinese context, critical thinking is not only closely related to Clinical Reasoning but also has a hierarchical relationship with Clinical Judgment: Reasoning is a thinking process, judgment is the result of decision-making, and critical thinking runs through both, playing the role of a "cognitive intermediary" for supervision and evaluation.

Therefore, clinical critical thinking can be defined as: the ability of doctors to conduct reflective analysis and judgment based on evidence and logic in complex clinical environments to achieve the optimal decision. It is both a way of thinking and a professional quality that can be cultivated.

3. Evolution of Assessment Tools: From Traditional Scales to Intelligent Evaluation

The assessment of critical thinking is a key link in teaching reform. Internationally, relatively mature assessment tools include the California Critical Thinking Skills Test (CCTST) and the Health Science Reasoning Test (HSRT). CCTST focuses on analysis and logical reasoning, while HSRT is closer to medical contexts and is often used to evaluate the performance of medical students in clinical diagnosis and evidence-based reasoning [10].

Domestic research has been localized and revised on the basis of introduction. The Chinese version of "CTDI-CV" developed by Peng Meici et al. [11] has been widely used among medical

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students. Subsequently, the medical professional version of "CTDI-CM" was launched, enhancing the clinical relevance of the assessment dimensions.

However, traditional scales mainly rely on questionnaires and paper-and-pencil tests, which cannot truly reflect the thinking process of medical students in dynamic clinical situations. In recent years, artificial intelligence (AI) and natural language processing (NLP) technologies have been introduced into the field of critical thinking assessment, forming a new trend. For instance, Alizadeh and Sameri (2025) pointed out in their systematic review that intelligent assessment systems based on semantic analysis can automatically identify the logical connections and the integrity of the evidence chain in students' clinical reasoning texts, thereby achieving quantitative evaluations of thinking depth, reflection frequency, and reasoning bias [12]. Some domestic universities (such as Zhejiang University and Sichuan University) have attempted to combine AI composition scoring with case analysis for the formative evaluation of clinical reasoning and critical thinking of medical students [13].

Furthermore, visual assessment systems based on Learning Analytics have gradually emerged. By integrating data from students' classroom interactions, case discussions, and written reflections, they generate "thought development trajectory maps" to provide precise teaching feedback for teachers [14].

This marks that the assessment of critical thinking is evolving from static to dynamic, from results to processes, and from single scales to multi-dimensional data integration. In the future, it is expected that an intelligent and ecological assessment system for critical thinking will be constructed.

4. Multidimensional Factors Influencing the Development of Clinical Critical Thinking

The development of critical thinking is a complex process influenced by multiple factors. The four dimensions of individuals, education, culture and institutions interweave and interact, jointly shaping the thinking characteristics of medical students.

At the individual level, learning motivation, self-efficacy and metacognitive level are regarded as key factors. Students with high self-efficacy are more inclined to actively question and conduct in-depth reflection, thereby forming a positive thinking cycle in their studies [15]. Recent studies have found that there is a significant positive correlation between the emotional intelligence and critical thinking of medical students. A high level of emotional intelligence helps students maintain rational judgment when facing clinical uncertainties [16]. In addition, the level of information literacy has gradually become a new variable influencing critical thinking, effectively distinguishing between "passive acceptors" and "active inquirers" learners.

At the educational level, the teaching model, the quality of interaction between teachers and students, and the curriculum structure directly determine the effectiveness of cultivating critical thinking. PBL (Problem-based Learning), CBL (Case-based Learning), and TBL (Team-based Learning) have all been proven to enhance students' analytical and reasoning abilities [17]. Research shows that when teachers adopt heuristic questioning, reflective feedback and multiple rounds of group discussions, students' critical thinking scores improve most significantly [18]. Furthermore, if interdisciplinary elements (such as psychology, sociology, and ethics) can be integrated into the curriculum design, students will be more likely to form a comprehensive analytical framework, thereby enhancing their critical judgment skills.

In terms of cultural factors, the differences in educational concepts between China and the West have a significant impact on the formation of critical thinking. Western education advocates independent questioning and reflective exploration, while traditional Chinese education emphasizes knowledge accumulation and authority recognition. This difference leads students to exhibit varying degrees of "silent thinking" in classroom interactions [19]. In the Chinese

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context, the culture of respecting teachers and exam-oriented teaching may unintentionally suppress students' questioning consciousness. Therefore, it is particularly crucial to build an open and inclusive learning atmosphere.

The clinical practice environment is also an important external factor for critical thinking. Studies have pointed out that students with experience in teamwork and doctor-patient communication score significantly higher in critical thinking ability than those lacking clinical internship experience [20]. The multidisciplinary ward rounds, case analyses and reflection meetings during the internship process are the "catalysts" for stimulating critical thinking. If teachers can guide students to analyze the condition from multiple perspectives and compare different diagnostic approaches when providing guidance, it will significantly enhance the depth and flexibility of their thinking [21].

5. Exploration of Major Cultivation Models and Practical Pathways

The cultivation model of clinical critical thinking shows a trend of diversification and integration. The traditional inquiry-based teaching centered on PBL has been proven to effectively enhance students' ability to identify problems and integrate information. The CBL model enables students to conduct logical reasoning and evidence evaluation in simulated decision-making through real case-oriented teaching [22]. The latest research indicates that when PBL is combined with CBL, students' comprehensive performance in the three dimensions of "reasoning depth", "logical consistency" and "reflective judgment" is superior to that of a single teaching mode [23].

In addition, TBL emphasizes teamwork and joint decision-making, and its learning mechanism is highly consistent with the operation of real clinical teams. Many medical colleges in China (such as Central South University and Fudan University) have introduced a formative assessment system in the TBL course. Students are required to write a "Reflective Journal" after group discussions to promote the development of metacognitive abilities. Research shows that reflection logs can effectively promote students' self-awareness of reasoning biases and are an important tool for critical thinking training [24].

With the development of artificial intelligence and Virtual reality technologies, the Virtual Patient System (VPS) has been widely applied in medical education. VPS enables students to practice decision-making in a risk-free environment through highly simulated clinical scenarios, and real-time feedback can help them identify blind spots in reasoning and correct errors. A study published in Medical Education in 2024 indicated that AI-assisted virtual patient teaching significantly enhanced students' critical thinking scores and clinical adaptability [25].

Evidence-based medicine (EBM) teaching is also a key path to cultivating critical thinking. By retrieving literature, assessing the quality of evidence and applying it in specific cases, students can learn how to transform data into clinical decisions. Research from the School of Medicine of Zhejiang University shows that after combining EBM with CBL, students' scores in the two dimensions of "logical reasoning" and "evidence integration" increased by more than 30%[26].

In recent years, a Blended Learning that integrates PBL, VPS and reflective logs has been regarded as the most promising model for development. It can analyze students' thinking paths through data tracking technology and provide personalized guidance in combination with teachers' feedback, thereby achieving a closed-loop mechanism of "intelligent feedback - reflection and correction - ability improvement" [27].

6. Existing Challenges and Future Directions

Although research on clinical critical thinking at home and abroad is increasingly abundant, there are still several bottlenecks. Firstly, the ecological validity of the evaluation system is

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insufficient. Most scales are developed based on the Western educational context and are difficult to fully reflect the cultural characteristics and ways of thinking in the Chinese clinical situation [28]. In addition, although the localization tools have been initially established, the dimension design still leans towards the static cognitive level and lacks the measurement of dynamic reasoning and team collaboration. In the future, technologies such as AI semantic analysis and learning trajectory modeling should be integrated to develop intelligent assessment systems capable of capturing "thought processes" [29].

Secondly, research designs are generally limited to cross-sectional surveys and lack longitudinal follow-up and intervention experiments. Establishing a continuous research framework covering the undergraduate, postgraduate and resident training stages is conducive to revealing the dynamic trajectory of the development of critical thinking. Conducting causal analysis in combination with clinical performance indicators (such as misdiagnosis rate and complication rate) will make critical thinking research more practically valuable [30].

Thirdly, the insufficiency of teachers' critical thinking teaching ability is the main bottleneck that limits the effectiveness of training. Surveys show that over 60% of clinical teachers have not received systematic critical thinking teaching training, resulting in insufficient depth of classroom questioning and reflection guidance [31]. In the future, a systematic teacher development system should be established. Through training, teaching communities and peer evaluation, teachers' ability to design and guide high-level thinking tasks should be enhanced.

Furthermore, the transformation of educational culture is the fundamental guarantee for the long-term development of clinical critical thinking. Only by creating a teaching environment that encourages questioning and tolerates mistakes can students' independent thinking and rational judgment be truly stimulated. In the future, medical education should incorporate critical thinking into the competency-oriented model under the three-dimensional framework of "knowledge - ability - value", achieving a deep transformation from knowledge imparting to thinking shaping.

7. Conclusion

In conclusion, clinical critical thinking is an indispensable skill in medical education, essential for improving the quality of clinical decision-making and ensuring patient safety. The cultivation of critical thinking must be integrated with innovative teaching methods, such as PBL, CBL, and TBL, and be supported by comprehensive assessment systems. It is crucial to enhance teacher training, adopt intelligent evaluation systems, and foster an open learning environment. The future of medical education lies in a deep transformation towards fostering not only knowledge but also critical thinking as a core competency.

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