British Journal of Educational Technology *Vol 42 No 4 2011* 608–615
doi:10.1111/j.1467-8535.2010.01057.x

Developing simulations in multi-user virtual environments to enhance healthcare education

Luke Rogers

Luke Rogers is a PhD student with the Virtual Reality and Simulation Laboratory, University of Ballarat. His research interests focus on the optimisation of virtual reality learning environments. Rogers' honours thesis explored the benefits and issues of using a three-dimensional multi-user virtual environment as a simulation tool for undergraduate nursing students and he is currently continuing this research by investigating how multi user simulations can be engineered to enhance learning. Address for correspondence: Luke Rogers, University of Ballarat, P.O. Box 663, Ballarat, Vic. 3353, Australia. Email: l.rogers@ballarat.edu.au

Abstract

Computer-based clinical simulations are a powerful teaching and learning tool because of their ability to expand healthcare students' clinical experience by providing practice-based learning. Despite the benefits of traditional computer-based clinical simulations, there are significant issues that arise when incorporating them into a flexible, co-operative and collaborative learning environment. Unlike traditional technologies; immersive multi-user virtual environments such as Second Life can incorporate comprehensive learning materials with effective learning strategies, allowing healthcare students to obtain a simulated clinical experience in an immersive social environment. The purpose of this research was to investigate how a simulation could be optimised in Second Life to encourage teamwork and collaborative problem solving based on the habits, experiences and perceptions of nursing students towards Second Life as a simulation platform. The research was conducted by placing groups of nursing students in separate locations and exposing them to a series of clinical simulation developed in Second Life. The simulation involved a series of problem-based scenarios, which incorporated concepts of technical skills, patient interaction, teamwork and situational awareness. Using qualitative feedback from a series of evaluative case studies, the study determined good practices and issues involved with a virtual computer-based clinical simulation. A common theme which emerged from this research, which is discussed in this paper, was the student's ability to work in an artificial social structure where they could actively co-construct mental models of technical and interpersonal skills through experiencing human interaction in a computer-based simulated environment.

Introduction

Simulations are used in healthcare for a variety of teaching and learning purposes. These include, but are not limited to, teaching facts, principles, and concepts; assessing the student's progress or competency with a certain skill; integrating the use of technology in the learning experience; and developing problem solving and diagnostic reasoning skills in a safe, non-threatening environment (Jeffries, 2006). Studies have established that simulations can lead to increased self-confidence and improved clinical judgement (Thiele, Holloway, Murphy, Pardavis & Stuckey, 1991) and problem-solving abilities (Johnson, Zerwic & Theis, 1999). Simulations in all forms are increasingly accepted and implemented in healthcare education because of their ability to focus on a student's experience to solve problems, perform skills and make decisions in a safe and

non-threatening environment. In the past decade, computer-based simulations, specifically, have become a popular platform for simulating clinical experience in healthcare education as they have a relatively low cost, allow for flexible learning, have a student-centred approach and promote engagement in active learning (Benson, 2004).

In 2008, a small project team developed a computer-based clinical simulation in Second Life. Second Life is a virtual world created by Linden Laboratories which enables learners to interact with and manipulate information and representations of an environment and synchronously communicate with other people via a digital representation known as an avatar, regardless of their location. The simulation was created with the intention of extending a text-based simulation into a learning activity which encouraged students to interact with apparatus and patients to identify, solve and perform the tasks themselves; allowing them to construct their own understanding of the problems at hand, rather than simply read about it. This learning task was to be used at two separate campuses and was expected to be completed outside of class, requiring the student to explain why the steps taken in the scenario where necessary and discuss the acute care of the patient from their own perspective. Various computer-based simulation products had been trialled in the past, but these systems were often nothing more than disconnected activities involving the student passively viewing information or playing games. However, research suggests that that learning does not occur in isolation but by teams working together to solve problems (Jonassen, Peck & Wilson, 1999) and that on average, students retain 10% of what they read and 30% of what they see; whereas students retain 50% of group interaction and 90% of what they act on (Petty, 2004). Therefore, the simulation required a social structure involving a team aspect where students could co-construct knowledge in a collaborative environment. Using a text-based scenario used in a nursing course and theory from various literature sources as a guide, a simulation was created within Second Life, named Critical Life. Because of the unique nature of the social simulated environment, before performing a series of experiments to determine what value it could add to conventional methods of clinical healthcare teaching and learning simulations, it was deemed necessary to investigate what attitudes nursing students had towards using the simulation as a learning tool as well as how they perceived it could provide them with meaningful learning experiences.

Simulating problems to construct meaningful experience

The constructivist learning theory is an essential educational technique to consider when designing effective educational simulations. The fundamental belief of constructivism is that knowledge is constructed, not transmitted and that learners play an active role in the learning process (Jonassen *et al*, 1999). As discussed earlier, a clinical simulation incorporates strategies that provide students with practice in *problem-based* decision making, based on real-life situations. Kolb (1984) describes the learning process involved in problem-based simulations as experiential learning. Experiential learning is the process of developing an understanding of a concept from direct experience. The model is based on the idea that concrete experience provides a basis for observation and reflection, suggesting that learning through observation and interaction with a virtual simulated environment will allow the student to make illuminating discoveries and develop a superior cognitive understanding, as opposed to reading about an environment from a book—'Knowledge results from the combination of grasping and transforming experience' (Kolb, p. 41). Furthermore, Kolb describes that these observations and reflections are refined and assimilated into abstract concepts which can be applied to new experiences, suggesting the learning obtained from a simulation can be transferred into the real world. Hanson and Sinclair (2008) support the constructivist theory suggesting students learn more effectively by engaging in collaborative problem-solving activities. The authors propose that the purpose of a learning activity is not so much the problem being solved, but the learning experience which helps students

develop a cognitive understanding 'that may be generalised beyond the specific problem' (p. 3). This makes an important point in relation to computer-based clinical simulations (CBCS), in that it implies a simulation should provide experience in, and appreciation for, problem-based learning in a social environment.

As the popularity of healthcare simulations increases, so too do the problems educators are faced with in integrating the technologies with traditional teaching practice to create an effective learning environment. These issues include the cost, time efficiency, physical location, flexibility, availability, accessibility and productivity of a healthcare simulation (Benson, 2004). Healthcare students are hardworking, can juggle multiple demands and are often stressed (Henderson, 2005). Nursing students are also required to complete clinical placements and therefore cannot always be physically on campus. CBCSs are a popular platform for simulating clinical experience as they have a relatively low cost, allow for flexible learning, have a student-centred approach and promote engagement in active learning. However, there are serious challenges relating to teaching and learning practices being incorporated into CBCSs and the effect the simulation has on the students' learning (Jeffries, 2006). These include lack of collaboration, focused reflection, articulation and team-guided practice, all of which are instructional methods that have been shown to promote clinical reasoning and encourage learning (Murphy, 2005). In the past decade, technology has become an important element in teaching the necessary skills and knowledge to develop competent healthcare students. However, the learning outcomes from using technology cannot be educationally effective unless the design of the learning activities are made based on the evidence and concepts presented from cognitive science. Three-dimensional multi-user virtual environments (MUVEs), such as Second Life, have gained significant interest with educators as they can provide people with a digital presence that offers a unique and comprehensive three-dimensional social environment. Through the use of an avatar, a digital representation of the user, people can participate together in a computing network to communicate with voice as well as text, interact with objects, and create, view, send and receive information. Although Second Life is not necessarily a game, its unique environment allows educators and simulation developers to incorporate gaming principles supported by current cognitive science research, allowing game-like environments to be created where learning involves structure, collaboration between team members and some form of motivation (Gee, 2003). Immersive MUVEs have a distinct ability to create effective non-threatening simulated role playing environments where students can obtain experiential knowledge by adopting and acting on a specific role which requires them to embrace and apply specific knowledge, values and skills.

The idea of using Second Life to simulate an environment or event for health education is not new. There are examples of Second Life being used to simulate the affects of unhealthy eating, the sound types of different heart murmurs and health information libraries (Boulos, Hetherington & Wheeler, 2007). However, Berge (2008) suggests that simulations within Second Life that can be accomplished in regular websites may in fact disrupt the learning process. For a simulation in Second Life to be effective, it involves more than just students practising protocols and skills; it also requires a human dimension where non-technical skills such as teamwork, communication or leadership are applied (Alinier, 2007). Although virtual worlds can provide students with an interactive environment, currently in Second Life, healthcare students are not co-constructing knowledge in a collaborative context, providing students with a valuable clinical experience allowing them to practise and understand skills and characteristics critical to their development as a healthcare professional.

Method

The unique characteristics of virtual worlds, such as Second Life, have been well documented; however, little is known about the actual learning benefits it can provide to nursing students as a

simulation platform. The study compiled a series of investigative interviews to research the attitudes and experiences of a sample of nursing students enrolled in a Bachelor of Nursing Program, who were exposed to six simulated clinical scenarios created in Second Life. Sixteen students were placed into groups based only on their year level and exposed to the simulation in separate locations to replicate the intended purpose of the simulation. The grounded theory method was used for this research, not only for testing the hypotheses, but also for generating hypotheses. The grounded theory approach was employed as it thoroughly investigates a phenomenon and can illustrate problems or indicate good practices, and thus generate hypothesises which could be extensively researched in the future (Blaxter, Hughes, & Tight, 2006). Using a series of individual interviews, the students habits, experiences and perceptions where generated, organised and developed into an overall description of an experience. Using an iterative process, the simulation was developed based on deductive reasoning from general principles found in the literature, the qualitative feedback from the students and the learning objectives of an undergraduate nursing course.

Results—designing a virtual simulation model to promote social constructive learning

Although many themes emerged from this study, the focus of this paper is to highlight the ability to develop a simulation in Second Life that can assist, and even enhance, teamwork and collaborative problem solving in regard to simulated learning activities. A major theme that emerged from the interviews was the positive attitudes the students had towards working as a team in Second Life. By considering evidence and concepts presented from various literature sources, the learning objectives of an undergraduate nursing course and qualitative feedback from a sample of nursing students, a MUVE simulation model was developed in the Critical Life simulation.

Briefing stage

The briefing stage involves the students becoming familiar with the Critical Life simulation. Students spend some time creating their own avatar allowing them to familiarise themselves with the Second Life interface and also develop a sense of identity with their avatar. The participants can then view in world videos which introduce them to the Critical Life: demonstrating how to interact, copy and view objects, navigate the simulation and communicate with peers. This process can be repeated until the student is ready to enter the clinic, allowing them to develop a sense of trust and association with the simulation and their peers. Feedback indicated that all the students were able to communicate efficiently and share thoughts, ideas and nursing experiences. This was indicated by feedbacks such as

> 'I think it's good doing it as a team; you've got the chat thing and discuss it. We had students who've worked on cardiac wards, and other people who haven't worked anywhere to do with cardiology. So one student was like 'oh yeah I've seen that' and then they start on their story. Then you go off and treat them.'

> 'I think the teams are a good idea … it get's everybody to interact. We discussed everything before doing it. It made you think about it, and about your practice. Some of the tasks you questioned it a lot more with your team members, otherwise you would just do stuff without thinking.'

> 'She (a team member) could give you her ideas and you could give her yours to come up with a solution.'

Presenting clinical problems which requires action

The students enter Critical Life by teleporting into the clinical room. A simple detection script is used to count the number of people in the room, and once the maximum number of four is reached, no more students can enter the room. Students can leave and enter the simulation at any time (if the maximum number of avatars has not already been reached) which simulates the process of debriefing. The students are presented with an in-world video which presents a verbal handover for a particular scenario and the student is also given accompanying documentation.

This process allows the student to adopt the role of a nurse and presents them with background information relating to the patients problem. The problems are organised around relevant, authentic problems or questions where the student is required to develop a hypothesis of the required patient care by using the information provided and interacting with patient and apparatus. For example, the student can take the patient's blood pressure, examine oxygen saturation, listen to breathing patterns and ask the patient questions via the instant message interface. Although most students expressed feelings of anxiety at the beginning of the simulation, by the completion of the trial all of the students indicated they felt comfortable using the Second Life platform, with the majority suggesting they did not have any issues working as a team in the online virtual environment. The majority of students indicated that working as a team in the simulated learning environment could enhance their learning experience, compared with traditional methods of text-based case studies or dummies. This was indicated by comments such as

'I've been teamed with a couple of people from [a campus in another city] and that was really difficult because the whole thing was just over emails ... it was really messy. I think [Second Life] was easier. There was no issues, I was comfortable talking.'

'If (the other team members) were there we'd end up looking at each others work. You were doing it together but also by yourself, it was more of a team effort.'

'You're doing group work without acknowledging your doing it, having to ask questions, having someone else you can give feedback ... It's sort of like the next level of what we do, but even better than that.'

'I guess this has more depth; you have to apply more skills to the simulation. Whereas one on one work I don't cope with sort of group situations, so I think the simulation would help assist me more than just the group work.'

From a design perspective, the problem then becomes how to encourage the student to articulate their hypothesis and co-develop a solution as the team in a collaborative environment. Previous studies have shown that although there are not any differences in the amount of communication between students in virtual environments and face-to-face environment; there is a significant reduction in the amount of turns taken to communicate and collaborative reasoning and as a result, new concepts may not be elaborated and understood. (Gao, Noh & Koehler, 2008; McLaughlan & Kirkpatrick, 2004; Whitton & Hynes, 2006). This could be attributed to the fact that there is no hand raising mechanism in Second Life, which can allow a student to bypass the team process and perform an action without reasoning with team members. Therefore the Critical Life design required a model in which team work and collaboration was encouraged and no single student could control the simulation themselves, as this may damage the learning process.

Formulating a prediction and performing a solution as a team to solve the problem

Controlled by the simulation, no action is taken in a scenario without a unanimous decision. This process engages the students in developing evidence-based explanations, articulating their ideas and reflecting on discussions made. Many of the scenarios in Critical Life require multiple steps, some of which need to be performed in a particular order. It is therefore crucial that group discussion occurs before any action is taken to ensure the team develops an understanding of the reasoning behind any decisions made. For example, an action may be turning the oxygen tank on to increase the patient's oxygen saturation, or giving drugs to the patient to reduce pain. The Critical Life simulation will not perform an action until the entire group agrees on a decision by detecting the unique identification of an avatar (the avatar name) and storing this information in a list. When a student uses their avatar to perform a particular action, the name is cross-checked with an action list and checked off. Once all names in the action list are checked off; the action is performed, thus ensuring that a group decision is reached before performing an action. Unlike traditional CBCS, this model supports effective clinical judgement as it not only encourages students to develop a prediction by applying the concept of a problem to their *own* knowledge; it

also encourages students to develop a prediction by applying the concept of a problem to their *peer's* knowledge. With traditional simulations, if a student is unable to form a hypothesis, they can simply obtain the desired result with a few clicks of the mouse. However, the student is not developing a cognitive understanding of the underlying concept that can be transferred into a clinical practice by learning which combination of buttons to press to achieve the desired results. In the Critical Life simulation, if a student is unsure they understand the problem and are not able to derive their own prediction, the student can collaborate with their peers to acquire abstract information and then relate it to their experience obtained from the simulation. This process assists the student grasp the concept at hand and ensures the students can develop a co-constructed mental model. Because of the students being put into random teams, the majority of students did not know their other team members. This process was to replicate the process taken in most simulated activities used in the nursing course. During the individual interviews, the majority of students indicated that they felt *more* comfortable working online and the simulation encouraged them to discuss their ideas, thoughts and experiences with their team members before taking an action in the simulation.

'You have to be really conscious of talking. Talking out loud and talking out your ideas, I think it really had the ability to improve your interpersonal skills, because you really do need to spell out what you wanted or where your heading.'

'You had to be a bit clearer, a lot more clearer, because we were in different rooms, it was very necessary and beneficial.'

'There's no embarrassment, you're on another computer in a separate room and you can just talk and it doesn't affect the social side of things ... It encourages you to learn, whereas in another situation you might not learn as much.'

Observing and determining whether the action was valid

Once a concept has been agreed upon and an action has been carried out by all team members, information from the particular apparatus object is parsed to the patient object—which, in most cases, will change the state of the patient. For example if the oxygen tank is turned on, the patient's visual and auditory attributes such as facial colour and breathing patterns may change. When the student observes the patients vitals after turning the oxygen on, they would see changes in the patient's heart rate, blood pressure, oxygen saturation, etc. This allows the group to observe their actions and determine whether their predictions were valid. This entire process can be repeated many times allowing the students to experience clinical practice and develop a cognitive understanding of the concepts being practised while developing skills required for effective teamwork. After each scenario is completed in Critical Life, the simulation prompts the students to answer questions in their personal log relating to their experiences of clinical judgement, teamwork and specific skills carried out in the simulation to encourage reflection and self-directed inquiry. Another interesting concept that emerged was that the students were able to help each other with not only what to do in the simulation, but also how to use the simulation. The majority of the students indicated they did not experience any technical barrier as they were able to ask for help on how to use Second life to perform the simulation, improving the technical learning curve. The Critical Life simulation enabled nursing students to be actively involved in solving clinical problems presented to them by interacting and communicating with peers, the environment, equipment and the patient, enabling a broader range of specific skills and characteristics to be practised and understood by healthcare students.

Conclusion

Overall, this study indicates that virtual clinical simulations within Second Life are ideal settings for proactively engaging students in constructing knowledge which relate to realistic problems

and assisting in the development of problem-solving skills in a collaborative environment, without inflicting harm to patients. Results from the study suggest that the Critical Life simulation can create an artificial social structure where problem-based scenarios can be created, allowing students to actively co-construct mental models of technical and interpersonal skills through experiencing human interaction in problematic environments. Although the simulation does not teach the students motor skills such as *how* to correctly obtain a patient's blood pressure, the study showed promising results that Critical Life could develop cognitive understanding of team-orientated procedural and problem-based decision-making skills.

Further research is currently being undertaken to investigate the experiences and attitudes of healthcare students in higher education on the use of Second Life as a simulation tool measure and what educational benefits it has for student learning in terms of retention and comprehension. The study will also further develop an understanding of the issues involved when designing and incorporating virtual simulations into teaching and learning practices and what specific skills can be transferred into real-life situations. Unlike traditional technologies, immersive virtual worlds such as Second Life can incorporate essential learning materials with effective learning strategies. Healthcare educators should consider incorporating interactive virtual worlds into teaching strategies to further enhance simulated clinical learning. For this practice to be successful however, the scenarios within the simulation require vigorous testing to ensure there was no risk of students developing incorrect mental models. This study shows promising results with regard to student uptake and engagement with team-based learning simulations in virtual worlds.

References

Alinier, G. (2007). A typology of educationally focused medical simulation tools. *Medical Teacher*, *29*, 8, 243–250. Retrieved March 5, 2009, from the EBSCOhost Academic Search Premier database.

Benson, P. (2004). Online learning: a means to enhance professional development. *Critical Care Nurse*, *24*, 1, 60–63.

Berge, Z. (2008). Multi-user virtual environments for education and training? A critical review of Second Life. *Educational Technology: The Magazine for Managers of Change in Education*, *48*, 27–31.

Blaxter, L., Hughes, C. & Tight, M. (2006). *How to research*. (3rd ed.). UK: Open University Press.

Boulos, M. N., Hetherington, L. & Wheeler, S. (2007). Second Life: an overview of the potential of 3-D virtual worlds in medical and health education. *Health Information and Libraries Journal*, *24*, 4, 233–245. Retrieved March 10, 2009, from the EBSCOhost Health Source Nursing database.

Gao, F., Noh, J. & Koehler, M. (2008). Comparing student interactions in Second Life and face-to-face role-playing activities. In *Proceedings of Society for Information Technology and Teacher Education International Conference 2008* (pp. 2033–2035). Chesapeake, VA: AACE. Retrieved March 10, 2009, from https://www.msu.edu/~gaofei1/research/08slpaper.pdf

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave/Macmillan.

Hanson, J. & Sinclair, K. (2008). Social constructivist teaching methods in Australian Universities—reported uptake and perceived learning effects: a survey of lecturers. *Higher Education Research & Development*, *27*, 3, 169–186. Retrieved March 2, 2009, from http://pdfserve.informaworld.com/13303-751313631-795273096.pdf

Henderson, D. (2005). Games: making learning fun. *Annual Review of Nursing Education*, *3*, 1, 165–183.

Jeffries, P. (2006). Designing simulations for nursing education. *Annual Review of Nursing Education*, *4*, 161–177.

Johnson, J., Zerwic, J. & Theis, S. (1999). Clinical simulation laboratory and adjunct to clinical teaching. *Nurse Educator*, *24*, 5, 37–41.

Jonassen, D. H., Peck, K. L. & Wilson, B. G. (1999). *Learning with technology: a constructivist perspective*. Upper Saddle River, NJ: Merrill/Prentice Hall.

Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

McLaughlan, R. G. & Kirkpatrick, D. (2004). Online roleplay: design for active learning. *European Journal of Engineering Education*, *29*, 477–490. Retrieved March 13, 2009, from the EBSCOhost Academic Search Premier database.

Murphy, J. I. (2005). How to learn, not what to learn: three strategies that foster life long learning in clinical settings. *Annual Review of Nursing Education, 3*, 1, 37–55.
Petty, G. (2004). *Teaching today: a practical guide* (3rd ed.). Cheltenham: Nelson Thornes.
Thiele, J., Holloway, J., Murphy, D., Pardavis, J. & Stuckey, M. (1991). Perceived and actual decision making by novice baccalaureate students. *Western Journal of Nursing Research, 13*, 5, 616–626.
Whitton, N. & Hynes, N. (2006). Evaluating the effectiveness of an online simulation to teach business skills. *e-Journal of Instructional Science and Technology*, *9*, 1. Retrieved March 1, 2009, from http://www.usq.edu.au/electpub/e-jist/docs/vol9_no1/papers/current_practice/whitton_hynes.pdf