International Journal of Education and Social Development
ISSN: 3078-9931 (Print), ISSN: 3078-2287 (Online) | Vol. 5, No. 2, 2025

Reform and Reflection on Biochemistry Experiment Teaching with Virtual-Real Collaboration

Kaihua Guo, Xiangling Wang

Department of Biological and food Engineering, Lyuliang University, 033000, China

Abstract: Biochemistry is a compulsory course for bioscience majors. In teaching practice, special emphasis must be placed on integrating theory with practice, aiming to enable students to systematically master the basic knowledge, principles, and methods of biochemistry, understand various biochemical experimental techniques and their basic applications in different fields, and develop students' professional skills. However, due to insufficient funding at our university, the allocation of experimental equipment is inadequate. Some experimental instruments are expensive and sophisticated, making it impossible to meet the needs of many students for simultaneous operation. This has restricted the implementation of biochemical experimental teaching. With the development of information technology, experimental teaching activities can no longer be limited to traditional physical experiments; the reform of the virtual-real collaborative hybrid experimental teaching model is imperative.

Keywords: Virtual-Real Collaboration, Biochemistry, Teaching Reform.

1. Introduction

Biochemistry, as a basic theoretical course for bioscience majors in colleges and universities, is a fundamental and leading discipline in life sciences, serving as a key and hub course in this field. Studying this course is of great significance for cultivating creative and high-quality talents [1]. The integration and mutual supplementation of theory and practice are reflected in the smooth implementation of biochemical experiments. Biochemical experiments lay the foundation for students to study subsequent courses, conduct graduation thesis research, and engage in scientific research. Meanwhile, they are important means to enhance students' hands-on learning abilities and cultivate their rigorous scientific attitude and experimental skills. The traditional experimental teaching model adopts a pattern of "teachers lecture, students listen, and follow the textbook to operate," allowing students to gain intuitive practical experience and thus understand and master relevant theoretical knowledge. However, in this process, teachers hold outdated teaching concepts, students lack independent thinking, and there is insufficient innovation. Additionally, constrained by factors such as time and space limitations, equipment investment, experimental materials, and drug safety, physical experiments are difficult to promote and apply on a large scale in all teaching scenarios [2]. In recent years, the rapid development of virtual simulation technology and related platforms has provided new possibilities for experimental teaching. For example, the NOBOOK virtual laboratory software constructs an experimental environment to simulate real experimental processes, enabling experimenters to perform experimental operations interactively and break through the limitations of traditional experimental teaching. Nevertheless, virtual experiments are always a beneficial supplement to physical experiments and cannot completely replace them. Therefore, empowering traditional biochemical experimental teaching with virtual simulation technology and promoting the collaboration between virtual and physical experiments have become a new direction for the reform of experimental teaching models in colleges and universities [3].

2. Advantages of Virtual Simulation Experiments

The advent of the "Internet +" era has not only changed the way knowledge is acquired but also shaped students' new learning methods and concepts. Virtual simulation experiments organically integrate teaching content, virtual equipment, and experimental objects to create a simulated environment. With computers and networks as carriers, they assist in various links of traditional physical experimental operations, free from the constraints of venue, class hours, and experimental conditions, and thus possess unique characteristics and advantages [4].

2.1. Safety with No Hidden Risks

Toxic, harmful, flammable, and explosive reagents are often used in biochemical experiments. Due to the control of potential safety hazards in laboratories, some reagents are difficult to purchase, making it impossible to complete physical experiments. The application of virtual simulation platforms avoids risks such as toxic reagents, radioactive substances, and flammable reactions in biochemical experiments, allowing students to master experimental principles without safety accidents caused by operational errors.

2.2. Reduced Consumption of Supplies

Due to limited funding in some colleges and universities, the allocation of experimental supplies is often insufficient and incomplete, failing to meet the needs of each student for physical experimental operations. Virtual simulation experiments, however, can make up for this deficiency—they do not require repeated consumption of expensive reagents, scarce biological samples, or precision supplies, thereby significantly reducing teaching costs.

2.3. Breaking Experimental Limitations

Some experiments involve toxic and harmful chemical reagents, while others are time-consuming and often require continuous operation for several days. Some experiments even pose safety risks such as explosions. Virtual simulation experiments can simulate experiments with long duration, difficult-to-control reactions, etc., making up for the shortcomings of physical experiments.

2.4. Enhanced Learning Interest

Through 3D animations that visualize biochemical reaction mechanisms and molecular structure changes, abstract theories are transformed into intuitive scenarios. This attracts students' attention, improves their learning enthusiasm, and enhances learning efficiency.

2.5. Support for Repeated Trial and Error

In physical experiments, due to constraints such as time and supplies, students often cannot repeat experiments multiple times. In contrast, virtual simulation experiments allow free adjustment of experimental parameters and re-attempts of incorrect steps, helping students deeply understand the impact of variables on experimental results and cultivate their scientific research thinking.

3. Disadvantages of Virtual Simulation Experiments

As a product of the "Internet +" era, virtual simulation experiments can make up for the shortcomings of physical experiments, but they also have many disadvantages [4,5].When using virtual simulation software, students cannot perceive the weight, tactile sensation, or operational resistance of experimental equipment (e.g., the feel of pouring reagents or adding drops of reagents).It is difficult for software platforms to simulate the real consequences of equipment failures or operational errors (such as instrument short circuits and reagent contamination), resulting in a lack of emergency response drills. Virtual experiments lack the sensory experiences present in physical experiments, such as odors (e.g., the smell of chemical reagents), sounds (e.g., the operation sound of instruments), and visual cues (e.g., subtle changes in precipitates).

The construction of virtual simulation software platforms generally requires high-performance computers and dedicated peripheral devices (e.g., VR equipment). Low-configured devices are prone to lagging and distorted images, increasing usage costs.

Virtual simulation focuses on process memory rather than proficiency in hands-on operations. Long-term reliance on software platforms may weaken students' practical skills such as hand-eye coordination and precise operation.

4. Characteristics of the Virtual-Real Collaborative Teaching Model

4.1. Balancing Safety and Efficiency in the Reform of Biochemical Experimental

Teaching ModelVirtual preview avoids risks in high-hazard and high-consumption scenarios, while physical operation focuses on core skills—this significantly reduces the rate of experimental accidents and the cost of supplies.

4.2. Dual Improvement of Cognition and Skills

Virtual visualization supplements students' understanding of microscopic mechanisms and complex processes, while physical operation strengthens tactile and sensory experiences as well as precise operation abilities, forming a complete knowledge chain.

4.3. Strong Personalization and Expandability

The virtual environment supports repeated practice and variable expansion, adapting to different learning progress. Physical experiments verify the rigor of data and can also extend the boundaries of exploration.

4.4. Closed-Loop Teaching Effect

The process of "virtual preview → physical operation → virtual review" helps accurately identify errors, solidify optimal solutions, and improve the pertinence of teaching and the conversion rate of teaching achievements.

5. Teaching Design Ideas for the Virtual-Real Collaborative Teaching Model

Both virtual simulation experiments and physical experiments have their own advantages and disadvantages. Taking the experimental teaching of the Biochemistry course as the research object, we reflect on and reform the biochemical experimental teaching model. Relying on a variety of online learning tools, we analyze the teaching model of the virtual learning platform for Biochemistry, sort out the materials included in the virtual simulation experimental teaching content of this course, establish a virtual simulation experimental teaching platform, guide students to carry out various innovative activities, analyze complex experimental verification issues, and cultivate professional talents who meet the requirements of the information age [6-8].

5.1. Teachers' Activities

Before Class: According to the syllabus requirements and combined with the characteristics of the experiment, teachers select the experiments to be conducted in advance and assign preview tasks to students. In Class: Teachers guide students to enter a scientific research mindset, stimulate their enthusiasm, and encourage them to think independently, laying the groundwork for the development of scientific inquiry. During the practice process, teachers observe students' performance while providing methodological guidance. They listen to students' discussions, work with students to identify problems in the experiment, explore solutions, and guide each student to actively participate in the group's experimental activities. After the Experiment: Teachers organize students to summarize the experimental process in a timely manner, reflect on the problems encountered, and repeat the experiment if necessary until the optimal results are achieved. They also assign after-class assignments, requiring students to review the experiment using virtual simulation and write an experimental report.

5.2. Students' Activities

Students preview the experimental content by operating the virtual simulation experimental platform. In class, they carefully listen to the teacher's explanations of relevant principles and operation methods. During the experiment, they refer to the content on the virtual simulation experimental platform, and group members cooperate to complete the experiment in accordance with the operational procedures, applying the methods learned from the virtual platform to practical operations. Any incorrect operations can be corrected in a timely manner—i.e., virtual and physical methods collaborate to complete the experiment and the learning tasks assigned by the teacher, making up for any deficiencies. After the experiment, students independently review the experimental operations and reflect on and evaluate their own and their group members' experimental processes. After class, they use the virtual simulation experimental platform to review the content of the experiment.

6. Conclusion

The virtual-real collaborative biochemical experimental teaching model enables students to master physical experiments that are difficult to implement in laboratories and enhances students' enthusiasm. While cultivating professional talents who meet the requirements of the information age, it also innovates the experimental teaching model and realizes the integration of "Internet +" with traditional teaching. However, virtual simulation cannot replace physical experiments. If completely separated from physical experiments, students' hands-on operation abilities will be weakened, and the cultivation of their rigorous scientific research attitude and scientific spirit will also be greatly compromised. Therefore, we should give full play to the advantages of both experimental methods; only through virtual-real collaboration can we achieve complementary advantages and jointly accomplish the teaching goals.

Acknowledgment

This work was supported by the Teaching Reform and Innovation Project of Institutions of Higher Learning in Shanxi Province (J20241421) (J20241409).

References

[1] Liu Ping, Gong Zhu Nan. A Comment on the Teaching Reform of Biochemistry Experiment Course. Education and Teaching Forum [J], 2018 (44), 232-233.

[2] Liu Chuan Ning. Research on the Application of NOBOOK Virtual Simulation Software in High School Physics Experimental Teaching. Master's Thesis [D], Huanggang Normal University.

[3] Wang Ya Juan, Yang Quan Zhong. Discussion on the Application of Experimental Teaching Design Based on VR Technology in Biochemistry Experimental Teaching [J]. Henan Medical Research, 2019, 28(5), 863-865.

[4] He Mou Hai, et al. Reform and Exploration of the Hybrid Biochemistry Experimental Teaching Model Combining Virtual and Real [J]. Journal of Green Science and Technology, 2020, (19), 203-205.

[5] Xu Zhao Wei, et al. Application and Exploration of Virtual Simulation in Biochemistry Experimental Teaching [J]. Scientific Research and Education, 2023, (28), 26-28.

[6] Zhang Ya Qin, et al. Application and Discussion of Virtual Simulation in Biochemistry Experimental Teaching [J]. Basic Medical Education, 2024, 26(1), 70-75.

[7] Lai Xiao Hui. Discussion on the Hybrid Teaching Model of Biochemistry Experiments [J]. Biological Chemical Engineering. 2024, 10(1), 148-151.

[8] Wang Ya Juan, et al. Practice and Reflection on the Virtual-Real Combined Experimental Teaching of Medical Biochemistry [J]. China Higher Medical Education, 2022, (5), 56-57.