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Study on the Pedagogical Reform of Biochemistry Experiments Focusing on the Cultivation of Innovative Abilities

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Abstract: Experimental teaching is a crucial component in the field of biochemistry education. However, traditional methods often rely on confirmatory experiments, resulting in a limited teaching approach with unoriginal content, simplistic results, uniform reports, low student engagement, and inadequate development of independent learning skills. The advancement and utilization of biochemical theory and technology have led universities, research institutes, hospitals, and enterprises to increasingly prioritize professionals with strong innovation skills. Consequently, biochemistry courses should expedite the enhancement of experimental teaching methods, emphasize the integration of innovative experiments, and foster the holistic development of students' proficiency in their field, practical skills, and capacity for innovation. This study focuses on biochemistry experiment teaching as the subject of research, conducting a thorough analysis of the current state of innovation ability cultivation in teaching. It proposes corresponding reform measures with the goal of advancing the teaching reform of biochemistry experiments and nurturing innovative applied talents to meet the demands of the new era.

Keywords: Pedagogical reform; Biochemistry; Experimental teaching; Innovation ability

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1. Innovation education and innovation experiment

The research history of innovative education in the Western world spans nearly a century. The concept of creativity was first introduced by Guilford in 1950, leading to widespread interest in innovative education, particularly in the West. In American universities, biochemistry education is characterized by multi-level teaching that emphasizes the development of "scientific research methods" [1]. Upon entering the school, students should begin by mastering fundamental experimental operation skills before engaging in representative experiments guided by their teachers. This approach aims to cultivate students' analytical and problem-solving abilities, rather than simply teaching the principles of experimentation to enhance their overall academic and personal development. Ultimately, students are required to select topics that align

with the teacher's guidelines, utilize their creativity to the fullest extent, propose their methodologies, and independently execute all experiments [2].

In 1997, the National Education Commission of China released the Opinions on Enhancing the Development of Teaching Facilities for Foundational Engineering Courses, emphasizing the importance of not only updating experimental equipment and instruments but also innovating experimental teaching methods and content. Engineering courses in multiple universities are mandated to provide thorough experiments, design projects, creative endeavors, and other related content. This marks China's inaugural attempt at categorizing experimental initiatives and implementing the novel concept of innovative experiments.

Central South University suggests that students must fulfill a minimum of 4 credits in extracurricular innovation tasks prior to graduation as part of their practical innovation education. In the realm of innovative experimental teaching, each student is assigned an individual mentor to provide guidance throughout their participation in extracurricular innovative activities. Throughout this process, students have the autonomy to either apply for projects independently or engage in projects under the supervision of their mentors. The supervisors will allocate innovation credits to individuals based on their performance in practical activities. Furthermore, Jilin University has implemented an experimental center comprising backbone teachers, experimental teachers, experimental technicians, and graduate assistants. All faculty members are required to engage in theoretical teaching, scientific research, and experimental instruction, thereby creating an experimental team that integrates theoretical teaching, experimental instruction, and scientific research [3].

2. The necessity of teaching reform in biochemistry experimental course

2.1. The teaching status of the biochemistry experiment course

The teaching status of the biochemistry experiment course is examined in relation to the cultivation of innovation ability. An analysis of the dilemma surrounding the development of students' innovation skills in biochemistry experiment teaching at the school is presented, focusing on various key aspects:

(1) Students typically follow the experimental procedures outlined in the mechanization process as directed by the instructor. However, the absence of active student involvement in the formulation of the experimental plan may hinder the cultivation of critical thinking skills [4].

(2) Experimental teaching is centered around the verification experiment, with a restricted scope of experimental content that may hinder the stimulation of students' curiosity for exploration and the cultivation of innovative thinking [5].

(3) In the field of biochemistry, junior students may be impacted by the instructional methods employed in senior high school, leading to a passive mindset and diminished enthusiasm for learning [6].

2.2. Significance of teaching reform in biochemistry experimental course

Biochemistry is a burgeoning field in modern academia. Within the realm of biochemistry education, experimental teaching plays a crucial role [7]. However, traditional methods of experimental teaching fall short of cultivating innovative applied talents and meeting the demands of the contemporary era. Therefore, biochemistry courses must expedite the reform of experimental teaching, prioritize the utilization of innovative experiments, and enhance students' professional knowledge, practical skills, and innovative capabilities.

(1) The theoretical meaning. Through an examination of research data on innovation ability training and biochemistry experiment teaching theories, this study aims to investigate the significance of

fostering students' innovation ability and proposing reform strategies. This exploration can contribute to the enhancement of the theoretical framework, the enrichment of teaching ideas and methods for innovation ability training, and the provision of theoretical guidance and experiential insights for biochemistry experiment teaching and innovation education.

(2) Practical significance. Drawing on previous teaching experience and current teaching practices, this study examines the challenges and obstacles in the current biochemistry experiment instruction. It also proposes strategies and initiatives for educational reform aimed at fostering students' innovation capabilities.

In summary, this study has the potential to offer guidance on theoretical frameworks and teaching tools for educators in the new era, facilitating enhancements in the quality of biochemistry instruction. It can also contribute to the optimization of teaching strategies, the development of a more scientific and comprehensive instructional framework, the enhancement of pedagogical methods and perspectives, and the advancement of overall teaching reform and the successful implementation of innovative biochemical education practices. By implementing innovative experiments, students can improve their understanding of biochemical concepts, develop practical and innovative skills, broaden their knowledge base, and enhance their critical thinking abilities, ultimately contributing to the cultivation of well-rounded individuals [8].

3. Reforming the plan for the biochemical experimental course

3.1. Examine the trajectory of experimental pedagogical reform

In response to the increasing need for innovative application talents in the modern era, vocational colleges must prioritize the comprehensive development of students' innovative abilities and practical skills. Educators must accurately and comprehensively understand the unique features of biochemistry experimental teaching and the challenges present in current instruction to identify the appropriate direction for educational reform. By developing scientifically sound teaching plans, establishing precise experimental assessment criteria, enhancing experimental teaching facilities, offering students opportunities for independent exploration, and ultimately improving the effectiveness of biochemistry experimental teaching, teaching reform can be promoted and students' innovation abilities effectively cultivated.

3.2. Investigate the dilemma of experimental pedagogical reform

The study will focus on biochemistry teachers and their biochemistry experiment classes, conducting field investigations across all biochemistry courses offered at the school. The research will analyze the challenges associated with fostering students' innovation abilities in biochemistry experiment teaching. A questionnaire will be administered to assess biochemistry teachers' perceptions of innovation ability cultivation and the utilization of innovative experiments, to investigate and analyze the obstacles in developing students' innovation skills in biochemistry experiment teaching.

3.3. Formulate course objectives

An analysis of the current state of biochemistry experiment instruction and its impact on fostering innovation skills, as well as an examination of the challenges present in biochemistry experiment teaching, is necessary. Tailoring the curriculum to the unique characteristics of biochemistry and the diverse needs of students can enhance the effectiveness of instruction by allocating additional time for fundamental experiments and

ensuring adequate time for hands-on learning experiences [9]. Furthermore, it is recommended that the content of experimental courses be tailored to align with the prevailing clinical landscape [10]. This includes the removal of outdated and irrelevant experimental courses, as well as the incorporation of experiments that are directly linked to contemporary clinical research. These proposed actions aim to enhance the teaching of biochemistry experiments and foster students' innovative capabilities, thereby facilitating the integration of innovative experiments into biochemistry teaching and the development of students' innovative skills.

3.4. Enhance the quality of instruction provided by teachers and further develop their pedagogical abilities

To effectively teach biochemical experimental courses, educators should tailor the duration and content of experiments to align with the course material and objectives. For instance, basic biochemistry experiments, such as serum protein electrophoresis and nucleic acid component identification, are straightforward and lend themselves well to student-led experimental planning and execution. For the dynamic experiment, the content of the metabolic portion is inherently complex, thus necessitating the implementation of demonstration experiments. To facilitate student understanding and mastery of experimental principles and methods, teachers are advised to provide advanced prompts or utilize virtual laboratories for conducting virtual experiments. It is imperative for teachers to promptly enhance their teaching methodologies, tailor their approach accordingly, and refrain from solely imparting theoretical knowledge to students. During experimental teaching, educators are advised to adopt an encouraging approach to enhance students' learning enthusiasm. It is recommended that students integrate their professional and biochemical knowledge, form groups, autonomously select topics, and systematically devise experimental plans. Subsequently, they should refine the plan, and compile it before presenting the experimental findings in a report with the guidance of teachers and peers [11]. Therefore, students must gain hands-on experience in scientific research training. The teacher plays a crucial role in fostering students' research skills in the biochemistry experiment course by enhancing their innovation capabilities and integrating innovative experiments into the curriculum, thereby improving the overall teaching methodology of the biochemistry course.

3.5. Design of innovative biochemical experiments

In the context of biochemistry experiment instruction, educators must conduct innovative experiments aligned with course objectives and tailored to student's learning characteristics to enhance students' experimental proficiency and literacy, as well as foster comprehensive development of their innovative thinking abilities. To optimize the efficacy of experimental procedures, educators should afford students a degree of autonomy by allowing them to actively engage in the development and execution of experimental protocols. In the realm of pedagogy, educators have the opportunity to enhance the practice of validation experiments by incorporating open, design, comprehensive, and inquiry experiments. This shift in teaching methodology encourages active student engagement in experiment design and implementation, and meticulous examination of experimental objectives, principles, procedures, and outcomes. By fostering collaborative thinking, inquiry, discussion, and reflection, this approach effectively cultivates students' capacity for innovation [12].

3.6. Cultivate students' experimental level and innovation ability

Historically, the traditional teaching approach involved teachers delivering lectures, demonstrating concepts, and students passively absorbing information. This method has proven ineffective in engaging students'

enthusiasm and fostering their creative thinking skills. Furthermore, the limited number of class hours dedicated to experimental activities has resulted in students having insufficient practice opportunities, ultimately hindering their proficiency in experimental operations. To optimize the efficiency of experimental teaching within the constraints of limited time, educators may strategically allocate time based on the specific experimental project, thereby enabling students to acquire a greater breadth of knowledge in the allotted timeframe and enhance time utilization [13]. In addition, instructors can leverage online resources, such as virtual experiment courses on the Internet, and capitalize on multimedia teaching techniques to engage students and foster a deeper interest in the subject matter. In the establishment of a virtual experiment class, educators should provide comprehensive explanations regarding the utilization of the necessary instruments in addition to outlining the principles and procedures of the experiment. Students are encouraged to familiarize themselves with the operation and precautions associated with the instruments while studying the experiment materials, enabling them to acquire and proficiently apply the fundamental knowledge and skills essential for the experiment class. Upon completion of the virtual experiment course, supplementary topics and background information should be provided to stimulate critical thinking, encourage extensive reading, and expand students' intellectual horizons. For instance, students may be presented with a set of questions to prompt the development of their experimental concepts and engagement in experimental course competitions [14]. By incorporating innovative experiments into the instruction of biochemistry, students are allowed to autonomously devise and refine experimental protocols, as well as investigate the execution of experimental procedures. This approach effectively fosters creative thinking and reinforces cognitive skills among students. The implementation of experimental classes has been shown to effectively stimulate students' biochemistry thinking, enhance their initiative, enthusiasm, and participation, and ultimately improve their ability to apply knowledge. In addition, this approach can facilitate the reform of biochemistry experiment teaching, fostering students' experimental proficiency and innovation capabilities.

4. Epilogue

Currently, there is limited data available regarding the reform of biochemistry experiment teaching [15]. Future research will comprehensively evaluate the current state of innovation education and biochemistry experiment teaching research both domestically and internationally. This will involve conducting field investigations and utilizing various online resources such as QQ groups, WeChat groups, Tencent conferences, and academic websites to collect and analyze data. Through iterative arguments, analysis, and summarization, reform experiences will be drawn upon to fully leverage the crucial role of innovative experiments in enhancing the effectiveness of biochemistry experiment teaching. Ultimately, the goal is to promote the reform of biochemistry teaching and enhance students' innovation skills.

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