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Virtual reality therapy in special needs education

From therapy to inclusion

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The Virtual Reality (VR) technology has become a part of our everyday lives. The VR systems allow the users to be directly involved in human-computer interaction. The Virtual Environment provides artificial sensory information, while Virtual Tools allow direct interaction from the users side. Virtual devices such as computers, smartphones, and interactive whiteboards often appear both in general and special education. Education and rehabilitation professionals also use VR systems in various fields. The aim of the study is to summarise the wide range of VR system applications in diversified areas of special education. Our literature review focuses on special education and rehabilitation, moving towards the context of inclusion. Based on the numerous research, applying VR tools to the educational field has been increasing year by year. In the early '90s, researchers began using virtual learning environments and they demonstrated that the application of virtual methods can be extended to behavioral therapies (relate anxiety), physical therapies (e.g. wheelchair simulators), and to develop cognitive performance (to develop attention) or social skills (learning to navigate community literacy). VR systems allow the possibility of providing continuous feedback and the opportunity for interactive learning and skill development. In the practice of special needs education, VR systems are useful in intervention, as well as monitoring, and evaluation. By using VR systems, users from any age group can be motivated. Furthermore, these systems apply their own natural semantics and can be used without spoken language or other conventional symbols. VR can promote education more accessible and differentiated for children with disabilities. This is one of the conditions for the effectiveness of co-education. The VR systems make no distinction between the users, on the other hand, users with special needs may require more adaptation or support in using VR. Hungarian professionals in the field of special needs education are also using VR tools, which offer opportunities to develop skills for independent living.

Keywords: virtual reality, special needs education, rehabilitation, inclusion

Virtual Reality and Virtual Environment

The development of Virtual Reality technology has come a long way since the 1960s when the first computer notepad, Sketchpad, was released. Its general application for common use has evolved since the 1990s and virtual reality has become a part of our everyday lives. All Virtual Reality systems are based on the same elements: environment, computer, user, sensory systems simulation, interaction, immersion experience, and presence (Bamodu, 2013). Numerous research reports that virtual games are gaining more and more ground, especially among young people. First, it is important to distinguish between two key phenomena in the field, Virtual Reality (VR) and Virtual Environment (VE) (Mintaze et al., 2014).

"Virtual Reality can be interpreted as an improved form of human-computer interaction that allows the user to be a part of and interact with the computer-generated environment. Reconstructed reality requires an active presence on the part of the user. The Virtual Environment provides artificial sensory information and allows the user to acquire real experiences" (Mintaze et al., 2014, p. 279). Moreover, Virtual Tools represent the tangible aspect of the system and allow direct interaction from the user side. For example, in a virtual tennis match against the computer Wii controller represents the tennis racket.

Virtual Reality systems

Virtual Reality therapy is now an existing concept (Massie, 2010). During the last decades, interest in the VR devices developed by multinational companies has been increasingly growing in the field of education and rehabilitation. Primarily, the devices mentioned above were developed for entertainment purposes. Parallel with this process, more and more professionals began to use them for teaching, development, and rehabilitation purposes. Initially, the therapeutic environment was adapted for applying VR tools, but nowadays VR systems are evolving according to rehabilitation needs.

Virtual devices can be categorized according to the purpose of the activity performed by them, as follows in Table 1.

Table 1

Fields of application of the most common virtual devices

GAME	LEARNING/STUDY	REHABILITATION
Nintendo Wii; Nintendo Wii Fit; Nintendo Wii Fit U	Nintendo Wii	Nintendo Wii; Nintendo Wii Fit; Nintendo Wii Fit U
Sony Eye Toy		
Sony PlayStation VR	Sony PlayStation VR	Sony PlayStation VR
		Pediatric Intensive Therapy System (PITS)
Xbox; Xbox Kinect	Xbox; Xbox Kinect	Xbox Kinect
		Interactive Rehabilitation Exercise System (IREX)

Virtual devices such as computers, smartphones, and interactive whiteboards often appear both in general and special education. Exergames, or active video game systems, have become an integral part of everyday education. “Exergaming is the combination of exercise and video games” (Bogost, 2007, cited in Di Tore, 2012). These systems allow the whole body to be involved in human-computer interaction and the possibility of providing continuous feedback and opportunity for interactive learning and skill development (DiTore, 2016).

VR systems exert their influence on body and mind. Education and rehabilitation professionals operate VR systems in various fields for improving movements and cognition. The classification, based on the affected field proposed by Galvin and Levac (2014) is shown in the following:

- Systems that require a straight posture;
- Systems that focus on whole body movements, as well as movement of lower and upper limbs;
- Systems that focus on the quality of movement and
- Systems that affect cognitive and motor relationships.

Games require a high degree of concentration, as the user observes a quasi-projection of real life on the screen. Users learn and improve skills by interacting with the virtual environment. This phenomenon applies to the use of all Virtual Reality systems. Learning in a virtual environment is based on both direct and indirect experiences. Here, direct individual learning is combined with the learning from others’ actions and their consequences. The latter is called observational learning and is a form of learning that is not based on the direct experience of an individual (Burke, 2010).

With direct and indirect experiences, VR provides an opportunity for variable practice and learning complex skills. Skills acquired in a virtual environment (VE) may be further applied in the real environment. During this process, previously learned skills promote performance in novel settings, a phenomenon called positive transfer (Anderson, 2000). Regarding motor learning, this process refers to the general application of practiced, learned movements in multiple situations (Censor, 2013). For example, the transfer of balancing skills acquired on the Wii Fit Balance Board to keep equilibrium during walking. While in the field of motor learning there are a number of methods to track transfer effects (Berencsi et al., 2016; Vámos et al., 2018), it is still complicated to assess how effectively we can transfer the variety of acquired skills to real-life settings (Levac, 2019).

Virtual Reality in special education

Virtual Reality systems have been used in special education for decades. The first Virtual Reality and Persons with Disabilities Conference was held as early as 1992. At this conference, people with disabilities and professionals from a wide range of disciplines were present. The aim of the conference was to share ideas and develop concepts on how Virtual Reality systems can be applied to special education (JEFFS, 2009).

In the early ’90s, researchers began using virtual learning environments to teach children with physical disabilities how to navigate a wheelchair (Inman, 1994, cited in Jeffs, 2009). From this time on, more and more researchers have become interested in the study of virtual learning environment in the field of rehabilitation. The first wheelchair simulators were designed as early as 1998 by Desbonnet, Cox, and Rahman, and then by Niniss and Nadif in the early 2000s (Jeffs, 2009). In these early stages of application in the field of rehabilitation, the thought that there is a need for Virtual Reality systems to focus on strengths already appeared (McCommas et al., 1998).

As early as 1998, North demonstrated that the application of virtual methods can be extended to behavioral therapies, such as those related to resolving anxiety. Virtual imagination and manipulation of the environment helped to solve certain phobias such as anxiety in a crowd, claustrophobia and fear of flight or height (Sik Lányi, 2006). By the late 20th century, professionals predicted that the Virtual Learning Environment would be common in classrooms and was expected to assist the building of the educational environment, promote research, development, and the use of creative applications (Jeffs, 2009). Decades later, we have witnessed the realization of this previously predicted process as educators are increasingly integrating virtual learning environments into classrooms by using more and more widgets and different games in education.

Application methods of VR in special education

The amount of research in the international literature that examines the relationship between Virtual Systems and special education is increasing. The categorisation of the systems is created according to areas of use, types of disabilities, and possible users. In most cases, unique human-computer interfaces are presented and these interfaces display reactive, animated models (Sik Lányi, 2006). According to proposals made by Sik Lányi (2006), Laufer (2011) and Jeffs (2009), we can briefly categorise the possible fields of application based on the type of disability, as can be seen in the following summary.

Sensory impairments: In a Virtual Environment, it is possible to support or reduce or remove some stimuli, e.g. visual or auditory information. An example is the AudioChile, which is a virtually-created environment developed for visually impaired or blind children for the purpose of exploring the city. Another similar program is MathsignerTM, a 3D-animated program for learning math or sign language.

Autism spectrum disorders (ASD) and mental disorders: In most cases, VR systems are used to practice social interaction and facilitate the use of social skills. Developed by Kellems et al (2020), the iAnimate Live project can facilitate the acquiring and usage of these critical skills. Their results show that the use of VE and virtual characters (avatars) is more cost-effective than traditional methods and suitable for the acquisition of social skills. Furthermore, it affects the quality of life.

Verbal and nonverbal communication, cognitive skills, and impulse control can also be developed in VR. Lorenzo (2013) used Immersive VR to develop social competencies and executive functions in ASD. Within the framework of the Autism Spectrum project, the users practiced social interactions such that of boarding a crowded bus. In the context of ASD, Parsons (2016) highlighted the use of VR in the field of measurement and evaluation. Furthermore, VR can facilitate learning and the generalisation of skills in the real world. Stone et al (2019) investigated the effect of online multiplayer games on social interactions. Their results showed that playing online games supports social interaction through speech, writing, and gestures.

Communication impairment and social disorders: For children with speech impairments, VR systems may help them practice communication situations via the augmentation or alternative usage of images and sounds. Some projects help to improve the social interaction of children with Down syndrome (Sik Lányi, 2006). For example, as a means of promoting active social interactions, an online environment has been created where anyone from the world can participate.

Attention deficit hyperactivity disorder and learning difficulties: In a recent study by Cheng and Lai (2020), the application of VR systems in education has been rated as fundamentally successful among this population. Here, the goals are to use these devices is to aid adaptation to the learning environment and improve learning performance. Different learning problems may require the use of distinct systems and technical solutions. An example is the Adjustable Virtual Classroom, in which teachers and students are presented virtually (in the form of avatars). This virtual environment models a classroom or a crowded room where the user can practice public speaking.

Multiple/severe disabilities: In this context, the distinguished components of using VR systems are fair usage flexibility and simplicity. In general, these programs are intuitive, have a high tolerance for mistakes, and require less physical effort. They are often used to develop social skills and learning to navigate community literacy (e.g., the comprehension of printed brand names on products). Additionally, the learning process is controllable and users have the option of repetition.

Intellectual disabilities: Among this diverse population, VR is basically used in the learning of three main areas: social skills, cognitive performance, and independent living. The limitation may be that these learned skills do not necessarily transfer to other areas. However, a number of studies have proven that individulas with intellectual disabilities are able to transfer the learned skills to real life (Standen, 2005). VR is also suitable for monitoring the learning process. In the case of intellectual disabilities, VR is convenient for practicing skills because no others are present as a pressurising or frustrating factor while learning a new skill. The other advantage is that users can make mistakes without experiencing any real consequences (Standen, 2005; Cheng & Lai, 2020).

Standen et al (2005) and later Sik Lányi et al (2006) present opportunities to develop skills for independent living, including a shopping simulation, food preparation, orientation, and road safety. However, understanding the use of devices could present some difficulties. Furthermore, handling these devices can be demanding due to oft-associated, fine motor difficulties.

Physical disabilities: Limited movement and limitation in the exploration of the environment may in turn affect spatial perception and orientation in children with physical disabilities. Since the '90s, these functions could be facilitated by wheelchair simulators. A lab environment in which the users practice with a joystick is another possiblility. In the field of motion development, the use of exergame systems is the most popular. Cooper and Williams (2017) authored six studies that appropriately documented the use of the Nintendo Wii in the education of children with cerebral palsy (CP) and basically concluded that this tool is suitable for balance training, although in their opinion long-term studies would be necessary to confirm this finding. In our research with paraplegic children, we also worked with Nintendo Wii Fit and the Wii Balance Board. During the daily therapy classes, we evaluated the effect of Wii games on balance. Based on the results, we found the tool potentially good for balance development in this population (Ardai & Vámos, 2016).

Other professionals applying similar tools also underscored the aforementioned positive results. In Ojeda-Castelo's research (2018), Kinect sensors were used since these are already validated development tools. They wanted to develop a game-like system that could be easily applied in special needs education for different disabilities. The goal was to develop an algorithm that recognizes the user and excludes the outside world. The algorithm with sensors is able to detect the user's skeletal system and joint position. Its forms of application in learning are very diverse. After a preliminary assessment, it recommends a program tailored to user needs (e.g. learning numbers or letters). The tool provides a new opportunity for interaction specifically for children with special educational needs. In terms of rehabilitation, the main advantage of this system is its availability for home training. It is also based on Microsoft Kinect and the application focuses on three main areas: physical difficulties with motion; posture (keeping the correct pose); balance and coordination. (Ojeda-Castelo, 2018).

Special considerations for use in special education

The previously mentioned devices (like Nintendo Wii or Xbox Kinect) play a prominent role in this field. These Active Video Game Systems are easily integrated into pedagogy and are suitable for teaching purposes (Cooper & Williams, 2017). Several research groups (Cagiltay et al., 2019; Cooper & Williams, 2017; Ojeda-Castelo, 2018; Kavanagh, 2017; López-Serrano, 2017) consider VR technologies to be potentially adequate in special education because they provide alternative interaction, fast response, advanced graphics, communication, and collaboration support. VR is also an appropriate choice in the case of learning difficulties as it helps to deal with associated challenges, such as a short attention span, low memory performance, the need for many repetitions, and frequent feedback.

Cagiltay et al (2019) demonstrates that VR systems may build bridges between school and at home application in multiple fields, such as (1) video games that help movement, kinaesthesia, (2) tablet and interactive whiteboard for practice (e.g., letters, numbers), and (3) smart devices that help in storytelling and communication. VR systems are also useful in intervention, monitoring, and evaluation and can be more manipulated than reality. Furthermore, these systems apply their own natural semantics and can be used without spoken language or other conventional symbols (Standen, 2005; Chadwick & Wesson, 2016).

Motivational factors

The alleged emotional impact of virtual reality (VR) and active video game systems (AVG) is a key marketing strategy. One aspect of the application of such systems in rehabilitation and education is the motivational factor (Rorhrbach, 2019). Computer games and smart devices have been popular below the age of 18 since the '90s. Sáringer (2010) reported that one third of boys and one fifth of girls between the ages of 10 and 18 have some virtual device. The proportion of children playing games on their smartphones increased to 61% among the age range of 8-17 years, a figure that shows how these activities have become integrated into everyday activities according to IPSOS survey in Hungary. Researchers hypothesise several reasons underlying the phenomenon of high incidence of virtual games usage. One reason may be the sense of security provided by a virtual world containing real elements but without real stakes, a situation that provides an opportunity to experience subjective conflicts (Standen, 2005).

Several studies emphasise the motivating power of VR systems in the educational process (Ojeda-Castelo, 2018; Kavanagh, 2017). Some of these systems are designed to improve customisation. Tasks are game-oriented and help to control attention and motivation.

Interactive whiteboards are already being widely for different tasks in the educational environment (Cagiltay, 2019). Kinect is one of the most suitable tools for developing digital competencies and cognitive and physical skills. Kinect, like other devices such as Wii or smartphones, are also cheap and easy to use. (Ojeda-Castelo, 2018). Furthermore, the natural interactions generated by these tools can be defined as communication between human and computer. The aforementioned interaction has a develompental and motivating factor and can therefore be successfully applied to the diversified field of special education (Cagiltay, 2019; Torres-Carrión, 2018; Kavanagh, 2017; Panzavolta, 2018). Altogether, VR tools provide a cheap, easily adaptable and effective alternative in the learning process.

From teachers' perspectives

Despite some difficulties, the use of VR systems in education is becoming increasingly popular among teachers. In their study in 2019, Cagiltay et al examined the relationship between educational technologies (including a wide array of teaching- and learning-related software and hardware, such as computers, interactive whiteboards, multimedia, VR devices) and special education. They primarily focused on teachers 'perceptions. Their goal was to understand what opportunities, experiences, and perceptions teachers have regarding Educational Technologies. A questionnaire was used to assess what teachers thought about the new technical solutions offered by VR. The results showed that the teachers use these options less because of the absence of infrastructure and instructions. The attitude of teachers was positive and open. Their opinion was that the application of technology improves school performance and job satisfaction, but it would be necessary for them to learn how to apply the technologies as well. They preferred to use devices that can be applied from an early age. According to them, the application of VR makes students more motivated to learn and raises the quality of learning, as it is a completely different educational method compared to traditional solutions. Furthermore, it allows more interactions among teachers and students and promotes the engagement of students with interactive, common tasks (Kavanagh, 2017).

Virtual Reality for inclusion

The structure of education and its adjacent areas are fields that constantly evolve to adjust to the needs and demands of the students. Either individualised or system-centered procedures can be encountered in situations that enable the inclusion of groups of minorities or individuals with disabilities (Papp, 2012). VR can promote this process by providing a tool for inclusion in which the quality of education rather than the environment is emphasised. Making education accessible and differentiated for children with disabilities is one of the conditions for the effectiveness of co-education (Papp, 2007). In many cases, it is emphasised that the aim of the application of VR in education is to increase independence, social and community involvement, and to reduce individual differences. Co-education has a similar goal system in which the categories of self-development, autonomy, and social participation also appear (Papp, 2012).

Digital communication is now accepted by the majority of the world's population. "However, it may be difficult to distinguish between the digital and the real world. Digital inclusion is an increasingly important social issue, reflecting human rights and includes equity. It enables social participation, community, and civil participation. Instead of classical linguistic elements and conventional symbols, it also provides alternative opportunities for communication for people with disabilities" (Chadwick & Wesson, 2016, p. 19).

In the virtual world, everyone has a chance to try various things that may not be available or possible in real life. In this world, anyone can be included: the game does not make any distinction between individuals with or without disabilities. Kavanagh et al. (2017) studied VR systems in terms of accessibility for participation, users' experiences, and interactivity before categorizing them according to areas of use:

- Simulation: The importance of being able to actively participate in interactions. Simulation increases opportunities in areas where there would be, for example, financial barriers to access (e.g., walking in the Pantheon virtually).
- Training: This aspect provides an opportunity to engage in activities that individuals would not be able to do in a real environment. An example is a VR Classroom, where children with ADHD, or who are afraid of public speaking, can practice appearances in front of a crowd.
- Access to Limited Resources: Lists cases where VE is used, for example, to simulate laboratory practice, or a virtual walk in a museum that a financial budget would not otherwise allow.
- Distance learning: In this context, they emphasised that VR helps access the learning environment. It helps prevent isolation and makes learning more real. They mentioned tools (especially for the home training for children with CP) to practice physiotherapy tasks and continue rehabilitation at home.
- Motivation: The virtual learning environment (VLE) was compared to traditional education. The result was that students learn better and are more motivated than when in a traditional learning environment.

For people with physical disabilities, environmental or physical accessibility is one of the most important factors in terms of participation. In the case of this population, getting to school can be one of the greatest challenges (Pivik et al., 2002). Accordingly, VR can be a new device for distance learning and the engagement in the learning process from home can help inclusion. The point is not only to be able to study at school, but also to take learning out of it (Sik Lányi, 2006).

In 2018, Gómez made a workshop summary for people with disabilities, professionals, and all VR users. The subject of the summary was about the entertainment applications which can be a part of the learning process and the use of VR devices promotes the inclusion of people with disabilities and reduces the gap between male and female players. They foster researchers, people with disabilities, designers, and users to form a community that supports and helps with this. The use of exergames systems is becoming increasingly popular in special education. In this context, inclusion is akin to the last stage in the process of diagnosis, education, and self-realization in which the goal is inclusion (Gómez, 2018).

In spite of its facilitating nature, a systematic review by Torres-Carión (2018) emphasises that the literature on the relationship between VR and inclusion is still scarce. Just thinking about the example of trying out a wheelchair simulator can be a sensitising experience for intact peers, which can increase acceptance, inclusion (Pivik et al., 2002).

Conclusion

In the present literature review we summarised the increasing use of VR systems in special needs education. The successful application of VR and

VE highlighted elements are immersion, presence, interaction, transduction, and cost-effectiveness (Panzavolta, 2018). In terms of its limitations, the inexperience and incomplete knowledge of teachers could be a challenge. At the same time, the openness of teachers and children indicates that VR systems can be successfully integrated into education.

In the 21st century, VR systems are part of the everyday lives of the rising generations and provide a means of connecting to young people through the field of their interest. VR sysytems could help with learning, development and, last but not least, establishing social relations and inclusion. Therefore, it is worth considering the use of VR systems in special needs education as well as taking active part in the amelioration of such systems for diagnostic, monitoring, and developmental purposes in the support for individuals with special needs.

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