



Research on Virtual Simulation Experiment Teaching Method of “Sensor Principle and Application”

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Abstract. Virtual simulation experiment teaching is the organic combination of educational information development and experimental teaching reform in the new era, which makes up the deficiency of traditional experimental teaching limited by space and time. It provides an effective means for experimental teaching quality improvement at present. In this paper, the virtual simulation teaching experiment platform is constructed. VR technology is used to virtualize teaching practice and virtual reality and multimedia are comprehensively used to build the simulation experiment environment. The role of computer terminal and mobile multimedia terminal in experimental teaching is realized, and the three-level network management of “equipment management - teacher guidance - student learning” is carried out for the course. The practice result indicated that students who often log in the virtual simulation experiment platform can operate the sensor system more skilled and their scores are generally better. In addition, it can better cultivate students hands-on practice, independent creation and other abilities.

Keywords: sensor principle and application · virtual simulation experiment · teaching reform · experimental teaching platform

1 Introduction

Sensor is a kind of detection equipment which can sense the information of the measured object [1]. Sensor is one of the necessary tools for artificial intelligence to obtain information, and its technological development is closely related to the degree of automation in the field of intelligence [2, 3]. In order to have a foothold in today’s information age, we must learn the “sensor” course which mainly focuses on information acquisition, processing, conversion and display [4]. However, the pure theoretical teaching content is rather boring. Students are less motivated to learn and gain little. Compared with theoretical courses, experimental teaching is intuitive, comprehensive and innovative, which is particularly important for the study of sensor courses [5–7]. It is a key link to cultivate students’ practical and innovative ability.

Traditional experimental teaching methods are limited by specific course time and teaching space, and are vulnerable to emergencies in the external environment, such as the global spread of COVID-19. Theoretical teaching relies on Internet teaching tools and teaching resources, and teachers mainly teach basic theoretical knowledge in the course. Theoretical knowledge and experimental teaching links are disjointed, it is difficult to ensure the teaching effect [8–10].

In order to solve the above problems, this paper studies the experimental teaching method of “sensor principle and application” based on virtual simulation technology, and gives the construction scheme of virtual simulation experiment platform. Virtual reality and multimedia technology were comprehensively used to establish simulation teaching experiment environment, VR technology was equipped to virtualize experimental teaching links, and background management system of “Sensor Principle and Application” course was built to realize foreground monitoring and network reservation experiment.

2 Design Principle and Overall Process

2.1 Design Principle

The new experimental teaching model requires teachers to be able to skillfully use the virtual experimental platform teaching software, edit and produce more diversified electronic teaching materials. After the completion of basic principle teaching, students can apply for carrying out design experiments [11, 12]. The sensor virtual experiment software is used in combination with the hardware platform to realize the collection, display and analysis of sensor data. Students can complete design experiments such as temperature detection system, intelligent traffic light control system, smoke alarm system and so on. Design the front panel and background program of the system, through the combination of hardware and software, the selection of sensors, design and debugging have a relatively systematic understanding and understanding, greatly mobilize the enthusiasm of students to learn sensors and participate in the experiment.

Virtualization and intelligentization are important trends of experimental teaching at present [13]. Through the laboratory construction in recent years, the traditional experimental equipment must integrate new technology and new teaching carrier in order to continue to play its role.

Therefore, the virtual simulation experiment platform in this paper combines Arduino system with AR system to create an open source electronic platform integrating hardware and software. Arduino can sense the external environment through various sensors with strong operability, which can not only be used alone, but also communicate with other software quickly. Using Arduino and Virtual Reality(hereinafter referred to as VR) to develop physical experiments instead of DIS experimental system has significant advantages. First of all, the price is cheaper compared to DIS experimental system. It can not only solve the current DIS experimental equipment shortage dilemma, but also can realize group experiment. Secondly, Arduino software and hardware are open source, which is convenient for secondary development. Teachers and students can develop new experiments by themselves. In the process of developing experiments, students can develop their thinking and improve their innovation ability.

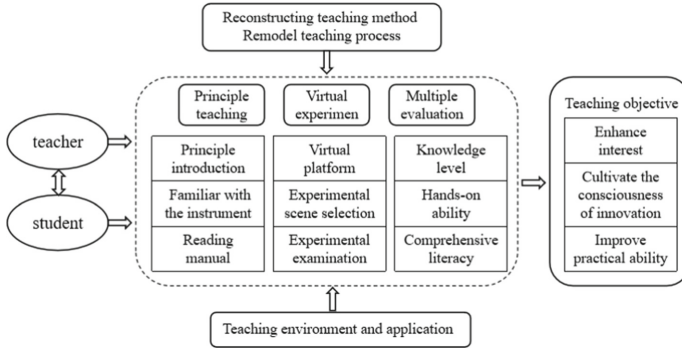


Fig. 1. Sensor virtual simulation teaching design principle

2.2 Simulation Experimental Overall Process

The course teaching design is mainly divided into principle teaching, experimental guidance and multiple evaluation (Shown in Fig. 1).

Basic principle teaching refers to the introduction of basic principles of sensors and basic theoretical knowledge necessary for experiments to students by teachers, including understanding, familiarity with and mastering the principles and application technologies of strain sensors, inductance sensors and other types of sensors. Explore the important core technologies in the field of sensor detection, involving the application principle of sensors, selection and design of measurement systems, A/D, D/A interface integrated circuit in measurement and control devices, signal amplifying circuit in sensor products, signal conditioning circuit, and noise control and linearization of the output loop of sensor products and other aspects of knowledge.

The experiment instructor leads the students to familiarize themselves with the sensor AR system experiment manual before the experiment begins. During the experiment, the scanned physical sensor is displayed visually on the handheld device (mobile phone, tablet). At the same time, the system is touch-type structure, supporting autonomous interaction, realizing manual or automatic rotation, parts can be freely scaled in the interface, and its functions are introduced in the form of animation playback and voice explanation. There is also a Q&A communication link in the interface, which can answer the problems existing in the experiment process for students.

3 Virtual Simulation Experiment Platform

3.1 Platform Establishment

The virtual simulation experiment teaching system of “Sensor Principle and Application”, based on the structural decomposition of the sensor, virtualizes the experimental operation process and has stronger human-computer interaction ability. At present, VR technology can be combined with 5G transmission technology, which can not only realize long-distance real-time teaching, but also realize the integration of various experimental equipment resources between schools, so as to improve the efficiency of resources. The



Fig. 2. Effect of sensor virtual laboratory



Fig. 3. Sensor virtual experiment platform

effect diagram of the sensor virtual laboratory and the platform scene diagram are shown in Fig. 2 and Fig. 3.

The sensor virtual experiment platform covers the main sensor characteristic experiment, complete virtualization operation, the whole platform is composed of hardware system and software system.

The hardware system includes: traditional sensor test bench, computer (CPU I7 or above), visual robot (Sensor shape, color, number recognition, operation process recognition).

The software system includes: arduino system and sensor AR system. The product includes the 3D virtual augmented reality structure decomposition of stress signal, capacitance sensor, differential sensor, piezoelectric sensor, strain sensor, Hall sensor and other experimental standard sensors.

The experimental examination includes various evaluation systems, which can score the virtualization experiment operation, and the actual operation can be carried out only if the score is qualified. In this way, a complete set of experimental teaching system is formed, which can effectively reduce the damage rate of traditional sensor experimental equipment, and better enhance students' learning interest and understanding of theoretical knowledge.

3.2 Virtual Simulation Platform Teaching Case

Taking virtual simulation platform to develop simple harmonic motion teaching experiment as an example, shown in Fig. 4. The experiment course requires students to understand the characteristics of simple harmonic motion, and use formulas and images to describe simple harmonic motion. In the virtual simulation experiment platform, the

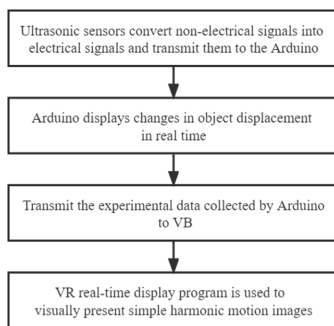


Fig. 4. “Simple harmonic motion” simulation teaching case design

image of simple harmonic motion can be explored by means of a left-to-right swinging brush, and then ultrasonic signals can be converted into electrical signals by ultrasonic sensors and transmitted to the Arduino. In this way, the position of objects can be recorded in real time and the changes of the position of objects over time can be visually displayed on the VR software.

4 Effect Analysis of Virtual Simulation Experiment Teaching

From 2020 to 2022, the traditional laboratory teaching methods has been improved. The course grade comparison analysis is shown in Fig. 5. It shows that the data basically follow a normal distribution which accords with the law of teaching. Three semesters before the teaching reform (2017–2019), the proportion of students failed the course (<60) is at about 7% averagely, good (60–79) accounted for about 50%, and excellent (80–100) accounted for about 43%. After applying the virtual simulation teaching platform to course teaching, it can be obviously found that with the continuous optimization of the virtual simulation platform and the continuous improvement of teaching design, the number of excellent students accounted for a steady increase. The corresponding data became 5%, 44% and 51% respectively, which means the percentage of students failed the course has decreased and the percentage of students with high score has increased at the same time. Combined with the analysis of assessment results, students who often log in the virtual simulation experiment platform can operate the sensor system more skilled and their scores are generally better.

The virtual simulation experiment teaching method of “Sensor Principle and Application” can be used for reference in the virtual simulation teaching construction of other courses. Teachers can adjust and reform according to the actual teaching needs, develop and construct the corresponding virtual teaching system and teaching resources system; Enable students to complete virtual simulation tests independently, to overcome the lack of experimental equipment and site limitations. With the continuous deepening of experimental teaching research, the content and form of practical teaching are constantly improved, and the teaching reform of relevant courses is gradually carried out. Through “Internet + education”, the network virtual experiment teaching is carried out to cultivate students’ consciousness and ability of innovative practice.

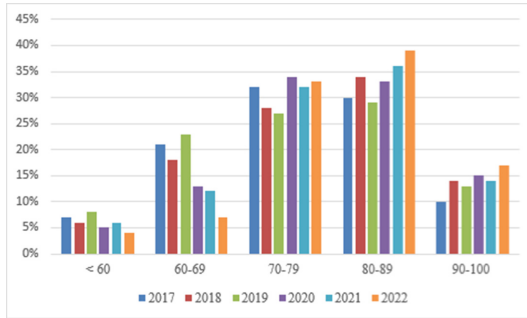


Fig. 5. Course grade analysis and distribution

5 Conclusions

The development and construction of virtual simulation experiment course system is an expansion of the construction of conventional practical training base and traditional laboratory, which can further enrich the connotation of practical teaching, promote the innovation of practical education mode of information technology-related courses, and drive the establishment of professional laboratories. The new experimental teaching model will also fully arouse students' interest in learning and improve the quality and effectiveness of learning.

In addition, students can also use virtual software to carry out innovative experimental projects, participate in various kinds of sensor discipline competitions and other experimental activities, so as to exercise students' practical engineering application ability and innovation ability. Through these measures, we can change the limitation of students doing experiments according to the experimental instructions step by step, improve students' interest in the course of sensor technology, and cultivate students' innovative consciousness and practical ability.

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