Application of Pathogenic Biology Virtual Laboratory in Experimental Teaching of Medical Microbiology

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Abstract. Medical microbiology experiment is an indispensable course for medical colleges and universities, and is also special course involving laboratory biosafety. In order to avoid the possible harm to the students and pollution to the environment caused by pathogenic microorganisms during the experiment, our school built a virtual simulation laboratory of pathogenic biology to assist the traditional experimental teaching. Through experimental exams and questionnaire survey of the students, it is shown that the virtual experiments could complement and assist traditional experiments, and it helps to the pre-study and after-school review of the students. For some experiments involving biosafety risks, students can obtain training through virtual experiments. Through the operation training of virtual experiments, students can be inspired to think and improve their ability of self-learning. Using virtual simulation lab to assist traditional experimental class can significantly improve the quality of experimental teaching, and has a good application value.

Introduction

With the rapid development of information science and technology, virtual reality technology has been applied in various fields \cite{1-2}. In the field of higher education, virtual reality technology has gradually become an effective teaching medium, which has revolutionized the teaching model \cite{3-6}. Virtual experiment is the use of computer and simulation software to simulate the experimental operating environment and process. Virtual experiments can replace some real experiments with high cost and high risk. Experiments carried out by the internet can achieve repeated previewing and reviewing of experimental operations, and can also be used for the students’ experimental exams.

The pathogenic microbiology experiment is a special subject involving biosafety risks. In order to prevent possible harm to students caused by pathogenic microorganisms during the experiment, the relevant state departments have formulated biosafety regulations for pathogenic microorganisms. However, in large-scale experimental teaching, due to lab conditions, some experiments involving safety hazards are difficult to open in the lab. Therefore, the construction of virtual lab of pathogenic microbiology has important application value for experimental teaching of pathogenic microbiology.

In order to meet the experimental teaching needs of our school, the Basic Medical Experimental Teaching Center built a virtual simulation lab of pathogenic biology in 2016 by the Pathogen Biology and Immunology Laboratory and Shanghai Mengzhilu Digital Technology Co., Ltd. And apply it to the experimental teaching. This paper evaluates and summarizes the application effects of pathogenic microbiology virtual simulation lab.
Composition and Characteristics of the Virtual Simulation Lab

The pathogen biology virtual simulation lab consists of four sections: basic microbiology, parasitological, clinical microbiology virtual simulation experiments, and knowledge assessment, as well as two fun virtual tests in the observation of bacterial morphology by Gram staining and the separation and identification of intestinal pathogens. Each virtual simulation experiment has six parts: experimental purpose, experimental principle, supplementary knowledge, experimental video, experimental animation, and operation training. Each experiment is mainly composed of two areas: the experimental material area and the experimental operation area. At the same time, there are operational tips for the experimental key points, and the learner operates by manual selection. After the experimental exercise, the corresponding knowledge assessment part is set.

The software uses pictures, animations, videos and other forms to introduce the experimental techniques, instruments, drugs, etc. The entire virtual experiment system is structurally complete and rich in content, providing scientific guidance for students to understand and master experiments. Learners can understand the purpose and principle of the experiment through virtual simulation experiments, to learn and review the experimental operation techniques. The fun virtual experiment is created by using Photoshop, Flash and network technology, and setting the corresponding experimental operation scenarios. According to the importance of the operating skills that students need to master in the experiment, set the background automatic scoring and feedback.

The virtual simulation lab enters by means of client login. Students can login through campus or external network, even by mobile phone, regardless of time and space.

Evaluation of Virtual Simulation Lab in Experimental Teaching

Evaluation Object

According to the school's major training program, the grade of 2016 pediatrics and 2016 anesthesia undergraduate students have the same medical syllabus. Thus, two classes were randomly selected from 2016 pediatrics major and set as parallel experimental groups, and two classes were randomly selected from 2016 anesthesia major and set as parallel control groups. The number of students in each class was 36. There was no significant difference in the proportion of boys and girls in the 4 classes, the age composition and the average experimental score before the study, so the basic information of the students was comparable.

Evaluation Method

Comparative studies were conducted between the above selected experimental group and control group. The control group used the traditional teaching method to carry out experimental teaching; the experimental group used the virtual lab to assist the traditional teaching method to carry out experimental teaching.

Traditional experimental teaching methods: using board books combined with multimedia for teaching. First, the teacher systematically explains the purpose, principle, materials, methods, results and precautions of the experiment, and writes the main flow and precautions of the experimental operation, also uses multimedia to display the pictures or video materials related to the experiment. Secondly, the teacher demonstrates the experimental operation, and then allows the students to operate on their own. During the student's operation, the teacher conducts a patrol to correct the wrong or irregular operation. Finally, summarize the class.

The virtual lab assists the traditional experimental teaching method: the teacher asks the students to visit the virtual lab and conduct pre-class study before each experimental class. Each student can flexibly arrange their time, log on to the virtual lab platform and preliminary understand the experimental content. Students can also learn in advance the structure and use of some related instruments and reagents. According to the virtual lab login record, the teacher urges the students to prepare for the pre-test class. On the basis of pre-study, in the experimental class, the teacher does not
need to introduce the experimental content and experimental steps in detail, only need to guide the experiment, and reserve more time for the students to do hands-on operation. During the experiment, each student first log in to the virtual lab to learn, and then carry out the actual experiment operation. At last, the teacher summarizes.

**Evaluation Contents**

The experimental teaching effect was evaluated through two parts: the students' experimental exams and anonymous questionnaire survey on students' experience after using the virtual lab.

The experimental exams consist of two parts: the end-of-class experimental test and the actual operation test. The full score is 100 points, 2 parts each account for 50% of the total score, 60 points pass. The contents of the experimental exam include: identification of pathogenic microorganisms, identification of bacterial cultures, and determination of bacterial biochemical reactions. The actual operation content includes bacterial smear Gram staining observation and simulating tuberculosis patients smear for acid-fast bacilli. The final scores of the experimental group and the control group were statistically analyzed using Graphpad Prism 6.0 software, and P < 0.05 indicated that the results were significantly different.

The anonymous questionnaire survey evaluates the experience of the experimental group students using virtual lab learning. The contents of the questionnaire survey include: the evaluation of the pre-study effect of the virtual lab; the auxiliary effect of the virtual experiment on the actual operation; the degree of support for virtual lab is used to assist the traditional experiment. Results of the survey were analyzed using Graphpad Prism 6.0 software.

**Results**

**Virtual Lab Benefits Pre-Class Study**

72 students in experimental group used the virtual lab to conduct pre-study preparations. The results of the questionnaire survey were divided into three levels: very good, good, and no effect. The results show that 61 people think that the use of the virtual lab preview is very good, accounting for 85%, 8 people think the effect is good, accounting for 11%, and 3 people think that there is no obvious effect, accounting for 4% (Fig. 1). It indicates that preliminarily study of the experimental principle, content and steps in the virtual lab is more conducive to the understanding and mastery of the experiment in the experimental class.

**Virtual Lab Assists in the Actual Experimental Operation**

On the basis of the students' pre-study, during the experiment operation, each student first log in to the virtual lab simulation platform to learn, and then actually conduct the experiment. They can compare the results of the virtual experiment with the actual experimental results, which inspire students to find the reasons for the mistakes in the experimental results and improve the efficiency and success rate of the students' actual experimental operations. The questionnaire surveys on virtual lab assists in the actual operation show that 36% of students believe that the virtual experimental platform is very helpful for the actual experimental operation, 61% of the students think it is somewhat helpful, and 3% of the students think it is unhelpful (Fig. 2). The results indicate that the virtual lab can better complement and assist actual experiment and achieve better teaching results.

![Figure 1. Virtual lab pre-study effect.](image1.png)

![Figure 2. Virtual lab assists in actual operation.](image2.png)
Analysis of Experimental Exams

The relevant knowledge test and actual operation test scores of the experimental group and the control group were respectively summarized, each part accounted for 50% of the total score, and the final experimental course score was calculated. For average experimental scores, the score of the control group was 80, and the score of the experimental group was 91. The experimental group's average score was significantly higher than the control group, with significant difference, $P=0.0389$, $<0.05$ (Fig. 3). This result indicates that the experimental group students mastered the relevant knowledge and operational skills better than the control group students after using the virtual lab.

For the distribution of scores, 12.5% of students with a score of 100-95 in the control group, 20.8% of students between 95-85, and 33.3% of students between 85-75, students with 75-60 points accounted for 25%, students with 60 points or less accounted for 8.3%, and the scores were normally distributed. Students in the experimental group with a score of 100-95 were 12.5%, students between 95-85 were 54%, students between 85-75 were 20.8%, between 75-60 students accounted for 8.3%, students below 60 scored 4.2%, also with a normal distribution (Fig. 4). This result indicated that after the experimental group students used the virtual lab to assist the learning, the overall experimental scores were significantly improved. Compared with the control group, the proportion of students with high scores in the high partitions increased significantly.

Support Surveys for Virtual Lab to Assist Experimental Teaching

According to the students' experiences, the questionnaire surveyed whether the students supported the virtual lab for experimental teaching. The results of the questionnaire survey of the experimental group students showed that 50% of the students were very supportive, 41% of the students supported, and 9% of the students said no support (Fig. 5). Explain that most students are extremely interested in using this virtual lab to assist in experimental learning. However, the virtual lab was first established, and some functions and experiences need to be further improved.

Summary

In medical experiment teaching, virtual experiments are mainly used for experiments that students must master but experimental conditions difficult to achieve. Since the outbreak of SARS in 2003, in order to protect the safety of experimental personnel and the public, the State Council of the People's Republic of China (No.424) promulgated the “Regulations on Biosafety Management of Pathogenic Microorganisms Laboratory” on November 12, 2004. The regulations stipulate that microbiological
operations involving biosafety above level II should be performed in the appropriate biosafety lab. Our school is a teaching and research university with thousands of students per semester. Therefore, it is very difficult for experimental teaching to achieve Level II biosafety. In fact, most medical college student labs only meet the requirements of Level I biosafety, and the teaching preparation room reaches Level II biosafety level [8]. Even if students conduct experiments in a Level II biosafety lab, since large numbers of students conduct experiments, it is difficult to achieve the biosafety lab's operational specifications, and the teachers are also responsible for the risks of student safety. Therefore, constructing a virtual simulation lab for pathogenic biology experiments is one of the effective ways to solve the above teaching problems [9].

The virtual simulation lab for pathogenic biology constructed by our school contains all the experiments required by the medical pathogen biology. The corresponding teaching experiments will not be limited due to the shortage of equipment or experimental sites, which greatly eases the hardware pressure of the school. Some experiments that need to be carried out in the II and III biosafety labs, in the virtual experimental environment, students can directly participate, thus acquiring perceptual cognition [10] and greatly improving the students' experimental operation ability.

In this study, undergraduate students of two majors (anesthesia and pediatrics) with the same medical syllabus were selected, and traditional experimental teaching and virtual lab assisting traditional experimental teaching were relatively used. The experimental exam showed that not only the average score, but also the interval of score distribution, the experimental group using the virtual lab to assist the traditional experimental teaching was significantly higher than the control group only using the traditional lab teaching. And the questionnaire of experimental group students used the virtual lab reflecting that most of the students showed a strong interest in learning. It shows that the virtual simulation lab can further improve the efficiency and quality of experimental teaching and has a good application value.

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References
