

Exploration and Practice of Enhancing Students' Independent Learning and Innovation Ability in Biochemistry Based on the "Innovation and Entrepreneurship Competition"

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Abstract. Biochemistry plays a crucial role in cultivating hands-on practice and scientific research literacy among students majoring in bioengineering. In order to cultivate students' innovative and practical abilities, as well as the ability to analyze and solve problems, and to change the drawbacks of traditional teaching, we fully leverage the role of science education integration in biochemistry teaching. We rely on the science education integration teaching team to optimize the design of the curriculum teaching system, incorporate competitions into biochemistry teaching, stimulate students' learning interest, and cultivate their independent learning and innovation abilities.

Keywords: Innovation and entrepreneurship competition, biochemistry, reform in education, ability development.

1. Introduction

The theoretical development of biochemistry is closely related to research activities, and the quality of biochemistry education is also closely related to the research literacy of teachers. Actively integrating research activities into teaching is one of the important ways to further improve the effectiveness of biochemistry education.

Science and technology competitions, starting with the basic knowledge of subject specialties, combine new problems, new technologies, and new applications, and focus on examining students' innovative consciousness and practical abilities. They are an effective way and important carrier to enhance college students' innovation spirit, creativity, and engineering practical abilities. In recent years, with the support of government policies, corporate sponsorship, and university implementation and promotion, a mature competition platform system has been formed in China, such as the "Internet+" College Student Innovation and Entrepreneurship Competition, the "Challenge Cup" National College Student Entrepreneurship Program Competition, and the "Challenge Cup" National College Students' Extracurricular Academic and Scientific Works Competition. Meanwhile, each province is also promoting various provincial-level science and technology competitions for college students based on their own situations, such as the Shandong Province College Students' Biochemical Skills and Innovation Entrepreneurship Competition, Shandong Province College Students' Science and Technology Innovation Competition, etc.

2. Exploration and Practice of Enhancing Students' Independent Learning and Innovation Ability in Biochemistry

As a course closely related to theory and practice, biochemistry is a fundamental course for engineering schools specializing in bioengineering, biotechnology, brewing engineering, food science and engineering, and provides theoretical and technical foundations for students in these majors to participate in innovation and entrepreneurship competitions. The combination of biochemistry course content with science and technology competitions is an important way to bring

theoretical knowledge into practical application. Combining science and technology competitions with theoretical teaching can greatly avoid the boredom of traditional teaching, increase students' learning interest, enhance their ability for self-directed learning, and cultivate their innovative thinking and creativity.

Biochemistry is the main basic subject of biological engineering majors, with complex and abstract characteristics, knowledge points covering multiple fields, and a variety of obscure professional vocabulary, which is a high challenge for both teaching and learning. Static biochemistry introduces the structure, properties and functions of biomolecules; molecular structure, molecular recognition and molecular interactions are the basic elements to perform the functions of biological information molecules, and the research in this field is one of the hot spots in biochemistry. The dynamic biochemical part mainly depicts substance metabolism, energy metabolism and regulatory control. Bioengineering is an applied discipline whose main purpose is to obtain products. It is the study of how to use various organisms to maximize the production of products required by humans. The regulation and control of biological metabolism is an important theoretical basis for improving the quality and yield of products, and it is the basic guarantee for elucidating fermentation mechanisms, selecting process pathways, improving product quality, exploring new processes and developing new products, etc [1]. Theoretical breakthroughs in biochemistry have been accompanied by significant advances in life sciences and medicine. Half of the Nobel Prizes in physiology or medicine awarded in the last 50 years are related to biochemistry [2], which shows that biochemistry is a continuous breakthrough, cutting-edge crossover of life sciences. Biochemistry is also a fundamental discipline based on experiments and guided by practice; therefore, it is a basic need for biochemistry teaching to cultivate a solid and systematic knowledge system for bioengineering students and to have the ability to identify and solve scientific problems with the level of thinking and the ability to integrate with production practice.

Currently, the teaching of biochemistry needs to focus on addressing the following three points: First, the knowledge points of biochemistry are complex, abstract, and difficult to remember, and students often spend a lot of energy and time memorizing key knowledge points, while teachers lack guidance on the corresponding learning methods for these knowledge points. Second, the teaching content is not updated in a timely manner: the development of biochemistry discipline content is rapidly changing, and due to the time lag in writing and publishing textbooks, there is a certain degree of obsolescence, which requires teachers to read the latest literature in a timely manner to update their own teaching content [3]. However, some teachers rely too much on textbooks, their knowledge concepts are outdated, and they lack enthusiasm for combining their own research advantages with teaching resources. Third, students have insufficient understanding of the application of knowledge points, especially the application of biochemistry in production practice and scientific research activities, which leads to a separation of basic knowledge and its application, and is not conducive to forming a systematic knowledge framework.

Based on the characteristics of the biochemistry course and the current reform requirements of higher education teaching, we plan to focus on the following aspects in the teaching process of biochemistry:

First of all, establish a biochemistry interdisciplinary teaching team. The team consists of teachers with reasonable knowledge structure and research directions. There are teachers who undertake national research projects in different research directions, teachers who convert scientific research resources into teaching resources and have achieved remarkable results, and teachers who have been deeply involved in curriculum research and teaching methods and have achieved multiple results. This ensures that the course content is closely linked to scientific development, constantly researching specific teaching methods, keeping pace with the times, and having a distinct interdisciplinary teaching characteristic. Taking the School of Biological Engineering of Qilu University of Technology as an example, we have established the "Bio-synthetic High Polymer Polymers-Biochemistry Interdisciplinary Teaching Team" and received funding from the Excellent Teaching Team Construction Project of Qilu University of Technology (Shandong Academy of Sciences).

Biochemistry is an important professional basic course in the field of life sciences, but due to its many knowledge points, strong theoretical nature, and fast updating of knowledge points and related technologies, the combination of scientific research and teaching has great practical significance for breaking the framework of traditional teaching and carrying out effective teaching reforms. The research direction of the bio-synthetic high polymer polymer team mainly includes: (1) research on the efficient synthesis of 10-HDA and related medium-chain active fatty acids in microbial cell factories; (2) research on the microbial synthesis of functional sugars, rare sugars such as glucosamine, trehalose, and sodium gluconate; (3) research on the modification of polyol-producing strains, pathway optimization, process optimization, and application; (4) research on the microbial synthesis of human essential amino acids represented by L-lysine; (5) exploration, analysis, and utilization of functional brewing microorganisms and products in liquor production; (6) research on biological detection, early cancer diagnosis, and artificial photosynthesis using microfluidic chips. The team's scientific research not only provides rich cases for different chapters of biochemistry but also helps students understand the research frontier issues of related chapters, and encourages students to participate in the teacher's scientific research practice in the classroom teaching process. Encourage students to participate in the application for innovation and entrepreneurship training program projects for college students at all levels in a "project-based" manner, guide students to form their own teams, write project proposals, design experiments, write papers, and complete projects. For example, teacher Su Jing, a member of the teaching team, has long been engaged in the research of enzyme structure and function, and has completed the heterologous expression and purification, protein crystallization and structure analysis of various enzymes such as *Thermoplasma Acidophilum* amido peptidase, *Pseudomonas* sp. nitrophenol reductase, firefly luciferase, *Bacillus subtilis* single oxygenase BdsA, and *Thermobaculum terrenum* trehalose synthase. The related research work can be used as teaching material in the process of carrying out biochemistry teaching, and can vividly explain the relationship between protein primary and advanced structures, and the catalytic properties of enzymes in theoretical terms.

In recent years, the teaching team of biochemistry has guided students to obtain 5 innovation and entrepreneurship training program projects at various levels, and nearly 30 students have participated in team formation and collaborative research, which has driven the learning atmosphere of the class and cultivated students' innovative thinking. In addition, nearly 20 students participated in various competitions at all levels and achieved excellent results, promoting the cultivation of students' independent learning ability.

Secondly, fully tapping into the school's relevant policies, funding, and management systems for the use and guarantee of teaching resources, to increase the enthusiasm of the teaching team to transform scientific research advantages into teaching resources. Taking Qilu Industrial University (Shandong Academy of Sciences) as an example, we have sorted out the relevant documents related to the "Innovation and Entrepreneurship Competition" of the university. Documents such as Qilu Industrial University (Shandong Academy of Sciences) Letter No. 62 [2021] "Promotion and Evaluation Conditions (Trial Implementation) for Professional and Technical Positions during the 2022-2025 Employment Period", and Qilu Industrial University (Shandong Academy of Sciences) Letter No. 77 [2021] "Promotion and Evaluation Program for Professional and Technical and Skilled Workers during the 2022-2025 Employment Period" clearly stipulate that teachers who guide students to participate in the China "Internet+" University Student Innovation and Entrepreneurship Competition or the "Challenge Cup" National University Extracurricular Academic Science and Technology Works Competition, or the "Challenge Cup" China University Students' Entrepreneurship Plan Competition, and win a provincial first prize (gold award) or above, can be used as one of the elements to meet the requirements for promotion and evaluation of job tasks during the employment period. Qilu Industrial University (Shandong Academy of Sciences) Letter No. 74 [2021] "High-Quality Teaching Academic Achievement Performance Reward and Recognition Management Measures (Trial Implementation)" recognizes that teachers who guide students to participate in subject competitions organized by the national education administration department,

and win A-level awards, are entitled to corresponding performance rewards. Qilu Industrial University (Shandong Academy of Sciences) Party Letter No. 71 [2022] "Performance Appraisal Method for Counselors" stipulates that projects guided by counselors that have won provincial and above competition awards can be quantified for additional points. Qilu Industrial University Teaching Letter No. 8 [2018] "Provisional Measures for Substituting Science and Technology Innovation Achievements for Graduation Design (Thesis)" stipulates that if a student represents the school to participate in national or provincial university subject competitions, and their work wins a national third prize or above (inclusive), or a provincial second prize or above, they can apply for substitution. Qilu Industrial University (Shandong Academy of Sciences) Letter No. 39 [2022] "Implementation Measures for the 'Second Transcript' System (Trial Implementation)" includes a compulsory module on scientific and technological innovation, which includes academic science and technology and innovation and entrepreneurship competitions, and different credits are given based on the level of the award. The "Interim Measures for the Management of University Student Subject Competitions of Qilu Industrial University" stipulate the subject competition funds required for materials, competition fees, registration fees, conference fees, and travel expenses for teachers and students during the competition period.

Thirdly, reform experimental teaching and cultivate students' innovation ability. To cultivate students' basic experimental skills, comprehensive experimental skills, and research innovation ability, the experimental content is divided into three levels: First, basic experiments mainly train students' basic biochemical experimental techniques and methods. Second, comprehensive experiments cultivate and train students' ability to analyze and solve problems comprehensively. Third, research and innovation experiments explore students' potential for scientific and technological innovation. Students form research groups and voluntarily apply for "open experiments", "college student research projects", "college student innovation and entrepreneurship training projects", etc. All biochemical research laboratories and teaching laboratories are open to students. Students choose their own topics, design their own experimental plans, and independently carry out project research. Through the development of research and innovation experiments, students' independent exploration spirit and practical ability have significantly improved, and a group of outstanding students with potential for cultivation have emerged.

Fourthly, a virtuous cycle of "knowledge reconstruction - interest stimulation - science and technology competition" is formed. The teaching team utilizes the research results of disciplinary features to serve undergraduate teaching in the process of teaching reform. Teachers reconstruct knowledge based on their own research examples to make it more easily accepted by students, greatly increasing their interest in learning. As a result, students actively participate in teachers' scientific research practice, and the achievements of science and technology competitions further enhance students' interest in learning biochemistry, forming a virtuous cycle. Based on the characteristics of the construction of the biochemistry course, in recent years, the integration teaching team of biochemistry at Qilu University of Technology has guided undergraduate students to participate in innovation and entrepreneurship competitions such as the "Challenge Cup" and "Internet +," achieving excellent results.

3. Summary

The "Innovation and Entrepreneurship Competition" is an effective means to enhance students' independent learning and innovation in biochemistry.

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3. Research on the design and teaching methods of biochemistry teaching based on the OBE concept (2020zd18), an undergraduate teaching reform project of Shandong Province.

4. Reform research and practice on the construction and management of the biochemistry virtual teaching and research laboratory (Z202205), a bidding (major) teaching reform research project at Qilu Industrial University (Shandong Academy of Sciences).

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