An open source engineering practice assistant training system based on virtual reality

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***Abstract*—** The Engineering training course takes the responsibility of cultivating students' innovation, team cooperation and practical operation ability. Now there are two ways to improve the innovation training performance in the engineering practical course. The most popular way is to carry on a project-based curriculum which has the practical training as one section of the course. Another way is to create new practice teaching methods. Our research is a combination of the project curriculum and the innovative training methods. It is focused on the Virtual reality (VR) for the engineering practice teaching. First of all, the project-based course named "Comprehensive innovation training" was offered for the junior or senior students. VR methods applied for the practice course was one of the projects in the course. Instructors built the initial model from the real practice situation into the virtual environment by the software Unreal Engine (UE) 4, and guided students the basic operation of the software. Then the students in the class would design the motion of the equipment based on the reality rules, finish the operating system with the VR device, and debug the program for the final application. Thirdly, this project was applied as an assistant practice method for the sophomores in their practice training class, and the students would give feedbacks to the system. Finally, when those sophomore students become juniors and seniors, they could involve in the project-based course, and contribute to the VR training project. Now the project is carried on, and the model of drilling machine and lathe machine are established in the virtual environment. The engineering practice assistant training system based on VR has already applied for the junior students, and some of feedbacks have been received. There is 81 percent of the students shown interest in the new method. As the platform depends on the open source software, and the whole project is sustainable and the system will be abundant in the next few years.

Keywords*—Virtual Reality; Teaching Assistant Platform; Engineering Practice; Open Source*

I. INTRODUCTION

The undergraduate engineering training education plays a major part in a university[1-4]. Nowadays, innovation training in practical education is a necessary measure to promote the quality of engineering training education. There are two ways to improve the innovation training performance in the engineering practical course. The most popular way is to carry on a project-based curriculum. Through the whole process students can put forward innovative ideas, improve the practical skills and understand the importance of teamwork. Another way is creating new practice teaching methods to increase the efficiency and interest of the courses with advanced strategy and technology. This research is a combination. In this research, a project-based curriculum system was established, and virtual reality(VR) was applied as the innovative methods for the courses.

II. THE CURRICULUM SYSTEM OF THE ENGINEERING TRAINING

The project-based curriculum system is the basis for the innovation training platform. As shown in figure1, there are 3 stages in the engineering training curriculum system. The first stage aims to teach the concepts and basic knowledge of engineering. The mainly supporting courses include "the principle of interchangeability", "processing technology" and "engineering materials". This stage would help the freshmen in the university building the engineering cognition. The second stage is for the sophomore students with the main courses such as "mechanical design", "manufacturing practice" and "electrical engineering". This stage aims to improve the engineering training and practice ability by teaching engineering training methods. The last stage aims to combine the knowledge and methods to help the junior students finish an engineering project through the course "comprehension and innovation training". The final stage is the most important one in the system, which cultivates the students with the problem solving and innovation training ability.

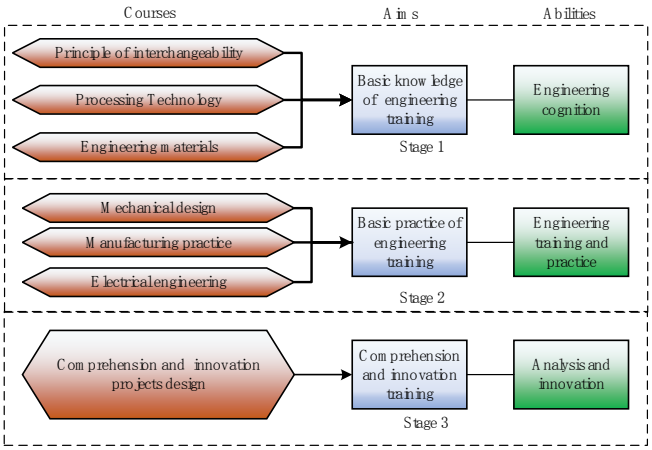

Fig.1 curriculum system of the engineering training

This system accepted thousands of students every semester. The first stage courses were taught through the class

with a large capacity, but the second and final stages could only be guided through groups with 2-4 students each. The engineering training instructors were experiencing unprecedented challenges. This research aims to establish an open source engineering practice assistant training system based on virtual reality to provide instructors with an alternative way for ensuring teaching quality with a large number of groups of students as well as empower students with the ability of creativity.

III. THE PRACTICE TRAINING PLATFORM BASED ON VR

A. The operation process of the system

Virtual reality technology first appeared in the French dramatist Antonin Aalto's book "Dramas and Their Shadows" in 1938. It can be applied to the field of practice training education to solve problems such as the shortage of instructors, equipment and space. It can also allow students to be fully trained in a virtual environment, which improves the training effect and reduces training costs [5,6].

At present, VR teaching in colleges and universities is mostly based on the mature platform provided by outside companies, which is not an independent research and development. The platform does not have a completely open source environment [7-14].

This paper aims to build an open source engineering training VR platform researched by the instructors and students in the university independently. The establishment of the system depends on the "Comprehensive innovation training" and "manufacturing training" courses, as shown in fig 2. First of all, in the "Comprehensive innovation training" course, one or two groups are guided by the instructors to establish the VR system. Instructors build the initial models from the real practice situation in the virtual environment and import the models to the software Unreal Engine(UE) 4. They also guide students on the basic operations of the software, teach them how to use the machine tools and supply the VR device. Then the junior students of the project would design the motions of the equipment in the software according to the rules in reality, establish the operating system with the VR device, and debug the program for the final application. Thirdly, this project will be applied as an assistant practice method for the sophomore students in their practice training class, and the students would give feedback to the system. Finally, one year later, those sophomore students could involve in the project-based course, and contribute to the VR training project.

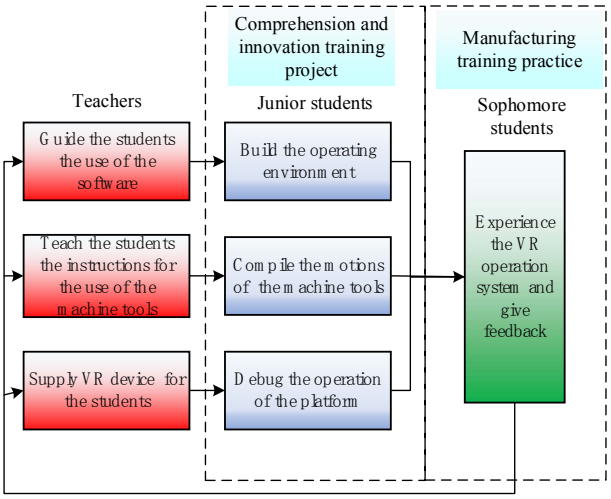

Fig. 2 Operation process of the VR system

B. Establishment of the drilling machine operation system based on VR

(1) Software environment and hardware equipment of VR platform

The construction of the virtual training platform relies on an open source software environment and the matching hardware equipment. UE is selected as the software engine for platform development because it provides an open source platform for education. HTC Vive is a virtual reality head-mounted display device developed by HTC and Valve. The device has a precise positioning effect and high resolution (1280×1080). At the same time, UE can provide good support for HTC Vive devices.

(2) Development and practice of the drilling practice teaching platform based on VR

The Drilling machine is the simplest practice training equipment, and the operation training is also an indispensable part of the manufacturing practice course. To Combine the guidance of drilling machine operation with the software, the practical teaching assistant platform system based on VR was developed. This system was composed of two parts, the first one was the conducting part, which included the VR motion video and the teaching audio guidance, and the second part was the drilling machine operation test in the VR environment.

Fig. 3 VR animation and audio instruction

In the first part, the operation process and rules of the drilling machine would be recorded into audio by the instructor, which would be used as the instruction in the virtual reality environment. At the same time, the drilling machine in the VR environment would present the corresponding motion animation like a video, as shown in figure 3. During the whole process, students need to wear a VR headset. The operating handles are only used to change the observation viewpoint, but couldn't operate the machine in the platform.

Fig. 4 Operation process of VR drilling machine

In the second part, students would operate the drilling machine in the virtual environment. The operation process includes the 4 steps: the first step, positioning the part under the drilling bit; then clamping the part by the vice; after that, pressing the white button to start the machine; at the end, feeding the drilling bit through the part to finish the job, as shown in figure 4. The whole operation process is arranged in a certain order. Only when the previous content is completed, the next part of the content will be continued. If dangerous operations occurred in the VR environment, the system would give a serious warning. This would avoid dangers caused by the same operational errors in the actual engineering practice.

IV. Feedbacks and Improvement of the Practice Teaching Assistant Platform

A. *Feedbacks from instructors and students*

This VR practice platform is arranged before the real machine practice. The students couldn't carry on the actual engineering practice training until they has completed the same processes in the virtual environment. The VR platform can save the cost as well as release the teaching pressures. Those are advantages of the virtual and reality combination.

Fig. 5 Students and instructors experience with the VR platform

The system has been experienced among 37 students and 13 instructors involved in engineering practice teaching, as can be seen in figure5. As shown in figure 6, about 54% of the respondents considered the experience environment reaching 50-80% authenticity, 16% considered beyond 80% authenticity. About 54% of the respondents think that the basic operation has reached more than 50%. At present, the virtual reality platform system of the drilling machine has basically realized the function of the drilling machine, and the reality can basically meet the needs of the experiencer. Meanwhile, the experiencer also gives some suggestions to improve the operating environment and enrich the operation content.

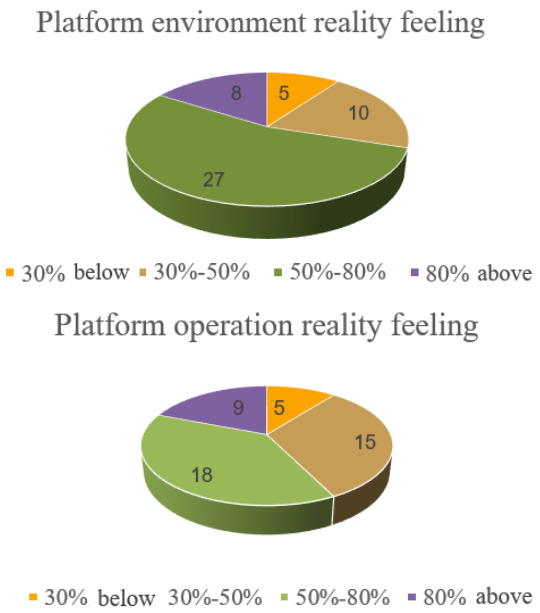

Fig. 6 Feedback on the feeling of the platform from instructors and students

B. *Improvement and Development of Teaching Assistant Platform System*

In response to the problems of insufficient machines of the platform and monotonous operating environment, two groups of students improved the platform under the guidance of the instructors. The first group improved the operations of the drilling machine by installing a cross workbench on the original one. Three more operation steps were developed, and the new drilling machine can improve the positioning accuracy of the parts. The second group had developed a lathe machine in the virtual teaching assistant platform. It enriches the content of practical training and expands the type of parts that can be developed, as shown in figure 7.

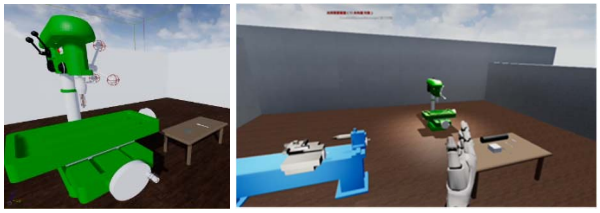

Fig. 7 Virtual drilling machine with cross table and virtual lathe operating platform

V. Conclusion and Prospect

The VR-based engineering practice teaching assistant system provokes students' interest and enthusiasm in learning, ensures the personal safety of operators, and saves cost and space. Now the project is carried on, and more machines such as grinding machines and milling machines will be established in the virtual environment. The engineering practice assistant training system based on VR has already applied for the junior students, and some of the feedbacks has been received. All the instructors and students recognize the value of the platform and put forward suggestions for the improvement. There is 81 percent of the sophomore students shown interest in the new method and would like to participate in the project. Because the system depends on the open source software, the whole project is sustainable and the system will be abundant in the next few years.

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