Physical Experiment Simulation Based on Virtual Reality (VR) and Augmented Reality (AR) Technology

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Abstract: The application of virtual reality (VR) and augmented reality (AR) technology in physics education provides students with new learning opportunities and experiences. The purpose of this study is to explore how to use virtual reality (VR) and augmented reality (AR) technology for physics experiment simulation to improve the effectiveness of physics education. By creating a virtual experimental environment, students can simulate various physical experiments to enhance their understanding and practical skills. This article will explore the design and development of virtual experimental simulation systems, learning effectiveness evaluation, and teaching practice applications.

Keywords: virtual reality; Augmented reality; Physical experiment simulation; Physics education

1. Introduction

Traditional physics education often faces problems such as restricted experimental conditions, insufficient equipment, and safety hazards, which limit students' participation in and understanding of physics experiments, and make it difficult to stimulate students' interest and motivation in physics learning. The development of virtual reality (VR) and augmented reality (AR) technologies has brought new opportunities for physics education. Through the use of VR and AR technologies, highly immersive and realistic experimental environments can be created to provide students with more experimental opportunities and space for independent learning, fully mobilize students' interest and initiative in learning, and improve the quality of physics teaching so as to enhance their physics learning outcomes.

2. Background to the study

The new standard focuses on scientific inquiry and strengthens scientific thinking, using emerging information technology, it is possible to design richer, more colorful and close-to-life experimental content, and to display more uniquely appealing physical phenomena.VR and AR technologies can create highly immersive and realistic experimental environments. Traditional physics experiments are often limited by experimental conditions, and VR and AR can solve this problem. Students can enter a simulated experimental environment to operate and observe through virtual reality headsets or augmented reality devices. They can experience first-hand how the laws of physics work and feel the effects of real experiments, so that they can better understand and memorize the relevant knowledge.VR and AR technology can also provide students with more experimental opportunities and independent learning space. In traditional physics classrooms, experimental equipment and time are often limited, resulting in students not being able to fully participate in experiments and exploration. With VR and AR technologies, on the other hand, students can conduct experiments anytime, anywhere and are no longer constrained by time and location. They can choose their own experimental projects, explore physical phenomena, and develop hands-on and problem-solving skills through the virtual experiment platform.

3. Content and methodology of the study

3.1 Experimental design

This study will adopt the method of designing and developing virtual experiment simulation systems for different grades and contents by combining teaching theories and practical experiences in the field of physics education. Firstly, a demand research is conducted to understand students' needs and expectations of physics experiments and to determine the functions and characteristics of the virtual experiment simulation system.

Next, virtual reality and augmented reality technologies are used to create realistic virtual laboratory environments and develop corresponding interactive interfaces and operations. Through the use of high-quality 3D models, real physics engines and realistic physical effects,

students are able to perform various physical experimental operations, such as measuring, building experimental devices, and changing experimental parameters, in the virtual laboratory. At the same time, augmented reality technology is utilized to combine the virtual experimental scene with the real environment so that students can observe and operate on real objects.

3.2 Data analysis

Mean scores and standard deviations were calculated for the pre- and post-test scores and, questionnaires. In order to compare the validity of the students' gain in knowledge of physics concepts before and after the experimental improvement, Mann-Whitney's U test (two-tailed, α=0.05) was conducted to determine significant differences between the groups on the existential questionnaire and interaction data.

A total of 38 students completed the experiment and filled out the questionnaire form, and the questionnaire data were analyzed using SPSS 25. 18 students (47.4%) indicated that they had never used a VR device before, 19 students (50.0%) had used a VR device occasionally, and 1 student (2.6%) indicated that he or she had extensive prior experience using VR. Meanwhile, only 3 students (7.9%) indicated that they had some prior experience with force feedback devices, and the remaining 35 students (92.1%) had never used related devices before.

Mann-Whitney's U test (two-tailed, α=0.05) was used to compare the scores of the experimental and control groups. The experimental group scored 0.855, 0.771, 0.838, and 0.805 on the four main factors of the test, for an overall score of 0.918.The control group scored 0.832, 0.901, 0.879, and 0.777 on the four factors, for an overall score of 0.937.The results indicated that the experimental group received higher scores on each factor.

In order to assess the learning effect of the virtual laboratory simulation system in physics education, this study will use a comparative research method between the experimental group and the control group. One part of the students will be assigned to the experimental group to learn physics experiments using the virtual experiment simulation system; the other part of the students will be used as the control group to learn physics experiments using traditional methods. The effectiveness of the virtual laboratory simulation system in improving students' learning outcomes will be assessed by comparing the differences between the two groups of students in terms of academic performance, laboratory skills and learning motivation.

4. Conclusions of the study

4.1 Academic Achievement Enhancement

Students' understanding of physics concepts and mastery of experimental skills improved significantly when they used the virtual lab simulation system. By actually operating the equipment and performing various experimental operations in the virtual lab, students were able to gain a deeper understanding and application of the physics knowledge they had learned. This hands-on approach to learning motivates students to achieve better academic results in their physics studies.

4.2 Increased interest and participation

Students generally believe that virtual laboratory simulation systems can increase their interest and participation in physics experiments. Traditional physics laboratory teaching is often a one-way transmission of knowledge by the teacher, while the use of virtual laboratory simulation systems to assist teaching methods can break this one-way transmission situation. Through the realistic virtual experimental environment and interactive operation, students are able to participate more actively in the experimental process and experience the fun and challenges of experimentation. This active participation and engagement promotes their positive attitude and enthusiasm for physics learning.

4.3 Increased flexibility and scalability

The virtual lab simulation system is highly flexible and scalable. Physics experiments of different grades and contents can be designed and developed through the system, and adjusted and updated according to students' needs. This provides more choices and possibilities for physics education and enables teachers to make flexible teaching arrangements according to the actual situation of students.

5. Discussion and application

5.1 Introduction of virtual laboratory simulation system in educational institutions

Based on the results of the study, educational institutions may consider incorporating a virtual lab simulation system into their physics curriculum. Such a system can provide students with a safe, convenient and interactive learning environment that helps them better understand and apply physics concepts. By actually operating virtual laboratory equipment and performing various experimental manipulations, students are able to learn physics in greater depth and improve their skills in physics experiments.

5.2 Stimulate students' interest in learning physics

Virtual experiment simulation systems can increase students' interest and motivation in participating in physics experiments. Through realistic virtual experimental environment and interactive operation, students can participate in the experimental process more actively and experience the fun and challenge of the experiment. For example, through the VR/3D virtual simulation laboratory, students can experience the experimental process and understand the experimental principles without the laboratory. In observing the abstract microscopic electric field lines and magnetic field lines, VR technology can be used to visualize the electric field lines and magnetic field lines, so that students can be immersed in a different physical world. Educational institutions and teachers can take advantage of this feature to design attractive virtual experiment scenarios to stimulate students' interest in physics learning and increase their motivation to learn.

5.3 Optimize the design and user experience of the virtual experiment simulation system

Optimization and improvement are needed to further enhance the effectiveness and continued application of virtual lab simulation systems. Researchers can continue to explore in depth the application of virtual reality (VR) and augmented reality (AR) technologies in physics education to improve the fidelity and interactivity of the system. There is also a need to consider the user experience so that the system interface is user-friendly and easy to use, and provides clear instructions and feedback to ensure that students are able to make full use of the virtual lab simulation system for their learning.

5.4 Promote and share best practices

Educational institutions and teachers can actively promote and share best practices in the use of virtual laboratory simulation systems. By exchanging experiences and sharing cases, cooperation and sharing in the educational field can be promoted to further improve the quality and effectiveness of physics education. In addition, researchers can collaborate with educational practitioners to develop virtual experiment simulation systems in more fields to meet different educational needs.

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