

Virtual Reality and Special Needs

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Abstract

The use of virtual environments for special needs is as diverse as the field of Special Education itself and the individuals it serves. Individuals with special needs often face challenges with attention, language, spatial abilities, memory, higher reasoning and knowledge acquisition. Research in the use of Virtual Learning Environments (VLE) targets both cognition and behavior (Rizzo, et.al, 2001). Virtual environments encourage interactive learning and provide a variety of opportunities for the learner to have control over the learning process (Pantelidis, 1993). Virtual reality technology is an exciting tool that involves a safe and supportive environment to transfer knowledge between virtual and real worlds. Through such technology, individuals with special needs can look carefully at their own strengths, abilities, and learning preferences in comparison to the required learning task and expected learning outcome. This article reviews relevant research that explores the use of virtual reality for individuals with special needs.

Introduction

The use of virtual environments for special needs is as diverse as the field of Special Education itself and the individuals it serves. Individuals with special needs often face challenges with attention, language, spatial abilities, memory, higher reasoning and knowledge acquisition. Research in the use of Virtual Learning Environments (VLE) targets both cognition and behavior (Rizzo et.al, 2001). Virtual environments encourage interactive learning and provide a variety of opportunities for the learner to have control over the learning process (Pantelidis, 1993). Virtual reality (VR) technologies are exciting tools that involve a safe and supportive environment to transfer knowledge between virtual and real worlds. Through such technology, individuals with special needs can look carefully at their own strengths, abilities, and learning preferences in comparison to the required learning task and expected learning outcome.

This article provides an overview of relevant research that explores the use of virtual reality learning environments for individuals with special needs. A systematic search of the literature reveals that current research typically consisted of an investigation of the effectiveness of a specific VLE to execute a specific skill set completed by individuals with a specific disability. Virtual Reality studies have involved individuals with

- 1) physical disabilities,
- 2) sensory impairments,
- 3) moderate /severe cognitive disabilities,
- 4) autism,
- 5) learning disabilities,
- 6) attention deficit,
- 7) behavioral disorders and
- 8) traumatic brain injury.

As a result, this article is organized into three major sections. The first explores the different VLE and their use and effectiveness with individuals within eight disability areas. Highlights for each of these disability areas will be discussed. This is followed by a discussion of the role of virtual reality and assessments. The article concludes by taking a closer look at the use of virtual reality and the desired functional learning outcome rather than focusing on a specific disability area.

Virtual reality and specific disabilities

Physical disabilities

In the early 1990s, researchers began using virtual learning environments to teach children with physical disabilities how to operate and navigate powered wheelchairs (Inman, Peaks, Loge, & Chen, 1994). Such mobility training through traditional ways proved to be costly in terms of needed manpower and supervision and was potentially unsafe for the wheelchair user and others in the environment. In addition, many wheelchair users experienced frustration and became non-productive in reaching the essential navigational skills needed to obtain control over their wheelchair.

Virtual Learning Environments focus closely on platform structure and performance in order to improve realism of the simulation. Desbonnet, Cox, and Rahman (1998) studied a non-immersive VR training system (VRTS) that enabled users to manage the virtual environment using a simulator and controller fitted to their wheelchair. They concluded that the system was of limited value as a training tool due to the

inadequate virtual realism and relatively crude modeling of the behavior of the wheelchair. McComas, Pivik, and LaFlamme (1998) emphasized that VR systems should be designed with innovative features that enable the strengths of the individual rather than allowing the disability to limit interactive capabilities. Niniss and Nadif (2000) developed and studied the effectiveness of a simulation system that facilitated users to experience wheelchair navigation across ramps, and different terrains. Furthermore, they had gained familiarity with acceleration and deceleration of their wheelchair as they would in real-life experiences. Harrison, Derwent, Enticknap, Rose and Attree (2002) research revealed that maneuverability and route finding skills were two major components that determined success in independent mobility in a powered wheelchair; thus emphasizing that it is critical to build both physical and cognitive skills within the same environment.

As technology advanced so did the customization and design of VR systems needed to build navigational skills and independence. Researcher Dean Inman at the Oregon Research Institute of Applied Computer Simulation Labs provides students with physical disabilities an opportunity to engage in mobility training through either a laboratory simulation or an Internet version of the program that enables multiple users from all over the world to practice driving skills in a shared virtual space (<http://www.ori.org/Research/scientists/inmanD.html#currentprojects>). Such virtual learning environments incorporated joystick control computer simulations; utilizing a similar skill needed to operate a powered wheelchair; as a useful solution (Harrison et al., 2002).

Researchers began to design academic virtual learning environments that enabled students with physical disabilities to use such joystick access to manipulate tools and devices in a virtual science laboratory. This instructional environment was designed with accessible and interactive activities that would simulate tasks completed in a real science laboratory. Barriers that typically existed in a real-world science laboratory were completely eliminated, thus allowing the users to learn, problem-solve and gain independence (Inman, as cited in Smedley & Higgins, 2005).

In addition to training and assessing students with mobility impairments, virtual reality is also implemented to teach non-disabled peers about the barriers that exist within a school/classroom. Researchers at the Rehabilitative Sciences Virtual Reality Lab at the University of Ottawa in Canada developed Barriers: The Awareness Challenge (http://aprioriresearch.com/Pivik_files/barriersplash.html). Within this VLE, children and their teachers without disabilities sit in virtual wheelchairs to experience a common school setting with narrow hallways and doors, stairs, objects, and even inappropriate comments, to help them understand what it is like to live with and go to school with mobility impairments.

Sensory impairments

An individual with a sensory impairment faces challenges in one or more of the three senses- vision, touch, and hearing. While the use of technology does not remove such impairment, it can play a key role in enabling a person to build functional and cognitive skills. People with sensory impairments interact and perceive their immediate surroundings in different ways. They learn to use sounds and smells that serve as cues for orienting and navigating their environment. For example, when walking down a street, the sound of children playing on a playground or the smell of coffee roasting from the local coffee shop provide important points of reference on a daily stroll to the downtown farmers' market.

Virtual environments provide powerful, customizable learning by having the ability to promote or remove various activities and actions, and manipulate visual and auditory inputs and outputs. Applications used most often for individuals with visual disabilities include the use of auditory information as the main output channel and haptic devices for input. Haptic devices may include items such as force feedback gaming devices such as joysticks, gloves, pen-type devices and mice.

Vision impairments or blindness

Research involving individuals with visual impairments or blindness primarily focused on the skills and strategies needed to overcome standard computer interfaces and the 3D audio interfaces to build skills needed in recognizing spatial environments through sound. Researchers Sánchez and Sàenz (2006) identified a scarcity of research studies investigating the use of 3D sound to enhance problem-solving skills with children with visual impairments. Funded by the Chilean National Fund of Science and Technology, they designed, developed and investigated the efficacy of a 3D interactive sound environment for children with visual disabilities. This role-playing system is known as AudioChile. It enables children to build everyday problem-solving skills through hyperstories that provide opportunities to explore life, culture and idiosyncrasies of different regions of Chile. Children select a character and begin to search, move, localize, design strategies, and build orientation skills through integrated tasks. Interactive components and actions are accomplished through a force feedback joystick and keyboard.

Findings of this study highlighted the need for designing and redesigning the VLE to meet the diverse needs of the learners. The use of AudioChile allowed children in the study to differentiate and identify surrounding sounds that assisted them in orientating spatially. Sounds were essential to attention and motivation. Contrasting interface colors were key to users with residual vision. Sánchez and Sàenz concluded that "Different virtual environments with diverse problems to be solved allowed multiple experiences for children to identify, solve problems, and evaluate their course of action (Sánchez & Sàenz, 2006, p. 376).

Hearing impaired or deafness

Twenty years ago, the majority of computer use involved mostly productivity software. There were relatively few adaptations needed to the standard computer for individuals with hearing impairments or deafness. Computer operating systems provide visual alternatives to standard auditory cues/beeps. With Internet2 and the increasing use of multimedia applications, there is a growing concern for accessibility for individuals with hearing impairments or deafness. It is often the exception for video presentations to contain captions and/or a transcript. Individuals with hearing impairments and deafness require visual elements instead of auditory elements.

One of the first virtual reality learning environments for deaf children was the Virtual Reality Education for Assisted Living project (VREAL) (Adamo-Villani & Wilbur, 2007). This virtual environment enabled deaf students to learn basic life skills, and apply basic academic skills (math and reading), as they explored a virtual community. This virtual environment provided real-life opportunities to interact with characters, to utilize an on-screen sign language interpreter, and to build confidence in social situations.

Passig and Eden (2003) investigated the effects of practicing the rotation of Virtual Reality 3D objects on structural inductive processes and flexibility of thinking skills of students with hearing impairments or deafness. Findings support positive results of such virtual practice. Overall, students that practiced in the 3D environment manipulating and rotating shapes enhanced their ability to perform better in other intellectual skills as well. As the students were immersed into the virtual experience, moving the pieces and looking for the right shapes, they began to build inductive reasoning skills. One explanation for these findings could be that the abstract became less vague and more concrete in the virtual learning environment.

Researchers at Purdue University are designing stimulating VLE for children with hearing difficulties or deafness that use interactive animation and high quality graphics. Collaborative efforts of the Department of Computer Graphics Technology, Envision Center for Data Perceptualization and the Department of Speech, Language and Hearing Sciences have spent three years in the development of a 3D sign language virtual environment to teach math skills to early elementary students with hearing impairments or deafness. A non-immersive approach uses Mathsigner™, a 3D animated-based program for teaching math concepts and related American Sign Language (ASL). A demonstration of Mathsigner in different stages is available at <http://www2.tech.purdue.edu/cgt/I3/>.

An immersive approach involves SMILE™. SMILE is an interactive virtual world containing an imaginary town with 3D characters or avatars. Children engage in learning activities through the use of pinch gloves and a projected display system. The development and specific details of the SMILE system is found in Adamo-Villani, Carpenter,

& Arns (2006). Portable demonstrations of SMILE are available for download at <http://www2.tech.purdue.edu/cgt/I3/smile/> (Adamo-Villani & Wilbur, 2007).

Virtual environments are breaking down barriers for students with hearing impairments and deafness by providing real world applications to practice essential basic skills needed to obtain better job opportunities and higher educational opportunities in the areas of math, science and technology.

Moderate or severe disabilities

Within new learning situations and the use of technology, individuals with moderate or severe disabilities generally face two major barriers to gaining new skills and achieving functional and academic success. These barriers involve: 1) intellectual processes and 2) access to learning. Intellectual processes include tasks such as reasoning, planning, sequencing, remembering, processing and cognitive speed. Access to learning entails the opportunity to use and engage in learning materials in the appropriate format. Individuals with moderate or severe disabilities benefit greatly from the principles of universal design, which include: equitable use, flexibility, simple and intuitive, tolerance for error, and low physical effort.

Studies involving individuals with moderate/severe disabilities involve computer-based video instruction (Cuvo & Katt, 1992), interactive video-based computer simulations (Wissick, Lloyd, & Kinzie, 1992) and virtual environments to teach community literacy and daily living skills. Langone, Clees, Rieber, and Matzko (2003) provide examples of such skills:

- Community literacy skills – e.g., reading or discriminating printed brand names on products/labels
- Mobility skills – e.g., navigation within a store
- Purchasing skills –e.g., buying groceries
- Social skills – e.g., asking for assistance
- Safety skills – e.g., reading signs that decrease danger.

Project Shop is an interactive learning environment that incorporates the best attributes of microworlds, simulations, and games (Langone et al., 2003). A U.S. Department of Education development project at the University of Georgia, Project Shop is a video and interactive multimedia CD-ROM that will help students with moderate/severe intellectual disabilities learn community literacy and daily living skills. For more information visit <http://www.coe.uga.edu/projectshop/index.html>

Research conducted by Standen and Brown (2006) examined closely virtual reality learning environments and the advantages and barriers that exist for individuals with moderate to severe disabilities. Advantages of VLE involve the opportunity for repetition and control over the learning process. For individuals with such disabili-

ties, interaction and engagement can be guided through the use of human tutor or through tutoring strategies embedded within the learning environment/software itself. Findings also suggest that some individuals with severe disabilities may have difficulty understanding the three-dimensional space created in the VLE, thus the use of two dimensional learning environments may provide a more appropriate interface.

Computer access plays a significant factor in success in interacting in VLE. Many researchers examined desirable access devices (Brown, Neale, Cobb, & Reynolds, 1999; Hall, as cited in Lannen, Brown, & Powell, 2002). A variety of such interactive control units or navigation devices were studied. They conclude:

- 1) Individuals with moderate to severe disabilities often experience difficulties using the computer due to physical abilities and device construction;
- 2) Joystick navigation limited to two degrees of freedom had the greatest utility; and
- 3) the more functions a device possesses, the more difficult it is to operate for individuals with moderate to severe disabilities.

Virtual environments can enable students to explore, manipulate, and obtain specific learning outcomes if provided when the correct interface is chosen or designed. Advocacy and research in the design, development and use of emerging technologies to assist individuals with moderate to severe disabilities must continue to overcome the impediments of commercialization and consumer abandonment (Braddock, Rizzolo, Thompson, & Bell, 2004).

Autism

Individuals with autism often face challenges in the pragmatics of social interaction, verbal and nonverbal communication, and cognitive tasks such as contextualization, impulse control, inhibition, and other behaviors. There is a tendency for individuals with autism to be rigid and inflexible in their language, behavior, and mental models. Over the years, innovative learning tools such as robots (AuRoRA Project, <http://homepages.feis.herts.ac.uk/~comqbr/aurora/background/robots.html>;

Iromec, <http://www.iromec.org/>; and Kaspar, <http://kaspar.feis.herts.ac.uk/>) and virtual learning environments have been designed to assist individuals with autism to build everyday routines and social skills such as turn taking, imitation, and play. For a complete listing of issues and related research studies see Herrera, Jordan and Vera (2006). In addition, Cobb (2007) highlighted virtual learning environments that can be used as tools to support communication skills for individuals with autism, thus enabling independence.

Designing such learning interfaces requires careful attention to customization to meet the unique user's needs. Earlier work of Strickland (1996) shared the advantages of VLE for individuals with autism. Since many VLE offer extensive graphics and visual representations, this builds on the learning strengths and the use of visual perception of many individuals that have autism. In addition, within a VLE the complexity of a situation or scene can be controlled to allow the user to isolate and focus on specific skills. Grynszpan, Martin, and Nadel (2008) examined multimedia interfaces for users with high functioning autism and concluded that richer multimedia learning interfaces did not provide more learning cues to make learning easier for individuals with autism. In fact, simple interfaces work best for these individuals. The work of Parsons et al. (2000) reiterates the considerations of using colors, sound, text and the order and speed of presentation. Through years of developing the AS (Asperger's Syndrome) Interactive Project (<http://www.virart.nott.ac.uk/asi/Index.htm>), such considerations dictated Parsons and fellow researchers to design three-dimensional VLE where an individual with autism can control and manipulate an animated character to perform daily activities and interact with 2D and 3D interface elements. The AS Interactive Project also addresses and adjusts the VLE to individual users' functioning ability level and learning needs by providing two modes of functionality (one passive and one active), and an option for the educator to select a series or sequence of learning activities for each individual. Earlier AS Interactive projects involved life skills and a virtual city that was constructed in 1998-1999. It consisted of four main components: a virtual house, virtual supermarket, and virtual café (Cobb, 2007).

The most current AS Interactive Project involves the Individualised Café (available from <http://www.virart.nott.ac.uk/asi/individualised.htm>). It was designed for adolescent users (ages 13-19) who are or soon will be transitioning from school to post-high school opportunities. In this VLE the user is faced with three usability goals: understanding task instructions, navigating throughout, and interacting with virtual objects. Everyday tasks such as finding a table to sit at can be challenging depending on the VLE level selected. In some cases, there may be no empty tables available and, therefore, the user may have to interact by asking an appropriate question (from given choices) to the avatars. Thus, the design and learning support enables users to engage in social situations and practice asking appropriate questions and interpreting responses. Parson and Mitchell (2002) emphasize the importance of providing opportunity for repetition of tasks, thus facilitating rote learning and practice of social rules in a specific context before moving on to different contexts.

Articulab (<http://articulab.northwestern.edu/projects/>) a partnership between the School of Communication and the School of Engineering at Northwestern University allows researchers to study communication with and through technology. Three current projects of the Articulab involve virtual reality:

- a) Innovative Technology for Autism;

- b) Culturally Authentic Virtual Peer; and
- c) Collaborative Storytelling with a Virtual Peer.

The Innovative Technologies for Autism project carefully examines the underlying mechanisms of communication and social reciprocity in individuals with autism spectrum disorders. These researchers use virtual environments to study the interaction of human-to-human communication and needed skills. This is accomplished through interacting with virtual peers (embodied conversational agents), as well as human interaction with other users in an online virtual environment. In supporting the importance of customization, developers at Articulab are designing authorable virtual peers. This would allow children to tell stories through the manipulation and use of speech and gestures within their very own avatar.

Research supports that individuals with autism are able to transfer skills learned in virtual worlds to real world applications and situations Self, Scudder, Weheba, & Crumrine, 2007; Cobb, 2007; Parsons, et al., 2000; Parson & Mitchell, 2002; Herrera et al., 2006; & Charitos, Karadanos, Sereti, Triantafillou, Koukouvinou, & Martakos, 2000). Thus, VLEs can provide a viable and safe option for teaching skills that are dangerous to practice in real world settings. Self et al. (2007) investigated the use of VLE to teach fire and tornado safety training skills to children (ages 6-12) with Autism Spectrum Disorder, in their school environment. Participants in this study were divided into two groups. Group one received training to develop safety skills through the use of typical educational aids such as social stories, picture cards, role-playing/rehearsal, visually structured directions, and video. Group two trained within a virtual environment that provided multiple views of a safety training situation. Findings support that both groups were successful in learning fire and tornado safety skills. Those using the virtual training environment used approximately half the time to learn targeted safety skills than those engaged in typical instructional methods. In addition, significantly more time was needed to create typical educational aids versus the VLE for the safety training.

Research involving individuals with autism and the use of virtual reality is very promising. The unique learning needs of individuals matched with the customization of VLE provide viable learning tools. In the future it will be imperative that research studies involving VLE take place within the classroom setting. This will provide insight into the degree of replication and the need for teacher/staff training (Self, et al., 2007).

Learning disabilities

A user-centered designed VLE looks closely at the user, the task, and the environment. This approach is especially effective for designing learning environments for individuals with learning disabilities. Lannen, Brown, and Powell (2002) researched

the requirements for selection or development of VLE interface devices for young people with learning disabilities. They describe two independent phases of operation within a VLE: navigation and interaction. Navigation was found to be one of the most difficult tasks for individuals with learning disabilities to achieve. Thus, it is essential that the input device is compatible in performing the desired learning tasks.

VLE provide rich details and redundancy of critical information through realistic, graphical representations of real world concepts, thus enabling users to use alternative methods of information processing and less reliance on written and spoken information. Hands on learning activities with consistent feedback provided within the VLE are empowering for people with learning disabilities to practice and acquire new skills; especially abstract concepts that can be difficult to comprehend (Cromby, Standen, & Brown, 1996).

In the past decade, virtual reality for individuals with learning disabilities focused on life skills, social skills, and vocational/occupational skills (Cobb & Sharkey, 2007). With today's educational standards and a greater emphasis on achieving academic goals, a shift is occurring in the development and use of VLE for individuals with learning disabilities from life skills to academic outcomes. For example, there are several VR educational applications in the area of science that students with learning disabilities could benefit from using:

- Newton World (http://www.virtual.gmu.edu/ss_worlds/newton.htm)
- Maxwell World (http://www.virtual.gmu.edu/ss_worlds/maxwell.htm)
- Pauling World (http://www.virtual.gmu.edu/ss_worlds/pauling.htm)
- Material Worlds (<http://www.materialworlds.com/>)
- Virtual Garden (<http://www.evl.uic.edu/tile/NICE/NICE/intro.html>)
- Virtual Gorilla World (<http://openskies.net/gorilla/>)
- Zoning in on Physics (<http://cehd.gmu.edu/assets/ziop/index.html>).

Activities in these VLE allow the user not to just view the events, but to experience them. This could be effective in learning and understanding abstract science concepts, such as the solar system, Newton's laws of motion, kinetic energy, linear momentum, electrostatic forces and electrical flux. For example, the Zoning in on Physics VLE encourages students to explore force and friction in order to determine the speed and distance their shuttle will travel. They have the capability to move by applying different levels of force. Friction is determined by the student choosing the ground texture (i.e., outerspace, ice, grass, and bricks) (Schaff, Jerome, Behrmann, & Sprague, 2005). Through a series of explorations, students begin to understand Newton's laws.

Zoning in on Physics is the only science VLE that is specifically designed for students with learning disabilities. This is encouraging, since typical learning environments for

students with learning disabilities consist of direct instruction and the teaching of isolated, discrete skills. The use of VLE enables these students to reach their potential and apply higher order thinking and problem solving skills to complex phenomena. It is a promising avenue to provide students with learning disabilities educational opportunities that they otherwise would never experience.

Attention deficit, behavioral disorders, and traumatic brain injury

To date, less than a handful of research studies and VLE projects focus on the use of virtual reality to enhance the academic and social skills of individuals with traumatic brain injury, attention deficits, and behavioral disorders in the educational setting. Muscot and Gifford (1994) discussed virtual reality and its potential applications in teaching social skills to students, especially those with behavioral disorders. Encouraging a pro-social skills approach, learning can take place through the VLE without students or their teachers getting hurt in the process. For example, the student would select and control a virtual agent representing themselves and interact with others in the virtual environment. Such VLE would allow students to experiment with problem solving techniques, making choices, and experiencing consequences.

Attention Deficit/ Hyperactivity Disorders are chronic disorders characterized as demonstrating difficulties in the following areas: attention span, impulse control, and hyperactivity (in some). AD/HD can have negative impact on an individual's life at home, school and within the community. One example of this is the research conducted by Knouse (2007), at the AD/HD Clinic at the University of North Carolina – Greensboro. She examined adolescents and young adults with AD/HD and road/driving safety in a virtual environment. Findings revealed greater motor vehicle accident rates and less safe driving behavior for adolescents and young adults with AD/HD.

Few individuals would disagree that attention skills are essential to school success. Rizzo et al. (2006) look closely at the assessment and rehabilitation of attention deficits through the development of the Virtual Reality Classroom (http://vrpsych.ict.usc.edu/vr_classroom.html). They state, "A primary strength that VR offers assessment and rehabilitation is in the creation of simulated realistic environments in which performance can be tested and trained in a systematic fashion" (Rizzo et al., 2006, p. 36). In the Virtual Reality Classroom, users enter a realistic looking classroom to complete different tasks. Over 20 different distracters can be employed. In addition, normative data is collected on standard scenarios for comparison purposes across gender and age. Students may be asked to perform a variety of attention challenges.

Individuals with Traumatic Brain injury often experience attention problems as well as cognitive impairments that impact long-term function in everyday life. Only a few studies examined the use of virtual reality and assessing cognitive damage and cogni-

tive processes (Lengenfelder, Schultheis, Al-Shihabi, Mourant, & DeLuca, 2002; Matheis, Schultheis, Tiersky, DeLuca, Millis, & Rizzo, 2007) and these studies had no direct relationship to educational tasks or the classroom setting. Perhaps this can be explained by individuals with traumatic brain injuries having similar learning characteristics and academic needs as students with learning disabilities and attention problems. Thus, they are included within VLE studies and projects designed for these populations.

Virtual reality and assessments

The flexibility and controllability of virtual reality provides a vehicle for interactive, ecological and valid assessment tools. VR systems enable researchers, clinicians and educators to probe and assess behavior while maintaining control over stimulus delivery and measurement. In addition, VR systems have the capability to increase the complexity of the tasks and measure performance. Researchers at the Institute for Creative Technologies Center for Virtual Reality and Computer Simulation Research - University of Southern California (<http://vrpsych.ict.usc.edu/research.html>) are designing many VLE projects for assessment of different disabilities and educational settings. Such human performance testing environments could supplement traditional assessment tools and produce new methodologies for diagnosis and assessment of disabilities. Furthermore, such assessment tools could guide the design and development of learning interventions that may be needed.

Function over disability

When looking at specific learning tools necessary to ensure learning success, special educators are often encouraged to focus on the functional learning outcome, rather than technology for a specific disability. For example, voice recognition technology was designed for individuals with low vision or blindness, yet today many individuals with learning disabilities and high functioning autism benefit from this technology. This practice could also be beneficial to researchers and developers, when designing VLE for increasing social and academic skills. Examining the learning task(s) at hand in relation to the user's learning characteristics and the desired learning outcomes, VLE could be designed for a variety of uses to meet the needs of diverse individuals and multiple disability types. An example of this is the Virtual Classroom Project. Rizzo et al. (2006) originally designed the system for individuals with attention problems. Today, that same environment has morphed into an assessment and learning tool that accommodates multiple learning outcomes and varying disabilities (i.e., anxiety assessment and therapy for children with Social Anxiety Disorder, and earthquake safety for individuals with developmental and learning disabilities). Such design and flexibility of VLE will enhance the practicality of these learning tools being integrated into the educational process and benefit all learners.

Conclusion

Nineteen ninety-two was the year of the first Virtual Reality and Persons with Disabilities Conference; individuals with disabilities and professionals from all disciplines came together to share ideas and concepts of how virtual reality can make an impact on the lives of individuals with disabilities. It was predicted then that VLE would be commonplace in the classroom. Sixteen years later in our gadget and gaming society of today, we are just breaking the surface towards integrating virtual learning environments into the classroom. This article provides a brief summary of virtual reality applications developed for persons with disabilities. It is not meant to be an inclusive list but one that we can at a glance see the progress of developing and implementing VLE used in the classroom by students with disabilities. After reviewing the list of current virtual learning environments with classroom applications for students with disabilities (see Table 1), one cannot help but to feel hopeful that VLE will continue to infuse into the mainstream of the educational process with concentrated efforts in research, development and creative applications.

Table 1. Current Virtual Learning Environments with Classroom Applications for Students with Disabilities (listed in the order presented in the article)

Virtual Reality Project	Functional Skill Area	Available From
The Awareness Challenge	Mobility Awareness	http://aprioriresearch.com/Pivik_files/barriersplash.html
AudioChile	Geography through sounds, orientation and mobility skills	http://www.c5.cl/audio/pags/software/s/audiochile/audiochile_01.htm
Mathsigner	Sign language math	http://www2.tech.purdue.edu/cgt/l3/
SMILE	Math and science skills and sign language	http://www2.tech.purdue.edu/cgt/l3/smile/
Project Shop	Community literacy and daily living skills	http://www.coe.uga.edu/projectshop/index.html
AuRoRA Project	Robots- play and social skills	http://homepages.feis.herts.ac.uk/~co mqbr/aurora/background/robots.html
Iromec-	Robots - social and cooperative play	http://www.iromec.org/
Kaspar -	Robots- social skills	http://kaspar.feis.herts.ac.uk/
AS Interactive Project	Social skills	http://www.virart.nott.ac.uk/asi/Index.htm
Individualised Café	Social skills	http://www.virart.nott.ac.uk/asi/individualised.htm

continued

Table 1. (continue)

Virtual Reality Project	Functional Skill Area	Available From
Articulab	Social and Communication Skills	http://articulab.northwestern.edu/projects/
Zoning in on Physics	Science: Newton's law of motion	http://cehd.gmu.edu/assets/ziop/index.html
Newton World	Science: Newton's law of motion, kinetic energy and linear momentum	http://www.virtual.gmu.edu/ss_worlds/newton.htm
Maxwell World	Science: Electrostatic forces and fields	http://www.virtual.gmu.edu/ss_worlds/maxwell.htm
Pauling World	Science: Molecular representations	http://www.virtual.gmu.edu/ss_worlds/pauling.htm
Material Worlds	Science experiments and simulations	http://www.materialworlds.com/
Virtual Garden	Science, ecosystems	http://www.evl.uic.edu/tile/NICE/NICE/intro.html
Virtual Gorilla World	Science, biology, and animal behavior	http://openskies.net/gorilla/
Virtual Reality Classroom	Attention, safety skills, overcoming anxiety	http://vrpsych.ict.usc.edu/vr_classroom.html

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