Application of Virtual Reality Technology in Practical Teaching of Printing Machines

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Abstract. The integration of virtual reality (VR) technology into education has always been a focal point of researchers. This study explores the integration of VR technology into teaching electrophotographic printing machine operation. Utilizing VR device and Unity3D software, a VR simulation software was developed with 12 operating modules. Compared to traditional methods, the VR technology provided a more engaging and interactive learning experience. Moreover, students who received VR-based instruction achieved higher learning effectiveness than those who received only traditional practical training. This study highlights the potential of VR technology in enhancing practical education and training.

Keywords: Virtual Reality · Practical Teaching · Electrophotographic printing

1 Introduction

Virtual reality (VR) technology has emerged as a powerful tool in enhancing practical education and training. This technology creates a simulated environment in which users can interact and immerse themselves, enabling them to gain valuable experience in a safe and controlled environment.

One of the primary advantages of VR technology in practical education is that it can simulate real-life scenarios that are difficult to replicate in the physical world. For example, medical students can practice surgical procedures in a safe and controlled environment without the risk of harming a patient [1, 2].

Similarly, engineering students can simulate the construction of complex structures and machines, allowing them to gain valuable experience before entering the workforce [3, 4]. VR technology can also provide a more engaging and interactive learning experience, which can lead to improved learning outcomes and higher levels of retention [5, 6].

The use of VR technology in practical education is still in its early stages, but it has been gaining momentum in recent years. Many educational institutions and training organizations are beginning to adopt VR technology to supplement or even replace traditional training methods [7, 8]. In the medical field, VR technology is being used for surgical training, patient diagnosis, and rehabilitation [9]. In engineering and manufacturing, VR technology is being used for design simulations, prototyping, and assembly line training

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Fig. 1. Pico neo3 VR headset

[10]. In the aviation industry, VR technology is being used for flight simulation and pilot training [11, 12].

This study introduces the incorporation of virtual reality (VR) technology into the teaching of electrophotographic printing machine operation. Based on traditional teaching methods, the combination of VR simulation exercises and practical operations has improved the learning effectiveness of students.

2 Implementation

2.1 Hardware Platform

In this study, we utilize the Pico neo3 VR all-in-one device, which comes with an Android-based operating system and employs an optical controller-based positional tracking solution. The device is integrated with a built-in processor, sensors, battery, storage memory, and display, which makes it capable of operating independently without a connection to a PC or smartphone.

The device is comprised of a head-mounted VR display and two controllers, as shown in Fig. 1. This device was chosen for the study for the following two reasons:

Firstly, this device offers a high degree of integration and does not require a computer for data processing or graphics rendering, nor does it require laser base stations for positioning, as in traditional PC-based VR headsets. Its simple setup and ease of use significantly reduce the learning costs for students using this new teaching equipment.

Secondly, this device is moderately priced at approximately 300 US dollars, which is relatively lower than PC-based VR devices, and is therefore crucial for the widespread adoption of VR in education. Despite the availability of low-cost devices that utilize smartphones for VR display, this device offers significant advantages in display quality. With the continuous advancement of technology, it is anticipated that the cost of this type of VR device will continue to decrease, while its performance will improve.

2.2 Teaching Software

Using industrial 3D modeling software combined with real-world printing equipment, a 3D model of the printing equipment is created and a teaching software is developed using Unity3D software that can be run on VR devices. The software includes two main parts: a four-color electrophotographic printing machine training and a multi-color electrophotographic printing machine training. Each part includes six operating modules: introduction of the printing machine, ink replacement, waste ink unit replacement, paper loading, charging unit replacement, and output virtual training. The software module composition is shown in Fig. 2.

After entering the corresponding module, students can see the four-color or multi-color electrophotographic printing machine, the printing machine server, and related accessories. There is a text display above the printing machine to facilitate students to view operation prompts and operation scores, as shown Fig. 3.

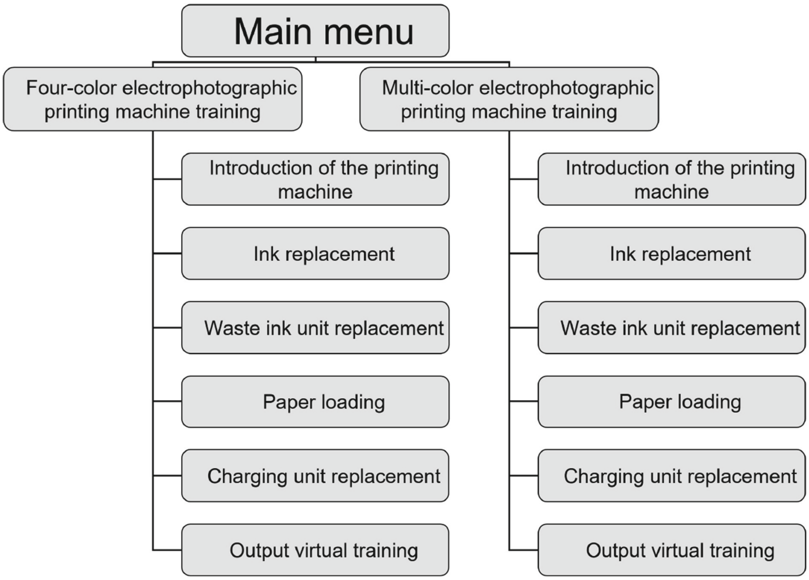

Fig. 2. Software module composition

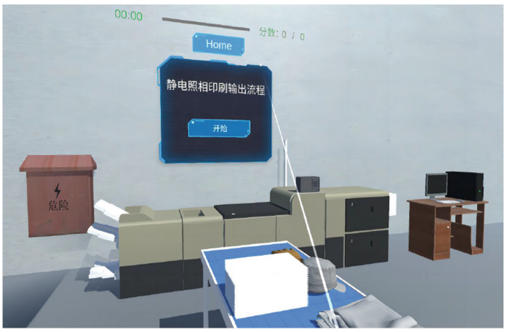

Fig. 3. Software interface

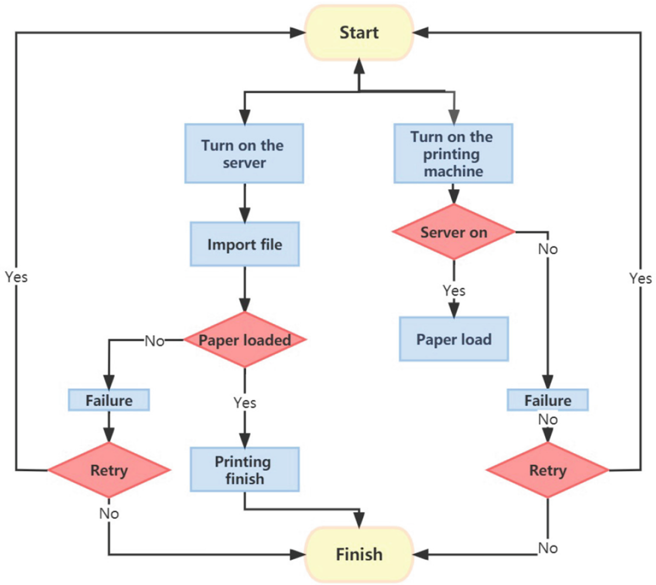

Fig. 4. Software flowchart

The software can be used in two modes: stationary and mobile. The main difference is whether the operator needs to move positions or use the joystick to move when moving. According to the actual teaching situation, the operational space for each student is limited, so the stationary mode is chosen.

2.3 Software Logic

Taking the example of the four-color electrophotographic printing machine output training, Fig. 4 shows a brief software flowchart. The logic of other modules is similar.

The software has high flexibility and provides prompts for students in case of incorrect operations. The students can repeat the exercise after a failed attempt. Each step in the operation has a corresponding score, which is evaluated based on the correctness of the operation and the time taken.

2.4 Screen Projection Monitoring

The VR device can wirelessly connect to a computer for screen casting and the output image is a monocular image. Compared with wired screen casting, this method has a certain delay, but the operation is simple and avoids the use of cables. Through the computer near the students, the teacher can view the students' screen in the VR glasses and provide guidance. The teacher can also use computer software to summarize the student operation interface to the teacher's computer, making it convenient for the teacher to view and discover problems in a timely manner.

Table 1. Teaching schedule

Class hour	Group 1	Group2
1–2	VR learning	Teacher demonstration
3	Teacher demonstration	Practical learning
4–8	Practical learning	Practical learning

2.5 Implementation of the Teaching Plan

24 students majoring in digital printing were divided into two groups. Group 1 received VR-based instruction in combination with hands-on training, while Group 2 received traditional practical training. The teaching experiment consists of eight class hours. The schedule is shown in Table 1.

The group 1 adopts the teaching method of VR learning in the first two class hours, one class hour of teacher demonstration and five hours of practical learning. The group 2 adopts two hours of teacher demonstration and six hours of practical learning.

3 Result and Discussion

3.1 Questionnaire

After the training, all students anonymously completed a questionnaire about their subjective impressions. A total of four questions were included in the questionnaire.

Question 1: Was the training interesting?

Question 2: Did you find the learning easy?

Question 3: Did you feel anxious during the practice?

Question 4: Have you fully mastered the operation of the electrophotographic printing machine?

The result is shown in Fig. 5.

For the first question, 10 students in group 1 gave a positive response, while only 5 students in group 2 gave a positive response. For the second question, 9 students in group 1 gave a positive response, while 3 students in group 2 gave a positive response. For the third question, 3 students in group 1 felt anxious, while 8 students in group 2 felt anxious. For the fourth question, 11 students in group 1 gave a positive response, while 9 students in group 2 gave a positive response. It can be seen from the results that compared to the second group, the first group had more students who found the training more interesting, easier, less stressful, and had better learning outcomes.

3.2 Learning Outcome

In order to evaluate the learning outcomes of the two groups of students, they were required to complete a printing output operation during the last class hour of the training. Figure 6 shows the number of mistakes and the number of students who made mistakes.

From Fig. 6, it can be observed that the number of mistakes and the number of students in group 1 are significantly lower than those in group 2.

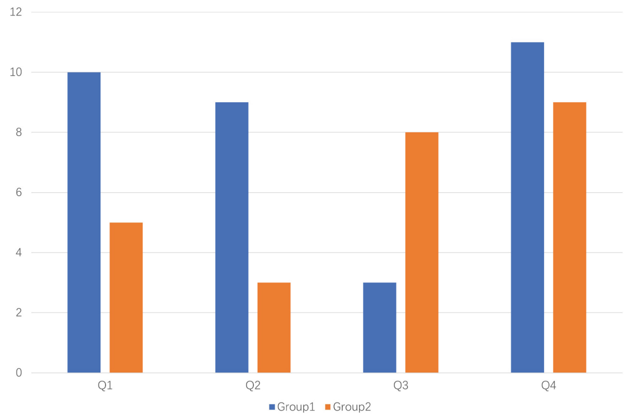

Fig. 5. Questionnaire results

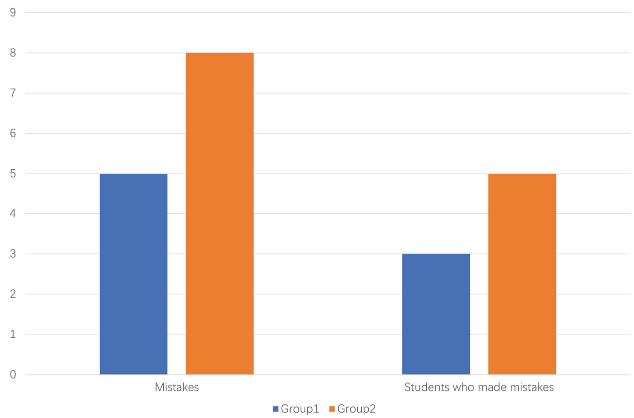

Fig. 6. Learning outcome

4 Conclusion

This work proves that VR teaching is a useful supplement to practical teaching. By combining VR-based training with practical experience, a better learning outcome can be achieved than with traditional instructional methods. However, VR should not be seen as a replacement, but rather as a supplement to classic demonstration instruction.

To make VR-based instruction more attractive in the future, research efforts should focus on how to supplement traditional teaching methods with VR-based instruction, how to integrate VR-based instruction with traditional teaching methods, and how to develop VR software that close to course content.

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