Virtual Social Competence Instruction for Individuals with Autism Spectrum Disorders: Beyond the Single-User Experience

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Abstract: While the potential of three-dimensional virtual learning environments (3D VLEs) has been recognized for individuals with Autism Spectrum Disorders, little research exists on the use of collaborative, multi-user three-dimensional virtual learning environments for teaching social competence to these individuals. This paper reports the results of study which aimed to gain an understanding of four participants' interactions in the medium by exploring the extent to which participants engaged in appropriate and inappropriate reciprocal interactions as they took part in a single unit of a five-unit social competency curriculum provided via the 3D VLE. Findings indicate that participants took part in reciprocal interaction, the majority of which were verbal responses, that these interactions were predominantly socially appropriate and that they share some similarities with real-world interactions reported in other studies.

Introduction

Interest in collaborative virtual environments as a viable medium for delivering online instruction is growing among educators and researchers. Systems such as Quest Atlantis (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005), Whyville (Neulight, Kafai, Kao, Foley, & Galas, 2007) and River City (Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005) are currently in use and under investigation in a number of school districts. Early research results indicate that these environments can be highly engaging (e.g., Dede et al., 2005; Squire & Jan, 2007) and have the potential for students who use them to show learning gains (e.g., Barab et al., 2005). Interest in these learning technologies is also growing among educators who address special needs populations. In the special needs area of Autism Spectrum Disorders (ASD), practitioners, researchers and technologists are starting to advance the notion of using three-dimensional virtual learning environments (3D VLEs) for social competence instruction.

Individuals with ASD often have social deficits which can result in problematic behavior (National Research Council, 2001; Sasso, Garrison-Harrell, McMahon, & Peck, 1997). Social competence instruction shows promise for remediation of these individuals' social deficits (Stichter, Randolph, Gage, & Schmidt, 2007); however, as we discuss later, access to such instruction is limited, and providing access can be challenging. 3D VLE technology, however, holds promise as a collaborative learning tool which can broaden access, reduce implementation challenges and be leveraged to specifically address the needs of learners with ASD. Evidence to date indicates that individuals with ASD undertaking social competence instruction in 3D VLEs show gains in performance (Leonard, Mitchell, & Parsons, 2002; Mitchell, Parsons, & Leonard, 2007; Moore, Cheng, McGrath, & Powell, 2005; Parsons, Leonard, & Mitchell, 2006; Parsons, Mitchell, & Leonard, 2004, 2005; Rutten et al., 2003). However, the appeal of 3D VLEs as a promising medium for delivering online social competence instruction is tempered by limited knowledge regarding use of these environments and how use impacts interaction and learning. Further research into fundamental issues pertaining to individuals with ASD using 3D VLEs for social competence instruction is needed to better understand how the design of these environments might impact learning outcomes.

The majority of existing work in this field focuses on single-user experiences of practicing discreet skills and does not consider how such instruction might be experienced mutually by multiple users, nor the impact of adding a collaborative dimension to the experience on design, implementation and learning outcomes. We argue that multi-user, Internet-based 3D VLEs have potential to provide access to intervention, qualified guides and social cohorts while maintaining a focus on essential features of social competency instruction in an engaging, highly social and collaborative context. However, little evidence exists to support this assertion. To explore this potential, a virtual world was developed and a research study conducted with individuals with ASD. The goal of the study was not to assess learning outcomes, but rather to explore the nature of participants' interaction in the 3D VLE and to identify to what extent and with what variability participants engage in socially appropriate and inappropriate reciprocal interaction while taking part in instruction in the medium.

Conceptual Framework

Individuals identified with high functioning autism (HFA) or Asperger's Syndrome (AS) are typically characterized as having a desire to be social (Myles & Simpson, 2002), but lacking sufficient social competencies to do so. Emerging research indicates that interventions which specifically target acquisition of social competence can help remediate these deficits (Solomon, Goodlin-Jones, & Anders, 2004; White, Keonig, & Scahill, 2007); however, access to evidence-based interventions is limited and problematic. Training, budgets and organizational factors can affect the intervention (see Gresham, Sugai, & Horner, 2001), and the decontextualized nature of many such interventions has been found to impact their success (Gresham et al., 2001). Additional issues arise when considering delivery to rural areas, low-income school districts, home-schooled students, etc. 3D VLEs may provide an effective medium for delivery of social competence instruction and have unique characteristics which hold promise for approaching access and delivery issues associated with traditional interventions.

The notion of using 3D VLE technology for treatment of ASD emerged in the mid-1990s with the notion that virtual reality might be useful for treatment because it allows for control of input stimuli, modification for generalization, safer learning situations, primarily visual worlds, individualized treatment and responsiveness to computer technology (Max & Burke, 1997; Strickland, 1996, 1997; Strickland, Marcus, Mesibov, & Hogan, 1996). These traits are of importance for individuals with ASD because of these individuals' need for highly individualized instruction, their characteristic rigidity and difficulty generalizing skills between contexts and the tendency for these individuals to be bullied. Findings from this early work provided some support for the proposed benefits but were preliminary and inconclusive. Much of the literature that follows this early work focuses on design issues and justification for using 3D VLEs (Charitos et al., 2000; Dautenhahn, 2000; Kerr, Neale, & Cobb, 2002; Max & Burke, 1997; Parsons et al., 2000; Parsons & Mitchell, 2002).

A cadre of studies conducted at the University of Nottingham through the AS Interactive project provides some initial support for the use of 3D VLEs for facilitating learners' acquisition of social competence. Researchers maintain that virtual environments offer an ideal platform for realizing cognitive approaches because the technology can provide stability, predictability and familiarity, and because it is adaptable to individual needs (Parsons et al., 2000, Parsons & Mitchell, 2002). Findings provide preliminary support for these assertions. Moore and colleagues (2005) found that participants were able to recognize facial expressions in avatars in a VLE. Leonard, Mitchell and Parsons (2002) found significant improvements in participants' ability to make social observations in identical contexts, but noted difficulties in generalization. Rutten and colleagues (2003) found that participants could learn a skill in a 3D VLE and could apply this learning to a video clip depicting a similar context, providing some evidence that skills acquired in the virtual environment may indeed generalize to other contexts. However, all researchers caution against using 3D VLE technology as a stand-alone intervention. In a 2006 study (Parsons et al.), the researchers found that participants appeared to interpret virtual scenes meaningfully, that they could provide examples of how what they learned in 3D VLEs had helped or could have helped them in the real world and that they valued the learning that happened in the 3D VLE. In a later study (Mitchell et al., 2007), the researchers found evidence of improvement in judgments and explanations about social situations using both 3D VLE and video technologies depicting different contexts. However, a weakness that Parsons, Mitchell, and Leonard found in previous work (2004, 2005) was that the majority of their participants engaged in off-task behavior and displayed a limited understanding of the VLE. They hypothesized this was due to low verbal IQ and weak executive functioning.

The Social Dimension

Single-user 3D VEs allow for structured, controlled training environments (Charitos et al., 2000) but only allow for a limited range of activity, interaction and communication possibilities. Multi-user virtual environments (MUVEs) allow for a broader range of activity (Ducheneaut, Moore, & Nickell, 2007) and may provide for a less intimidating medium for practicing activities (Cobb et al., 2002). However, little is known about using MUVEs for this purpose. Most research focuses on individuals working with a facilitator at a terminal and does not explore how multiple users might mutually interact within 3D VLE systems. Multi-user VLEs can allow peer groups and a facilitator to discuss social competence collaboratively (Cobb et al., 2002; Kerr et al., 2002) and are flexible in that social norms can be negotiated and developed between users (Parsons et. al, 2005). However, research has yet to emerge supporting these claims. Given the espoused benefits and increased flexibility of multi-user 3D VLEs, further investigation is needed. To this end, we built a multi-user 3D VLE named iSocial. iSocial is a 3D-VLE-based intervention for social and behavioral outcomes for youth 11-14 years old with ASD. The 3D VLE implementation is an adaptation of a clinic-based curriculum, Social Competence Intervention based on a framework of Cognitive Behavioral Intervention (SCI-S), with demonstrated impact for improving social competence (Stichter, Herzog, Visovsky, Schmidt, Randolph, et. al, 2010a). The 3D VLE was designed for participants, in separate locations, to take part in 20 one-hour lessons

with an Online Guide who acted as an instructor. While a comprehensive explanation of the design of iSocial and how it is experienced by youth is beyond the scope of this paper, further information is available in prior publications (Laffey, Schmidt, Stichter, Schmidt, et. al, 2009a; Laffey, Schmidt, Stichter, Schmidt, et. al, 2009b; Laffey, Stichter & Schmidt, 2010b; Schmidt, Laffey, Stichter, Goggins, et. al, 2008).

Methods

A field-test was undertaken to explore how best to study interaction in a multi-user 3D VLE with the specific goal of gaining an understanding of participant interaction in iSocial. The research questions that guided this exploration were: 1) To what extent and with what variability can youth with ASD engage in appropriate reciprocal interaction (RI) in our 3D VLE? 2) To what extent and with what variability do youth with ASD engage in inappropriate behavior in our 3D VLE? To approach these questions, one unit from the SCI-S curriculum was implemented in the 3D VLE and data were gathered. The Turn-Taking in Basic Conversation unit was selected, consisting of four one-hour lessons. Four youth in two groups of two undertook the instruction with assistance by the Online Guide and facilitators who physically sat with them. Two groups were used in order to provide a counterbalanced research design. Participants were between 11-14 years old, had a medical diagnosis of autism determined by the Autism Diagnostic Interview Revised (ADI-R) (Rutter, Le Couteur, & Lord, 2003) and/or the Autism Diagnostic Observation Schedule (ADOS) (Lord, 2002), were verbal/capable of speech and had an intelligence quotient within one standard deviation of the mean for the typical range (e.g., a score of 85-115).

Data were collected at an interdisciplinary autism research and treatment center in the Midwest. The unit of analysis consisted of four one-hour lessons delivered over a two-week period. The lesson activities consisted of the youth having opportunities 1) to learn about social competency through lessons provided by an online guide, 2) to try out and practice the skills in both structured and more naturalistic contexts, and 3) to interact in social ways with peers and the online guide. Video camera recordings showing the users physically at their computers as well as screen recordings were captured. These videos were coded by four trained graduate students based on a reciprocal interaction coding scheme (Laffey, Schmidt, Henry, Wang, et.al, 2010; Schmidt, Laffey, Henry, Wang, et. al, 2010). This coding scheme captured participants' reciprocal interactions (e.g., conversational initiations, responses and continuations), the 3D VLE affordance which made those interactions possible (e.g., verbalizations, avatar gestures) and the curricular context promoting the interaction (e.g., introduction of the skill, verbal practice). These various aspects of reciprocal interactions were coded in tiers in the coding software used, ELAN Linguistic Annotator (http://www.lat-mpi.eu/tools/elan/). Upon completion of the coding process, inter-observer agreement measures were calculated for 25% of all videos, with final agreement between coders being 91.3%.

Coded data from ELAN were imported to Microsoft Excel in order to prepare graphical displays of behavior for visual analysis. Ratios of reciprocal interaction behaviors were plotted over time on a graph. The resulting graphs provided an aggregate view of reciprocal interactions in context with reciprocal interaction rates plotted on the Y-axis and corresponding contexts on the X-axis. Following this, percentages of affordance codes were calculated and added to the graph. Percentages of affordance codes were calculated by dividing the sum of specific affordance codes (e.g., gesture) by the total of all other affordance codes. Stacked 100% column charts were then plotted over time, depicting the percentages of discrete affordance codes within lesson context.

The resulting visualizations not only provide graphical depictions of discrete reciprocal interaction behaviors-in-context (e.g., initiation, response, continuation), but also representations of affordance-in-context (e.g., verbalization, text chat, gesture). Contexts are demarcated along the Y-axis, affordance codes are characterized as 100% stacked columns within those contexts and the model of reciprocal interaction is characterized as a line chart within contexts and superimposed on top of the affordance codes' columns. The graphs were used for visual analysis, each visually depicting one participant's coded reciprocal interaction-in-context for a single lesson.

Findings

Graphs were examined across lessons for trends between and within participants. Findings provide compelling evidence to approach the research questions. Analysis indicates on average high (<80%) levels of appropriate reciprocal interaction, but indicates some variation across youth and across context. The data also show that response is the dominant appropriate reciprocal interaction, with the number of continuations being relatively small in comparison to responses. In addition, interruptions are the dominant inappropriate behavior, with all other inappropriate behaviors combined accounting for less than 2% of all interaction.

Across all participants and all lessons, the dominant reciprocal interaction behavior was response. The mean percentage of response across participants and lessons was 55.65%. The second most dominant reciprocal interaction behavior was continuation, with a mean percentage across participants and lessons of 21.06%. Initiation was the least dominant reciprocal interaction behavior, with a mean percentage across participants and lessons of 20.99%. Initiation and continuation are functionally equivalent, with only a .07% difference in

average rate. For some participants (Participants 1 and 2), initiations were on average higher, and for others (Participants 3 and 4), continuations were on average higher. Across participants and lessons, the most dominant form of inappropriate behavior was interruption, with a mean of 9.33% of all reciprocal interaction codes. The mean of all other inappropriate behaviors, aggregated, was less than 1.8%. Breakdowns of average percentages of reciprocal interaction behaviors are provided in Table 1. Figure 1 provides an example visualization illustrating response as the dominant reciprocal interaction behavior.

Table 1: Percentile means of initiations, responses, continuations and interruptions among participants for all avatar treatment conditions.

	Initiations	Responses	Continuations	Interruptions
Participant 1	26.19%	51.03%	21.83%	4.58%
Participant 2	29.09%	45.25%	17.38%	21.08%
Participant 3	8.82%	72.01%	19.17%	2.76%
Participant 4	19.85%	54.31%	25.84%	8.92%

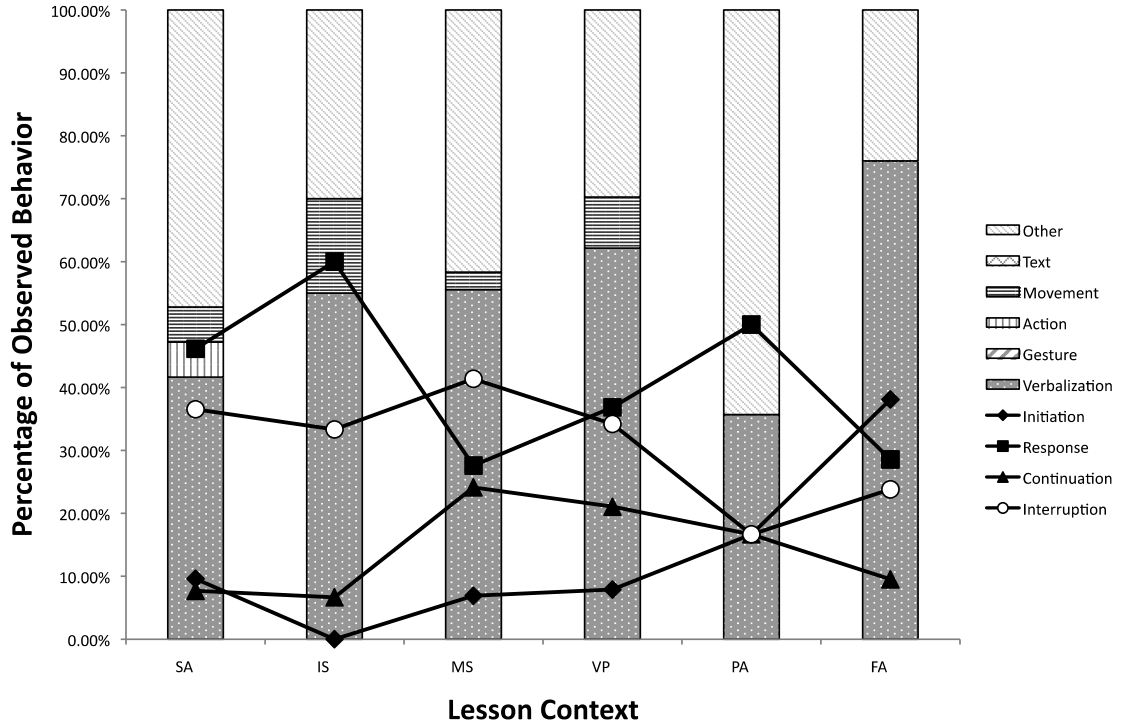

Figure 1. Example visualization indicating response as the dominant appropriate reciprocal interaction behavior and interruptions as the dominant inappropriate behavior. Lesson contexts are abbreviations: 1) starting activities (SA), 2) introduction of the skill (IS), 3) modeling of the skill (MS), 4) verbal practice (VP), 5) practice activities (PA) and 6) finishing activities (FA).

Across all participants and lessons, the dominant 3D VLE affordance used for interacting with others was verbalization. The mean percentage of verbalization across participants and lessons was 51.48%, followed by movement at 7.62%, gesture 5.95% and action at 3.64%. Text was the least dominant affordance, with a mean percentage across participants and lessons of 0.66%. Breakdowns of average percentages of affordance codes are provided in Table 2.

Table 2: Mean percentages of interaction mode codes for all avatar treatment conditions.

	Verbalization	Gesture	Action	Movement	Text
Participant 1	49.41%	3.40%	5.97%	3.91%	0.99%
Participant 2	48.13%	5.23%	6.20%	6.73%	0.46%
Participant 3	47.52%	5.35%	1.77%	14.62%	0.00%

Participant 4	60.86%	9.81%	0.62%	5.22%	1.17%

Findings indicate that from the reciprocal interaction level of coding, the dominant appropriate interaction behavior was response and the dominant inappropriate interaction behavior was interruption. From the affordance level of coding, the dominant affordance used was verbalization. In other words, participants in the 3D VLE were typically responding verbally, with occasional interruptions.

Discussion

The advancement of research on individuals with ASD using 3D VLE technology indicates high potential and promising, albeit preliminary, results. A weakness of preceding systems is that they were constrained to a pre-programmed single-user experience and that the range of activities and interactions in the environment was very limited and did not share the richness and complexity of natural communication. Drawing from prior research efforts, the current study attempted to further the field in its use of a multi-user 3D VLE for delivering social competence instruction. The goal of this study was to gain an understanding of participant interaction in a multi-user, collaborative 3D VLE by investigating their interactions in the medium. The driving question for this study was whether and to what extent the participants, who are limited in their social competence and have difficulties being social, could act reciprocally when asked to learn together in a 3D VLE. The findings show that participants can indeed interact appropriately, although with occasional episodes of inappropriate behavior.

Generally speaking, participants in the iSocial 3D VLE were responding verbally and their interactions were predominantly socially appropriate. This finding is meaningful not only in that it indicates participants were engaging in socially appropriate reciprocal interactions, but also in that this interaction pattern is mirrored in research on reciprocal interactions of individuals with ASD in the physical world. Findings by other researchers (e.g., Koegel et al., 2001; Roeyers, 1996) indicate that individuals with ASD tended to have lower rates of initiations as compared with rates of responses, and that their interaction tended to be predominantly socially appropriate. That participants in the current study were able to engage in successful reciprocal interactions in the multi-user environment and that their interactions in the environment showed similarities to real world interactions appears to support the assertion that 3D VLEs have the potential to provide a "vehicle for social encounters and social interactions" (Mitchell et al., 2007, p. 599). These findings provide foundational support for future research and lend credence to the notion that using multi-user 3D VLEs for social competence instruction for individuals with ASD is both feasible and socially valid.

Taking a different perspective, consideration must be given to user supports, not only to initiate and maintain interaction, but also to ensure the social appropriateness of interaction. Indeed, Rutten and colleagues (2003) found that participants needed support in initiating and maintaining interaction or else their interaction quickly halted. Prior researchers have cautioned against using 3D VLEs as a stand-alone intervention (Leonard et al., 2002; Moore et al., 2005; Rutten et al., 2003). Nonetheless, interventions like iSocial have the potential to promote changes to educational practices in that they can make evidence-based curricula and interventions taught by highly trained instructors and practitioners widely available to individuals with ASD. While the promise of networked, multi-user 3D VLEs for providing social competence instruction over a distance may seem obvious since this would allow for access to instruction and instructors in underserved areas, consideration should be given to what other supports can promote acquisition of social competence in conjunction with, but outside of, the 3D VLE. Indeed, we have not yet tested the degree to which skills learned in the 3D VLE generalize to real world contexts. While the current study provided some evidence that participants were able to be social in the environment and that the majority of their interaction was positive, it was limited by its small sample size and it did not investigate whether skills generalize to different contexts. Supporting and measuring generalization from the virtual world to the real world is critical if efforts like iSocial are to be successful. This remains an area that is open for further investigation.

References

Due to space constraints, references are included at the following URL: http://goo.gl/fhdfe

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