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Design and Implementation of "SHU-AP" system for Biomedical Engineering Course "Anatomy and physiology" in COVID-19

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***Abstract*—Online courses played important roles in biomedical engineering (BME) teaching during the COVID-19 epidemic. However, existing virtual experiment systems are not suitable for BME course "anatomy and Physiology". Therefore we developed a virtual experiment system "SHU-AP". The system is composed of six virtual experiments. To judge the feasibility and teaching effectiveness of the system, we used it for real teaching in Year 2020 and compared it with offline teaching. We divided BME students into two classes: Class A (offline experiment) and Class B (virtual experiment). Both classes were taught by the same teacher. At the end of the semester, we issued questionnaires for the two classes. The results showed that there was no significant difference in students' performance and teaching satisfaction under the two teaching methods. As a conclusion, virtual experiments could achieve the same teaching effectiveness same as offline experiments.**

***Keywords*—Biomedical Engineering, Anatomy and physiology, Virtual experiment, COVID-19**

I. INTRODUCTION

Online courses had been widely applied in Biomedical engineering (BME) during COVID-19. BME was a branch of engineering that applies principles and design concepts of engineering to healthcare. Medical experiment courses were necessary in BME teaching. One example was the course "anatomy and Physiology", which was taught for fresh BME undergraduates in Shanghai University, China. However, a few of students could not complete the traditional physiological and anatomical offline experiments during the epidemic period. Therefore, virtual experiments were required [1-4].

Currently, with the development of multimedia technology and virtual reality technology, the concept of virtual laboratory was put forward[5]. For example, Google launched a web application called Body Browser (http://bodybrowser.googlelabs.com/) in December 2010. This WebGL-based application supported users to explore the human body, adjust skin, muscle and tissue, etc. However, we found that existing systems were not suitable for our teaching in "Anatomy and Physiology". The specific manifestations were as follows: (1) existing systems were too professional and need pre-training, which were not suitable for fresh undergraduates; (2) existing systems required professional software and computer operation systems, which were not suitable for the cross-platform teaching[6-9]. Therefore, in this study, we developed a new virtual experiment system, called "SHU-AP", and used it for real teaching in Shanghai University.

II. SYSTEM DESCRIPTION

A. System Design

The virtual experiment system was built using axure RP8. Axure RP8 is a professional rapid prototyping tool that enabled experts to define experimental requirements; design features and interfaces, and realize applications on Web sites. Fig.1 showed the overview of our system with block diagrams. As shown in Fig.1, the system included four functional modules: authority management module, experiment library module, task module and data management module. The system can support two hundred students for online study at the same time. Six experiments were employed in current version.

B. Module Introduction

Authority Management Module: In order to ensure the security and reliability of the system, it was necessary to manage user rights. The authority management module included two parts: user authentication and user authorization. The user authentication method of this system was based on account-password login. The experiment library module, task module, and data management module were only able be changed for teachers, when students only had the right to view.

Experiment Library Module: The experiment library module contained six experiments, including anatomical experiment of bullfrog, specimen bullfrog sciatic nerve gastrocnemius physiology experiment, anatomical experiment of crucian, anatomical experiment of pig heart, anatomical experiment of clam, and image acquisition and artificial intelligence analysis of nail fold capillaries.

Task Module: The task module was only open for teachers to assign homework, including questions for anatomical knowledge and skills. The system would automatically grade answers.

Data Management Module: The data management module was mainly used for teachers to upload reference materials, including documents, Power Point, videos and other common formats.

C. Graphical User Interface of the System

Figure 2 showed the Graphical User Interface (GUI) for one experiment: image acquisition and artificial intelligence analysis of nail fold capillaries.

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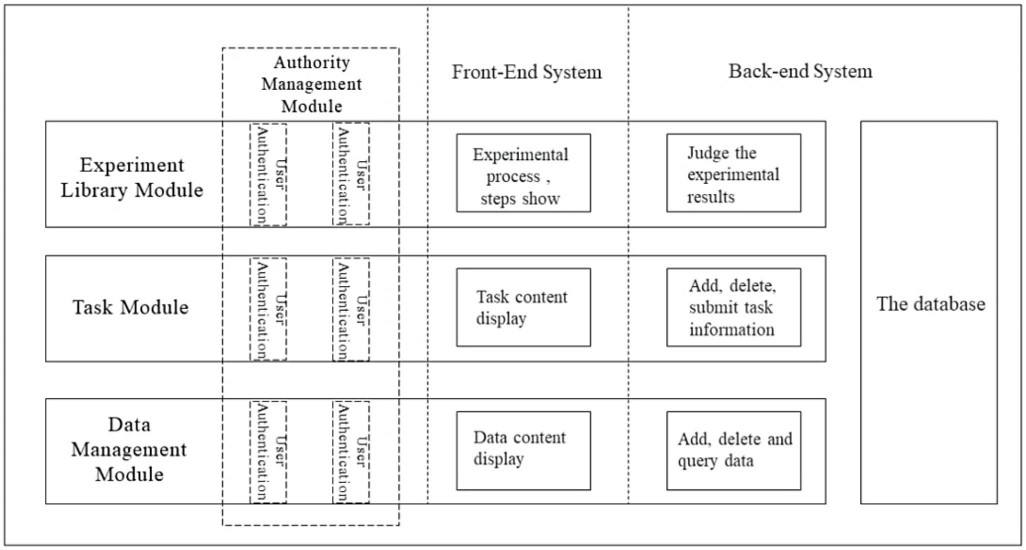

Figure 1. System block diagrams

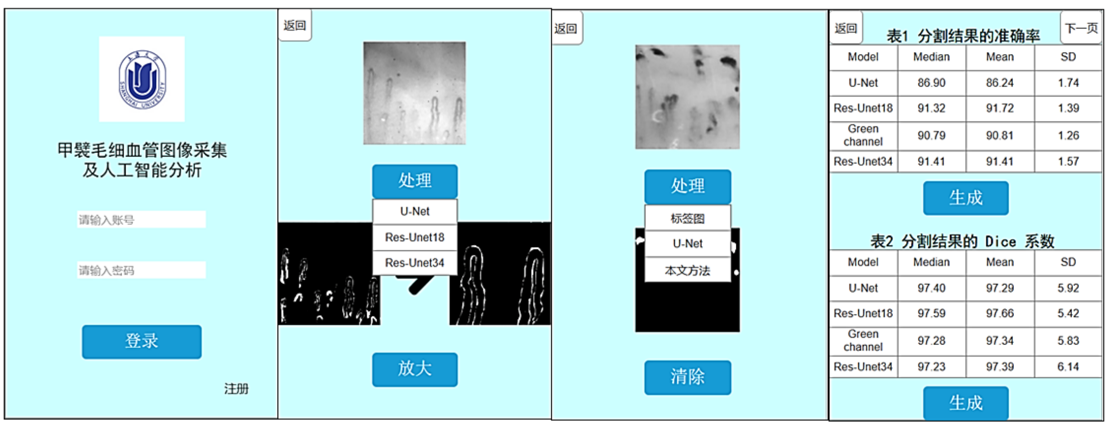

Figure 2. GUI demonstration of the system

III. Implementation of the System

A. Subjects

In order to test the teaching effectiveness of "SHU-AP", we applied it and compared it with traditional offline experiments in Year 2020. All BME fresh undergraduates were divided into two classes: Class A was composed of 27 students. These students were local and allowed to attend offline courses. Class B was composed of 29 students who were only allowed to attend online course because of the epidemic. "SHU-AP" was applied for Class B. The two classes were taught by the same teacher (Dr. Jiehui Jiang) and used the same grading standards. There was no significant difference in gender (p>0.05) between two classes.

B. Teaching Process

The course lasted for 10 weeks, with a total of 50 class hours (30 class hours for theory plus 20 class hours for experiment) from April 26, 2020 to July 4, 2020. Students in both classes were asked to complete all six experiments as shown in the previous section. Figure 3 showed the experimental scene of class A.

Figure 3 Offline experiments for Class A

Class B students were taught online. “SHU-AP” was used for Class B. Exams were held in July through online exam system in Shanghai University. All students from both classes were signed same exam tests. The teaching satisfactions were also selected in the exam. After the course, we conducted a questionnaire survey for both classes, respectively.

C. Questionnaire

We designed two questionnaires for Class A and B respectively. The questionnaire for Class A included 16 questions in three aspects: (1) basic information of students, including gender, whether they have studied programming, computer usage, etc.; (2) survey on the traditional experimental teaching methods, such as "What is the general way you use when preparing before class?", "What kind of offline teaching methods do you prefer? “; (3) survey on the knowledge for virtual experiments, such as "Would you like to use online virtual experiment system?".

The questionnaire for Class B included 18 questions in three aspects: (1) basic information same as Class A; (2) survey on the differences between online virtual experiments and traditional offline experiments, such as "What do you think about the advantages of online virtual experiments compared with traditional offline experiments?"; (3) survey on the scores (from1 to 5 points) for “SHU-AP”. For example, “What level do you think “SHU-AP” can develop your ability of independent self-learning?” “What level do you think the virtual simulation experiments are helpful in this course?”.

D. Statistical analysis

After the exams, we compared the differences on the final exam scores between two classes. The teaching satisfactions between two classes were also compared. Two-sample t test was used. All statistical analyses were performed in SPSS Version 22.0 software (SPSS Inc., Chicago, IL). All P value < 0.05 was considered significant.

IV. RESULTS

We evaluated the teaching effectiveness of “SHU-AP” in two aspects. The first aspect was the results of questionnaires, and another was based on students' exam scores and teaching satisfaction from two classes.

A. Results of Questionnaire for Class A

The results showed that 92.6% of the students in Class A had learned programming language, and the degree of computer application was proficient. This indicated that most students had skills to use the virtual experiment system. 59.26% of the students preferred traditional offline experiments rather than online virtual experiments. This showed that offline experiments were still necessary in the course “anatomy and Physiology”. 74.07% of the students chose “yes” to try the online virtual experiments, while 18.52% chose “not sure”. This indicated that students had a high degree of accepting the virtual experimental system.

B. Results of Questionnaire for Class B

The results showed that all students had learned programming languages and were proficient in computer applications. For the question ""What do you think about the advantages of online virtual experiments compared with traditional offline experiments?", 65.52% of the students reported that the differences between online virtual experiments and offline experiments. However, 62.07% of the students also reported that “SHU-AP” need be improved. This pointed out the development of the system were necessary. Moreover, 79.31% of the students said that “SHU-AP” could cultivate the ability of autonomous learning. All students reported that “SHU-AP” was useful for self- learning. The average assessment score on the system was 4.07.

C. Exam and teaching satisfaction

There was no statistical difference on the final exam scores between Class A (76.4) and Class B (75.1) (Figure 4). The teaching satisfactions in two classes were also without difference (Class A: 97.8 and Class B: 97.9).

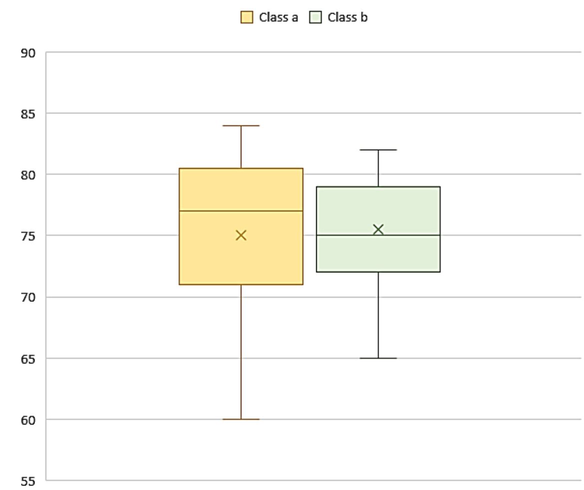

Figure 4 Final exam scores for Class A and B

The statistical analysis results indicated that “SHU-AP” achieved the similar teaching effectiveness compared with the traditional offline experiments.

V. DISCUSSION

The survey results showed that, compared with the traditional offline experiment teaching, the virtual experiment system showed the following advantages:

Expand educational resources: The virtual experiment system can integrate sound, light, electricity, graphics, videos and other corresponding multimedia elements with modern technology. It creates a vivid experiment environment and simulated experiment content for students[5] . For example, in the experiment “image acquisition and artificial intelligence analysis of nail fold capillaries”, the traditional offline experimental teaching cannot guarantee that every student can accurately operate instruments such as nail fold capillary camera, while the virtual experiment system can enable every student to learn the use of the instrument. In the process of virtual experiments, students can effectively strengthen their perceptual cognitions on the experimental principles [6] . As a result, the quality of teaching can also be guaranteed. In addition, the virtual simulation system is only operated on the computer, which can effectively avoid contact with toxic and harmful substances, as well as avoid the excessive utilization and waste of limited resources[7] .

Learning at anytime and anywhere: In traditional offline anatomical experiments, students must study in the anatomy laboratory, while the virtual experiment systems allow students to study effectively in real time through the Internet at anytime and anywhere. For example, during this epidemic, teachers and students cannot come to the laboratory to conduct experiments. The virtual experiment system played important roles in this case. The virtual experiment system allowed students to conduct remote experiments, and teachers could provide online guidance, which guaranteed the teaching and learning process.

Reduce the difficulty of experimental teaching: In addition to above, the virtual experiment system also showed unique advantages in time costs. In the traditional offline teaching, teachers usually had to explain the experimental process and to operate the experiments first, which cost a lot of time. Using the virtual experiment system, students could completely learn the experimental process by themselves. Moreover, students could also revise the complex experimental procedures by themselves. As a result, the teacher could save time and spent more time for individual coaching. The virtual experiment system then could be used as a tool for students to preview, review and self-learning, which provided students a certain sense of image, made students easy to understand, and improved the teaching effectiveness [8].

Although “SHU-AP” was useful in BME teaching in Shanghai University during COVID-19, it still had several shortcomings, including (1) the number of virtual experiment in current version was not enough. We planned to design at least 20 experiments in the future; (2) the interaction system in current version was not good enough. We planned to expand the social communication functions of the system and combined it into the online teaching system of Shanghai University in the future.

VI. CONCLUSION

“SHU-AP” provided a lot of conveniences for the experiment teaching in “Anatomy and Physiology”, which effectively expanded educational resources, reduced the teaching difficulty, and aided students to learn the experiments at anytime and anywhere.

As a conclusion, the virtual experiment system made up for the shortcomings of traditional offline experiments.

REFERENCES

[1] L. Wei and H. Huang, "Design and Implementation of Virtual Simulation Teaching System of Solar System," in 2018 International Symposium on Educational Technology (ISET), 2018, pp. 29-32.

[2] J. Li, Y. Feng, and L. Jing, "Design and Application of Civil Engineering Experimental Teaching Management Platform in Mobile Environment," in 2020 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS), 2020, pp. 489-493.

[3] J. Wang, X. Chen, and X. Gao, "Economic Management Teaching Mode Based on Mobile Learning and Collaborative Learning," IEEE Access, vol. 8, pp. 200589-200596, 2020.

[4] A. Altalbe and N. Bergmann, The Importance of Student Feedback in Development of Virtual Engineering Laboratories. 2017.

[5] R. Estriegana, J.-A. Medina-Merodio, and R. Barchino, "Student acceptance of virtual laboratory and practical work: An extension of the technology acceptance model," Computers & Education, vol. 135, pp. 1-14, 2019/07/01/ 2019.

[6] M. D. M. Quiroga, "A virtual experiment improved students' understanding of physiological experimental processes ahead of a live inquiry-based practical class," AJP Advances in Physiology Education, vol. 43, no. 4, 2019.

[7] J. Lang, "Comparative study of hands-on and remote physics labs for first year university level physics students," Transformative Dialogues: Teaching and Learning Journal, vol. 6, pp. 1-25, 01/01 2012.

[8] A. A. Altalbe, "Performance Impact of Simulation-Based Virtual Laboratory on Engineering Students: A Case Study of Australia Virtual System," IEEE Access, vol. 7, pp. 177387-177396, 2019.

[9] P. Xia, "Reform of Network Security Technology Practice Teaching System Based on Virtual Simulation Training Platform," in 2020 International Wireless Communications and Mobile Computing (IWCMC), 2020, pp. 199-203.