Building iSocial: Lessons learned from 3D virtual learning environment research and development

Matthew Schmidt, James Laffey, Krista Galyen, Ryan Babiuch, Janine Stichter
University of Missouri

Abstract

The iSocial project is an instance of a collaborative three-dimensional virtual learning environment which attempts to integrate social and experiential educational processes to engage individuals with Autism Spectrum Disorders in the acquisition of social competencies. The technological infrastructure was built using Open Wonderland (http://openwonderland.org/), an open source toolkit licensed under the GNU General Public License (GPL) v2. The virtual learning environment implementation is an adaptation of a five-unit curriculum designed for face-to-face, clinic-based instruction that has been shown to be effective. The goal of iSocial is to make this promising intervention and others like it more broadly available through the Internet to rural families and schools as well as others without access to the highly qualified personnel and specific strategies needed for success. In this paper we report (1) the method of development and how the research and development team has approached design and development, (2) the iSocial experience and how the youth experience the curriculum and technology, and (3) key lessons we have learned from the development and testing of the first three units of the curriculum to help advance our development efforts and to improve our understanding of the human-computer interaction and human to human mediated by computer interaction of three-dimensional virtual learning environments.

Introduction

The dual themes of advancing technology, such as processing power and visual rendering, and increased appreciation for situated and active learning make virtual environments intriguing to educators. Educators can envision designed environments that carry the student from a traditional classroom of sitting behind a desk and learning “about” subjects to a virtual experience in which the student engages with subject matter. 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) demonstrate the potential of virtual learning experiences. These systems and others are being used in a variety of learning domains, such as environmental science (Squire & Jan, 2007), social studies (Barab et al., 2005) and physics (Meisner, Hoffman, & Turner, 2008). Early results of research indicate that these environments can be highly engaging (e.g., Dede et al., 2005; Squire & Jan, 2007) and have potential for student learning gains (e.g., Barab et al., 2005).

However, in addition to the efforts to make education experiential and the powerful fit of situating learning in active experiences with the potential of 3D virtual environments, education is also a social practice. As a social practice, students learn with peers and from knowledgeable others. The widespread availability of high bandwidth and the implementation of social and collaborative functions in virtual environments enable three-dimensional virtual learning environments (3D-VLEs) to be a solution for solving some key problems of educational access. Today a student who lives in a rural community and needs access to a course not offered by his or her local school can usually access a distance learning course, but these courses provide access primarily to information resources, whether they be delivered through a course management system or video feed. However, many students may have need and may benefit from more social and experiential learning. The need for an experiential-based education and for greater social engagement, whether that simply means the presence of an instructor or requires collaborative activity with peers, may be even greater for special needs students. With new virtual and collaborative learning capabilities, educators can now envision bringing special needs and distance learning students together in collaborative environments with high degrees of instructional guidance, social presence and experiential learning.
The iSocial project is an instance of this new form of collaborative 3D-VLE that meets the requirements for a social and experiential educational process and is directed at bringing this type of learning experience to youth who otherwise may not have access to a needed curriculum. Our project, iSocial (Laffey, Schmidt, Stichter, Schmidt, & Goggins, 2009; Laffey et al., In Press; Laffey, Stichter, & Schmidt, 2010; Schmidt, Laffey, Stichter, Goggins, & Schmidt, 2008), is being developed to support social and behavioral outcomes for youth with Autism Spectrum Disorders (ASD) by expanding access to specialized training for developing social competence. Individuals with ASD often have social deficits which can result in problematic behavior (National Research Council, 2001; Sasso, Garrison-Harrell, McMahon, & Peck, 1997). 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. Social competence instruction shows promise for remediation of these individuals’ social deficits (Stichter, Randolph, Gage, & Schmidt, 2007); however, access to such instruction is limited, and providing access to instruction that conforms closely to specialized approaches demonstrated to be successful can be challenging.

Conversely, 3D-VLE technology 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. Using virtual worlds built on top of Open Wonderland (http://openwonderland.org/), an open source toolkit licensed under the GNU General Public License (GPL) v2, the iSocial project seeks to adapt and implement in a 3D-VLE a clinic-based curriculum with demonstrated impact for improving social competence (Stichter et al., 2010). In this paper we present 1) the method of development and how the research and development team has approached design and development, 2) the iSocial experience and how the youth experience the curriculum and technology, and 3) key lessons we have learned to help advance our development efforts and improve our understanding of the human-computer interaction (HCI) and human to human mediated by computer interaction (H2HCI) of 3D-VLE.

iSocial Approach

iSocial is a faculty-initiated, university-based project and thus operates with certain advantages and constraints afforded by the university context. Key advantages of a university project are 1) the ready source of innovative ideas and the knowledge base to shape how those ideas can be advanced and influence practice, 2) smart, talented and energetic students from undergraduate to graduate levels who can be mobilized even when funds are scare to help advance an idea and 3) faculty who have a great deal of flexibility in which projects they choose and experience developing startup efforts such as grant seeking and building new knowledge to advance the project. Among the limitations of doing a software research and development project at a university are issues such as typically having no staff (designers, programmers, testers, etc.) who can be assigned to a project and having little in the way of infrastructure to support and sustain a project. So while there are ready resources, talent and flexibility in the system for getting a project started, the processes, structures and roles to sustain and succeed with a project need to all be built on the fly and as needed.

Over a number of years, Dr. Janine Stichter, a faculty member in special education, had been researching and developing a social competence curriculum for implementation in face-to-face, small group sessions in a clinic setting. Dr. James Laffey, a faculty member in learning technologies, had been researching and developing methods to improve the social nature of online learning. In 2005 they met informally to discuss their mutual interest in supporting social ability and decided to write a proposal to achieve support for some initial ideas about the use of online systems for supporting children with ASD and their families. After two unsuccessful proposals seeking funding, the idea for a collaborative project migrated from an earlier focus on supporting teachers and parents through a community of practice model to a model of directly teaching youth with ASD via a 3D-VLE. At this point Matthew Schmidt, a doctoral student in Learning Technologies with an eye to doing his dissertation using iSocial, volunteered to work on the project, and faculty members used funds in their university accounts to hire Ryan Babiuch, an undergraduate in Computer Science, for some programming and to provide some resources for start-up. At this point the project was using Croquet (now OpenCobalt: http://www.opencobalt.org/) as a development environment and making slow progress. Two more unsuccessful proposals and a move to using Project Wonderland (now Open Wonderland) at last positioned the project for two successful small grants of internal university funds. Subsequently, two funding sources from outside the university, AutismSpeaks and the US. Department of Education – Institute of Education Sciences (IES), provided funding for
research and development efforts. The project is currently in the second year of a three-year grant from IES that will allow the project to complete the development of the virtual environment for the full social competence curriculum and to field test iSocial in local schools.

Design-Based Research

Another aspect of a faculty-initiated, university-based project is that while the project team is clearly focused on developing a system that will be implemented, provide value to youth with ASD and be successfully maintained, the project also (perhaps predominantly) focuses on developing new knowledge and sharing that knowledge through scholarly, peer-reviewed publication. To accommodate these dual goals of product development and scholarship, iSocial adopted a Design-Based Research (DBR) approach. Design-based research (DBR) is theory-driven design, wherein the goal is not only the iteration of a product but also the advancement of a design theory for optimal learning and performance within a naturalistic context, usually in relation to the use of technology (Design-based Research Collective, 2003; Brown & Campione, 1996). In addition, DBR addresses specific, complex, and important educational problems (Reeves, 2006) by systematically testing designs in context with each implementation and analysis informing the next iteration of the design theory. It has been called an “iterative cycle of design and enactment or implementation”, followed by analysis of the implementation, theory iteration and redesign (Wang & Hannafin, 2005).

This process is reflected in principles of DBR. While there is no one way to conduct DBR, these principles are used to guide the methods employed. Reeves, Herrington and Oliver (2005) forward a series of principles which focus on developing solutions to broad, complex educational problems by integrating known and hypothetical design principles with technological affordances. These solutions are reflected upon and tested to both refine learning environments and reveal new design principles that ultimately contribute to construction of theory and explanations in the process. Key features of these principles are a strong focus on collaboration between researchers and practitioners and continual refinement of processes, questions and protocols.

Given DBR’s focus on iteration, collaboration, consistent refinement and improvement, it may seem obvious that agility, adaptability and flexibility are essential to a successful DBR process. To be sure, when implementing a design in a complex system, many (and in fact, most) contextual variables are not known a priori (Barab & Squire, 2004). The DBR process allows for discovery of additional contextual variables, thereby further informing design theory through subsequent design and testing iterations that address these variables.

Over the several years of development, the project has seen each iteration of an instructional unit as an opportunity to improve our understanding of how youth with ASD can participate and contribute in a VLE and how the online guide can be supported to manage behavior and provide instruction in a collaborative VLE. For example in the first version of an iSocial unit tested with the target youth, we observed that the online guide struggled at times to keep the youth focused on the lesson activity. The youth were interested in the virtual world and frequently wandered away to explore aspects of it. The online guide had only limited means to direct their attention and had timelines to meet for completing various aspects of the lessons. In a different context the exploration might have been valued, but in the context of timed lesson it needed remediation. Following that usage test we developed a construct of “social orthotics” as structures in the environment that would invite desired behavior and constrain undesired behavior. To address this need of shaping exploration to fit the lesson timelines, we developed lesson spaces which could be locked or unlocked for entering and exiting, “personal pods” for maintaining appropriate orientation and distance to others and barriers to keep certain sections of a world closed until it was time for that lesson activity. In each iteration of our units we are improving our implementation of social orthotics by adding elements such as color cues and building a better understanding of when and how to implement the design features.

Free/Open Source Software

iSocial couples the conceptual and iterative nature of DBR with the ability for customization, flexibility and evolution available in Free and Open Source Software (FOSS). FOSS is an approach to software development and distribution that includes source code and forms of licensing which permit ready
customization and evolution while preserving the software as a common good. FOSS’s ability for ready customization and evolution, to meet local needs, to be iterated loosely in regards to special requirements of target users and free access to source code makes it a natural partner for design-based research, which requires flexibility, ability to control iterations and innovativeness in how one approaches unknown contextual variables. FOSS accommodates the needs of DBR to agilely revise, adapt, make changes and re-implement to fit the target context.

FOSS provides opportunities for designers, developers and users to participate in the community development effort that simultaneously contributes to meeting local needs (Lin & Zini, 2008; Carmichael & Honour, 2002). Open source software is particularly useful for educational application development in that it helps to establish a closer relationship between development communities, educators and users, so that the software can be iterated based on the needs and special requirements of the target users. FOSS is gaining traction for its potential benefits over proprietary counterparts in the development of multi-user 3D VE s both for educational and enterprise applications. This interest is spurred by the flexibility, customizability and extensibility of FOSS 3D VE platforms such as Open Cobalt, Open Wonderland, OpenSim and realXtend. For example, Young (2010) discusses the decision to use the NSF-sponsored FOSS platform Open Cobalt over the proprietary Second Life platform due to educators’ lack of control of the proprietary environment. While Young reports on issues related to higher education courses, the issues mirror concerns we have in comparing proprietary to open source methods for developing systems for K-12. In addition to concerns about ownership of content and who can access spaces in the environment, when working with K-12 schools there is a high level of concern for security in many forms. Additionally, we were concerned with how well the environment could be customized to unique requirements. For example, we anticipated that novel structures such as social orthodoxies might be needed to optimize the environment for our special needs youth, hence, we opted for the environment that would allow maximum flexibility in responding to requirements. Issues of ownership, security and flexibility in meeting requirements underscore the benefits of the FOSS approach for development of 3D-VLEs. However, FOSS software solutions bring with them unique challenges. Laffey, Schmidt and Amelung (2010) maintain that while FOSS allows for substantial flexibility, it can also result in difficulties due to potential diversity in implementations and the need for highly knowledgeable local staff who have the capability to participate in broader FOSS communities. This sentiment is consistent with assessments from other researchers’ (Kappe & Guetl, 2009; Young, 2010; Zutshi & Sharma, 2009) of their particular FOSS implementations. Indeed, those studies note the high requirements of hardware and professional knowledge of the personnel in the implementation. This challenge could well be the primary impediment to implementing FOSS 3D virtual environments.

**iSocial Experience**

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 five-unit clinic-based curriculum called Social Competence Intervention based on a framework of Cognitive Behavioral Intervention (SCI-S). The curriculum challenges the youth’s thinking patterns and includes key components such as the use of metacognitive strategies, self-monitoring and self-regulation and exposure and response situations. In each of the five curricular units, the lesson plans follow a consistent structure of learning and rehearsing skills, practicing these skills first in structured activities and then in more naturalistic contexts. Results of using the SCI-S curriculum indicate promising trends for growth across pre- and post-intervention assessments among youth with ASD (Stichter et al., 2010). iSocial, the 3D-VLE implementation of SCI-S, was designed for participants, in separate locations, such as across rural communities in Missouri, to take part in 32 lessons of 45-minutes with an Online Guide (OG) who acts as an instructor and an Online Helper who provides technical support and assists the OG with the technology. Each participant sits in the physical world with a Physical Facilitator, an individual who can help the youth with ASD if hardware or behavioral issues arise.

To provide a sense of what the learning experience is like, the following scenario depicts the experience of a youth participating in a lesson activity in iSocial. We have selected the “Lost at Sea” activity from the third lesson of unit two. By the time the youth gets to this activity, the youth is well-oriented to his group of three to five peers and his OG, as well as to the general methods and tools of iSocial. We start with the OG congratulating the group on completing the prior activity and asking them to
move to the area where they will decide which roles they will take on for the upcoming “Lost at Sea” task (see Figure 1).

*Figure 1:* On the left, the ship where students undertake the lesson. On the right, students, Online Guide and Online Helper gather in an area on the ship to discuss their roles for the upcoming activity

After having spent several lessons on the ship, students are told that the ship is sinking. Their mission during this lesson is to do four tasks: 1) decide on which role each member will take, 2) go into the cargo hold and collectively decide on which eight (out of 15) items to take with them, 3) escape to the rescue boat where they will need to negotiate which part of the island they think it is best to go for their survival and 4) arrive on the chosen part of the island. The lesson is designed to require discussion and negotiation among the students, activities that the online guide facilitates to build students’ social competence.

The OG facilitates the students’ choosing of their roles. One student chooses the “items task manager” role, putting him in charge of picking up the items in the cargo hold for the rest of the team. Another chooses the “task manager for the campsite” role, putting him in charge of leading the group through a portal, that is, an object in the world that allows users to “teleport” from one area to the next immediately. Two others choose “island chore task manager” and “timekeeper” roles. The students negotiate who will do what, and why they think they should have a certain role of their choosing.

After the role selections are completed, the OG leads students into the cargo hold where they choose eight out of the 15 items to take with them to the island (see Figure 2). Each student must express what they think would be good to take and why. Disputes over what would be most important to take with them to the island lead to the negotiation of agreed-upon items and their worth on a deserted island. The timekeeper warns the team it is time to move on because the ship is sinking; they need to get to their rescue boat. As they decide upon items, the items disappear from the environment and appear in their “inventory”, a list that is visible to all team members. The team hurries to negotiate quickly and make a final decision regarding their eight items, after which they escape to the rescue boat (see Figure 3).
Figure 2: On the left, Joey selects a basket and is presented with the option to leave it (left button) or take it (right button). On the right, Joey has selected to take the basket, so it has disappeared from the 3D-VLE and appeared in his inventory.

Figure 3: While on the rescue boat, the team decides which of the four parts of the island best suited for the group.

Following this, the OG briefly orients students to their task. In front of them is a description of the island and the attributes of each of the four parts of the island. Students discuss the pros and cons of each part of the island, including which part they think would be best for survival with the items they chose. The students are given four areas to choose from: 1) volcano area, 2) rocky area, 3) grassy area and 4) cave area. All areas are described in terms of shelter, how far from fresh water and food and elevation. One student states, “I like the volcano area because it has the highest elevation,” while another responds, “Yes, but it’s far from fresh water and food. I prefer the rocky area because it’s closer to water and food.” After much negotiating, the team comes to a consensus that the “rocky area” is the best place to live on the island since it is the closest to food and water. The students then go through a portal and arrive on the island in their chosen area, where the lesson comes to an end.
Lessons Learned

The examples provided in this article emphasize how the iSocial project has leveraged FOSS to enable considerable customizations and to respond to student and instructor needs, thus informing our design theory for supporting youth with ASD in virtual worlds. The challenges of forwarding a software research and development product at the university, such as having no staff and little infrastructure, necessitated considerable effort in building sustainable technology and manpower infrastructure to support the project. The exploratory nature of our work often led to unanticipated discoveries about how individuals used the system. These experiences and others gained over five years of designing, developing and implementing iSocial provide a unique perspective on using FOSS-based 3D-VLE solutions for education in general and for individuals with ASD specifically.

From the perspective of building and sustaining a technology ecosystem to support FOSS 3D-VLE development and implementation, we have learned that knowledgeable and skilled staff are critical. While one may be inclined to consider the potential of FOSS development as essentially unlimited, the fact is that the capability of FOSS to specifically address local needs is limited by local development capacity. The contributions from the broader community and ability to modify source code can be of great benefit, but in order to reap these benefits, knowledgeable personnel with requisite skills are essential. The challenge, however, is finding staff with the necessary skills. To be sure, there is no pool of Project Wonderland developers to hire from. Instead, individuals with related skills and interests must be found and then given sufficient leeway and support to learn the job. Designers and developers must be given broad freedom to explore the system, must be trusted that they are able to learn on their own and must be empowered to become responsible community members. Freedom to explore the system is important because FOSS systems may be lacking documentation and learning resources may be scarce. Trusting staff to learn on their own is necessary since sometimes the only way to make progress is by trial-and-error. And finally, empowering staff to become responsible community members allows them to reap the benefits of the FOSS model of software development: they are able to share their knowledge, collaboratively problem-solve and participate in collective invention. Such skills are essential when implementing software that is in a constant state of flux, as are the majority of current FOSS 3D-VLE systems.

In addition to this, our exploratory research using 3D-VLE technology for teaching social competence to individuals with ASD has provided us with insights regarding the human-computer interaction (HCI) and human to human mediated by computer interaction (H2HCI) of our 3D-VLE. Our early work revealed difficulties in facilitating efficient social experiences, as participants were challenged by an environment that was difficult to navigate, lacked many of the social cues afforded by real-world interaction and had few constraints. As our understanding of learning in the 3D VLE improved, we began to experiment with creating more open virtual spaces to ease navigation, incorporating visual and software cues to indicate behavior expectations and building structures to invite desired behavior and constrain undesired behavior. In terms of virtual worlds design, we have found that students are better able to navigate more open virtual spaces (for example, a garden as opposed to a room in a building). These spaces allow for greater visibility of the environment thus enabling students to see group activity and appropriately orient to such activity. Further, visual cues such as icons indicating when students should raise their hand to speak and “tokens” which recognize good behavior help communicate behavior expectations and provide a reference point for the online guide when addressing problematic behavior. Finally, social orthotics help constrain undesirable behavior and invite appropriate behavior. For example, providing a “personal pod” for students to stand on when the online guide is delivering instruction allows students to maintain appropriate distance with their avatars from one another and the guide, as well as stay together as a group. Refinement of our virtual world designs, implementation of visual cues and use of social orthotics underscore not only how our understanding of teaching and learning in 3D-VLEs is evolving, but also the unique opportunities of 3D-VLEs to enhance the learning experience.

Conclusion

In this paper we presented the iSocial project as an ongoing university research and development project, emphasizing the advantages and limitations of this approach. In addition, we provided an overview of the iSocial project’s method of design and development, highlighting the principles of design-based research
which guide our research and development trajectory and allow us continually refine our design theory. We also discussed the Free and Open Source Software ecosystem in which the project operates and the benefits that use of such software provides our project from the perspectives of control of data and customizability. These attributes are interrelated and in some ways symbiotic. The university culture in which the project is being forwarded values such principles as innovation, shaping ideas and building new knowledge. The DBR process allows us to collaboratively iterate and improve the design of our virtual learning environment, thus advancing the principles valued by the university. And the adaptability and customizability made possible by the nature of the FOSS Open Wonderland virtual worlds toolkit allows us to powerfully and flexibly implement the design improvements suggested by the DBR process.

In five years of research and development, the iSocial project has evolved from a simple prototype of a single unit in the SCI-S curriculum into a complex learning environment with the capability to deliver 32 social competency lessons to students who are located remotely throughout the state and beyond. Key lessons we have learned from the process of building out the system and developing and testing units from the curriculum have enabled us to not only improve our development efforts, but also our understanding of user interaction with the iSocial system and the overall user experience. Recruiting knowledgeable personnel who have the skills and capability to harness the benefits of the FOSS model of software development is critical to success. Perhaps equally important is allowing personnel sufficient leeway to learn how to be successful in the deployment of systems that are still under construction. In addition, being mindful of users’ interaction with the system, identifying weaknesses in the user experience and iterating designs to improve users’ interaction both with the system and with others in the system forwards our understanding of teaching and learning in the 3D-VLE.

The iterative improvement of our ideas, designs and implementations contributes to making students’ experience in iSocial engaging and distinct. Our focus on how users interact with the system also reveals unique opportunities to make enhancements to the learning experience. As researchers, designers, developers and implementers of 3D-VLEs, there is much to learn and discover about 3D-VLEs and their potential. As we complete development of the final units of the SCI-S curriculum and prepare to undertake field tests of the system in local schools, we will continue to refine the principles that guide our research and development of 3D-VLEs, thus contributing to our understanding of using these advanced technologies to situate learning in meaningful contexts and engage students actively in the learning process.

References


Acknowledgements
The authors wish to acknowledge support for the research and development represented in this report from the Thompson Center for Autism and Neurodevelopmental Disorders and the University of Missouri Research Board. Support for this work was also provided by grant # 2915 (PI: Laffey) from Autism Speaks and grant # R324A090197 from the US. Department of Education – Institute of Education Sciences (IES).