Virtual Learning Environments for Students with Disabilities: A Review and Analysis of The Empirical Literature and Two Case Studies

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Abstract

Students with autism spectrum disorder (ASD) show varying levels of impairment in social skills situations. Interventions have been developed utilizing virtual environments (VEs) to teach and improve social skills. This article presents a systematic literature review of peer-reviewed journal articles focusing on social interventions in VEs involving K-12th grade students with ASD. This exhaustive analysis across four major online databases was guided by operational terms related to intervention type and K-12 students with ASD. The empirical search yielded a very narrow body of literature (n=19) on the use of VEs as social skill interventions for students with ASD. Two case study examples of experiments exploring the use of VEs and students with ASD are presented to illustrate possible applications of this technology.

Keywords: virtual reality, virtual environments, autism, social skills interventions, educational simulations

The inability to develop social relationships is one of the most challenging and ubiquitous delays in the majority of individuals with autism spectrum disorder (ASD; Kanner, 1943). A key component of eligibility criteria for ASD is a communicative impairment (Faja, Aylward, Bernier, & Dawson, 2008). Specifically, these individuals experience problems with the initiation and reciprocation of conversation in social situations (DiGennaro Reed, Hyman, & Hirst, 2011). Scholars attribute these social deficits to a lack of Theory of Mind (ToM; Baron-Cohen et al., 1999; Begeer et al., 2011; Golan et al., 2010), the ability to empathize or understand the feelings or thoughts of another individual. As a result, students with ASD often struggle to maintain relationships and acquire meaningful employment in post-school environments. This article provides a summary of current research related to the use of virtual environments as a means to teach critical social skills to students with ASD. It concludes with two illustrative case studies which highlight unique features in virtual environments holding the potential to enhance social skills performance.

Researchers analyzing behavior and neuroimaging suggest individuals with ASD have difficulty processing faces in the same manner as their peers (Faja et al., 2008; Golan & Baron-Cohen, 2006). Individuals with ASD can identify (i.e., recognize) faces but struggle to discern emotions accurately or assess the social implications appropriately (Hopkins et al., 2011). When attempting to navigate a social situation, individuals with ASD may study each specific portion of a face "locally" as opposed to "holistically," a concept known as the inversion effect (Golan & Baron-Cohen, 2006; Hopkins et al., 2011). When compared to typically developing peers who may interpret nuances and more complex emotions with ease, individuals with ASD may prefer a systematic method for reading emotions. The Empathizing-Systemizing (E-S) theory offers an explanation regarding the propensity of individuals with ASD to seek sameness and favor repetitive behaviors over the random and unstable world of social interactions (Golan et al., 2010).

To address these deficits in social interaction and empathy, several researchers have designed and continue to develop interventions for individuals with ASD. Traditional social skills instruction does not explicitly teach awareness

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of facial expression but, rather, focuses on ancillary content, such as hygiene and conversation (Golan & Baron-Cohen, 2006). Many of the empirical and descriptive studies focused on intervention in social skills training lack satisfactory methods and design (DiGennaro Reed et al., 2011). In a systematic literature review investigating social deficits and individuals with ASD, over half of the literature involved studies regarding the initiation of conversation, one-third involved interventions for social skills deficits, and only a very few (i.e., less than two specific instances) involved studies on the reciprocity of emotions (DiGennaro Reed et al., 2011).

The most commonly cited form of intervention for social skills acquisition with individuals with ASD is video modeling and feedback designs (DiGennaro Reed et al., 2011). Ogilvie (2011) recommended video modeling for social skills instruction as the ideal intervention type for individuals with ASD. Video or DVD modeling programs take the guesswork out of social situations by providing tangible examples of real-life social interactions student may imitate. Video modeling programs are beneficial for repetition of social content, generalize well to authentic social experiences, and may be reinforced with peer mentors to extend learning outcomes (Ogilvie, 2011). A further extension of this intervention is video self-modeling (VSM), the practice of editing video footage of one's self in the most positive light possible to visualize and believe in one's ability to perform successfully in social situations (Buggey, Hoomes, Sherberger, & Williams, 2011). Although video modeling interventions continue to be the most common practice for teaching social skills to individuals with ASD, widespread acceptance of technology as a methodology also is increasing, especially with emerging virtual environments.

Technology-based Approaches

Technology-based approaches may soon surpass traditional forms of social skills instruction, given their cost effective and user-friendly format (Buggey et al., 2011; DiGennaro Reed et al., 2011); however, the propensity that students with ASD show toward technology is perhaps even more promising. Given how technology may lessen their anxiety with direct face-to-face interactions (Mintz, Branch, March, & Lerman, 2010) and their ongoing need for sameness and routine, technology-based interventions may be most effective.

Computer-based Learning

Technology encompasses computer-based learning (CBL), a growing trend for interventions in school and clinical settings, which may help individuals with ASD overcome cognitive limitations regarding social interactions (Moore, Cheng, McGrath, & Powell, 2005). The benefits of computer-based learning (CBL) are numerous (Golan & Baron-Cohen, 2006) since they may be designed according to the specific interests of a student and may also be repeated, routinized, and made financially accessible. Of most value, however, is how much more effective CBL may be compared to traditional models of intervention.

Faja et al. (2008) suggested computerized, face-specific training programs could improve the facial processing abilities of individuals with ASD. Golan et al. (2010) measured the effectiveness of *The Transporters,* an animated series of 3D vehicles with super-imposed human faces systematically teaching facial awareness skills. Based upon the concept of *MindReading*, an educational software program and also the name of the intervention, users attune to vocalizations and facial expressions in an engaging multimedia forum. The Cambridge Mind-Reading (CAM) Face-Voice Battery was used to assess user-proficiency of a library of over 412 emotions at six different developmental levels ranging from ages four to adulthood (Golan & Baron-Cohen, 2006) and discovered technology-based applications are inherently rewarding and motivating to individuals with ASD. *FaceSay*, a CBL social skills program, uses avatar assistants to promote eye gaze, facial expressions, and emotions (Hopkins, et al., 2011). Students with high-functioning autism (HFA) manifested successful emotional recognition and social interaction skills as a result of this intervention (Hopkins et al., 2011), which begs the question whether simulated virtual environments (VEs) may actually generate as many results as a CBL model.

Virtual Environments

The use of virtual environments (VEs) for social skills acquisition is an underrepresented methodology (Moore et al., 2005), and further research is needed to realize its potential for students with ASD (Mitchell, Parsons, & Leonard, 2007). VEs are simulated platforms utilizing 3D technology with digital avatars. The user can practice real-life scenarios by interacting within the comfort of a digital environment. It is well-documented that students with ASD prefer simulated environments over traditional role-playing models because of the predictable, structured nature of the setting (Bricken, 1991; Cheng, 2005; Cheng & Ye, 2009; Cromby, Standin, & Brown, 1995; Parsons, Leonard, & Mitchell, 2005; Windham, 2005). Despite increased levels of engagement, students with ASD often do not generalize their learned skill sets well to other domains (Mitchell et al., 2007). However, the benefits of VEs for students with ASD are increasingly noted with each subsequent study.

According to Neale et al. (2002), there are two types of virtual environments: (a) the single-user VE (SVE) and (b) the collaborative VE (CVE). The CVE is fashioned to help students with ASD and their ToM deficit (Moore et al., 2005). Cheng and Ye (2009) noted strong reciprocal social engagements with the utilization of a CVE as reported by parents' reports of increased eye contact, emotional recognition, and attention during a social interaction. In post-test reports, students could provide specific examples of how the VE had helped with their social skills in real-life experiences and even reported the experience as enjoyable (Parsons, Leonard, & Mitchell, 2004). VEs also can control for extraneous variables, such as verbal statements from the avatars, which allow participants repeated attempts to practice without harmful consequences.

A VE affords a safe environment, controlling for physical proximity, level of sound, and body language to provide opportunities for participants to experience social interactions they would otherwise not achieve (Bricken, 1991; Cromby et al., 1995). Student behavior may also be shaped by responses from the avatar, such as expressions on the faces and emotional expressions (Cromby et al., 1995). Ultimately, several researchers note VEs to be of great value in teaching social skills to students with ASD (Bricken, 1991; Cheng, et al., 2005; Cromby, et al., 1995; Neale, Leonard, & Kerr, 2002). Further validation of existing studies, as well as randomized controlled studies of larger group designs, are needed to expand the literature base and continue to understand the potential benefits of VEs for students with ASD.

Literature Review and Case Studies

Selection of Empirical Articles

A systematic review of the literature was conducted across four major library databases for a 5-year period from 2009 to 2013. Specifically, the four databases selected for analysis included Ebscohost (ERIC), PsycInfo, Education Full Text, and Web of Science/Knowledge. To be included in this review, three critical elements needed to be present in the articles. First, articles were data based, using quantitative or mixed designs. Essays, literature reviews, rejoinders, and editorials were not included. Second, each study had to include students from grades K-12 with disabilities. Third, articles must have incorporated a VE component within the study. Researchers read each article and identified relevant information from the methods section, including participants' demographic information, setting of the study, type of empirical analysis, and disability diagnosis. The following question guided this review: What is the current state of the field related to empirical research on VE's as social skill interventions for students with ASD?

Data Collection and Analysis Procedure

Several research assistants participated in the data collection of the study. All assistants were doctoral students and volunteered to participate. The first author trained each research assistant and gave each a sample of articles from older issues to code for training purposes. Inter-observer agreement was evaluated across 30% of all search categories and clarifications were provided on any categories of disagreement using a point-by-point method. The researcher and assistants reviewed each journal issue and completed the following tasks: (a) counted the number of empirical articles published in each issue, (b) coded the methodological characteristics of each empirical article, and (c) reported the identified characteristics of each article on a coding sheet. The mean agreement was 96.4% with a range of 90-100%

Several aspects of each empirical article were coded to answer the research questions. The quantity of publications was analyzed with descriptive statistics to evaluate the proportion of articles focused on VE with students in K-12 settings. Finally, an analysis of the methodological characteristics of each article was conducted. The researchers assessed the characteristics of the sample, selection procedures, the type of study design and methodology, and the characteristics of the data collection procedures.

Results and Discussion of Literature Review

A total of 19 empirical articles presented studies involving K-12 students with a disability whose eligibility status was determined by IEP criteria. Disaggregating the 19 articles by disability type resulted in a total of 14 articles focusing on autism, 1 on ADHD, and 4 on intellectual or developmental disorders. The studies selected had a wide range of student ages (5-18), with 11-14 years of age being the most frequent. Sample sizes in the studies ranged from three to 56. (See Table 1 for demographics.)

Eight studies used a multiple baseline single-subject design with relatively small sample sizes (3 to 4 participants). The four largest studies were randomized group design experiments with 36-79 participants in varying treatment conditions. The VE types can be further specified as virtual reality (5), computer-based video instruction (4), CVLE (4), simulation training (1), 3D emotion system (1), animated television series (1), avatars (1), electronic screen media (1), and mobile cognitive support application (1). The social skills interventions included emotion recognition (8), social competence (5), functional and social life skills (4), and executive functioning (2). (See Table 2 for technology types.)

Based on the results of this search, it is clear the research into the use of VEs as a social skills intervention for students with ASD, while limited, shows promise. The studies focused primarily on the use of VEs to teach emotion recognition and social competence, which is not surprising given the core

Table 1.

Disability Type Categories

Disability Type	Number of Studies	Percentage (%)
Autism spectrum disorder (ASD)	14	74
Attention deficit hyperactivity disorder (ADHD)	1	5
Intellectual disability	4	21
Total	19	>100.0

deficits students with ASD face. In addition, VE technology affords students with ASD a safe, enjoyable environment in which to practice social skills such as reciprocal communication. (See Table 3 for social intervention types.)

Case Studies of Virtual Environments

Given the review of literature results above, two formative studies were designed in 2013 to further understand the characteristics of interaction between students with ASD and

Table 2.

Virtual Environment (VE) Technology Types

Technology Type	Number of Studies	Percentage (%)
Virtual reality	5	26
Computer-based video instruction	4	22
Simulation training	1	5
3D emotion system	1	5
Collaborative virtual learning environment	4	22
Animated television series	1	5
Avatars	1	5
Electronic screen media	1	5
Mobile cognitive support application	1	5
Total	19	>100.0

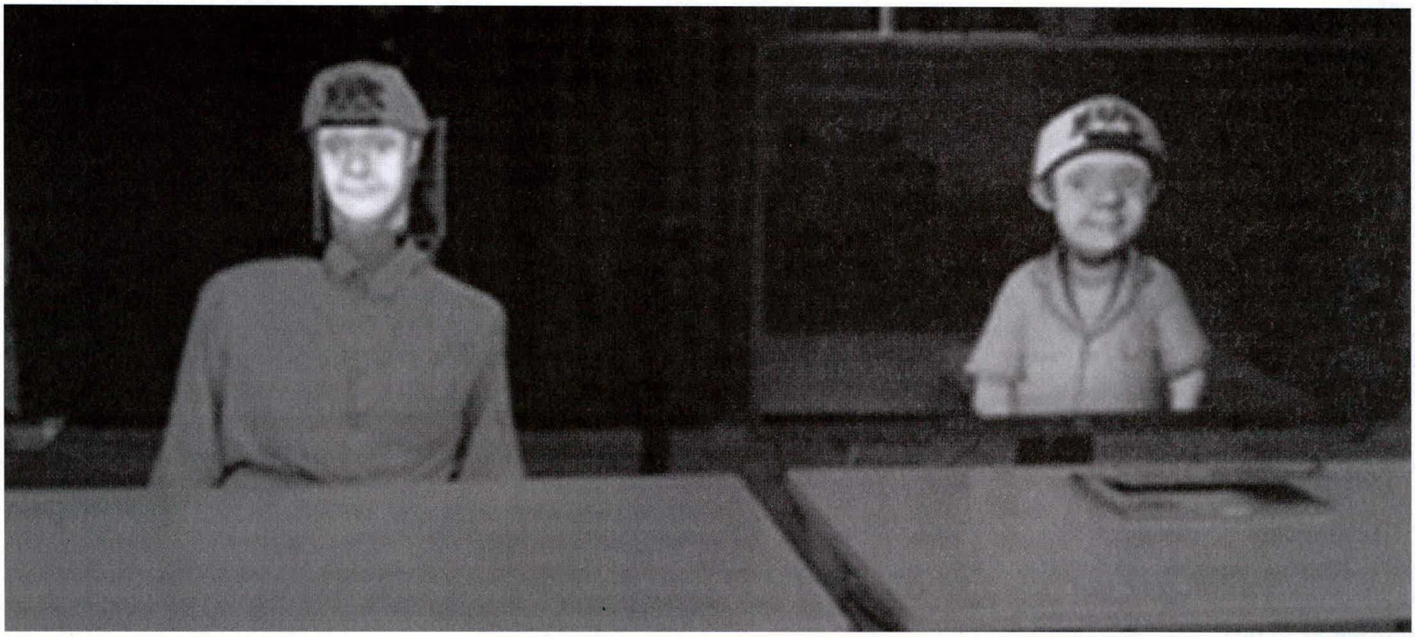
Table 3.

Social Skills Intervention Types

Intervention Type	Number of Studies	Percentage (%)
Functional and social life skills	4	22
Social competence	5	26
Emotion recognition	8	42
Executive functioning	2	10
Total	19	>100.0

Figure 1.

Different manifestations of the same virtual character (digital avatar) used during a formative study. Left: Robotic manifestation referred to as a Physical-Virtual Avatar. Right: 3D Virtual Avatar displayed on a large 2D Flat Screen.



multiple manifestations of virtual characters (digital avatars).

Case study 1. A team of researchers (Vasquez et al., 2014) led the first study at the University of Central Florida and involved a small number of subjects. The project team used two different manifestations of avatars for this study–one avatar was rendered on a large 2D flat screen while the other was a physical-manifestation of the same character via a robotic interface called a physical-virtual avatar (Lincoln et al., 2009). Figure 1 presents a screenshot from the formative study showing the two different manifestations: (a) a physical-virtual avatar (left) and (b) a 2D display (right).

Preliminary findings of the interaction data revealed an increase in reciprocal responses and duration of responses for nearly all subjects in both conditions (i.e., interaction with the 2D Flat Screen Avatar as well as the Physical-Virtual Avatar). While in no way conclusive, the study suggests that students with ASD seem to have a preference for interaction with the avatars in virtual environments when compared to traditional social human interaction. This is consistent with other literature in the area that has indicated these students have a preference for technology and these findings provide a basis for further investigating the value of virtual environments.

Case study 2. A team of researchers at the University of Central Florida (Nicsinger, Hughes, & Vasquez, E., 2104) also led a second study. The purpose of this study was to teach empathy and perspective taking to 5 children with autism. The team collected data using quantitative analysis of game play utilizing video and audio recordings, two observers, and pre-post-tests for emotional discrimination. Game data included response time to avatar needs, avatar "happiness" over time (a summation of all needs), achievements collected and achievements spent, time spent playing incentive games, individual needs fulfilled/unfulfilled (e.g., how often did they feed the avatar or how often did they take the avatar to the potty), response to changes in emotional or physical expression of the avatar (e.g., Does crying or eliminating on the floor elicit a response?), response to changes in meters (e.g., Does a 'red' meter trigger a response?), and other yet-to-be-determined game-play behavior. The back end data analysis of user interactions, when carried out with an appropriate sized population, will be the most innovative aspect of the project utilizing big data for insights to improve the game and identify the social outcomes for students with ASD. Preliminary data suggest students with autism successfully increased their ability to discriminate different emotions (Hughes, 2014). (See Figure 2 for a screen shot of the game.)

Conclusions and Recommendations

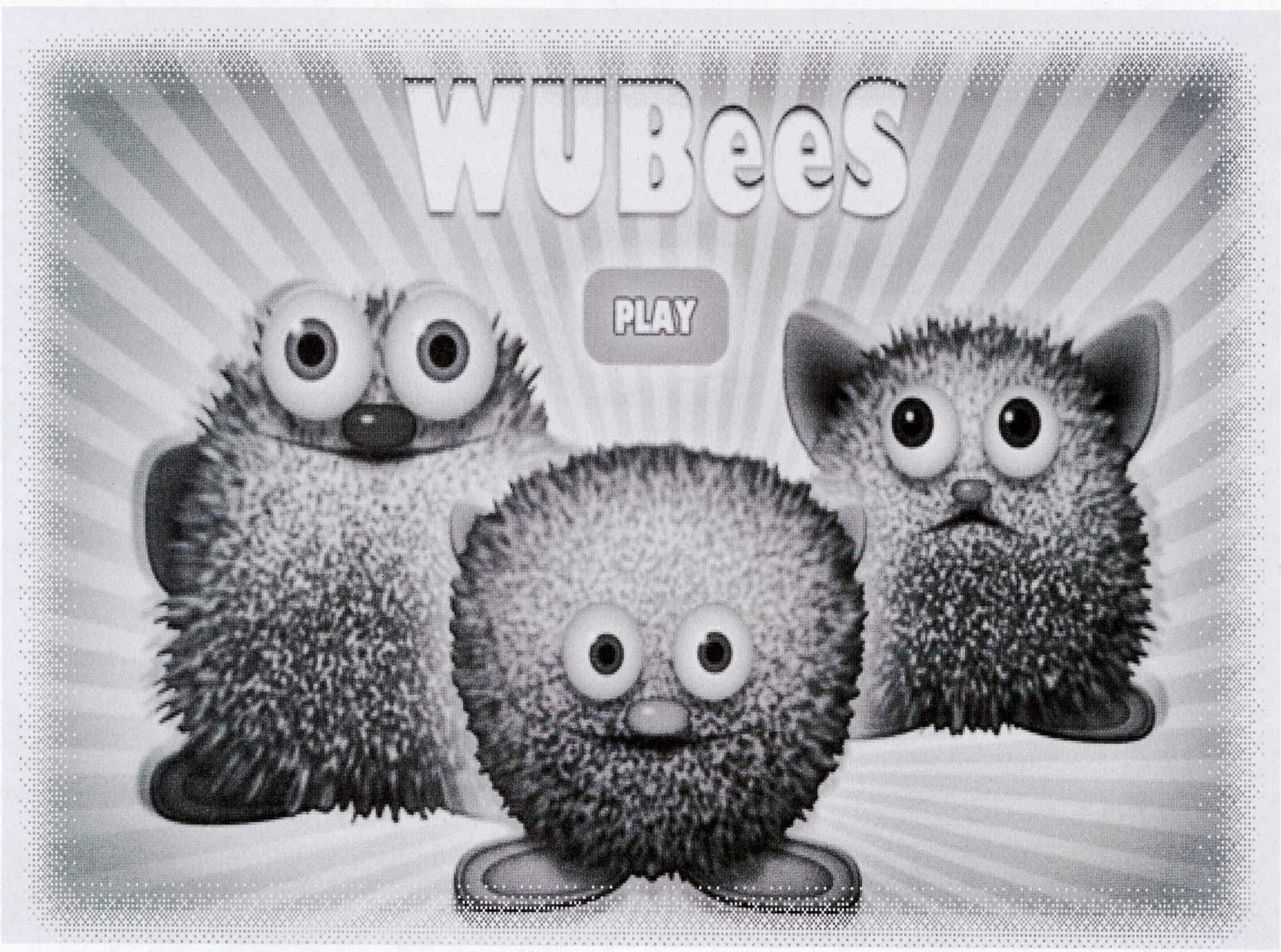
Simulations are already integral professional training tools in the colleges of business, medicine, and engineering and in the military. In education, simulations can be used to provide authentic personalized learning platforms customized to meet the unique needs of each user; however, a consistent limitation noted in many of the studies above and the existing professional literature is the inability of the participants with ASD to generalize the skills gained in virtual environments (VEs) to real-life social situations in K-12 settings. Further studies, whether replications or large-scale experimental designs, need to be conducted in order to identify strategies to promote generalization of skills, as well as to establish the use of VEs as an evidence-based practice. Further, the field needs more researchers to engage in this line of research given the ability of VEs to impact a broad number of students in many locations, including rural schools that may be isolated from large urban areas or lacking academic resources.

In addition, researchers also should study technological innovations occurring in the education field beyond virtual learning environments in order to take advantage of new technologies as they emerge. The 2014 New Media Consortium Horizon Report for the both K-12 Education http://www.nmc.org/publication/nmc-horizon-report-2014-k-12-edition/) and for Higher Education (http://www.nmc.org/publication/nmc-horizon-report-2014-higher-education-edition/) and the National Technology Leadership Coalition, a consortium of national teacher educator associations, national technology associations, and educational technology journal editors, identified the following technologies as the most important emerging trends to watch for their potential to impact the future of K-12 and post-secondary education. These technologies included the following:

1. *Wearable Devices*: Smart phones, health and fitness monitors (e.g., FitBit), and new wearable devices (e.g., Google Glass, the Apple Watch, and the soon-to-be released Samsung Gear S) make it possible for technology to be seamlessly integrated into daily routines.
2. *Mobile Interactivity*: Many schools have purchased tablet computers and other mobile devices allowing students to work anywhere. When every student has his or her own technology device, teaching and learning is transformed from the historical paper-based approach to learning to a digitally enhanced learning environment.
3. *Big Data*: As students engage with digital learning materials, significant amounts of data are generated providing a record of student interaction with the curriculum, the nature of their engagement, and evidence about learning outcomes. Big data in education will contribute to new advances in the learning sciences.
4. *Learning Algorithms*: Digital learning and big data will

Figure 2.

Screen shot of the WUBees serious game to teach children with ASD empathy and perspective taking.



provide the essential conditions to develop new learning algorithms guiding students through optimal learning pathways. Over time, the refinement of learning algorithms will guide students through instruction in ways that optimize learning.

The research community must establish a repertoire of evidence-based practices to match the selection of technologies and practices that have been validated in virtual environments. For example, to what extent does the academic performance of students with disabilities compare to general education peers in various content areas? The virtual environment is relatively uncharted land for students with disabilities. As the field of special education seeks to establish effective practices, what can be gleaned from the existing research base for students with disabilities learning in other environments? Researches can begin this process by translating effective practices to the virtual environment and empirically evaluating academic student performance. They should identify critical elements of interventions and match them with technologies supporting or enhancing delivery, with attention given to accommodations or accessibility issues for persons with disabilities. Vasquez and Slocum (2012) point the way to effective utilization of virtual technologies by weaving supports into instructional activities. Marino et al. (2014) illustrated the importance of universal design and accessibility standards for virtual instructional design, not only for students with disabilities but for *all* students. Underscoring this point, Izzo et al. (2010) indicated current assistive technologies intended for use in virtual environments are not utilized, and, consequently, students with disabilities may not be accessing online materials due to heavy reading demands. All of the above findings can be applied to improve virtual instruction for students with disabilities.

Finally, research findings related to virtual special education must be shared with instructional technology designers, for they work alongside educators as substantive co-teachers in the virtual environment. Special educators must hone their collaboration skills, befriend their technical friends across the technology divide, and coordinate efforts to improve access and accessibility to virtual learning environments. Further research must be conducted to bolster the level of evidence-based practices for using virtual environments and to demonstrate the impact of such instruction for the new generation of students with and without disabilities.

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