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Design of Virtual Physics Laboratory Based on STEAM Education

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ABSTRACT
Virtual reality is a new emerging sophisticated technology which can enable human to feel an object without a real touching. Physics experiments are the most visual and intuitive way for students to study physics, and are the best way to stimulate students' interest in Physics. We have applied Virtual Reality technology to build a Physic laboratory based on STEAM concept, which is a new educational concept that integrates multiple disciplines. Therefore, the combination of STEAM education with virtual Physics experiments enables students to conduct experimental operations at different levels and at different times, thereby improving students' knowledge learning ability and practical operation level, and promoting students' abilities and literacy.

Keywords: *STEAM education, virtual technology, Physics experiment*

1. INTRODUCTION

With the development of virtual reality technology, virtual laboratories have become an important topic in the study of virtual reality technology at home and abroad. In 1989, Professor Willian Wolf of the United States first proposed the concept of "virtual laboratory" to describe computer virtualization. Due to visualization and ease of operation, many universities have their own virtual laboratories, such as the Massachusetts Institute of Technology, Tsinghua University, and Zhejiang University.

There are some problems existing in traditional physics laboratory .First of all, traditional Physics labs have a long construction period and are costly. With the development of society, many schools have equipped new types of physical equipment, but some rural schools still do not have supporting physical laboratories, resulting in their lack of physical experiment tools, Besides, the number of experimental teachers and students is not equal, resulting in imbalance of resources. Finally, the traditional physics laboratory is just a simple explanation of the physical single subject at the same place at the same time, which violates the purpose of interdisciplinary cross-site and cross-time under quality education, so the virtual laboratory came into being.

Compared with traditional physical laboratory, virtual physical laboratory has many advantages. Virtual Reality (VR) is a new type of human-computer interaction technology with immersive, interactive and conceived features. Using this technology, people can generate a virtual scene with the help of a computer. People use specialized hardware to manipulate various objects in a virtual scene to achieve interactivity, and feel the real existence under the virtual environment in immersion [1]. With the advancement of science and technology, the combination of virtual technology and physical experiments, a virtual physics laboratory that meets the needs of various physical experiments has emerged. The virtual physics lab is an open network system based on VR technology and is the digitization of existing traditional physics labs. The entire virtual physics experiment can simulate and reproduce traditional physical experiments. We combines STEAM education concept with virtual reality technology to build a virtual physical laboratory.

2. STEAM EDUCATION CONCEPT

2.1. Overview of STEAM Education

In the 1990s, the American Science Foundation Committee and experts in science, technology, engineering, and mathematics jointly proposed STEM education. In 2006, Yakman and his team at the University of Virginia Tech University added Art the first time on the basis of STEM, and formed a complete STEAM model. It is a combination of the first five letters of Science, Technology, Engineering, Art, and Math. It aims to break the boundaries of the subject area and cultivate students' scientific thinking, technical thinking engineering thinking, artistic thinking, mathematical thinking, and training students' ability to solve problems comprehensively [2].

2.2. Characteristics of STEAM Education

Interdisciplinarity is the core feature of STEAM education. American scholar Abts describes STEM as a unified field of knowledge that represents science, technology, engineering, and mathematics. They exist in the real world and are indispensable and interrelated. This requires teachers not to focus on specific subjects in the STEAM education process, but should focus on specific issues, emphasize the use of multidisciplinary connections to solve problems, and achieve interdisciplinary boundaries to improve students' ability to solve practical problems [3].

STEAM education not only requires students to learn abstract knowledge, but also emphasizes students' hands-on experiences and participates in practical learning activities.

The knowledge learned in the participation and practice will have a profound impact on the students' future study and life [3].

The evaluation standard of STEAM education is different from traditional teaching. In the evaluation content, teachers not only make relevant evaluations on the understanding of scientific knowledge and the ability to solve problems, but also evaluate the authenticity of evaluation methods, and let students using video presentations, multi-media and other performances.

3. STEAM EDUCATION AND VIRTUAL PHYSICS LABORATORY

STEAM education takes "teaching science", "learning technology", "doing engineering", "seeking art", and "exploring mathematics" as the main purpose, while the virtual physics laboratory makes full use of STEAM guiding ideology. "Teaching science" means students should pay attention to scientific experimental attitudes in the operation of virtual physics laboratories, actively acquire relevant scientific and cultural knowledge, and gradually complete each part of virtual experiments with scientific rigor. "Learning technology" means inter-disciplinarity is the core feature of STEAM education. Students are required to not only learn basic physics knowledge, but also have good computer programming ability and model building ability, so that students can fully learn various technologies. "Doing Engineering" means practicality in STEAM education. Students are required to participate in the experiment in the process of virtualization experiment. They use the characteristics of project-based teaching of STEAM education to achieve everyone's participation and everyone's progress. "Seeking Art" requires students not only to learn basic cultural knowledge, but more importantly, to experience the fun they feel during the experiment, to cultivate interest in learning, and to improve their ability to solve problems. "Exploring mathematics" requires students to master good thinking and learning methods in the experiment. For example, conversion methods, analog methods, reverse methods, etc., have a good learning method, which will be of great help to the success of the experiment. In short, the combination of virtual physics lab with STEAM education concept provides theoretical support for virtual physics lab and a practical mean for STEAM education. Figure 1 shows the relationship between STEAM Education and Virtual technology.

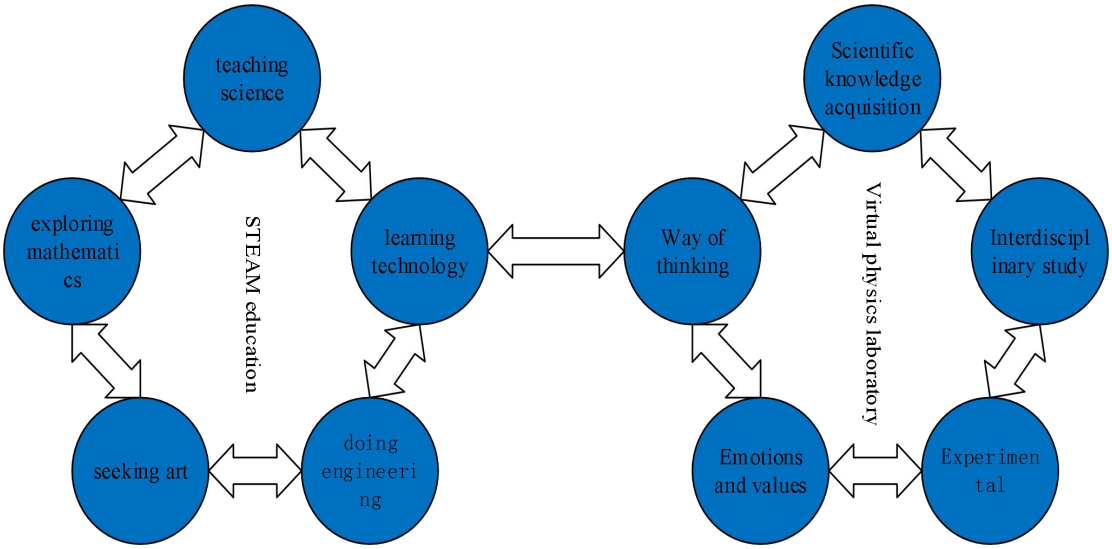

Figure 1 Relationship between STEAM Education and Virtual Physics Lab

4. VIRTUAL PHYSICS LABORATORY CONSTRUCTION

4.1. Construction of Virtual Laboratories

Virtual Physics Lab is built on 3dmax modeling, c# programming, and the unity 3D engine-led virtualization lab. Firstly, we need to model the laboratory settings, experimental equipment, and static modeling of virtual objects through 3dmax. Secondly, we set up the laboratory, build and develop virtual experiment scenes. Moreover, the virtual device is independently developed by the VS script compiler[4]. Finally, the experimental system is published and tested on the Windows platform. After the above four steps, a complete virtual lab will be formed.

4.2. The Specific Interpretation of the Virtual Laboratory

The virtual Physics Laboratory consists of virtual classroom roaming, mechanical experiment scene, and electrical experiment scene.

Figure 2 shows the virtual lab login interface. Users need to enter the correct account and password to log in to the experimental system. If the account password is incorrect, the system will report an error and prompt to log in again. A good login system ensures the independence and security of the students. Each account corresponds to a student, which enables normal communication between the teacher and the student. Figure 3 shows the virtual classroom roaming scene. Students wear virtual equipment. In the virtual classroom, each experimental equipment on the desk can be closely observed on the desk. Before starting the experiment, the

projector on the platform can play the teaching video and demonstrate through PowerPoint. Pre-read the relevant content to ensure that the students are fully prepared before starting the experiment. When finished, click the start experiment in the upper right corner to perform the experiment.

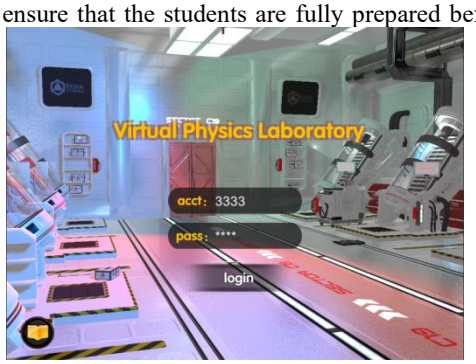

Figure 2 Virtual Lab Login Screen

Figure 3 Virtual Classroom Roaming

Figure 4 is an experiment of the relationship between the force and the motion of the object in the mechanical experiment. During the experiment, we use the handle to grab the experimental equipment and put them one by one. When we put the experimental equipment, the handle starts at the lower left corner. The demonstration will show that the ball will travel differently depending on the friction, and the distance the ball runs will be measured by the ruler below and recorded. When the handle is pressed back in the upper left corner, it will return to the previous step to re-execute the previous experiment. Students can observe the distance of the ball movement through the VR device and measure the data and record it. Figure 5 shows the experiment of electric temperature welding sound and light alarm in electric experiment. During the experiment, the experimental equipment is grasped by the handle and welded to the circuit board. The direction keys are used to adjust the angle and distance correctly to achieve true soldering to the circuit board. On the top, when the welding is completed, press the lower left corner of the handle to start the demonstration. When moving the distance between the fire source and the photoresistor, you will find that the light intensity of the LED light and the sound of the buzzer will change with the distance. The closer the light intensity, the louder the buzzer sounds. Also when the handle is pressed back in the upper left corner, the previous step is repeated. The VR device allows the student to properly solder the circuit. In the virtual environment, the student can feel the intensity of the LED light intensity and the size of the buzzer sound by moving the flame under the base.

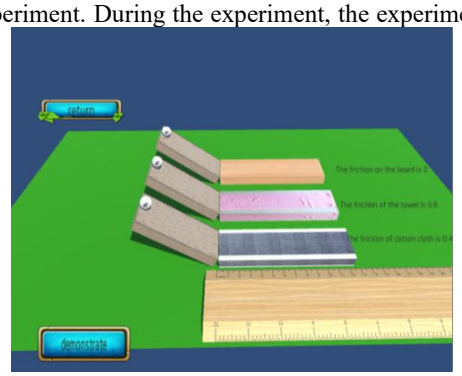

Figure 4 Mechanical Experiment Scene

Figure 5 Electrical Experiment Scene

5. SUMMARY

The establishment of a virtual physics laboratory is based on the rapid development of today's science and technology and a major breakthrough in the history of education in the traditional physics laboratory. It promotes students to master science and culture knowledge faster and better, and cultivate their cultural literacy. The STEAM education concept provides a good theoretical foundation for the virtual physics laboratory. In short, the purpose of the STEAM Virtual Physics Laboratory is to provide students with a comprehensive development. Combine modern scientific and technological means with modernized new educational concepts to cultivate new types of technical talents needed in the 21st century

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