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Innovative Approaches to Reforming Physiology Experiment Teaching under the New Medical Sciences Framework

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ABSTRACT

The construction of the New Medical Sciences aims to cultivate interdisciplinary medical talents, placing higher demands on physiology experiment teaching. In light of the challenges of traditional teaching, such as outdated content, a single assessment mechanism, low student engagement, and limited research experience among instructors, this study proposes a reform pathway centered on research competence development, supported by diversified evaluation methods and the deep integration of ideological and scenario-based teaching. By optimizing teaching content, introducing innovative projects, establishing a multidimensional assessment system, and strengthening faculty development, the proposed reforms effectively enhance students' Innovative ability and practical skills. This study provides theoretical insights and practical experience for training interdisciplinary medical professionals to meet the demands of the new era.

The construction of New Medical Sciences is a crucial support for the "Healthy China" strategy, emphasizing interdisciplinary integration in medical education. It aims to cultivate well-rounded medical professionals who possess clinical skills, research capabilities, and humanistic qualities. As a fundamental discipline in medical education, physiology plays a key role in bridging theoretical knowledge and clinical practice. However, traditional physiology experiment teaching often suffers from rigid content, monotonous teaching methods, and insufficient student innovation. This paper systematically explores reform pathways for physiology experiment teaching under the framework of New Medical Sciences, aiming to provide a theoretical basis for educational practice.

1. Overview of New Medical Sciences and Physiology Experiment Teaching

1.1 The Concept and Development of New Medical Sciences

New Medical Sciences represent both an upgrade to the existing medical education system and an enhancement of interdisciplinary integration. This approach places a strong emphasis on cultivating medical professionals with cross-disciplinary literacy, innovative thinking, and practical abilities. By breaking traditional disciplinary boundaries, New Medical Sciences incorporate interdisciplinary integration (e.g., medicine with artificial intelligence and big data), dynamic adjustments to teaching models, and

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a heightened focus on clinical practice and research capabilities [1]. With rapid technological advancements, the development trend of New Medical Sciences has become increasingly evident. Emerging fields such as precision medicine and smart healthcare continue to drive medical education to higher levels. Consequently, New Medical Sciences impose greater demands on medical education—not only must students acquire solid medical knowledge, but they must also develop cross-disciplinary thinking and innovative practical skills. These competencies are essential for adapting to the complex and evolving healthcare landscape and contributing to global health solutions.

1.2 The Importance of Physiology Experiment Teaching

Physiology serves as a cornerstone of medical education, providing an in-depth exploration of the physiological phenomena and functional regulations within living organisms. As a core subject, it is essential for medical students, as it links theoretical medical knowledge with practical applications [2]. Physiology experiment teaching acts as a bridge between theory and hands-on practice. By conducting experiments, students can transform abstract physiological theories into tangible experiences, thereby deepening their understanding, reinforcing their knowledge, and improving retention.Moreover, experimental teaching offers a valuable platform for students to develop practical skills. From operating laboratory equipment to collecting and analyzing experimental data, each step enhances their hands-on abilities and scientific thinking. Additionally, physiology experiment teaching fosters a rigorous scientific attitude and teamwork spirit, laying a solid foundation for students' future careers in medical and related fields. As such, it is an indispensable component in training high-quality medical professionals.

2. Challenges in Physiology Experiment Teaching

2.1 Limitations of Teaching Content and Methods

Traditional physiology experiment teaching often suffers from rigid content. For a long time, experimental courses have primarily focused on confirmatory experiments, where students follow predefined steps, analyze experimental data under teacher guidance, and submit a report afterward. This approach is monotonous, mechanical, and lacks engagement [3], making it difficult for students to deeply understand the principles and significance behind the experiments. Furthermore, the teaching model remains largely traditional, with instructors providing detailed step-by-step explanations while students passively follow along. This "spoon-feeding" method lacks interactivity, resulting in low student engagement and limiting their motivation to learn. Additionally, the slow update of teaching content fails to incorporate cutting-edge research findings and real-world clinical cases in a timely manner. This gap between current teaching methods and the interdisciplinary, innovation-driven goals of New Medical Sciences restricts students' exposure to broader perspectives and hinders the development of their comprehensive skills.

2.2 Deficiencies in the Assessment Mechanism

The current assessment mechanisms in physiology experiment teaching present several shortcomings in evaluating students' experimental competencies. Assessment methods are often singular, relying primarily on laboratory reports and final exam scores. Laboratory reports tend to focus heavily on presenting results while overlooking students' practical skills, analytical thinking, and teamwork performance. Final exams, which are mostly theory-based, fail to comprehensively evaluate students' hands-on abilities and practical application skills. Such a narrow assessment approach does not accurately reflect students' experimental proficiency, leading to rote memorization of procedures and outcomes instead of fostering genuine skill development and scientific reasoning. Additionally, the lack of dynamic evaluation throughout the learning process prevents early identification of student challenges, limiting the opportunity for targeted guidance and hindering the continuous improvement of their experimental skills.

2.3 Low Student Engagement and Insufficient Innovation Training

Students in traditional physiology experiment courses often exhibit low enthusiasm for learning, stemming from multiple factors. Firstly, the limitations of teaching content and methods make experimental courses less engaging and challenging, reducing students' sense of achievement and motivation. Secondly, the weak connection between experimental teaching and clinical practice results in students failing to recognize the real-world value of their knowledge, further diminishing their drive to learn. For instance, in experiments related to respiratory regulation, such as endotracheal intubation, the primary focus is placed on the main operator, limiting opportunities for all students to engage actively and develop creativity. Moreover, traditional teaching emphasizes knowledge transmission while neglecting the cultivation of innovation, critical thinking, and teamwork skills. Students are accustomed

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to passively receiving information rather than actively exploring and independently analyzing problems. In team experiments, unclear division of labor and ineffective collaboration often arise, failing to cultivate essential teamwork skills. These challenges hinder students' overall development and fall short of the competencies required for medical professionals under the New Medical Sciences framework.

3. Exploration of Innovative Teaching Pathways

3.1 Optimizing Teaching Content and Innovating Teaching Models

3.1.1 Enriching Experimental Teaching Content

To meet the requirements of the New Medical Sciences, physiology experimental teaching content should be appropriately expanded. Cutting-edge research findings should be actively integrated, such as incorporating cases of gene-editing technology applications in physiology studies, allowing students to stay updated on the latest disciplinary advancements and broaden their perspectives. Moreover, a significant proportion of experiments should emphasize comprehensive and innovative approaches. Comprehensive experiments should integrate knowledge across multiple systems; for example, designing an experiment that involves the cardiovascular, respiratory, and nervous systems to help students understand their interactions. Implementing project-based team collaboration not only fosters students' innovative and practical abilities but also enhances teamwork skills, preparing them as interdisciplinary professionals with both creativity and cooperation skills [4]. This approach not only stimulates innovative thinking but also improves problem-solving abilities, making experimental teaching more profound and extensive.

3.1.2 Innovating Teaching Methods

The Problem-Based Learning (PBL) approach should be adopted, where instructors pose thought-provoking questions, such as "How do different physiological systems coordinate during exercise?" to guide students in independently gathering information, analyzing problems, formulating hypotheses, and solving challenges, thus cultivating independent thinking and self-learning abilities. Team-based scientific research projects should also be encouraged, dividing students into groups to conduct small-scale research projects. Diverse interactive methods, such as group discussions and project presentations, effectively stimulate students' enthusiasm and motivation, fostering communication, collaboration, and comprehensive skill development [5]. This approach not only strengthens teamwork but also provides hands-on experience in scientific research, enhancing students' research interests and innovation skills while making the learning process more interactive and exploratory.

3.1.3 Integrating Modern Teaching Technologies

Modern educational technologies provide new opportunities for physiology experimental teaching. Virtual laboratories enable students to conduct high-risk or high-cost experiments in a simulated environment, such as simulating human cardiac surgery, thereby avoiding operational risks while allowing repeated practice to deepen understanding. Multimedia tools can vividly present abstract physiological processes through animations and videos, such as demonstrating neural impulse transmission, helping students grasp complex physiological mechanisms. Additionally, online teaching platforms allow instructors to share resources, assign homework, and facilitate discussions, achieving a blended online-offline teaching model that improves teaching efficiency and quality.

3.2 Improving the Assessment System

3.2.1 Diversifying Continuous Assessment

A more comprehensive evaluation system should be implemented to assess students' learning progress. Classroom performance should be considered, including attendance, participation in discussions, and innovative insights. Group discussions should evaluate teamwork, communication skills, and contributions to the discussion topics. The experimental operation process should also be incorporated into assessments, focusing on students' proficiency in handling laboratory instruments, adherence to experimental procedures, and ability to handle unexpected problems. A diversified assessment system provides timely feedback on students' learning progress, encouraging active participation in both theoretical and practical learning.

3.2.2 Refining the Evaluation Criteria for Experimental Reports

Experimental report evaluation should be more detailed and scientific. The experimental design section should assess the rationality, innovation, and clarity of objectives. The data analysis segment should examine students' ability to process data, apply statistical methods appropriately, and derive insights from experimental results. The conclusion should evaluate whether students can derive accurate and logical conclusions while reflecting on and discussing their findings in depth. Additionally, aspects such as report structure, writing quality, and logical coherence should be

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included in the evaluation criteria. A refined assessment system ensures that students focus on the quality of their reports while cultivating a rigorous scientific attitude.

3.2.3 Aligning Teaching Objectives with Competency Development

Teaching objectives should focus on cultivating students' comprehensive abilities rather than merely reinforcing knowledge retention. Under the New Medical Sciences framework, physiology experimental teaching objectives should be categorized into knowledge acquisition, skill development, and attitude formation. Beyond introducing experimental principles, objectives, methods, and procedures, long-term goals should include independent experimental design to foster innovative thinking and problem-solving skills.

3.3 Strengthening Faculty Development

3.3.1 Establishing a Professional Talent Hierarchy

Building a well-structured faculty team is crucial for improving physiology experimental teaching quality. Efforts should be made to recruit high-level experts with significant research achievements in physiology to infuse fresh perspectives and expertise. Simultaneously, professional development opportunities should be provided for mid-career faculty members, such as attending national and international academic conferences and training programs, ensuring they stay abreast of disciplinary advancements. A mentorship system should be implemented, where experienced faculty members guide younger educators through hands-on training, facilitating professional growth. Encouraging faculty engagement in teaching research and reform projects further enhances instructional capabilities, leading to a balanced, high-quality teaching team.

3.3.2 Incentive Measures and Faculty Development

Incentive mechanisms should be established to encourage faculty participation in advanced studies and innovative teaching. Special funding should be allocated to support faculty attendance at prestigious academic seminars and professional training programs, broadening their academic horizons. Outstanding achievements in teaching reform and scientific research should be rewarded through financial incentives and public recognition, such as awarding "Excellence in Teaching" and "Innovation in Research" honors. A comprehensive faculty evaluation system should be implemented, linking performance assessments with promotions and salary adjustments, motivating faculty members to enhance teaching quality. Additionally, cross-disciplinary research and teaching collaborations should be encouraged to expand faculty development opportunities.

3.4 Integrating Ideological and Political Education into Curriculum

Integrating ideological and political education into physiology courses aligns with modern higher education requirements. Rather than directly delivering moral lessons, this approach incorporates real-life cases, experimental observations, and historical developments in physiology to inspire students' engagement. Methods such as problem-based learning, case-based teaching, scenario simulations, and role-playing should be explored to stimulate active participation and critical thinking [2,3]. Additionally, ethics in animal experiments should be emphasized; medical students should develop a profound understanding and respect for animal welfare and bioethics[6]. Regulations prohibiting unauthorized photography or sharing of experimental animal images should be reinforced [7], and proper procedures for handling experimental animals post-experiment should be followed. Furthermore, incorporating the stories of Nobel Prize-winning physiologists into teaching can inspire students to embrace scientific innovation.

4. Effectiveness of Teaching Reforms

The physiology experimental teaching reforms at our institution have yielded positive results. According to an anonymous student survey, overall satisfaction with the revised curriculum reached 92.8%. The "virtual-real hybrid teaching model" (combining virtual simulations with hands-on experiments) was favored by 82.4% of students for addressing equipment shortages and time constraints in traditional experiments. The newly introduced "self-designed experiment module" received 85.1% approval, making it the most popular reform initiative. In terms of cultivating innovative abilities, our students achieved the best results in history at the 2024 National Undergraduate Basic Medical Innovation Research and Experimental Design Competition, winning three provincial third prizes and two national third prizes. Additionally, in the 2024 National Undergraduate Life Sciences Competition, they secured one provincial second prize, one provincial third prize, and one national third prize. These teaching reforms have played a positive role in enhancing the quality of practice-oriented education and establishing an innovative talent cultivation model.

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