Analysis of Educational Characteristics of Personalized Virtual Reality Terminal Devices

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ABSTRACT

Virtual reality technology has been continuously integrated with the education field in its development process. It has been widely practiced and applied in all aspects of teaching and learning. This paper presents five educational characteristics of personalized virtual reality terminal devices: student experience, cultivation of interest in learning, knowledge acquisition efficiency, hands-on capacity building and innovative ability training. We introduced four typical terminal devices used in virtual simulation experiments: PC, three-dimensional(3D) desktop, head-mounted display and mobile phone, compared their performance on the above five characteristics. The study summarized the use scenarios of each device and provided a reference for device selection of virtual simulation experiments.1

INTRODUCTION

Virtual reality is an emerging technology that integrates and penetrates many disciplines such as Computer Graphics, Sensor Technology, Network Technology, Artificial Intelligence, and Praxeology. It is a higher level of the development of multimedia technology, with intuitiveness, interaction and immersion. Virtual reality can bring a better user experience, thus providing a great help for a better understanding of the world from the macro and micro perspective [1].

Virtual simulation experiment is an important application of virtual reality technology in the field of education. In the process of experimentation, the

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A personalized virtual reality terminal device is a tool for students to interact with the virtual environment. Through their operation, students can complete the study of theoretical knowledge and the accumulation of practical experience. Combine their use in virtual simulation experiments, the devices can be divided into the following four categories: PC, 3D desktop, head-mounted display and mobile phone.

With the rapid development of virtual reality technology, terminal devices have also become increasingly diversified. This makes experimental teaching more flexible in the choice of educational equipment. However, with the increase in options, it also brings some confusion to the institutions. How to choose the appropriate personalized terminal device to maximize the advantages of virtual simulation experiments and enable students to obtain the best learning experience, this is an urgent problem to be solved. This paper proposes five educational characteristics of student experience, cultivation of interest in learning, knowledge acquisition efficiency, hands-on capacity building, innovative ability training. The features of these four terminal devices are summarized and compared around them, providing a guidance for device selection problem.

LITERATURE REVIEW

The education characteristics of four typical personalized terminal devices in virtual reality have been studied by scholars at home and abroad. The virtual reality system using PC as the main device can fully stimulate the interest of students in the demonstration experiment and make up for deficiencies in real experiments [2]. In the field of practical teaching, the scene created by PC provides a more humanized and interesting practice process, which is conducive to mobilizing students' non-intelligence factors. At the same time, it can be repeated by several times, and can obtain feedback information in time to understand the effect of practice quickly, thus making it possible for student to adjust their design [3].

The application of 3D desktops in the field of education involves the use of graphics, physical demonstrations, controls, and operations to illustrate relevant concepts. Its main purpose is to serve education rather than emphasizing immersive[4]. A virtual reality platform based on a 3D desktop generally uses an input method which is more interactive than PC’s, helps students to immerse themselves in the virtual 3D world for learning. Today, colleges and universities in all states in the United States have introduced the latest 3D desktop devices. The interaction between students and teachers, students' collaboration skills and hands-on capabilities have all significantly increased [5].

The head-mounted display has a function of stereoscopic audiovisual presentation and uses head motion tracking technology, enabling students to have a strong sense of immersion. It can help students interact with computer more natural and personalized, obtaining the best learning experience. But the head-mounted display needs to be connected to a high-performance host computer. The overall cost high, and it requires a certain amount of space when used [6].
Mobile phones have the advantage of networked transmission that is not limited by time and space. It is different from traditional media in that it disseminates rich information content and can carry out two-way interactive practical dissemination and personalized information dissemination. This approach can extend the education platform, enhance classroom interaction and meet the common use of students in ordinary classrooms or laboratories. Although it has not been used on a large scale in the current experimental teaching process, it still has broad prospects [6].

With regard to the educational characteristics of virtual reality personalized terminal devices, some articles have already mentioned some viewpoints. However, there is no one that specifically describes it. On the basis of the current research, this paper will horizontally contrast the indicators and summarize the application scenarios of various terminal devices, in order to guide the selection of device in the virtual experiment teaching process.

PERSONALIZED TERMINAL DEVICES OVERVIEW

The personalized terminal device refers to an equipment mainly for students to operate independently. The four types listed in this paper are all personalized terminal devices. Using it in experimental teaching is conducive to exerting students' subjective initiative and cultivating their creative thinking.

The technology of using PC to simulate has been widely used in the teaching process of virtual simulation experiment. When using a PC for experiment, students only use keyboard and mouse as interactive tools, the computer screen is used as the window to observe virtual world. Most PCs support Windows systems and are based on the web [7].

The 3D desktop is a higher representation form of the desktop virtual reality system. Unlike the PC which can only display two-dimensional images, it adopts a three-dimensional user interface and is equipped with auxiliary devices such as stylus pen to place objects on the screen, connecting the virtual world and the real one. The core technology is high-fidelity stereoscopic display system, low-delay tracking system and the corresponding software system, common auxiliary devices include stylus and stereo glasses [8].

The head-mounted display is equipped with two displays near the eyes. The built-in position tracker can detect the position and direction of the head in real time. The computer can draw scenes from the current perspective on the display based on real-time location information [9]. The typical head-mounted display can be divided into external helmet display, mobile terminal display and VR integrated machine. They are all equipped with VR handles and a high-performance computer. The device commonly used for teaching is external helmet display such as HTC vive and Oculus Rift [10]. Through this kind of device, student can observe the virtual world from all angles and perspectives and completely immersed in the it to operate on virtual items [11].
In the field of virtual simulation experiments, mobile phone also play an important role. In the teaching process, students need to bring their own mobile phone that meet the configuration requirements, and if necessary, install corresponding APPs.

As these devices are all related to virtual reality, they have "3I" characteristics (Immersion, Interactivity and Imagination) as their inherent attributes. Because the "learning—creating—relearning" process requires continuous design and verification experiments which are most convenient in the PC environment, so PC is the best in terms of imagination. Head-mounted displays perform best in immersion and interactivity. The virtual object operated by students in this way are closest to the real one, and the operations performed are most closely related to the actions in the real world. The "3I" characteristics of the four types of terminal devices are shown in Table I.

**ANALYSIS OF EDUCATIONAL CHARACTERISTICS OF PERSONALIZED TERMINAL DEVICES**

This section will focus on the five characteristics shown in Figure 1.

![Figure 1. Five educational characteristics of devices.](image)
### Table I. Summary of "3I" Characteristics of Four Terminal Devices.

|                  | Immersion | Interactivity | Imagination |
|------------------|-----------|---------------|-------------|
| PC               | Normal    | Normal        | Strongest   |
| 3D Desktop       | Strong    | Strong        | Strong      |
| Head-mounted Display | Strongest | Strongest    | Normal      |
| Mobile Phone     | Weak      | Weak          | Weak        |

### Student Experience

The head-mounted display has a strong sense of immersion and interaction, can provide students with the most realistic experimental scenes, restore the most realistic operating experience, and can break through the limitations of space. It has outstanding features in some experiments that require students to walk around. In a word, it can provide the best learning experience for students.

The 3D desktop is a relatively new application in education industry. It produces visual effects and interactive features that can give students a certain degree of novelty and enhance their interest in learning. At the same time, the 3D desktop provides a "one-man operation, multi-person collaboration" learning mode, which can provide a great learning experience.

Using a PC can take advantage of its highly conceived features to achieve the goals of early validation. Besides, the students are relatively familiar with the operation on PC. But its immersive feeling is not high enough to give students sufficient sense of novelty. In general, the learning experience for students is ordinary.

Due to certain disadvantages in immersion and interactivity, it is difficult for students to have a strong sense of reality when using a mobile phone to conduct experiments. The more common situation is to use them to carry out demonstration experiments. Relatively speaking, students' experience is not as good as the previous ones.

### Cultivation of Interest in Learning

The germination of the interest in learning often stays on the surface of things or phenomena. It depends to a large extent on the external features of stimuli. In the formation stage, it mainly depends on the students' purposeful cognitive processing of learning tasks. The development and improvement of the interest requires students to internalize knowledge and use them creatively [12]. Because the novelty of PC is not high enough, it is not effective in terms of germinating interest, but its advantages on imagination can help students improve and develop them, making up for the deficiencies of the previous stage. In general, PC’s ability to cultivate the interest in learning is ordinary.
Due to its novelty, the 3D desktop has certain advantages in the germination stage of interest, students can form better interaction with the experimental subjects, and more profoundly understand the characteristics of objects on the microscopic scale. In the stage of improvement and development of interest, the 3D desktop provides students with a good condition for the creative use of knowledge, and improves students’ interest in learning better than PC.

The use of head-mounted displays can fully stimulate students’ interest in learning in the early stage. The description of the virtual world is the most specific in this way to help students to establish the understanding of the entire system in the process of macro experiments. In the formation stage of interest, students can also be given strong support, and the cultivation of students’ interest in learning is most effective.

Since the display of the mobile phone is weaker than the other three, it has a certain disadvantage in the stimulation of interest, and only if the experimental content is properly set, the mobile phone can play its advantages of unlimited use time to help students form and develop interest in learning. They have poor results in the areas of interest.

Knowledge Acquisition Efficiency

Using PC can effectively control the teaching cost. In the situation where domestic colleges and universities generally adopt large class teaching, more students can perform experiments within the same period of time. At the same time, students spend less time adapting to the virtual environment and getting familiar with basic operations. In a word, PC can acquire theoretical knowledge with the highest efficiency.

The knowledge acquisition efficiency of the 3D desktop is lower than that of the PC. The first reason is the limitation on the number of equipment. Because of its higher cost, it cannot meet the needs of all students, the device needs to be used in turn so that each student's usage time is affected. Secondly, the operation on a 3D desktop is more complicated, students need more time to adapt, which also imposes higher requirements on the ease of use of the device.

Compared with PC and 3D desktop, the cost of head-mounted display is higher, which means that under the same conditions, fewer students can fully participate in the experiment. The operation of the headset is also the most complicated. In order to avoid the occurrence of physical discomfort such as dizziness after long-time operation, the time for students to conduct experiments is limited so that the efficiency of using this method to obtain knowledge is ordinary.

Mobile phones can provide a longer learning time and students are also familiar with related operations. However, due to the limitations of hardware, the information that mobile phones can present is limited. It displays teaching content in a relatively simple way. The knowledge acquisition efficiency of mobile phones is lower than that of PCs, but still higher than head-mounted displays and 3D desktops.
Hands-on Capacity Building

After doing a demonstration experiment with a certain theoretical basis, the operational experiment pays more attention to the cultivation of students' hands-on abilities. The advantage of PC is that the experiment can be repeated quickly and easily, but in the experiment which requires accuracy, it is less capable of developing hands-on capabilities than 3D desktops and head-mounted devices.

Head-mounted displays do the best in cultivating students’ hands-on abilities. In the building of hands-on capability, the head-mounted display performs the closest operation to the actual one. It is the best form of transition between theoretical study and practical operation.

Although the immersive feeling is not as good as the head-mounted display, there is also a great relevance between the operation on the 3D desktop and the actual one. The 3D desktop is stronger than PC in the cultivation of hands-on capabilities, in particular, there will be a very big advantage in the experiments that require accuracy.

Due to its lack of hardware support, mobile phones can only build relatively simple experimental scenarios and it is difficult to provide students with a real operating environment. The training of hands-on capabilities is the weakest.

Innovative Ability Training

Because PC can provide the strongest imagination, it can help students achieve their new designs and ideas early. It has outstanding advantages in the cultivation of innovation ability.

The 3D desktop is less conceivable than the PC, so it is relatively weak in the training of innovation ability. However, if the team collaboration can bring advantages to the experiment, the 3D desktop can also cultivate students’ innovative ability effectively.

Due to the limitations of popularity and usage time, the head-mounted display performs less well than PC in verifying students' new ideas efficiently, and the high cost of content development limits the diversity of functions and support students less in terms of innovation.

Due to hardware limitations, it is difficult for mobile phones to provide rich simulation resources in various forms and functions, they cannot build a very mature environment for the cultivation of innovation ability.

In summary, the educational characteristics of the four types of terminal devices are shown in Table II.
TABLE II. SUMMARY OF THE EDUCATIONAL CHARACTERISTICS
OF FOUR TERMINAL DEVICES.

|                      | Student Experience | Cultivation of Interest in Learning | Knowledge Acquisition Efficiency | Hands-on Capacity Building | Innovative Ability Training |
|----------------------|--------------------|-------------------------------------|----------------------------------|---------------------------|----------------------------|
| PC                   | Ordinary           | Ordinary                           | Best                             | Ordinary                  | Best                       |
| 3D Desktop           | Good               | Good                               | Ordinary                         | Good                      | Good                       |
| Head-mounted Display | Best               | Best                               | Ordinary                         | Best                      | Ordinary                   |
| Mobile Phone         | Bad                | Bad                                | Good                             | Bad                       | Bad                        |

CONCLUSIONS

In the course of development in recent years, virtual reality technology has gradually demonstrated its enormous potential for development and broad application prospects in the field of education. How to use it more effectively in experimental teaching will be a challenging topic. In the face of constantly updated related technologies and terminal devices, we should not blindly pursue the forefront, but fully consider its pertinence and applicability to make reasonable choices.

This paper proposes five educational characteristics of personalized virtual reality terminal devices, combines the use of each one in the practical teaching process, summarizes and compares their performance on the five indicators, provides a reference for terminal device selection of virtual simulation experiments. The institutions can combine their actual needs with the conclusions of this study to make reasonable and scientific choices. It can complement the real-world laboratory and give full play to the advantages and value of virtual simulation experiments.

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