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Construction of Virtual Experiment Teaching Platform based on 5E Teaching Mode and VI Technology

-- Taking the course of mechanical engineering testing technology as an example

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Abstract: Virtual instruments have many advantages such as low cost, comprehensive functionality, easy scalability, and easy replication. At the same time, they can also meet the special requirements of time and space for remote experiments. Based on Web technology and virtual instrument technology, a virtual experiment system is constructed, which combines data sharing, remote control, and real-time operation. More conducive to utilizing experimental and scientific research resources. At the same time, virtual instruments have high flexibility and are no longer limited by traditional experimental teaching modes, which can save a lot of repeated investment costs. They can also keep the teaching equipment in the laboratory up-to-date and closely follow the development trend of science and technology. As a compulsory course for mechanical engineering majors, although the existing experimental system has achieved certain results, there are still limitations to 'Mechanical Engineering Testing Technology'. This article aims to address the problems of insufficient instrument sets and outdated equipment in the experimental teaching of "Mechanical Engineering Testing Technology", as well as students' poor ability to apply theory to practice and insufficient innovation ability. By integrating the 5E teaching mode, a virtual experimental teaching platform based on VI (Virtual Instrument) technology is established. Students can break through traditional experimental methods and conduct various experiments through the network, obtaining experimental experiences that are very similar to real experiments. At the same time, it can deepen their understanding and recognition of experiments, and better grasp theoretical knowledge.

Keywords: Data Sharing; Remote Control; 5E Teaching Mode; Virtual Experimental Teaching Platform.

1. Introduction

With the continuous development and advancement of VI (virtual instrument) technology, the application value of virtual instruments in the field of education has gradually become prominent. By using virtual instruments, it is possible to obtain a near real experience without the limitations of cost, space, and personal safety. In recent years, the development has shown that the country is vigorously promoting the deep integration of high-tech industries and higher education, and carrying out the construction of virtual experimental systems based on VI technology. In the future, the teaching form of experimental teaching based on virtual instruments will be widely applied.

The virtual experimental teaching platform can provide students with experimental scenarios for independently solving problems, and has gradually become an important means to promote students' learning and cultivate their abilities. As an important carrier of students' learning ability, the virtual experimental teaching platform integrates theory and practice into the experimental teaching system. While learning theoretical knowledge, it can also simultaneously cultivate students' practical operation ability. At the same time, it can make abstract conceptual knowledge in books more concrete and vivid, thereby improving teaching effectiveness, enriching students' horizons, and enhancing their understanding ability.

1.1. Current Research Status Abroad

In foreign experimental courses, there are two main problems: high cost of manual experiments and increased demand for laboratory networking. Therefore, in foreign countries, the networking and unmanned operation of laboratories are regarded as the development direction of experimental teaching. As early as the 1970s, Britain was the first to propose a plan to connect the experimental instruments of universities across the country, so that everyone could use the instruments of each university to conduct experiments online through connected classrooms, and also exchange experiences and share data online. From the perspective of experimental teaching abroad, the use of computer-assisted management for networked and unmanned remote teaching has become a development trend.

At present, the use of computer-based virtual instruments for experimental teaching has begun to be applied. Some higher engineering colleges in developed countries have already applied virtual instruments in ordinary student experiments. For example, the Department of Mechanical Engineering at Stanford University in the United States requires third and fourth year students to use virtual instruments for data acquisition and experimental control during experiments. In recent years, due to the rapid development of network technology and virtual instruments, the construction of virtual laboratories through the Internet has been widely used abroad, and distance education learners have realized remote experimental teaching through the network.

BerkayErder et al. used LabVIEW software as a platform and error control coding technology to establish a real-time remote access virtual laboratory. Students are not limited by time and location, and only need a computer connected to the laboratory system network to conduct experiments through the local area network.

E. Fabregas et al. created a new interactive remote laboratory for engineering practical education through the control software Simulink and the Simplified Simulation

Animation Design and Production Environment (EJS).

Carlos A. Jara et al. established a dynamic collaborative e-learning system through the Internet, which integrates virtual laboratories within a synchronous collaborative e-learning framework. Combining their respective advantages, the virtual laboratories written in Java mini programs are embedded into EJS, thereby improving the programming skills of students using the system.

1.2. Current Research Status in China

Experimental teaching in universities is an excellent embodiment of the integration of theory with practice. It plays an irreplaceable role in cultivating students' hands-on ability, independent thinking ability, problem-solving ability, innovation ability, and rigorous scientific attitude, which cannot be replaced by other teaching processes. With the urgent demand for applied talents in society, strengthening experimental teaching has become an inevitable trend in modern teaching.

The course of Mechanical Engineering Testing Technology has strong practicality. In the process of teaching and learning, it is necessary to closely link with reality. Students must not only master basic theoretical knowledge, but also strengthen their practical skills. Through teaching experiments, students need to proficiently master relevant testing techniques and methods, and achieve the ability to conduct preliminary engineering testing work.

In recent years, the Ministry of Education has launched the construction plan of the "National Engineering Basic Course Teaching Base", which has opened the prelude to the construction of experimental teaching centers. Many universities have established virtual laboratories based on their own research and teaching needs. Among them, the Engineering Testing Laboratory of the School of Mechanical Engineering at Huazhong University of Science and Technology has publicly displayed its development results online. Teachers from Sichuan United University have developed the "Aviation Radio Second Line Comprehensive Tester" based on the design concept of virtual instruments, integrating 8 instruments into a virtual instrument system that is convenient and flexible to use. The Automotive Department of Tsinghua University has developed an automotive engine testing system using virtual instrument technology, which is used for factory inspection of automotive engines. The system mainly tests the power characteristics, load characteristics, etc. of the engine. After an engine is tested, a complete testing report can be printed out.

2. The Problems of Traditional Experimental Teaching Mode

In the teaching of mechanical engineering testing experiments, most universities still use the traditional experimental teaching mode, and students are at a loss when solving practical problems. The phenomenon of "high scores but low abilities" is very common. At present, China's higher engineering colleges still use traditional experimental teaching methods, which are mainly characterized by the following aspects:

(1) The laboratory occupies a large amount of space, has multiple equipment, and there is a situation of redundant construction. The levels are uneven, the update speed is slow, and the cost is high.

(2) The outdated experimental equipment and rigid experimental modes seriously weaken students' initiative and creativity.

(3) The experimental content is mostly theoretical verification experiments, and each student basically follows the same experimental mode, lacking innovation and independent development space.

With the development of computer technology and network technology, a new experimental teaching approach has been proposed in the field of teaching, which is to use virtual instruments to replace traditional instruments. The use of virtual instruments to replace traditional instruments has made up for the shortcomings of traditional experimental teaching. It not only alleviates the problem of insufficient funding leading to a lack of experimental resources, but also benefits the openness, flexibility, and diversity of experiments, providing technical conditions for the development of quality education.

3. Research on Teaching Mode of Virtual Experiment Teaching Platform

In order to improve the teaching effectiveness of virtual experiment systems, their application theories are also constantly developing. The three-dimensional virtual teaching mode, user experience design methods, cognitive load theory, immersion theory, and interface design theory provide theoretical support for the design of virtual experimental platforms. The widely used teaching modes currently include 5E teaching mode, COI teaching mode, I-MMLOE design mode, etc.

The 5E teaching model proposes five dimensions for conducting teaching, namely participation, exploration, explanation, refinement, and evaluation. In a 3D virtual learning environment, the participation dimension represents the character entering the virtual scene; Exploring dimensions represents learning through completing tasks in the storyline; Explanations represent necessary corrections to errors; Refining represents solving problems in practical scenarios; Assessment represents the evaluation of learners' performance and task status.

The COI teaching model mainly includes the following three aspects: setting tasks in an online or offline form that can be participated in at any time; Social existence, exchanging learning outcomes through online communication platforms, and recommending the use of social media for evaluation; Cognitive existence involves stimulating students' interest through challenging tasks and enhancing participants' skills through collaborative tasks.

The I-MMOLE teaching model integrates the construction of learning environment, problem-based learning, and experiential learning, and its process includes five stages: establishing a context and proposing learning tasks that stimulate learners' curiosity; Learner survey and exploration of reading materials, videos, and other necessary materials; Teachers provide experience and construct a knowledge system, while students experience and design learning tasks, experiencing the learning process; Showcase and share knowledge, test solutions, and evaluate learning outcomes; Follow up and expand on activities such as reflective learning, guiding the next learning task, enriching content, and transferring learning to a new environment.

Based on the current research status of teaching modes, the teaching mode of virtual experiment teaching is also

constantly developing. Summarizing the above teaching modes, the following conclusions are drawn: the above three virtual teaching modes are all based on text, images, and video information, which are intuitively mapped into virtual space to improve knowledge acceptance; In order to increase students' participation, most of them learn through tasks; The role of students as reviewers and participants is hoped to be achieved through students' self reflection to acquire knowledge, while also encouraging them to learn and acquire knowledge from others. Teachers act as reviewers to evaluate students' experimental results.

As a compulsory course for mechanical engineering majors, although the existing experimental system has achieved certain results, there are still limitations to 'Mechanical Engineering Testing Technology'. This project aims to address the problems of insufficient instrument sets and outdated equipment in the experimental teaching of "Mechanical Engineering Testing Technology", as well as students' poor ability to apply theory to practice and insufficient innovation ability. By integrating the 5E teaching mode, a virtual experimental teaching platform based on VI (Virtual Instrument) technology is established. Students can break through traditional experimental methods and conduct various experiments through the network, obtaining experimental experiences that are very similar to real experiments. At the same time, it can deepen their understanding and recognition of experiments, and better grasp theoretical knowledge.

4. Construction of Virtual Experiment Teaching Platform based on 5E Teaching Mode and VI Technology

This article closely combines the demand for talent cultivation in the economic development of Lvliang region, the talent cultivation goals of local undergraduate colleges, and the characteristics of mechanical engineering majors in our university's Department of Resources and Mechanical Engineering. Taking the experimental teaching of the course "Mechanical Engineering Testing Technology" as the research object, relying on the Mining Coal Machine Virtual Simulation Experimental Teaching Center and Testing and Detection Laboratory of Lvliang University, and based on the 5E teaching mode, explores the virtual experimental teaching platform of "Mechanical Engineering Testing Technology". VI (Virtual Instrument) technology is used to construct the virtual experimental platform of "Mechanical Engineering Testing Technology" course, and LabVIEW software is used as the carrier for software system design. This project can complete experiments such as testing common signals and sensor calibration.

The main construction contents are as follows:

(1) Propose a virtual experimental teaching model based on 5E (integrating VI technology);

The premise of platform construction is to clarify the training objectives and propose a new model of virtual experimental teaching. Students are the core of all activities and behaviors, and teachers play the role of leaders. The 5E teaching model focuses on students' performance and proposes a virtual experimental teaching model based on 5E, improve experimental teaching methods, fully tap into existing laboratory resources, and utilize the combination of network technology and virtual instrument technology Reasonable use can achieve experimental experiences that are very similar to real experiments, and complement and connect with physical experiments to form a complete experimental teaching system.

(2) Propose a strategy for constructing a virtual experimental teaching platform based on VI technology;

The core of platform construction: the construction of a virtual experimental teaching platform with VI (virtual instrument) technology as the core. The platform construction includes the following three parts: 1) design and development of virtual instruments; 2) Overall structural design of virtual experimental teaching platform; 3) Functional design of virtual experimental teaching platform; 4) Software system design for virtual experimental teaching platform.

This platform closely integrates the demand for talent cultivation in the economic development of Lvliang region, the talent cultivation goals of local undergraduate colleges, and the characteristics of mechanical engineering majors in our university's Department of Resources and Mechanical Engineering. It adopts virtual instrument technology to construct a virtual experimental platform for the course of "Mechanical Engineering Testing Technology", and designs the software system using LabVIEW software as the carrier. When installed on this experimental platform, it can complete experiments such as testing common signals and calibrating sensors.

(3) Design of Virtual Experiment Teaching Content for the Course of Mechanical Engineering Testing Technology;

The key to platform construction is to use the virtual instrument development platform LabVIEW to build a mechanical engineering testing and experimental platform, integrate the 5E teaching mode, and design experimental teaching content. Students can complete three types of projects through this experimental operation platform: basic experiments, comprehensive experiments, and engineering innovation experiments.

Basic experiments mainly include: water pump outlet pressure testing experiment, motor speed testing experiment, indoor environmental temperature testing experiment, etc;

The comprehensive experiments mainly include: gearbox vibration testing and analysis experiment, microphone sound signal output, cantilever beam stress testing experiment, cantilever beam natural frequency testing experiment, rolling bearing vibration signal analysis experiment, etc;

Innovative experiments include: gearbox rolling bearing fault diagnosis, calibration method of electronic scale, rolling bearing fault diagnosis experiment, methane sensor calibration, smoke sensor calibration experiment, etc.

(4) Development of a virtual experimental teaching platform for engineering practical experiments that integrates 5E teaching mode and VI technology.

Optimization of platform construction: In close combination with the demand for mechanical application-oriented talents in the economic development of Lvliang area, the virtual experimental teaching platform should be designed with coal mine sensors, such as wind speed sensors, smoke sensors, methane sensors, etc., and support later expansion.

5. Conclusion

The research on the Construction of Virtual Experiment Teaching Platform Based on 5E Teaching Mode and VI Technology, by proposing a virtual experiment teaching mode based on 5E, proposing a construction strategy for a virtual experiment teaching platform based on VI technology, designing the virtual experiment teaching content of the

course "Mechanical Engineering Testing Technology", and developing an engineering practice oriented experimental project for the virtual experiment teaching platform.

(1) Taking the course of "Mechanical Engineering Testing Technology" as an example, a virtual experimental teaching platform is constructed that integrates the 5E teaching mode and VI (Virtual Instrument) technology. Students can break through traditional experimental methods, conduct various experiments through the network, and obtain experimental experiences that are very similar to real experiments. At the same time, it can deepen their understanding and recognition of experiments, which is conducive to remote control and sharing of experimental resources.

(2) The project development of this virtual experimental teaching platform not only completes basic and comprehensive experiments, but also enables the completion of engineering innovation experiments, which has certain practical significance in engineering.

(3) With the help of LabVIEW software, a virtual experimental teaching platform is constructed to assist teachers in conducting confirmatory experiments on "Mechanical Engineering Testing Technology", helping and inspiring students to independently carry out innovative experiments. At the same time, it provides a practical and design environment for graduates, and improves students' practical and comprehensive abilities to apply scientific and technological theories to solve practical problems.

Innovation is the soul of mechanical testing. Through virtual experimental teaching platforms, students' innovative abilities can be stimulated, their participation can be increased, and a high degree of integration between teaching and experimentation can be truly achieved to enhance teaching effectiveness.

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