Practical application of virtual reality technology in education and rehabilitation of autistic children

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Abstract: The prevalence rate of autism is still on the rise. The education and rehabilitation of autistic children is becoming a focus of social and livelihood concern. The poor quality of rehabilitation services and the serious shortage of teachers are the two most critical problems in the education and rehabilitation of autistic children. To solve these two problems, the combination of digital technology such as virtual reality technology with special education and rehabilitation intervention is not only an effective strategy, but also a development trend, worthy of attention and more efforts to promote.

Key words: Virtual reality technology, autistic children, special education, children's rehabilitation

1 Introduction

UN Sustainable Development Goal 4 focuses on ensuring inclusive and equitable quality education, including ensuring "equal access to education and vocational training at all levels" for persons with disabilities, and establishing and improving educational interventions that address the needs of persons with disabilities and "provide inclusive and effective learning environments for all". Autism is a kind of neurodevelopmental disorder that seriously endangers the physical and mental health of children. The disability rate is very high, and most of them need lifelong support. According to a report on the website of the World Health Organization (WHO), there are about 76 million autistic children in the world [1], and China's Autism Industry Report estimates that there are more than 10 million autistic people in China [2]. There are still many problems to be solved in the education and rehabilitation of this group, and high-quality integrated education and rehabilitation services for autistic children and adolescents should be provided. It is not only needed for high-quality development of special education, but also one of the livelihood issues to be addressed in the 14th Five-Year Plan. It echoes the United Nations Sustainable Development Goals and has become an important consensus of governments around the world.

2 Literature Review

2.1Autism and its problems in education and rehabilitation

Autism , full name of autism spectrum disorder (ASD), is a kind of extensive developmental disorder of the

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https://doi.org/10.37420/j.cer.2022.047

nervous system that occurs before the age of 3 [3]. Its core symptoms are social interaction disorders, rigid behaviors and narrow interests. The cause of ASD is still unknown, but the prevalence is on the rise. The World Health Organization (WHO) reported a prevalence of 0.64%, and the Centers for Disease Control and Prevention (CDC) of the United States released the latest prevalence rate of autism as high as 2.3% (1/44) [4], which is 24% higher than the prevalence rate of ASD published in 2020 (1/54). In December 2007, the United Nations General Assembly adopted a resolution, starting from 2008, April 2 every year as the "World Autism Awareness Day", to raise awareness of autism and related research and diagnosis, and people with autism.

The cause of autism is still unknown, there is no cure for the disease, mainly rely on special education and rehabilitation means to intervene, most of the disorders may last for life, children difficult to integrate into society. Continuous and professional education and rehabilitation support can help children with autism better recover their function, adapt to society and play their own value. However, due to the large heterogeneity of ASDs, increasing prevalence and different development levels in different countries, there are many problems in the education and rehabilitation of ASDs, among which the most prominent problems are two aspects. First, the education and rehabilitation of autistic children are not professional and normative, and the quality of rehabilitation education is not high. Second, there is a serious shortage of teachers for autism education and rehabilitation, which cannot meet the needs of society.

One of the biggest demands of parents of autistic patients is to improve the quality of education and rehabilitation. Autism starts in infancy, and the golden intervention period is 3-6 years old. At this time, the plasticity of the nervous system is large, and high-quality intervention plays a key role in the prognosis of autistic children. There are great differences between individuals with autism. Currently, autism education and rehabilitation lacks professional standards and standardized procedures, and teachers' intervention behaviors lack consistency, which has a great impact on the quality of rehabilitation education. On the other hand, there are many education and rehabilitation methods for autism, but only 28 methods with evidence-based support [5]. There are still a large number of unproven methods used in clinical practice, which not only delays the precious recovery opportunity, affects the recovery effect, and even causes secondary damage to children.

In terms of teacher training, the quality and quantity of professionals cannot meet the needs of society. Autism belongs to the group of mental development disorders, which has been increasing rapidly in the past 20 years. The number of traditional disabled children (such as deafness, blindness and physical disorders) has been decreasing, and the current special education personnel training system is still aimed at traditional disabled children. There is a serious shortage of professionals for educational intervention of mental disorders such as autism [6]. On the other hand, the training of autism education intervention professionals requires a lot of practical training. Most colleges and universities are unable to have practical training conditions, and the training of professionals can only be based on theory, paper, or imagination. The training of professionals is difficult to meet the requirements of autism intervention institutions.

2.2Virtual reality technology and its application in the education and rehabilitation of autistic children

Virtual reality technology (VR) is a modern high-tech technology with computer technology as the core to

generate a realistic virtual environment integrating visual, auditory and tactile sensations. Users interact and influence objects in the virtual environment with the help of necessary equipment, thus generating immersive feelings and experiences [7]. It is a system reality technology of multi-source information fusion, interactive 3D dynamic view and entity behavior. Virtual reality technology has the characteristics of immersion, interaction, authenticity and perception [8], making teaching methods more interesting, interactive, intelligent and personalized.

VR technology can be divided into three categories according to immersive experience, namely, immersive, non-immersive and semi-immersive [9]. Immersive VR system is the most common and most widely used. Trainers need to wear head-mounted display (HMD) or other forms of display equipment. Combined with data gloves or tights, visual, auditory and tactile transmission to the experiencers, creating an immersive experience; In non-immersive VR systems, users directly manipulate the keyboard and mouse to give feedback in the face of 3D environmental stimuli. Semi-immersive VR systems use large-screen displays with higher display rates, projectors, or multi-level high-performance graphics computing systems to provide better immersion than non-immersive systems.

In recent years, in the field of education and rehabilitation of autistic children, the application of digital technology has become a trend. The application of virtual reality technology (VR) in the education and rehabilitation of autistic children has become a hot research topic at home and abroad, showing a broad application prospect. In the field of autism education and rehabilitation, VR applications mainly include curriculum construction, education and rehabilitation intervention, professional personnel training in colleges and universities, and autism intervention effect evaluation. According to the characteristics and training objectives of ASD children, education and rehabilitation professionals write scripts that meet the technical requirements, and VR technicians design them into VR courses. Such courses can involve the cognition, life, movement, perception and emotional behavior training of autistic children. VR courses are rich, intuitive and interesting. Designed VR courses, targeted training is carried out on professional VR equipment. The training has good repeatability and consistency. The immersion experience of ASD children can improve various functions, and lay a good foundation for self-care, school learning and community integration. Universities establish VR training rooms and develop ASD models, which are rich, intuitive and interactive, enabling students to quickly recognize the characteristics of autism and master the skills of interacting with ASD children, greatly improving the training efficiency and quality of professional talents, and alleviating the serious shortage of talents for autism education and rehabilitation.

Behavioral training is the main strategy for intervention and treatment of autism, which can rapidly enhance children's ability to integrate into society. However, behavioral training for children with autism has certain limitations in time and space, such as high requirements, large teacher-student ratio, low efficiency and benefits, which cannot bring real scenes to patients, make them tired and uncooperative, and affect the effect of educational intervention. Using virtual reality technology to highly restore the field environment to train autistic children can effectively enhance the training effect. For example, Adjorlu et al. [10] used virtual reality technology to train children with autism in their shopping skills. After training, it was found that children with autism had significant differences in the speed, accuracy, self-confidence and other aspects of completing shopping tasks in real supermarkets compared with children without training.

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https://doi.org/10.37420/j.cer.2022.047

Virtual simulation training system is a world simulation system designed based on the three basic characteristics of virtual reality technology: immersion, interactivity and conception. The whole system is composed of three parts: simulation client, server and management system. The system server provides communication services for the client and has a 3D scene simulation function system, which is used to store system resources and student data, network communication and the core functions of the scene imitation system. The client provides visual simulation and interactive interfaces for students. Students interact with virtual scenes through interactive integrated devices, in which visual system devices realize the presentation of virtual scenes. All scenes are modeled and set up according to scenario schemes and modeling standards. The user obtains real physical feedback through direct operation in the scene, and transmits sensing data to the model system. The model subsystem keeps the data synchronized with the server. Finally, the school can complete the unified management of data and training tasks through the management system.

It should be emphasized that for VR technology to play a full role in the field of autism education and rehabilitation, multi-party collaboration is needed, including VR professionals, education and rehabilitation professionals, and participatory leaders as education administrators. Participatory leadership has clear professional and organizational advantages in this field. The integration of professional, policy and social resources by participatory leadership can improve other participants' access to resources [11] and ensure the orderly organization, implementation and management of projects, thus playing an important guarantee and leading role.

3 Discussion

3.1Practical application of VR in the education and rehabilitation of autistic children

3.1.1Research and development of VR autism Education and Rehabilitation series courses

Curriculum is at the heart of autism education and rehabilitation. In practice, any course can be VR. VR course design requires the cooperation of autism education and rehabilitation professionals and VR technicians. For professionals, script writing and related course materials should be provided, including three aspects (tasks) : (1) Professional teachers should write task scripts according to the course of autism education and rehabilitation; (2) Professional teachers should write contingency scripts based on their experience with ASD children, such as what kind of stress response autistic children will have under what circumstances and how to comfort or guide their behaviors; (3) The teaching platform requires professional teachers to put forward specific requirements according to the teaching plan. The training content of the course can be involved in various functional areas of education and rehabilitation of autistic children, such as perception, motor, life, school, language, social, language, emotional behavior, etc. From a professional perspective, a complete training content requires a professional to provide scenario models, scripts and operational flows, and voice text.

According to the script, virtual simulation technology is used to display scenes that cannot be carried out and have potential security risks through 3D human modeling, animation and voice display, so as to highly restore the scene environment and improve the training effect [12]. At the same time, once the scene is realized, it can be repeated, and through repeated deployment, students can not be restricted by time, space and scene,

which greatly reduces the consumption of resources, and reduces the impact of education and rehabilitation training for autistic children on real normal social activities. Based on the development needs and physical and mental characteristics of autism, combined with the curriculum design and professional knowledge of the school, a series of virtual reality simulation scenarios within the system are introduced and designed to assist the implementation of rehabilitation education, and a series of precise education rehabilitation curriculum system is formed. For example, virtual simulation behavior intervention, social interaction, self-care, classroom behavior intervention, cognitive and behavioral ability improvement and other courses for children with autism. With the implementation of such courses, children can interact in a virtual environment, establish daily communication and simulate the real situation without causing negative effects [13], which is easy to be accepted by children and improves the training effect.

3.1.2 Research and development of VR autism model and professional talent training series courses

Based on the typical characteristics of autistic children and combined with VR technology, an autism model is constructed to form a teaching situation simulation system for autistic teachers, which can effectively make up for the urgent need for practical practice in the training of autistic teachers. Based on core professional knowledge and skills, teaching courses are designed, VR teaching resources are developed, and virtual situations of problem behaviors and intervention measures for children with autism are established, highlighting teaching priorities and forming multi-dimensional impressions, so as to provide students with a new learning environment combining theory and practice, and help theory to be transformed into practical experience.

Modeling VR autism is a dynamic and continuous process. First of all, it is necessary to accurately grasp the physical and mental characteristics of children with ASD, present the core symptoms, related symptoms and derived symptoms one by one, and at the same time, improve the model through continuous use of big data until the complete characteristics of ASD patients in virtual situations are fully reflected. On this basis, the training of teachers with autism can be divided into three levels of research and development courses. The first is the cognitive course on autism, the second is the practical course of intervention methods based on learning autism, and the third is the prospective course combining scientific research and practical training. In addition, the use of the model breaks the restrictions of time, place and object, solves the problems of autistic children who cannot be directly contacted by students during the teaching period, and improves the teaching efficiency, repeatability and participation of students. The experimental teaching platform of colleges and universities established with virtual simulation technology is the trend of future experimental education reform and the urgent need of applied talents training of colleges and universities [14].

Increasing the intensity and speed of professional personnel training is a crucial factor for the development of autism education and rehabilitation. The state has implemented the three-stage special education promotion plan, which all mentioned that it is necessary to promote and encourage normal colleges to open special education majors. There are many restrictive factors for the training of talents for autism education and rehabilitation, one of which is insufficient training conditions. The emergence of VR autism model, with its intuitiveness, interaction and immersion, not only solves the shortage of practical training subjects, but also avoids the ethical problems of experimental subjects, and effectively improves the speed and quality of professional talent training.

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3.1.3 Evaluation of practical application effect of VR in education and rehabilitation of autistic children

Autism education and rehabilitation intervention is affected by many factors, resulting in inconsistent or unstable effects. Effect evaluation is an integral part of autism education and rehabilitation. Through evaluation, it is not only necessary to understand the quality of intervention, but also the basis for intervention programs. In the practical application of VR in the education and rehabilitation of autistic children, users can get rid of human intervention to the greatest extent during the systematic training. On the one hand, various kinds of sensors are used to collect performance parameters of students or users. Through quantitative assessment criteria, objective assessment of training results of students or users can be obtained, so as to get rid of the assessment deviation caused by subjective factors such as teachers' experience, improve their skill level, and form a non-human intervention assessment evaluation system based on objective data. On the other hand, based on big data acquisition and analysis, it is of great importance to carry out the research on the characteristic data acquisition technology for the training system, obtain the key characteristic data for the status analysis of students, and realize the all-round and objective investigation of students, which is of great importance to the establishment of the system assessment criteria [15]. Through data analysis, the common problems and personality problems existing in the operation of students or users at all levels are understood, and the application effect and pertinence level of VR technology in autism education and rehabilitation are evaluated. According to the evaluation results, it is decided whether to adjust the course plan, so as to improve the overall effect of rehabilitation education.

The application of VR in effectiveness evaluation is divided into three parts. First, on the basis of evaluation, curriculum plan setting and operation specifications, including intervention time and frequency; The second is the data collection of the intervention process, the response, accuracy, cooperation of the intervention object, and the task passing rate; The third is to analyze the collected data, compare it with the course plan and operation standard, evaluate the intervention effect, predict and adjust the intervention intensity and frequency. Meanwhile, according to the data analysis, it is also the objective basis for whether the rehabilitation course plan needs to be adjusted. The application of VR in the evaluation of autism education and rehabilitation improves the effect of accurate rehabilitation. More importantly, it eliminates subjective speculation and standardizes rehabilitation education, which has important theoretical and practical significance for the sustainable effect of education and rehabilitation for autistic children.

3.2 The unique role of participatory leadership in the application of VR to autism education and rehabilitation

Participative leadership refers to the role in the specific implementation unit that not only has decision-making and resource allocation functions, but also participates in the project work, so that each participant becomes one of the decision makers and improves the effectiveness of complex projects. The application of VR technology in the field of autism education and rehabilitation is a systematic project, which involves multi-party collaboration, requires the integration of professional and social resources, and requires participatory leadership throughout the whole process. Participatory leadership has professional and organizational advantages, allowing each member to better play their respective roles and play an important role in the guarantee and guidance of the project.

3.2.1 The role of education management

Educational management refers to the coordinated activity process of rational allocation of educational resources, which includes people, money, materials, time, space and information, so as to make educational activities run effectively and achieve organizational goals. The application of VR in the field of autism education and rehabilitation requires the support of education administrators. Participative leaders are usually the leaders in education management, playing a decision-making role in the application of new technologies, and playing a leading role in planning, project approval and resource allocation.

3.2.2 Organization and implementation function

The leadership style of participatory leadership is democratic. Superiors and subordinates are in an equal position and have a complete trust relationship. Problems are solved through democratic consultation and joint discussion among multiple parties. The application of VR in the field of autism education and rehabilitation is a systematic project. In the implementation, the support and organization of participative leaders are needed to ensure the smooth implementation of the project, and all the special education teachers, autism rehabilitation teachers and VR technical support personnel are required to participate in the operation system of the implementation of the project for joint consultation and discussion. It is helpful to grasp the direction of research and practice, solve related problems, and ensure the effective implementation of technology.

3.2.3 The effect of practice and promotion

The application of new technology in the field of education is a development trend. As a new technology, VR is applied in the education and rehabilitation of autistic children, which not only improves the quality of education and the benefit of education, but also promotes the protection of the right to education of autistic children. To give full play to these functions, on the one hand, we need to ensure the success of technology research and development, on the other hand, we need to popularize the successful technology. Practice promotion belongs to cross-field docking, which is the work that professional and technical personnel cannot complete. Therefore, participatory leadership will play a unique role in the practice and promotion of technological achievements, so as to give full play to the value of technological achievements.

4 Conclusion

The fifth chapter of the 14th Five-Year Plan for National Economic and Social Development and the Outline of 2035 Vision Goals of the People's Republic of China, titled "Accelerating Digital Development and Building a Digital China", clearly states that we should embrace the digital era, activate the potential of data elements, build China into a cyber power, and accelerate the building of digital economy, digital society and digital government. The transformation of production mode, lifestyle and governance mode is driven by digital transformation as a whole [16]. Virtual reality and augmented reality technology are the key industries of digital economy. VR is used in the education and rehabilitation of autistic children and the training of professional talents. It not only has a good development prospect, but also responds to the "accelerating digital development and building digital China". It will certainly promote the development of traditional education and rehabilitation industry to a new level, and promote the high-quality development of special education.

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https://doi.org/10.37420/j.cer.2022.047

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