Leveraging Open Source Software and Design Based Research Principles for Development of a 3D Virtual Learning Environment

Matthew Schmidt Krista Galyen James Laffey Nan Ding Xianhui Wang <u>SchmidtMa@missouri.edu</u> <u>GalyenK@missouri.edu</u> <u>LaffeyJ@missouri.edu</u> <u>NanDing@mizzou.edu</u> xw7t4@mizzou.edu

University of Missouri

Abstract

Design based research (DBR) has been acknowledged as a productive approach for advancing educational technology. Coincidentally, open source software has been found to be a good fit for implementing design based research. This report presents a case study of a software project using a design-based research approach and free/open source software. The project, iSocial, is developing a 3D virtual environment for youth with autism spectrum disorders to develop social competence. The study illustrates how the flexibility and community features of FOSS fit with the iterative nature of design-based research to benefit the development of iSocial, and the report also discusses challenges of implementing FOSS and DBR.

Introduction

Educators and researchers are warming up to the notion of using three-dimensional collaborative virtual environments for delivering online instruction. Systems like 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 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), for enhancing, augmenting, modifying and even replacing traditional face-to-face and online curricula. Research indicates that these environments can be highly engaging (e.g., Dede et al., 2005; Squire & Jan, 2007) and that students who use them can show learning gains (e.g., Barab et al., 2005).

Interest in three-dimensional virtual learning environments (3D VLEs) is also growing in the field of social competence instruction for individuals with Autism Spectrum Disorders (ASD). Individuals with ASD often have social deficits that 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), and there is some evidence 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).

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 an Internet-based, three-dimensional virtual learning environment (3D VLE) to support social and behavioral outcomes for youth with ASD. The purpose of developing this system is to expand access to specialized training for developing social competence. iSocial seeks to adapt and implement in a 3D VLE a clinic-based curriculum with demonstrated impact for improving social competence (Stichter et al., 2010). The virtual worlds that implement the curriculum have been built on top of Open Wonderland (http://openwonderland.org/), an open source toolkit licensed under the GNU General Public License (GPL) v2.

To build iSocial, we have followed a design research trajectory through early work of building theory and testing pilots and prototypes to current work of iterating through the design and development of five units of the curriculum with usage tests for each unit. The trajectory is aimed at performing two levels of testing in public schools with the ultimate goal of understanding how to support the requirements of this special needs population in virtual learning and having a full-scale deployment of all five curricular units. The design research framework we employ provides the opportunity to advance our theory of how the learning of youth with ASD can be supported in a virtual environment and to advance the iSocial system so as to implement the curriculum and support social competence in a 3D-VLE. For example, in the first unit to be developed we conceptualized what was needed and important for the youth to interact effectively and learn from their social and cognitive experiences. This is especially challenging because the reason these youth need the training is that they are typically ineffective in social interaction. Following lessons learned in the first unit, we advanced our conception of what is needed and developed an implementation that better targets key needs and opportunities. As an illustration we are developing structures within the curriculum to scaffold the youth in social and group activities. As we then move from one unit to the next, we recalibrate and adjust the approach to the specific tools so that they both resonate with the youth and achieve the desired results.

In this paper we forward the general argument that the open and flexible nature of Free/Open Source Software strongly matches the needs of design-based research. We provide specific examples supporting this argument from the iSocial project, focusing on enhancements to virtual world design, tools to support students' ability to be social and expansions to the curriculum.

Design-based Research

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.

Free/Open Source Software

Free and Open Source Software (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 to approach 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. The integration of the practices of teaching and learning with the flexibility and freedom to develop makes FOSS a suitable alternative to commercial software.

FOSS is gaining traction for its potential benefits over proprietary counterparts in the development of multi-user 3D VEs 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 (http://www.opencobalt.org) over the proprietary Second Life platform due to educators' lack of control of the proprietary environment. In Kappe and Guetl (2009), the researchers discuss development of a virtual conference room for knowledge transfer and learning purposes and their preference for FOSS software toolkits due to the ability to customize and add functionality to such virtual worlds as well as their ability to interoperate with other virtual worlds, including Second Life. Zutshi and Sharma (2009) compared the usability and acceptability of two proprietary platforms, Second Life and Qwaq, and one FOSS platform, realXtend, for collaboration within an enterprise. While the authors reported success with the realXtend platform, they were unable to achieve their goals with the proprietary platforms. The authors also note that the flexibility of RealXtend enabled building an environment that users found more consistent with their real work situation than was possible with the other platforms.

Such reports of successful FOSS implementations 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 profound flexibility, it can also result in difficulties due to great diversity in implementations and the need for highly knowledgeable local staff who have the capability to participate in broader FOSS communities. This sentiment is mirrored in other researchers' (Kappe & Guetl, 2009; Young, 2010; Zutshi & Sharma, 2009) assessment 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: A Case of DBR/FOSS Symbiosis

The ultimate goal of the iSocial design research trajectory is both to inform design theory and develop a system that supports learning behavior and social interaction in a 3D virtual learning environment. To this end, iSocial must be both usable and useful to participants, and since there is no substantial nor sufficient research base for us to draw upon, we needed to learn how to make the user experience social for youth with ASD through our iterative design research process. The use of Free/Open Source Software is a factor that has had significant impact on our ability to meet our project goal. The flexibility, extensibility and customizability of FOSS afforded us a high degree of agility to revise, adapt, make changes and re-implement our designs.

Customization of OWL: Scenarios

What follows are scenarios that describe how iSocial has approached meeting the needs of participants by customizing the functionality of our virtual learning environment in order to accomplish the goal of facilitating social competence. These customizations fell primarily into three categories: environmental, social and curricular. After describing the scenarios, we present the strengths and weaknesses of using FOSS for this design-based research in relation to the scenarios presented.

Virtual Environment

Our virtual environment iterations led us to designing more open and spacious spaces. The initial space was an enclosed, round lighthouse building. Over time we learned that the easier it was to see across virtual landscapes, the easier it was to navigate through the world and be social. Figure 1 shows the differences in our environmental designs from the lighthouse to the garden world. These lessons helped us advance our understanding of building virtual learning to include the tangible nature of the environment as something that provides both opportunities and constraints. While it can be argued that proprietary systems also afford such modifications, the open nature of the Open Wonderland software facilitated flexibility and ease in this process. Because Open Wonderland supports open file formats and multiple tools for the creation of virtual worlds, the iSocial team was able to be efficient in its development of new virtual spaces.



Figure 1: Lighthouse world (left) and Garden world (right)

Tools to facilitate appropriate social interaction

While the new garden space was more open and allowed ease of navigation as well as naturally inviting social interaction, this openness also allowed students to move their avatars away from the group during a lesson. Thus began the need to build custom tools to facilitate appropriate social interaction, such as helping to group students together around lesson activities while maintaining the open environment.

Tools which facilitate appropriate social interaction are customized software supports that enable users to do what they would either not be able to do or be less able to do on their own. Since the opportunity to move away from the group was greater in the open garden world, spaces were developed that constrained students' ability to move away from the group during lessons and better indicated areas where students were to take part in activities, such as group areas and individual spaces (see Figure 2). Development of these tools was possible because programmers were able to study the source code of the Open Wonderland platform and extend it to work in new ways.



Figure 2: First iteration of group spaces (left); Second iteration of group spaces with personal pods (right)

Curricular Expansions

One of the major benefits of learning in a 3D VLE is the ability to have an intrinsically motivating and engaging environment. Over the course of several iterations, we were able to change the curricular activities so that they became more engaging. This often required flexibility in development. For example, one activity helped students learn communication strategies by collaboratively building a restaurant. Our curricular iterations moved from students discussing the kind of restaurant they wanted and viewing pictures to actually building a 3D restaurant and negotiating their choices for the restaurant building, furniture, types of food, etc. In another activity, students went from playing a game in a flat, two-dimensional window to being able to move their avatars from space to space and be "in" the game. These curricular expansions leveraged the symbiotic nature of FOSS and DBR. The iterative process of DBR helped to identify emergent variables that impacted our instructional design and the open and flexible nature of FOSS allowed us to approach these issues in very targeted ways.

Conclusion

In this paper, we argue that the open and flexible nature of Free and Open Source Software makes it a good fit for implementation of design-based research. In the case of iSocial, the FOSS Open Wonderland virtual worlds toolkit allowed for customization in order to fit the needs of our target population of adolescent students with ASD in need of social competence support and instruction. iSocial demonstrates how FOSS can enable considerable customizations to respond to student and instructor needs. These software changes in turn informed our design theory for supporting youth with ASD in virtual worlds. Primary among the benefits of using FOSS to our design based research were flexibility and community.

Flexibility afforded developers the ability to perform rapid prototyping and experimentation with a variety of innovations to meet anticipated and emergent needs. Developers were able to quickly and effectively respond to needs through customizations and additions to the virtual worlds toolkit because they had access to the underlying source code. Because developers were able to both view and change the source code, we were able to respond to variables that emerged during implementation and to iterate our designs and the virtual world itself to cater to specific needs of a special population. We maintain that such a high degree of flexibility would not have been possible with proprietary software.

The community surrounding Open Wonderland is another factor that has been key to the success of our project. The Open Wonderland community allows users of the software to share knowledge and problem-solve. When developing software supports for the social competence curriculum, the iSocial team would often rely on the online community to provide a knowledge base and pool of expertise far greater than was available locally. The community also contributed to what we refer to as "collective invention." Meetings of skilled individuals from around the world contributed to the design, development and implementation of iSocial.

However, for all of its benefits, FOSS is not without its weaknesses. While the FOSS source code is open and readily available, customization does require dedicated personnel with expertise. Finding and building that expertise takes time and money, both limited resources. 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.

We also show that the use of design-based research is a good fit for researching solutions to educational problems in naturalistic contexts, especially when paired with FOSS. Endemic to DBR is the ability to discover unknown contextual variables and adapt both the design theory and the technological innovation over time. While not a weakness, DBR's iterative nature does require a relatively long time commitment in relation to one-time studies. This often means a dedicated research and development team is needed. However, the pairing of FOSS with DBR can be a very flexible and powerful method for educational research and development

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