3D Virtual Worlds as Collaborative Communities Enriching Human Endeavours: Innovative Applications in e-Learning

Carl Dreher[1], Torsten Reiners[1, 2], Naomi Dreher[1], and Heinz Dreher[1]

[1] Curtin University of Technology, Western Australia, e-mails: c.dreher@curtin.edu.au, n.dreher@curtin.edu.au, h.dreher@curtin.edu.au

[2] University of Hamburg, Hamburg, Germany, e-mail: reiners@econ.uni-hamburg.de

***Abstract*—3D Virtual Worlds are potent Digital Ecosystems because the 3D interface simulates real-world environments and the community of users creates a dynamic, real-to-life economy and in-world culture. Some Virtual Worlds such as Second Life empower users to generate in-world content through object building tools and programming languages; indeed the content in Second Life is entirely user-generated. This promotes a rich culture of innovation surrounding this emerging technology that continually develops the capabilities of the 3D Digital Ecosystem. The collaborative culture spans both the 3D in-world environment and 2D ecosystems: for example, Web 2.0 applications such as wikis and blogs facilitate support, discussion, and documentation for user-generated innovations. Innovation in 3D Digital Ecosystems such as Second Life are applied to all domains of human endeavour that exist in the real-world, including recreation, socialisation, commerce, and education. This working paper shares the authors' professional experience using Second Life in tertiary Information Systems/Science education and describes specific educational applications. This is followed by discussion of the benefits of 3D Digital Ecosystems for education and suggestions for future research, development, and practice.**

***Index Terms*—3D Virtual Worlds; 3D Digital Ecosystems; Information Systems education; Information systems research.**

I. Introduction

Advances in cloud computing, Web 2.0, and 3D Virtual Worlds are revolutionising the way we interact as a society across the domains of socialisation, commerce, and learning [1-3]. 3D Virtual Worlds are one application that shows rich potential that has yet to be fully realised [4]. 3D Virtual Worlds are "online environments that have game-like immersion and social media functionality without game-like goals or rules. At the heart is a sense of presence with others at the same time and in the same place" [5]. They enable users to move through a 3D environment via an avatar (commonly a human-like animation). The content of more innovative and flexible Virtual Worlds such as Second Life is almost entirely user-generated. While some Virtual Worlds require a fee for entry (e.g., EverQuest, FusionFall), others allow free access (e.g., the Second Life viewer client is freeware and there is no charge for an avatar account).

Currently, 3D Virtual Worlds are a unique variety of Digital Ecosystems because they (a) simulate the real world both visually and functionally and (b) comprise a virtual community of users. It is the complexity of humans interacting socially and collaboratively in a Virtual World that make this application more than a simulation, but an immersive 3D Digital Ecosystem in every sense of the phrase. Users in Second Life express their 'real-world' personality traits 'in-world' but are enabled with more creativity and freedom and produce a rich culture of innovation in building and scripting in-world content. It is for reasons such as these that 3D Digital Ecosystems are fertile ground for all human endeavours (socialisation, recreation, creative/artistic expression, commerce, and learning). Consequently, the utility of 3D Digital Ecosystems in education warrants attention.

II. Applications in Education

The rich pedagogical opportunities that 3D Digital Ecosystems offer are illustrated using current educational applications that describe the implementation of student project courses. The authors' used one particular Virtual World called Second Life to teach Information Science at the University of Hamburg and Information Systems at Curtin Business School.

A. Information Science education

The University of Hamburg has a virtual campus in Second Life and runs an educational initiative called Students@Work that integrates virtual-worlds and the real-world in teaching Information Science. The Institute of Information Science offers a course entitled "Production and Logistics in Second Life" in which two student projects developed a supply chain and a bottle filling plant. The course uses blended learning to take advantage of Second Life's capabilities in order to host lectures, invite international guest speakers, cost effectively visit in-world production plants, engage in hands-on constructivist learning, and explore the valuable potential of 3D Digital Ecosystems in education and business.

The course gives students the choice of one of two formats, attending lectures in Second Life only (cf. distance education), or attending real-world lectures while simultaneously logged in to Second Life (cf. blended learning). A sophisticated yet elegant setting allowed all students to have equal access to pedagogical media by streaming the lectures live into Second Life (see Fig. 1). Regardless of their physical location, all students could function as one class through their in-world presence in Second Life where they were enabled with text and voice communication and could visit various in-world locations on educational excursions.

The University of Hamburg campus in Second Life boasts an accurate replica of an iconic University of Hamburg building (see Fig. 1, top panel). While it functions as a

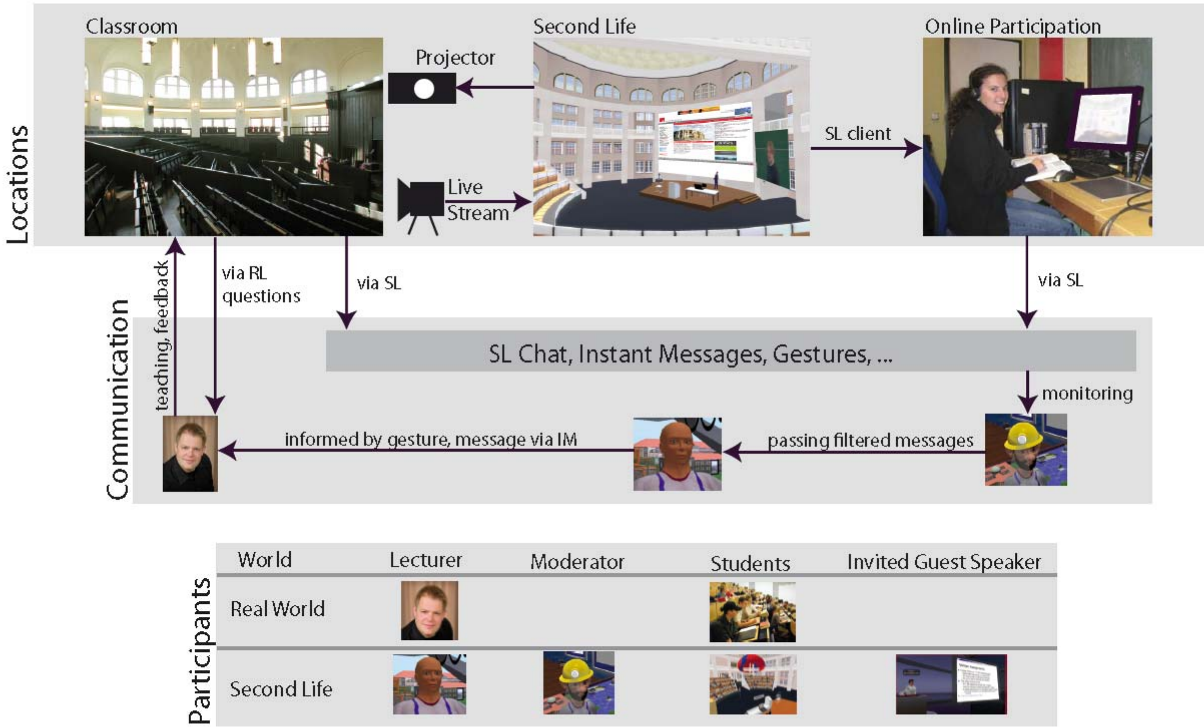

Fig.1 University of Hamburg implementation of Second Life
Note: RL = real life; SL = Second Life

fully operational lecture hall, perhaps an equally useful role is as an easily identifiable meeting point. In our experience, limiting pedagogy in Second Life to static classrooms is not utilising the full potential of the 3D Digital Ecosystem. A more useful orientation is that the whole ecosystem is the classroom (i.e., any relevant location and all possible functions).

This blending of the virtual-world and real-world educational contexts offered a number of pedagogical advantages. 3D Digital Ecosystems extend the capabilities of teleconferencing by adding a spatial aspect (i.e., the virtual representation of physical location) to text/voice communication (like in the real world). During seminars, students could see/hear the real-world lecture and participate in classroom communication/exercises in Second Life regardless of their location in the real world (i.e., on or off campus). Furthermore, in this blended learning format (see Fig. 1) the lecturer can be supported by a moderator operating an avatar in Second Life (e.g., a graduate student). The moderator receives queries from students as instant messages, answers technical questions, summarises pedagogical questions and sends them to the lecturer. This allows the lecturer to address students' queries at an opportune time without interrupting the lecture.

Another pedagogical advantage is the capacity for field trips that allow students to see and interact with in-world systems (both industrial simulations and actual businesses). In comparison to real-world field trips which are often prohibitively expensive in time, cost, and legal risk (e.g., industrial plants are dangerous); such excursions in Second Life are safe and have negligible cost. Consequently, students in this course met a successful Second Life artist/producer from New York, toured the artist's production plant for jeans while it was in operation, and could ask questions of experts. Students also visited production plants for cars, ice cream, and chips.

The augmented pedagogical capacities offered by Second Life are evident when considering the systems development projects that are included in the "Production and Logistics in Second Life" course. To date, groups of students have developed and implemented two real-to-life business systems, a supply chain and a bottle filling plant.

A systems development project utilised the powerful capacity of Second Life to generate real-to-life simulations using a menu-based object creation tool and an event- and state-based, object-oriented programming language (the Linden Scripting Language, LSL). For this project, students were asked to develop a system that demonstrates a production or logistics system, is interactive and dynamic, and can be used in a lecture. Aside from these requirements, students were given autonomy in designing and implementing the project. The result was a sea-land supply chain that receives medical products in shipping containers and transports them to a pharmacy (see Fig. 2) [6, 7]. Students worked in teams of four; the resultant deliverable was a complex interactive simulation that incorporated all supply-chain processes between the arrival of ships to the receipt of medication by customers. Another such in-world systems development project is that of a bottle filling plant.

A second student systems development project at the University of Hamburg is a simulation of a Bottle Factory in Second Life. A group of four students were tasked with demonstrating a production process that included interactive components. They produced a sophisticated bottle-filling conveyer belt (see Fig. 3). The specific functions that the bottle factory performs include filling soft-drink bottles with four types of soda, stamping a lid on them, checking for errors, boxing and shipping the bottles [8].

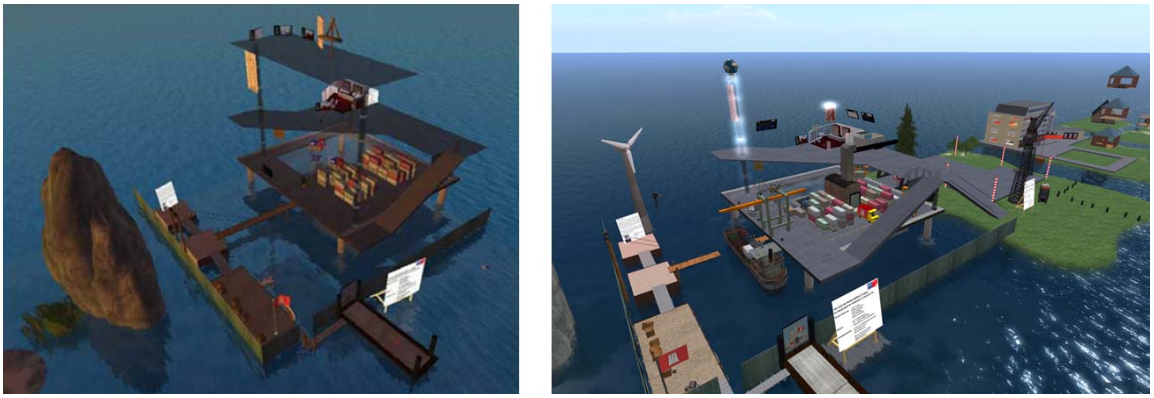

Fig.2 University of Hamburg Supply Chain Project (left pane: initial deliverable; right pane: subsequent developments)

Due to the student team's intrinsic interest in this Second Life-based systems development project, they went beyond the assignment requirements. While no student had previously learned programming, they refined the conveyer belt simulation (so as to be more life-like) by adding LSL code. This in-world programming facilitated the following advanced functions, it: synchronised the stamping of bottle lids with the presence of a bottle under the lid-machine by using time-event coordination (i.e., sensors to detect bottle position); ensured each bottle was only stamped once by assigning each bottle an identifier that was assigned to one of three lid-stamping arms, and; included a feedback mechanism for detecting bottles that were not processed correctly which removes them from the conveyer belt line. Due to the students' use of the Linden Scripting Language, this Second Life simulation modelled many real-to-life aspects of the conveyer belt in a sophisticated manner (both in physical representation and in functional capacity). It is the sophisticated capacity of Second Life to recreated real-world systems that makes it an ideal platform for teaching systems development.

Through this experience, various benefits were identified in using Second Life to implement student systems development projects. Foremost was the high degree of intrinsic motivation which led to an excellent standard of work, with outcomes that exceeded the normal level for student projects: students worked productively for long work sessions, were supportive of each other, efficiently produced high-quality work, and completed projects on time with no negative feedback. Indeed, the student projects attracted international attention: students published a number of papers and were invited to conferences as guest speakers. A number of students pursued postgraduate studies in the field.

Feedback from students during interviews regarding the course indicated that students enjoyed the autonomy given to them in all stages of systems development. Feedback also indicated that the Second Life environment promoted: enjoyment and creativity, which lead to productive, sustained collaborative work sessions, attention to detail, and enthusiasm in learning the Linden Scripting Language; development of project management skills (organisation, communication, and collaboration) that occurred almost exclusively through interaction in Second Life, and; a more interesting learning experience for students and more pedagogically effective learning outcomes than prior projects that did not use 3D Digital Ecosystems. These outcomes are important because Information Systems students can often lack motivation to learn programming [9, 10].

Students' intrinsic motivation was likely boosted by the powerful capacity of Second Life to facilitate user-generated content in an immersive, collaborative 3D Digital Environment. Indeed the menu-based object-creation tool allows novices to create sophisticated structures with minimal experience and effort. This facilitates rapid development of 3D prototype systems that would normally be done only in 2D (e.g., on paper). Students began constructing objects in a 'sandbox' area, and reported that this was a fun experience. The capacity of Second Life to build and simulate real-world systems allows for interactive, instant feedback from the resulting in-world creation. After only a short time in Second Life it becomes apparent that the normal limits of the real-world and Web 2.0 do not apply. Through avatars, users can fly, teleport, construct a wide variety of 3D objects, program them with LSL, all while immersed in a collaborative environment.

It is the collaborative capacity of Second Life that is maximally advantageous to group projects in Second Life. Students were empowered to work in parallel (which is not possible in other simulation programs), could see the real-time progress of team members, and could interact via text (instant messaging), voice (spatial voice-chat), or body language (gestures). Indeed the instructor can monitor the process and give life-like feedback on progress (e.g., a big smile and applause). Furthermore, while students worked primarily in-world, they were supportive, shared knowledge and experiences, and began to meet socially in the real-world. In short, attractive capacities of Second Life are that it enables user-generated content in a highly flexible, interactive, and collaborative fashion.

Fig.3 University of Hamburg Bottle Filling Plant Project

The success of incorporating 3D Digital Ecosystems into student project units at University of Hamburg has lead to the integration of Second Life into the Information Systems curriculum at Curtin Business School.

B. Information Systems education

Final year students in the School of Information Systems, Curtin Business School, are enrolled in a compulsory course, Information Systems Project 391/392, which brings together all prior learning (e.g., programming, systems analysis and design, project management) in an applied systems development project (comprising both software development and project management). To date, traditional programming languages (e.g., Java, JavaScript) have been used to implement web-based or stand-alone applications. While this course is well accepted, it is also challenging and could benefit from refinement. Students in this unit can suffer from lack motivation in applying themselves wholeheartedly and can fail to see the relevance of project units to industry. Group work is also hard to monitor and ostensibly there is an uneven division of labour. Consequently the course has been re-designed to incorporate innovative implementation of the system development process in Second Life.

To facilitate the new format for the course, an intelligent lecture theatre was built in on the “Australis 4 Learning” educational island in Second Life (see Fig. 4). It is an example of an educational innovation in Second Life because it empowers both the lecturer and students with flexibility regarding: presentation of slides, interaction during the lecture, use of a web-board connecting a tablet PC to a screen in Second Life, and the capability to teleport the whole class to educational locations in the seats provided (learning units called ‘l-pods’ that are user-interfaces for many of the functions described above). The course’s revised curriculum is outlined below.

The refined course comprises two phases: an individual introduction to Second Life and the Linden Scripting Language, and a group project component. The individual introduction to Second Life aims to homogenise the development of skills across all students by a series of structured tutorials that require submission of specific deliverables and associated documentation (e.g., a remote-control van carrier that interfaces with a website).

Fig.4 Lecture hall on Second Life island “Australis 4 Learning”

The group project component monitors student activity in order to promote a more equal distribution of input. This can be done via automated activity logs and object-creation tags in Second Life as well as via observation by the lecturer in Second Life. The group project gives students a choice of a variety of innovative applications to develop that are related to the research and educational themes of the “Australis 4 Learning” island. The functional requirements of the deliverable are set, as is the systems development process (design, specification, concept, implementation, and evaluation). However, students have autonomy to solve the problem creatively and innovatively.

An important element of the systems development project is that it will prepare students for industry. Students are required to develop business and marketing plans for their deliverables. This involves the requirement that all Second Life projects interface with the real-world via websites presenting the product and other functionality (e.g., databases, blogs, wikis). The course culminates in students giving an internationally announced presentation of their deliverables in order to increase the perceived value students hold for their projects.

To review, the current authors have used Second Life (as one particular 3D Digital Ecosystem), to enhance the pedagogical capacity of Information Systems/Science education in student project units. Following this contextual introduction, the next section summarises both the benefits and limitations of education enabled by 3D Digital Ecosystems.

III. Synopsis of Benefits and Limitations

For educators and academic institutions alike, this section summarises the benefits and limitations of using 3D Digital Ecosystems such as Second Life in Information Systems education. Benefits may include improved educational efficacy, as well as financial, environmental and social benefits. Limitations revolve around technical and social constraints.

A. Benefits of 3D Digital Ecosystems

Benefits of incorporating 3D Digital Ecosystems into Information Systems education include pedagogical efficacy and financial, environmental and social benefits.

In the authors’ experience, educational efficacy is promoted by the use of Second Life because it increases students’ intrinsic interest, productivity and quality of work. Systems development in 3D Digital Ecosystems emphasises learning-through-doing, which is highly valued in a constructivist approach to learning [11]. It also shows students the relevance of programming and systems development to industry because they gain real-time feedback by seeing their projects implemented in context (i.e., as simulations and/or functioning commercial systems).

The company that developed Second Life, Linden Lab, uses the promotional slogan “The limit is only the sky”. This is accurate in many respects; education in the real-world classroom is bound by the parameters of physics (space and time) and economic restrictions; in contrast, pedagogical activities in Second Life are empowered by the capacity to exceed these limitations. Educators can schedule learning experiences and set assignments that are not possible in the real-world. For example: classes may teleport between in-world locations to view simulations of industrial processes and in-world commercial ventures; international speakers can be invited without travel costs; with negligible expenditure, student projects can develop working models/replicas of systems that would be too costly or impossible to develop in the real-world. In this way education is not bound by space, time, or financial limitations. Furthermore the capability of Second Life to produce real-to-life user-generated content means that it is an excellent environment for constructivist learning.

Using Second Life for systems development projects offers a number of benefits over specialised software for simulation. First, specialised software is often only licensed for university computers, restricting its use to laboratories on campus. In contrast, the Second Life viewer is freeware which students can use at home, and in our experience this increases work duration and productivity. Second, specialised software often requires user-training and is limited in application; whereas Second Life has accessible usability and its highly flexible nature allows it to be used for a variety of applications (e.g., simulating real-world machinery plants). Third, the 3D 'game-like' interface of Second Life is more interesting for students and allows for instant implementation of programming. Notably, text-based programming editors are not inherently interesting and do not allow immediate contextual implementation of programs. Finally, the networked nature of Second Life (cf. cloud computing) promotes simultaneous collaboration between users in disparate geographical locations, in contrast simulation software is primarily PC-based and does not allow simultaneous collaboration via networks.

A number of financial, environmental, and social benefits are also evident from the use of 3D Digital Ecosystems. Financial benefits have been discussed above and exist because Second Life offers no start-up costs for individual users, and affordable rental for institutions that establish educational islands [12]. These benefits are compounded when it becomes apparent that Second Life facilitates such benefits as the invitation of international speakers, and whole-cohort educational excursions with no travel cost and no legal liability due to the dangers of travel. Environmental benefits can result from reduced greenhouse gas emissions by reducing the need to travel (to class, conferences, or for industrial/practical experience).

Finally, social benefits result from immersion in the Second Life environment, which promotes social interaction with educators that students often do not have when working with other technologies. This can enhance rapport between educators and students, further enriching pedagogical outcomes and the potential for postgraduate research. The rich potential offered by 3D Digital Ecosystems is not without a number of limitations.

B. Limitations and prohibitive factors

It is important to acknowledge the practical aspects of education at the front line of innovation in ICT-use that is tempered with the realities of the university bureaucratic system. Drawing from our own experience, we discuss some limitations to the use of 3D Digital Ecosystems (indeed Web 2.0 applications also) in tertiary institutions, and suggest possible ways to overcome them.

3D Digital Ecosystems require modern and relatively powerful hardware, software, and broadband internet connections [13]. In first-world countries this is not necessarily prohibitive, but it does currently limit the outreach this technology has for distance education in developing countries and remote/regional areas in developed countries. Furthermore, in countries such as Australia that bill internet usage, the relatively high usage quotas required by 3D Digital Ecosystems are prohibitive in educational institutions that both limit usage and charge high-rates when the allotted quota is exceeded. This institutional practice limits innovation in a networked economy. In contrast, countries such as Germany do not limit internet usage, which frees users to explore the potential of cloud computing, to be experimental and innovative.

However, there is the possibility that Linden Lab will move Second Life to a peer-to-peer format [14]. Indeed there are a number of peer-to-peer Virtual World initiatives in development such as VON [15], Solipsis [16], as well as commercial ventures such as Twinverse [17] and Project Outback [18]. In organisational contexts where internet usage is metered or internet connections are slow, 3D Digital Ecosystems using P2P and/or private servers will facilitate the use of an intranet, thus overcoming limitations in bandwidth and usage quotas. Moving to a peer-to-peer network and/or using private servers could also overcome criticisms about the speed, reliability and security of Linden Lab's service provision [19], who host all Second Life traffic on U.S. servers.

While there are challenges to the implementation of 3D Digital Ecosystems in tertiary institutions, these are not overwhelming, and indeed are to be expected because the spear-head of innovation can travel much faster than an institutional body. Furthermore, as reviewed in the educational applications and synopsis above, 3D Digital Ecosystems offer attractive benefits and hold much potential for innovation. Thus, it is pertinent to consider the possibilities for innovative research and practice incorporating 3D Digital Ecosystems in the context of e-learning.

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