The applications of virtual reality technology in medical education: a review and mini-research

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Abstract. Virtual reality (VR) technology has attracted great concern in computer science. As a cutting-edge computer simulation system, VR technology has undergone great development in scientific research, education and our daily life, etc. Herein, the development, characteristic, applications and potential limitations of VR technology was reviewed, especially, the applications of VR technology in medical science and professional education were highlighted. Moreover, a mini-research was carried out to study the teaching outcomes brought by VR technology from questionnaires. According to the results, it can be deduced that VR technology can solve the common problems in Chinese medical education.

1. Introduction

Virtual reality (VR) is a multi-informational, three-dimensional simulation system [1], and VR technology is a hot issue among the computer simulation technologies since it can simulate the virtual world and bring in the visual impact. Due to the immersive of VR technology, user may feel like they are in the reality when they experiencing the virtual environment. With the development of VR technology, it has been used in many fields [2-5]. Up to date, there are some studies about the introduction of VR technology in teaching abroad. However, to the best of our knowledge, there is few papers concerned on the applications of VR in medical education especially in China.

In this paper, the development, characteristics, potential limitations of VR technology were reviewed. Furthermore, a mini-research based on the teaching effect of VR technology for Chinese medical students was carried out, and the future developing orientations of VR technology in medical education for Chinese students was proposed.

2. Development history and characteristics of VR technology

VR technology was first proposed by Jaron Lanier, who was known as the “father of virtual reality” [6]. Virtual Program research (VPL research) was the first company, which made and sold the VR devices to the world. The complete set of VR devices was sold almost 50000 dollars. Owing to the high price, this set of VR devices did not open the channels to mass market, though it included all the hardware and software [7]. From1987 to 2014, Nintendo in Japan, HTC in China, and Google in America launched VR devices that made VR devices come into commercial products. But different companies had company-specific Research and Development (R&D) standards in software, and hardware designed in different companies mismatched each other. Users had to spend much to experience all the VR devices. The Global VR Association was formed by the cooperation of Oculus,
HTC, Samsung, Google, Acer and Sony in 2016, aiming to unify R&D standards, share experience in developing and unlock VR’s potential [8].

With the development of VR technology, this multi-informational and three-dimensional simulation system, great advances have been made in its character of imagining, interactive and immersive [1]. Laws of motion in Physics are applied in the virtual environment, and users will feel that all the virtual objects are around them when they are in the virtual environment. Besides visual perception, auditory perception, tactile perception, even olfactory perception can also be experienced in the virtual environment. Users can operate the objects and get feedback from the virtual environment simultaneously. Therefore, users can be completely involved in the virtual environment, just like all the surroundings including themselves are in the reality [9, 10].

3. Applications and limitations of VR technology in medical field

Due to the peculiarity of VR technology, it has been used in many fields such as games, medical treatment, architecture and emergency drilling [2-5]. In medical field, there are some cases about the applications of VR technology in clinical treatment and medical education around the world. A virtual reality simulator for laparoscopic surgery (MIST VR) can help surgeons with an improvement in efficiency and a reduction in errors [11]. It is effective to use virtual devices in medical and health science education through the study made in Bond University [12]. Colon carcinoma radical operation by using VR technology has been successfully completed in Ruijin Hospital of Shanghai Jiao Tong University. Doctors who cannot get to the scene can watch both the operation and views in laparoscope to learn skills and considerations in the operation by VR technology [13].

In medical education, there are several subjects using VR technology assisting teaching at present, for example, radiotherapy, emergency medicine, surgery and nursing [14-17]. Though there is no case using VR technology in animal experiments, some relevant software is being developed [18]. Radiotherapy, emergency medicine, surgery and nursing are all related to skill training, both the abilities and confidence of students can be improved after training by VR technology. As a consequence, VR is quite suitable for professional skill training. However, the applications of VR technology in medical education is still at the initial stage in China, and it is important to learn from famous university abroad, and some details should also be taken into consideration. For example, some experiments in medical imaging physics are not open to students due to the radioactivity. The way to solve this issue is adopting simulation experiment instead of traditional experiments in domestic medical universities. As a result, students cannot “touch” the equipments and the learning effect and interest are undesirable. The emergence of VR technology provides the possibility of changing this situation. VR environment makes users have a genuine sense of immersive. It brings us inspirations that the successful implementation of virtual environment for radiotherapy training (VERT) system at the University of Sydney. VERT system was adopted in medical physics education as an addition to traditional lessons. The system offered students the chance to learn knowledge and improve skills in an interactive, risk-free radiation therapy environment. Based on the students’ feedback, VERT system was considered as a useful learning tool. VERT system was found to provide a more relaxed environment and help students to have a deeper understanding of complicated issues [14]. Meanwhile, there is no limitation of space by using VR devices. A computer, a pair of VR glasses, a pair of gloves and hand gesture recognition are enough.

Even though VR technology may solve the problems in medical education, there are still limitations as follows: 1. The cost of a complete set of VR hardware which can assist teaching is about 30000 RMB. Software for teaching needs to be purchased separately. It requires massive capital investment and funding from the government [19, 20]. 2. Nowadays, VR teaching software is still in the development stage. Most software have quality problems, such as definition and contrast [20]. Besides, different companies have company-specific R&D standards. There may be mismatching situation between teaching software and hardware [8]. Due to lack of standards for selection, teachers are ought to evaluate several software in order to choose the best one to guarantee good teaching effects. 3. There is still difference between virtual environment and reality, for example, depth of field. The adaptation process is needed, especially for the students who have heart disease, hypertension and
claustrophobia. In addition, using VR devices for a long time may also cause visual fatigue or dizziness. Student should stop using it when feeling uncomfortable [5, 20].

4. Mini-research
The acceptance and wishes of students are also of great importance for medical education. Herein, we designed a questionnaire for the medical imaging students to investigate the teaching and learning effectiveness through the introduction of VR. The details of the mini-research are as following.

85 students majoring in imaging took part in this research. 84 completed questionnaires were returned. Students were requested to rate the expectations, helpfulness and effectiveness of VR devices using in teaching on a scale from 1 to 5, with score of 1 showing no and a score of 5 showing strong. The questionnaire suggested that most students desired that VR devices would be applied in teaching. The mean score by students who used VR devices as a useful teaching tool was more than 4. The score statistics were given in Table 1.

Table 1. Students’ attitude towards using VR devices in teaching.

| Questionnaire (n=84)                                      | Mean | SD   | Median | Rang |
|---------------------------------------------------------|------|------|--------|------|
| How would you rate your expectations of VR devices using in teaching? | 4.51 | 0.66 | 5      | 3-5  |
| How would you think the helpfulness of understanding key points by using VR devices in teaching? | 4.86 | 0.52 | 5      | 3-5  |
| How would you think the effectiveness of improving skills by using VR devices in teaching? | 4.39 | 0.62 | 4      | 3-5  |

Comments were positive. As following:

“I really expect I can experience VR devices in learning; I think it can help me have a better understanding in difficulties. I also suggest that VR devices can be used in combining clinical cases and experiments.”

“I think using VR devices can enhance the learning interest of students greatly, I hope VR technology could be used in both lecture and experiments as soon as possible.”

5. Developing orientation
VR technology can make up for the shortcomings of traditional education. As for medical education, there are two promising developing orientations, i.e., the combination of VR and augmented reality (AR), and the combination of VR and artificial intelligence (AI). It is a typical example that three-dimensional anatomy atlas published in People’s Health Publishing House. Students can acquire three-dimensional models though client-side scanning by using smart phones [21]. It is very easy for students to learn anatomical knowledge by using AR technology. In addition, there is a case showed that combination of VR and AR technology applied in dentistry [22]. Some improvement can also be done to make a deeper fusion of VR and AR to advance both advantages.

Besides, some advices and worries in the questionnaire can also give us some ideas. Some students think that learning efficiency may be improved if additional training should be considered for the weakness. If VR and AI can combine with each other, it is easier to achieve this goal. For one subject, AI system can record the number and analyze the behaviors of students after learning. After analyses, the AI system can provide additional corresponding training for the student to ensure teaching effectiveness. At beginning of the next class, AI system can help each student to review the weakness respectively. Teachers can also get the data analysis and statistic of different classes for AI system. According to different classes, teacher can adjust the teaching process in order to teach students in accordance with their learning bases. By studying the cases that using VR technology in medical education, the VR technology will be suitable to an increasing subjects. AI system can make
multidisciplinary cross-analysis depending on student’s situation. It can provide individualized review plan to realize personalized service. AI system can also give some advices to different students to help them become more confident in overcoming difficulties before the entry of hospitals.

6. Conclusion

VR technology has made certain contribution in clinical treatment and medical education, and it can be applied as a valuable addition to traditional education and can assist in skills training. It is a trend that the further integration of VR technology, cloud computing and big data to realize the mutual development of information technology and modern education. The modern teaching mode, which is student-oriented, modern information technology-based and teacher-assisted, may come into being. And we believe that VR technology will have a better future if designers can overcome the limitations and develop it according to different purposes.

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