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Investigation Design and Practice Research Based on Critical Thinking Training of Medical Students

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Abstract: This study designs and develops a 20-item critical thinking ability test tool, and uses problem-based learning (PBL) teaching method to intervene, to study the difference of critical thinking ability of 114 senior clinical medical students before and after traditional teaching mode and PBL course. The results show that the P values of the analysis level, understanding level and application level are all less than 0.05, indicating that PBL significantly improved students' critical thinking ability. The study suggests that educators should use more PBL methods in curriculum design, and policy makers should support the promotion of PBL teaching method and teacher training to improve the critical thinking ability of clinical medical students.

1. Introduction

Medical education is facing unprecedented challenges and changes. With the rapid growth of medical knowledge and the development of medical technology, medical students need to have higher professional quality and lifelong learning ability. Among them, critical thinking, as one of the core abilities, is crucial for medical students to analyze complex medical problems, make reasonable decisions and apply knowledge in clinical practice. However, the cultivation of critical thinking can not be accomplished overnight, it needs systematic educational design and continuous practice. Critical thinking is a rational, reflective thought process that includes the ability to analyze, evaluate, and reason. In the field of medicine, critical thinking ability is not only related to the professional growth of medical students, but also a key factor to improve the quality of medical services and patient safety. Therefore, the cultivation and evaluation of medical students' critical thinking ability has become the focus of medical education research. Although the importance of critical thinking has been widely recognized, it is still a challenge to effectively cultivate and evaluate the critical thinking ability of medical students in practical teaching. The existing researches mainly focus on theoretical discussion and case analysis, and lack systematic investigation and empirical data support. In addition, there are differences in the strategies and effects of critical thinking training in different educational stages and teaching environments. Through systematic design and empirical research, this study intends to explore the development status of medical students' critical thinking ability, analyze the

factors affecting its development, and put forward effective training strategies. Through this study, we hope to provide empirical evidence for medical educators and promote the comprehensive improvement of medical students' critical thinking ability.

One of the core objectives of medical education is to develop students' critical thinking ability, which is essential for their future clinical practice and patient management. Critical thinking involves multi-dimensional skills such as analysis, evaluation, reasoning and decision making, and is a basic quality that medical professionals must possess [1][2]. With the increasing complexity of the medical environment, medical students need to be able to process information effectively and make sound judgments and decisions [3][4]. In the field of nursing education, the concept map has proven to be an effective tool for improving students' critical thinking ability. The concept map facilitates the integration of interdisciplinary knowledge by linking new information to existing knowledge, helping students move from rote learning to active learning, and then to higher level metacognitive analysis and critical thinking. In addition, the concept map creation process requires students to utilize Socratic questioning, a deeper form of questioning that involves investigation, consequences, and consideration of evidence [5]. However, while the concept map has shown positive results in nursing education, it remains a challenge in medical education to effectively integrate critical thinking skills into the curriculum. To this end, this study intends to design and implement a medical student development investigate based on critical thinking training, and explore corresponding teaching practices in order to improve medical students' critical thinking ability in the preclinical and clinical stage. In medical education, traditional teaching models, such as classroom lectures, may not adequately engage current students, whose learning preferences differ from those of previous generations of students [6][7]. Therefore, educators need to constantly review and update teaching strategies to ensure that they are both relevant to current medical needs and aligned with students' learning styles. In addition, medical education is also facing a paradigm shift with the development of technologies such as mobile medical devices, electronic health records, and the application of other new technologies [8]. These changes require that medical students not only acquire the necessary medical knowledge, but also have the ability to adapt to new technologies and medical environments. To address these challenges, this study employed a novel learning tool designed to improve medical students' mastery of medical knowledge and assess their critical thinking ability. Based on the American Philosophical Association's (APA) critical thinking framework, the tool enables medical students to practice in a simulated clinical setting through online self-directed case scenario activities that improve their critical thinking ability [9].

2. Survey and methods

2.1. Research design

This study used a mixed approach to the research design, combining quantitative and qualitative research methods, to comprehensively assess the impact of PBL courses on medical students' critical thinking ability. This study designed a new tool for measuring critical thinking ability and applied it to medical education practice.

Problem-based learning (PBL) was used to implement intervention. The researchers divided the subjects into two groups, A and B, using the principle of random assignment. Group A was the experimental group and group B was the control group. Group A conducted pre-test and post-test before and after PBL course, that is, critical thinking ability test was conducted before PBL course, and critical thinking ability test was conducted again after the completion of the complete stage of PBL, so as to judge whether PBL has a potential effect on the improvement of medical students' critical thinking. Group B adopted the traditional medical teaching mode, that is, tested the critical thinking ability of the subjects before and after the traditional teaching to judge the role of traditional

teaching in improving the critical thinking ability of medical students.

2.2. Research hypothesis

H0: The critical thinking ability test results of students using problem-based learning (PBL) are not significantly different from those of students using traditional teaching methods.

H1: Students using problem-based learning (PBL) will have better critical thinking ability test results than students using traditional teaching methods.

2.3. Design of the questionnaire

After expert consultation, 20 items were finalized and answered with open questions. Experts and school teachers jointly formulate the item scoring standards, and each item is judged by 0-5 points. The questionnaire is divided into four levels: the knowledge level, the analysis level, the understanding level and the application level. We give a detailed explanation of its four levels and describe their importance (see Table 1 below). The total score of the questionnaire is 100, and those who score more than 80 can be regarded as having high critical thinking ability.

Table 1: Critical thinking ability questionnaire four levels.

Levels	Explanations	The importance
The knowledge level	In the framework of critical thinking ability, the knowledge level is the foundation, which involves the mastery and understanding of basic medical knowledge. This includes, but is not limited to, basic medical disciplines such as anatomy, physiology, pathology, pharmacology, and clinical medical knowledge such as clinical diagnosis, treatment, and patient management. The knowledge level competence is a prerequisite for effective clinical decision-making and patient care.	Understanding medical principles: Mastering basic medical knowledge helps medical students understand the pathogenesis, the development process and treatment methods of diseases, thus providing scientific basis for clinical practice. Support clinical decision making: Medical knowledge is the basis for clinical diagnosis and treatment. Only by fully understanding this knowledge can medical students make reasonable medical decisions. Promoting lifelong learning: Medical knowledge is constantly updated and medical students need to have the ability to continue learning to keep up with the latest developments in the medical field. Safeguarding patient safety: An in-depth understanding of medical knowledge helps medical students avoid errors and omissions in clinical practice, thereby improving the safety and effectiveness of patient treatment.
The analysis level	Critical thinking at the analytical level requires individuals to be able to break down complex problems into smaller, more manageable parts. It involves identifying the key elements of the problem, understanding the relationships between them, and evaluating the merits of different solutions. Problem decomposition: Breaking a complex problem into smaller components to better understand the nature of the problem.	Improve problem-solving skills: Through analysis, medical students can more effectively identify the core of the problem and propose solutions. Improved decision quality: Analytical competence helps medical students to consider more factors in clinical decisions and improve the accuracy of decisions. Facilitate knowledge integration: Analytical skills enable medical students to integrate knowledge from different sources and domains into specific problems.

	Hypothesis identification: Identify and clarify assumptions upon which problems are solved. Evidence testing: assessing the validity, reliability and relevance of the evidence presented. Argument building: building logically rigorous arguments based on evidence to form in-depth understanding and solutions to problems.	Cultivate scientific attitude: Cultivate medical students to treat problems scientifically and avoid blindly accepting unverified information or opinions.
The understanding level	Critical thinking skills at the understanding level require individuals not only to master knowledge, but also to be able to deeply understand the principles and concepts behind knowledge and their application in different situations. Conceptual understanding: Have a deep understanding of basic medical and clinical concepts and be able to explain their meaning and importance. Situational analysis: Ability to analyze and interpret medical problems in specific situations and understand how different factors affect medical decisions. Knowledge application: applying theoretical knowledge to practical situations to solve specific problems. Integrated insights: Integrating different sources and types of information to form a comprehensive understanding of complex issues.	Improve clinical competence: A deeper understanding of medical knowledge helps medical students make more accurate diagnostic and treatment decisions in clinical practice. Enhanced patient communication: The ability to understand levels enables medical students to better communicate with patients, explaining conditions and treatment options. Facilitate lifelong learning: Deep understanding of knowledge is the foundation of lifelong learning and helps medical students adapt to rapid updates in medical knowledge. Cultivate professional quality: in-depth understanding of medical knowledge helps to cultivate medical students' professional quality and improve the quality of medical services.
The application level	Application-level critical thinking skills refer to the ability of individuals to apply learned knowledge and understanding to new or complex situations to solve problems, make decisions, and innovate. Problem solving: Ability to identify problems and use critical thinking skills to find solutions. Decision making: Ability to make informed clinical decisions when faced with multiple possible treatment options. Clinical skills application: Translate theoretical knowledge into practical skills for effective patient assessment and treatment. Innovation and adaptability: Ability to think creatively and adapt to new situations or changes.	Improve the quality of patient care: be able to effectively apply knowledge to clinical practice to improve the quality of patient care. Facilitate professional growth: Employ ability helps medical students grow and develop in their professional fields. Coping with complex situations: Be able to flexibly apply knowledge and skills in the face of complex medical situations. Develop leadership skills: Applying critical thinking skills to teams helps develop leadership skills in medical students.

2.4. Sample selection

The subjects were senior students majoring in clinical medicine of Wenzhou Medical University. Random sampling method was adopted. 114 samples were included in this study. Under the premise of informed consent, the principle of random allocation was adopted. The 72 subjects in group B conducted pre-test and post-test before and after the traditional medical education course. Both pre-

test and post-test adopted self-developed and designed critical thinking ability measurement tools to explore the potential value of PBL course for medical students' critical thinking.

2.5. Data collection methods

At the beginning of the first class and the last class, the researcher conducted a questionnaire survey on all the subjects, and the subjects answered 20 items. Finally, non-researchers scored and judged each subject's pre-test and post-test respectively.

2.6. Data analysis methods

SPSS24.0 software was used to process the data. All subjects participated in the pre-test and post-test, and all data were valid. Critical thinking interventions were analyzed using a paired sample t-test with $P<0.05$ as the test criterion.

3. Results

3.1. Descriptive statistical analysis

114 subjects were included in this study. The results of each level analysis were as follows (see Table 2 below): the experimental group and the control group scored higher in the knowledge level in the pre-test; the experimental group scored higher in the four dimensions in the post-test, while the control group scored higher in the knowledge level.

Table 2: Descriptive statistics of critical thinking ability before and after test (full score of 100 points).

Levels	Pre-test		Post-test	
	Group A(n=72)	Group B(n=72)	Group A(n=72)	Group B(n=72)
Total score	63.19±6.79	82.69±6.04	63.08±6.16	62.60±7.23
The knowledge level	21.99±2.44	21.83±2.10	21.57±2.34	21.71±2.56
The analysis level	14.38±4.05	19.58±3.83	14.40±3.77	14.47±4.21
The understanding level	14.22±3.11	20.56±3.00	14.54±2.70	14.14±3.16
The application level	12.61±2.96	20.72±2.11	12.57±2.86	12.28±2.96

3.2. Critical thinking ability significantly improved

Table 3: T-test of group A critical thinking ability before and after test.

	The knowledge level	The analysis level	The understanding level	The application level	Total score
T value	0.396	-7.630	-12.530	-17.382	-17.312
P value	0.693	<0.001	<0.001	<0.001	<0.001

Using paired sample t-test, in the knowledge level, the analysis level, the understanding level, the application level in four levels, except for the knowledge level before and after the test P value is less than 0.05, indicating that the difference has statistical significance (see Table 3 and 4 below), further indicating that PBL the analysis level, the understanding level, the application level has a significant

role in improving critical thinking ability.

Table 4: T-test of group B critical thinking ability before and after test.

	The knowledge level	The analysis level	The understanding level	The application level	Total score
T value	-0.583	-0.310	1.809	1.770	1.048
P value	0.562	0.758	0.075	0.081	0.298

4. Discussion

4.1. Interpretation of the results

This study revealed the significant effect of PBL on critical thinking ability of medical students through quantitative analysis. PBL, as a student-centered teaching method, encourages students to learn actively in the process of problem solving by simulating real clinical problems, and develops their analytical, evaluation and reasoning abilities. The significance of the T-test results indicates that PBL has potential educational value in promoting the development of critical thinking among medical students. Considering that the knowledge level is mainly influenced by students' knowledge level, teachers' teaching level and other factors, PBL has little influence on knowledge level.

4.2. Research limitations and future directions

Although this study provides empirical evidence of the impact of PBL on critical thinking, its limitations should not be overlooked. First, there may be selection bias in the study sample, limiting the general applicability of the results. Second, the study was short in duration and failed to fully assess the long-term effects of PBL. Future studies should expand the sample size and extend the observation period to more fully assess the long-term effects of PBL. In addition, the synergy between PBL and other teaching methods can be explored, as well as the differences in the effectiveness of PBL in different cultural and educational contexts.

4.3. Implications for medical education

The results of this study emphasize the importance of PBL in medical education and suggest that educators should adopt more problem-driven learning in curriculum design. Educators should encourage students to ask questions, explore solutions, and develop critical thinking in the process. At the same time, educators should provide necessary guidance and feedback to help students overcome learning obstacles and optimize learning strategies.

5. Conclusions

5.1. The main findings of this study

The main findings of this study are that PBL as a teaching strategy can effectively improve critical thinking ability of medical students. By comparing the critical thinking test scores of the experimental group and the control group, we found that PBL students showed significant advantages in analyzing problems, evaluating evidence, and forming conclusions.

5.2. Recommendations for critical thinking development in medical students

Based on the results of the study, medical educators are advised to integrate PBL elements into the

curriculum design to stimulate students' interest in inquiry and critical thinking by designing challenging questions. In addition, educators should provide a wealth of learning resources and support to help students develop the necessary thinking skills during PBL. Meanwhile, educators should evaluate PBL effect regularly and adjust teaching strategy according to feedback.

5.3. Suggestions on medical student education policy

Policy makers should recognize the importance of PBL in medical education as part of medical education reform. It is recommended that policies be developed to encourage PBL teaching in medical schools and provide necessary training and resource support for teachers. In addition, policymakers should support interdisciplinary collaboration and research on innovative teaching methods to adapt to trends in medical education.

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