Connecting Students by Integrating the 3D Virtual and Real Worlds: We Need 3D Open Source Spaces to Keep Socialization, Communication and Collaboration Alive

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Abstract: Picture a world where imagination is the only limit; a world that stimulates students to learn, communicate, play and grow. The emergence of 3D Virtual Worlds has made this a virtual reality. Until recently this virtual experience has been separated from the real world by the limitations of software (proprietary systems), and constraints of hardware and networks (stationary consoles and network connections). Such separation limits the pedagogical utility that 3D Spaces can offer students. This article peeks around the corner of innovation by exploring a number of emergent open source developments that integrate the 3D Virtual and Real Worlds into a seamless reality, one that enhances pedagogical opportunities by integrating the practical and vocational actuality of the real world with the technical and imaginable possibilities of the Virtual Worlds. These possibilities are explored with reference to recent developments, pedagogical theory, and case studies in various open source 3D Virtual Worlds.

Introduction

It is still common in Higher Education that class attendance is not mandatory. Therefore, students might not attend class regularly, preferring instead to contact other students for the latest information and learning material. Non-physical attendance is facilitated by the use of modern technology, where the student can attend lectures virtually (e.g., recording podcasts, streaming live video of the lecture, lectures in 3D Virtual Worlds). While often seen negatively by academics, virtual classroom attendance provides certain pedagogical advantages for students, because the motivated student is empowered to engage with the learning environment optimally at their own pace and place. The emergence of *Public Virtual Worlds* (also known as 3D Virtual Worlds or 3D Spaces) such as Second Life (2009a, being one of the most well-known) has provided educators with an almost unlimited set of tools to redefine the classroom, especially in blended or distance learning. The recent period of hype regarding Virtual Worlds has raised the interest of educational institutions, and has resulted in new and innovative educational approaches that actually take advantage of these tools and opportunities, even in fields that were not predicted. According to Fenn et al. (2008), public opinion regarding Virtual Worlds is currently in a stage that the Gartner Hype Cycle calls the *Trough of Disillusionment*. In contrast Hayes (2009) sees Virtual Worlds as mature for (higher) education and as being located in the upper part of the *Slope of Enlightenment,* and therewith near the *Plateau of Productivity*. Considering the change of acceptance in the research community and the start of numerous projects over the last months, we feel confident to predict that 3D Spaces will become an integral part of education (i.e., in combination and seamless integration with other media and technology, and across a variety of learning paradigms).

Several questions and ideas for future research projects have been raised by the authors' evaluation of both empirical data and their professional experience teaching tertiary Information Systems/Science courses (i.e., from surveys and interviews administered in conjunction with project courses being conducted in Virtual Worlds, real classroom lectures, and via blended learning formats). One of these questions concerns the different spaces (real and virtual) being used during lectures – how are project students communicating and connecting? Even though several channels were used (instant message, voice, live stream of the real classroom, and projection of the Virtual World), students still reported not being fully connected when they were communicating with colleagues who were not in the same 'space'. There were too many limits – some criticisms were that the Second Life Client has an appetite for computational power, the user interface could be more intuitive, and the lock-in experienced by users of this proprietary software. In particular, students had trouble participating and benefiting from the rich media if they were not using high-end computer systems or broadband Internet connections. Some suggested adaptations were: reducing the amount of communication using video, audio, and instant message (which limits the opportunities for socializing and immersion); and providing multiple media to connect to the classroom (e.g., a white board in Second Life that is synchronized with a replica on the web, mobile devices, or even other Virtual Worlds).

This paper acknowledges yet does not dwell on criticisms of Second Life (and 3D Virtual Worlds in general). Instead we focus on the solutions and educational possibilities inherent in innovation. We take a look around the corner to find answers to some pertinent questions, such as: (1) are there alternatives to Second Life provide similar or additional features; (2) how can we increase students' connectivity and reduce the gap between the real and virtual worlds; (3) do we need to use commercial software? In discussing these questions we focus on the open source movement in Virtual Worlds (i.e. OpenSimulator, Project Wonderland and Croquet / Open Cobalt), as well as considering new technological gadgets that are becoming more commonly used by students (e.g., Wii controller and mobile devices). A clear indicator of the increasing popularity of mobile devices is that on the 23rd of April (over a period of only nine months), Apple sold the one billionth application for the iPhone/iPod Touch (Apple 2009). Instead of being online over specific (long) time intervals, mobile users tend to be continuously online but for shorter durations. As socio-technological adaptation is changing the way we live, recreate, work, and also study. Therefore this trend will likely drive innovation in instructional design throughout the educational sector. The accessibility of the virtual classroom can help students participate in socializing, communication, and collaboration independent of location, time, duration or media. In short, we present some devices and technological gadgets to provide inter-world connectivity and therewith increase the usability of 3D Virtual Worlds.

The open source principle is instrumental in overcoming certain drawbacks in using proprietary applications that limit possibilities for bridging the real and virtual worlds. For example, Second Life limits data transfer to a specific number of messages and offers no immediate APIs (Application Protocol Interfaces) to backup, transfer, or exchange objects and large amount of data with other applications. To satisfy the multiple channels being used by the heterogeneous group of learners, the course content and lectures need to be distributed in various formats while providing synchronous and asynchronous communication, collaboration, and immersive inclusion in the classroom. Open 3D Spaces generally provide new concepts and a higher degree of innovation because they are research oriented and *live* as a result of commitment by the user-community rather from the need to have a successful business case. Therefore this paper considers the Open 3D Spaces that are free and allow unrestricted APIs and modification to integrate new features.

The reader might question why Second Life is part of this paper because it involves proprietary software. The content of Second Life is predominantly user-generated; as such Second Life created a foundation for many universities to develop and discuss their own implementations. In general, the Second Life in-world experience is not restricted if you own land and work on more or less traditional settings. From our own first steps (Burmeister et al. 2008, Wriedt et al. 2008, Dreher et al. 2009c) we gained confidence to explore the boundaries of Second Life and notices many restrictions (i.e., regarding blended learning with heterogeneous groups of students, which can be done but the solution might not be textbook quality). Therefore, we have initiated further projects where the Virtual World is selected based on the idea and not vice versa. However, to give credit where it's due, Second Life is a stable environment in which it is relatively simple to teach classes, connect people, and realize dreams.

The next section (*Open Source in 3D Educational Environments*) investigates Second Life with respect to the open source principle and peeks around the corner of innovation by introducing other 3D Spaces that are currently developed as open source projects. The subsequent section (*Bridging Real and Virtual Worlds*) demonstrates how these ideas can be realized to bridge the barrier between reality and virtuality. Besides applications and features of the Virtual Worlds, we also describe some ideas using technological gadgets from various student projects. The paper concludes with our roadmap for addressing important research questions (i.e., regarding interfaces for the end user and applications in the field of Information Systems; see Dreher et al. 2009b).

Open Source in 3D Educational Environments

This section overviews key perspectives regarding open source software and introduces a number of 3D Virtual Worlds that offer open source functionality which has facilitated their use in educational settings. Especially in the modern information age, the domains of education and research are benefited by various pro-social changes to intellectual property rights, including the free publication of information (open access publishing; Suber 2007) and the freedoms to distribute and modify software which have been variously described using the terms free software (Free Software Foundation 2007) and open source software (Open Source Initiative 2007). Regarding the freedoms to distribute and modify software, we acknowledge that there is some overlap, discrepancy (and factionist rivalry) between the terms free software and open source software (Stallman 2007). In this paper we use the term open source software, which can be described as the collaborative, iterative development and free provision of software source code by an open community of software developers (Raymond 2000). Raymond (2000) defines and contrasts the 'Bazaar' model, where all source code developments are public (e.g., Linux), and the 'Cathedral' model, in which each software release publishes source code but where access to interim updates/revisions of that code is restricted (e.g., GNU Emacs). In a bid to affect standards of practice, the Open Source Initiative has specified a definition of open source software that emphasises freedom and equity in licensing and distribution, transparency in the development process and peer review (Coar 2006).

This paper uses the term 3D Educational Environments to describe the use of 3D Virtual Worlds for educational purposes, which often involves constructing virtual university campuses and/or facilities, but can also include any other aspect of 3D Virtual Worlds. Pedagogical applications of 3D Educational Environments often utilise a blended learning approach that integrates instruction and learning in both the Virtual World (i.e., using 3D Educational Environments) and the Real World (i.e., the physical world, which uses the familiar lecture hall and seminar/tutorial room format). A number of 3D Virtual Worlds have been used in educational settings. These are briefly introduced and reviewed below. Furthermore, various 3D Virtual Worlds differ in the (open source) functionality that they provide. The degree of extensibility that a Virtual World offers facilitates adaptation for educational purposes. Also reviewed below is the extensibility of key 3D Virtual Worlds that offer open source functionality, including Second Life, Project Wonderland, Croquet, and OpenSimulator.

Second Life seems to be the best choice when users require a Virtual World that provides a stable platform, minimum administration and maintenance, while providing maximal in-world development options, and the most flexibility regarding design and scripting – especially if compared to most other commercial platforms. In particular, the open source aspects of Second Life include the freedoms to: create in-world objects (called primitives, or prims) use the Linden Scripting Language (LSL) which allows one to alter both the structure and function of primitives; alter the physical terrain and atmospheric conditions of regions that one leases; and create and alter aspects of one's avatar (an in-world representation of the user, that is often humanoid). The Second Life engine is restricted, but as commonly occurs in the real-world, people have discovered ways to *change the environment* (using Megaprims with sizes far beyond the 10 meters permitted), and people have *hacked* features to provide innovative functionality (e.g. streaming videos, data communication, and web interfaces). However, Second Life is proprietary, and despite these in-world freedoms, consists of several limitations with respect to the open source principle. Linden Lab uses a closed source grid architecture; users do not have access to the source code that governs the operation of the Second Life environment (regarding virtual reality graphics, simulation of physics, and the flow of information between the client application and the Linden Lab servers) which raises questions about data security, privacy, confidentially, persistence, and durability – especially in case of server or business problems. Linden Labs plans to bring servers to the market that host up to 8 islands, which will still use a firewall, keep the source code confidential, and restrict individual enhancements (Linden 2009a). In addition, there is continuous discussion of whether Linden Lab will open the (back-end) grid source code (Wallace 2007), implement the Open Grid Protocol (Second Life 2009b), and how the open source program (which started with the Second Life client) will be pursued (Linden 2009b). However, there is no doubt that open source alternatives are needed (Wallace 2007).

When we initially began our educational programs using 3D Virtual Worlds, various Open Source 3D Spaces showed interesting features and innovative concepts, but could not match Second Life regarding stability, functions, or simplicity in administration and access. However, since our attention shifted from pure in-world scenarios to those bridging the real and virtual worlds, we have had to evaluate alternatives to Second Life due to many restrictions and missing features. In order to realize the scenarios described below (in *Bridging the Real and Virtual Worlds*), we considered the following criteria when evaluating potential Virtual Worlds: (1) active development; (2) existing versions that can be installed and used; (3) open source functionality so students can extend APIs or add required features; (4) capacity to import existing objects; and (5) applicability for classroom as well as businesses. We decided on OpenSimulator (which is very close to Second Life), Project Wonderland (with its server-client model yet advanced features like application and media integration), as well as Croquet / Open Cobalt (which is uses a different philosophy for building the world). These three applications are briefly described.

OpenSimulator is an open source solution that realizes a server architecture comparable to Second Life (OpenSimulator 2009). Even though being alpha software, the 3D application server is already used in various projects and provides most of the features that are known from Second Life. The main advantages of OpenSimulator (often abbreviated to OpenSim) are its extensibility due to its open source format, flexibility in terms of protocols and APIs, and capacity for further in-world programming languages besides LSL (which is not yet fully implemented). The server can be reached by various viewers and development software for configuration or importing objects. The concept for usability and look was modeled closely on Second Life, and is a promising alternative to imminently released (and expensive) Second Life servers. It will be interesting to follow how these two worlds will co-exist and to compare their functionality over the next few years.

Project Wonderland is written in Java, is open source, and uses a similar client-server architecture to Second Life. The development status is alpha and several functions need to be installed in parallel (e.g. the voice bridge to have audio communication). Project Wonderland is based on the Darkstar server (Sun Microsystems 2007) that was originally implemented for gaming, and which enables the 3D visualization and object handling. The communication between server and clients is realized by channels for the various functions: the client registers a channel and can send and receive messages for communication with other clients. Note that the communication as well as 3D engine is changing with the next version to improve the performance and provide new features. This Virtual World stores objects in XML-files and allows a simple process for design and creation – even without in-world editing. The current aim of Project Wonderland is not to cover large worlds but rather to provide a platform for companies or educational institutions with advanced technology to communicate and collaborate. Therefore, Project Wonderland provides features for using desktop applications in-world (e.g., OpenOffice, Firefox, or Eclipse), white boards and advanced communication options like web-cam, and voice conferencing (using standards in addition to uncommon interfaces like VoIP to call real-world telephones). Below (in *Scenario 2: Project Wonderland*), we demonstrate how information sharing can be done using different media and devices to bridge the real and Virtual World with Project Wonderland.

"Croquet has been designed from the ground up with a focus on enabling large scale peer-to-peer collaboration inside of a compelling shared 3D environment" (Smith et al. 2003). Rather than being a Virtual World itself, Croquet is a Software Development Kit for various settings in the context of 3D visualization, interaction, and collaboration. Even though the project has finished, the platform is used and further developed in the Open Cobalt project, which is about a virtual workspace browser and toolkit (Lombardi 2009). Croquet as well as Open Cobalt are open source projects and supported by several research and educational institutes. Compared to the other concepts, the Croquet SDK is based on different architecture and design principles. Instead of the server-client architecture used in other approaches, the Croquet virtual machine is object oriented (using the SmallTalk dialect Squeak), which allows run-time modifications of the world. The objects communicate and cooperate by different protocols, whereas the main advantage can be seen in the replicated computing and peer-based messaging. In particular, the peer-to-peer architecture allows decentralized worlds, where each part is maintained on standard hardware by individual users rather than a company providing the servers. Combined with OpenGL, Croquet SDK assembles all requirements for a 3D interactive, collaborative and highly flexible open source Virtual World for individual adaptations. While the project is pre-alpha, examples let us anticipate the future potential to have 3D educational spaces (which can be small experiments, classrooms or just interfaces to collaborative work on one application), that can be directly connected to a flexible grid as seen in Second Life; see The Future Invented (2009) for different examples demonstrating the features and benefits.

In summary, this selection of approaches is far from complete. Several open source projects are currently in development, where an important aspect is the interconnectivity of different servers and clients for visualization. For example, realXtend is a server/client Virtual World project where the software is compatible to Second Life and OpenSim. In contrast to Second Life with its limited interfaces, another important feature of the open source worlds is the provision of manifold APIs to allow third party software to connect directly to the in-world such that the functionality can be simply extended. Functions such as this are discussed below regarding their capacity to bridge the real and virtual worlds.

Bridging the Real and Virtual Worlds

The open source aspects of the 3D Virtual Worlds reviewed above provide the extensibility to integrate the real and virtual worlds; this makes 3D open source environments highly useful in educational contexts. Various innovations described below (e.g., using mobile devices) are bridging this gap between the real and virtual worlds.

In the classroom, the most prominent solutions for 3D virtual environments are the commercial world Second Life and the open-source projects Project Wonderland, Croquet and OpenSim. Despite the latter ones are still in development, how they can be used in education is already being explored, especially in contrast to Second Life. In this section, we demonstrate inter-world examples for Second Life and Project Wonderland. Furthermore, we focus on applications, tools and gadgets. We describe how classrooms can be realized that span both the real and virtual worlds in the contexts of blended or distance learning (see also Gregory et al. 2009).

Society has a large appetite for innovation in technological gadgets. Mobile phones are ubiquitous and 3G mobile devices (e.g., the iPhone) are becoming increasingly commonplace. These 3G devices are state-of-the-art and provide the required interfaces to connect the user to the Virtual World. The interface on mobile devices can follow different paradigms: (1) mobile devices running Windows CE or other Operation systems support applications that allow access to Virtual Worlds like Second Life just as they do on a general computer, or (2) manufacturers provide a device-specific interface with at least the same functionality as the standard application. Specific examples of these possibilities are explored in two scenarios below.

Scenario 1: Second Life

Vollee have designed an interface for Second Life that is customized to 3G mobile devices (The BOSL 2009). This allows users full access to Second Life via their 3G service provider or a WiFi connection. It is apparent that mobile access to Virtual Worlds integrates their use into potentially any Real World context. Consequently, user-based experimental innovation will surely present unanticipated outcomes that arise from the confluence of the real and virtual worlds. For example, students in project teams can meet and collaborate in Second Life with greater freedom from physical location (e.g., on a train, in a cosy armchair, or in a park inspired by the beauty of a sunset). A recent project of ours has facilitated the submission, grading, and provision of feedback for essays all in Second Life (Dreher et al. 2009a). While not specific to mobile devices, an open source educational innovation (Sloodle) has integrated a Second Life and Moodle, a popular Learning Management System (Eduserv 2009).

Future innovations in mobile 3D Spaces will generalize from existing technologies used in 2G mobile and Web-based applications. Sensors could be used to send location-oriented information between the real and virtual worlds – social networking could be facilitated simultaneously in the real and virtual worlds by mobile users receiving notification that a known avatar (an in-world 'friend') is near our virtual and/or physical world location. Already the real and virtual worlds are integrating information about physical location: hardware sensors in office doors can be used to indicate one's presence at work (similar to a Skype status), and pictures taken in the real world can be automatically sent to 3D Spaces (e.g., via video streaming).

To note the current limitations of mobile access to Second Life, the smaller interface of mobile devices presents certain viewing limitations, bandwidth and quota consideration (e.g., lag), and tracking students and their interaction in a 3D space is possible but generally requires large investments in technology. Given time these factors will surely be optimized, however we can suggest certain pedagogical applications that are suited to the current state of technology. The Wii Remotes are able to provide an interface that allows an immersive feeling in Virtual Worlds. The cost is below $100 USD for two remote controls and an Infrared-(IR)-pen. Following Lee's (2008) ideas, our students implemented an interface where the pen is tracked by two remotes for calculating a 3D position in front of the whiteboard. The coordinates and information about buttons pressed is send to the Virtual World to draw onto a white board at close to real-time (here the Second Life interface delays data flow and slows the process); see Fig. 1 for the hardware setup and an example with whiteboards. Additionally the pen can be used to interact with the projected computer screen as it would be possible on interactive whiteboards. This approach reduces complex navigation and uses an intuitive natural behavior (moving hands) for interaction. Yet the main advantage is how the solution is implemented. All movements and buttons are sent to a server where the user can register more than one world at a time, thus enabling the simultaneous use of whiteboards on different Second Life islands or even other Virtual Worlds. This technology is particularly useful for geographically disparate group collaboration or conferences. Scenario 2 below describes an implementation and that provides a communication platform bridging all (real and virtual) worlds to maximize immersion.

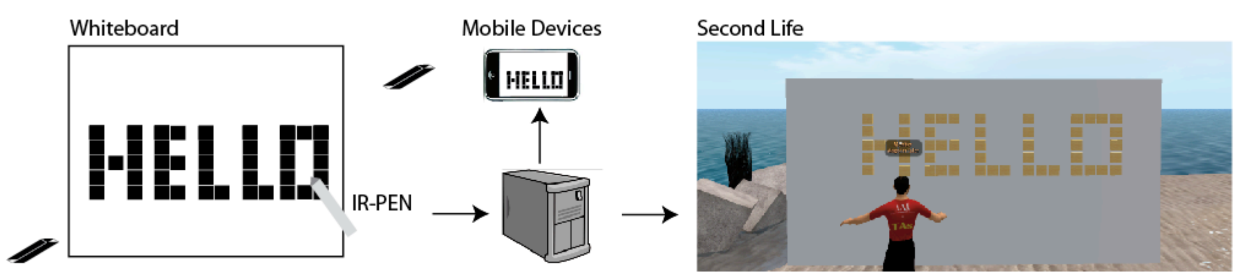

Figure 1: Interface to Second Life using Wii Remotes (left) for an Interactive Whiteboard (right). The usage of the server architecture allows a synchronization with multiple devices, i.e. mobile devices. [NOTE: The final paper will include photos on the left showing the experiment as well as a photo with the application on the IPhone]

Scenario 2: Project Wonderland

One exciting student project is a 3D virtual campus in Project Wonderland, with the main focus being the one-to-one mapping of a real university campus to a 3D virtual one. The idea is to mimic the real world in a Virtual World to lower the barriers-to-use and to maximize the seamless integration of the real and virtual worlds. To this end we have identified both structures (e.g., lecture halls) and functions/processes (information handouts) that need to be common to both worlds. A common process is the distribution of information from an institution to its members. In the real world this is mainly achieved by providing hand-outs, sending newsletters via email, or putting information on a website. All these formats are stored inside an information system. Today there are several possibilities to share digital information. One of them is to transform the information into an XML-based format like RSS or Atom. RSS feeds are well established in Web 2.0, therefore it is important to connect the 3D world to this information channel by implementing a 3D feed reader. This enables the user to stay informed about current news and events in a simple and unobtrusive manner. Additionally we implemented a possibility for the user to get further information by clicking the headline of a news item to open the users' browser which is redirected to the website. The reuse of known desktop patterns and the immediate connection between real-world application and 3D environment is quite important for a seamless user experience and to lower the barrier of new ways of user interactions.

The feed reader provides the functionality to get information into the Virtual World. The bulletin board *Grafitti* targets a deeper usage of media by providing a cross-platform communication (see Fig. 2). Most educational institutions provide bulletin boards for their students. It allows everyone to share information with each other. In the real world typical items on a bulletin board are flyers, posters, job offers, notices or announcements. The in-world implementation involves maps, items using text messages, and images in the Virtual World. Message- and image-items are the most basic content on a bulletin board but the technology allows even more media forms, such as video, audio, vcards, web-sites or interactive components like surveys. To offer a simple interaction with such a virtual board we chose a design that looks and feels like a board in the real world. Working at this board is very intuitive. Items can easily be posted on the board. By clicking on items it is possible to move, rotate or resize the item. A double click on items will open the users' browser with the relevant URL.

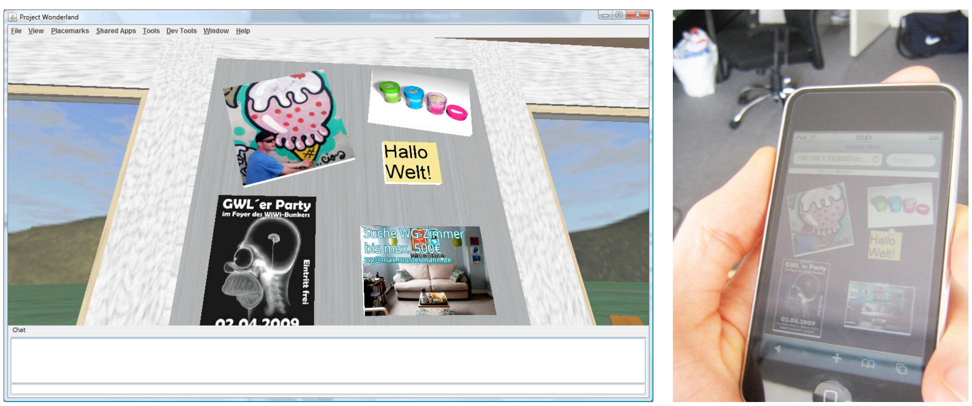

Figure 2: Same view on the Project Wonderland Grafitti wall as well as on the iPhone

We achieved a client independent domain model with the functionality to create asset previews of attached documents using an external server to manage the persistence of the wall objects. Clients can access the wall information and generate asset previews using http. This abstraction allowed us to take most of the functionality from the 3D world to the web application. In the case of the web application we tried to use a quite new approach for displaying data in a user friendly and detailed way by leveraging the html canvas object that will be part of the new html 5 specifications. By accepting and staying with the limitations of the web techniques we could use the new generation of mobile devices such as the iPhone to deliver the information of the wall to mobile users. It is common to have interfaces that allow interaction between the real and virtual worlds, but they generally use another look and feel. Our new bridge between the worlds allows students to get the same information at the same time in exactly the same version with the same interface. The current emerging technologies are netbooks (with touchscreens) and surface computing (Fenn 2006). These devices provide mobility and immersive interaction. They pave the way for cross-world applications to facilitate socialization, communication, and collaboration from anywhere to everywhere.

With respect to the open source principle, Project Wonderland allows several modifications that would not be possible in Second Life. Regarding Fig. 2, a moving asset must change on all devices immediately (this includes devices like whiteboards, mobile phones or netbooks, and media like images, videos, or audio). This capability is especially important for communication interfaces, which need to keep all worlds synchronous without delays.

Pedagogical Utility of a Bridge Between Worlds

3D Virtual Worlds that offer user-generated content provide various pedagogical advantages in their own right. Numerous developmental theories suggests that students' active interaction with the environment promotes learning, including Piaget's constructivist learning theory, Vygotsky's socio-constructivist theory, and Papert's constructionist learning theory (Ackermann 2004). The interactive nature of 3D Virtual Worlds allows students to create content and interact socially using a diverse array of media (text, graphical and audio) that reinforce learning via instant feedback in a 4-D environment (i.e., 3 spatial dimensions plus time). Additionally, the bridge between the real and virtual worlds offers further pedagogical advantages. Below we discuss various benefits presented by educational activities that integrate the real and virtual worlds, these include creativity, interoperability and communication, and generalizable learning experiences.

Creativity is stimulated by 3D Virtual Worlds, which offer the capacity to create objects that would not be practically possible in the real world and to program relationships between them. These objects and relationships can mimic real world physical laws, or can exceed them (e.g., objects can float, fly, materialise, vanish, or be totally intangible). The mobile access to 3D Educational Environments via 3G phones augments this creativity because the integration of the real and virtual worlds presents many novel and stimulating connections; socio-technological innovations often emerge heuristically via use in context (e.g., RSS and Twitter).

A central point in this paper is that for students to communicate and collaborate effectively, they need access to the same medium (e.g., learning management systems, 3D Educational Environments, a real world class room). The interoperability offered by open source 3D Virtual Worlds provides this platform for communication and collaboration; via 3G mobile access to a Virtual World, a student commuting to university can use that time productively to meet with project team members for example. Furthermore, content created in-world can be disseminated to the world via the Internet or carried into any compatible Virtual World.

Learning experiences in the Virtual World can generalise to various real world contexts because the Virtual World can operate using the same laws of physics, and can be used to teach various social and technical skills that are valued in the real world. This benefit can be augmented by designing 3D Educational Environments that teach certain skills using game-like formats for example, which could be created to teach domain specific skills (e.g., programming, project management, entrepreneurialism), creative and analytical thinking, emotional intelligence (e.g., goal setting and social skills), and ethical behaviour (Dreher et al. 2009b).

There are various similarities and differences between the real world and Virtual Worlds that are pertinent to educational applications. The real world and Virtual Worlds are similar in many respects, they both offer interactive 3D visual environments that contain valuable learning opportunities for students in both technical (e.g., computer programming) and social domains (e.g., developing social skills and moral values). The real world and Virtual Worlds also have important differences. The real world is more immersive (i.e., contains feedback from all our senses) but has immutable limitations (one can't teleport to the other side of the world for educational excursions), whereas the Virtual Worlds have comparatively less immersion (i.e., they currently rely on audiovisual feedback via display screens and the use of certain input devices such as keyboards and assorted hand-held devices) but provide greater functionality (i.e., in Virtual Worlds many physical laws do not apply and one can construct large machines or teleport to distant places of interest). Thus creating a bridge to integrate the real world and Virtual Worlds can optimise the learning experience. Our experience with Information Systems development project students has certainly supported this view; in comparison with project groups that use traditional development platforms (e.g., text-editors) we observe that student groups using Second Life have more intrinsic motivation, sustained productivity, positive social interaction, and group synergy. Thus both pedagogical theory (e.g., constructionism) and our professional experience suggest that a blended learning approach that integrates the real and virtual worlds is beneficial for students' educational outcomes.

Conclusions

In short, we have presented a case for the benefit of integrating the real and virtual worlds in education to allow seamless interactivity and communication. We have acknowledged the current limitations of mobile devices (e.g., small displays), and have suggested adaptations that are currently available (e.g., using the Grafitti wall and Wii-Whiteboard on the iPhone). We have also peeked around the corner of innovation by predicting some of the many possible developments in this area (e.g., tracking physical location between the worlds). It is our prediction that the future of Virtual Worlds (those described above and many more yet to be developed) to become an integral part of daily life. This will occur naturally as they integrate into dominant media technologies (e.g., mobile devices), which will be promoted by the extensibility of those 3D Spaces using open source software.

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