Author(s): Cobb, Stephanie; Heaney, Rose; Corcoran, Olivia; Henderson-Begg; Stephanie.
Article Title: The Learning Gains and Student Perceptions of a Second Life Virtual Lab
Year of publication: 2009
Citation: Cobb, S. et al (2009) 'The Learning Gains and Student Perceptions of a Second Life Virtual Lab', Bioscience Education 13
Link to published version: http://dx.doi.org/10.3108/beej.13.5
DOI: 10.3108/beej.13.5

bioscience education

Research Article

The Learning Gains and Student Perceptions of a Second Life Virtual Lab

Stephanie Cobb, Rose Heaney, Olivia Corcoran and Stephanie Henderson-Begg

University of East London, School of Health and Bioscience

Date received: 07/04/2009 *Date accepted: 30/06/2009*

Abstract

This study examines students' reactions to the virtual biosciences laboratory developed in Second Life® (SL) at the University of East London. Final year undergraduates and masters students studying biotechnology took part in a trial of a virtual Polymerase Chain Reaction (PCR) experiment in Second Life and evaluated their experience by anonymous questionnaire. Learning gains were measured at various points during the study using pre- and post-tests, and interaction with demonstrators was monitored and compared during the real life (RL) practical. Both groups showed a significant increase in learning gain over the pre- and post-tests, although no difference in gains between the two groups was detected. However, students who conducted the PCR experiment in SL required significantly less demonstrator assistance during the subsequent RL practical. The SL practical was well received by students, with 92% of participants reporting that they would like to use the system again and many requesting other experiments to be made available in this manner in the future.

Keywords: Second Life, PCR, virtual world, practical, bioscience

Introduction

The benefits of experiential learning are well documented (Kolb, 1984) but as the United Kingdom (UK) government continues its campaign to make education more accessible, increasing student numbers limit the opportunity for educators to provide an active learning experience for all. It is therefore essential for education providers to investigate innovative new teaching methodologies to provide a more satisfying learning experience in circumstances of limited space and resources.

The use of Virtual Worlds for educational purposes is one such field of pedagogical innovation that, while currently in its infancy, has massive potential for growth. For example, over 100 colleges, universities and other learning institutions, such as museums and libraries, have established a presence in Second Life® (SL), a virtual world that covers about 700 million square metres of virtual space (Atkinson, 2008). Second Life allows users to create an alter-ego (avatar) with which they can interact with other people and objects in cyber-space. Students who have created an avatar can attend virtual conferences, lectures, presentations and tutorials hosted by educational sites, including Harvard in the United States (US) and Oxford in the UK (Wood *et al.*, 2008).

On the first encounter of teaching in Second Life it is difficult to know how to structure lessons. There is a tendency for academics to replicate real world learning environments and lessons (Salmon, 2009). At present the body of research into using Second Life in an educational environment is relatively small and the majority centres mainly on the application of Virtual Worlds within the area of distance learning (e.g. Childress and Brasswell, 2006; Bronack *et al.*, 2006). There are, however, various qualities of the Virtual World concept that make it equally

beneficial for on-campus teaching and learning. Second Life has the potential to replicate expensive and potentially dangerous activities in a collaborative manner (Foss, 2009). Simulated representations of actual locations can be created and extreme situations, such as pandemics or crisis situations can be explored in perfect safety (Stott, 2007; Hewitt, *et al.,* 2008). Furthermore, Virtual World practicals and role playing may help students to overcome worries of 'getting it wrong' in real life groups (Broadribb and Carter, 2009).

Laboratories created in the Virtual World can enable students to repeat experiments many times over and receive feedback from the environment at no extra cost to the university for staffing or materials. Virtual laboratories may also provide opportunities for physically disabled students to conduct experiments in a risk-free environment and benefit from experiential learning that is not always available to them in the real world.

At the University of East London (UEL) a team of educators and researchers in the department of Health and Biosciences have developed a Virtual Biosciences Laboratory (Lab) in Second Life, which is currently being made available to students. The first experimental technique to be trialled with students in the Virtual Lab is the Polymerase Chain Reaction (PCR) experiment. This technique amplifies DNA and has multiple uses in molecular biology, biotechnology and forensics. There were 110 students studying the level 3/4 Commercial Biotechnology module at UEL at the time of the study, all of whom were required to learn to conduct the PCR experiment. This made for large class sizes during laboratory practicals requiring a large amount of costly laboratory consumables and high staff presence to run the session.

The aim of this study was to determine whether conducting the PCR experiment in the virtual world of Second Life produced similar learning gains to those observed in the physical world laboratory and to see if working in the Virtual Lab enhanced students understanding of the experiment. The student perceptions of the Virtual Lab as a teaching mechanism and the perceived impact on their learning was examined through questionnaires. At the outset of this study it was expected that students taught in the Virtual Lab would show no difference in learning gains to those taught by more traditional methods, and that the Virtual Lab would be well received by today's generation of technologically literate students, making it a useful adjunct to the Biosciences Commercial Biotechnology module at UEL.

Method

A total of 85 final year undergraduate and masters students registered for the Commercial Biotechnology module for the academic session 2008/9 participated in the study. Participants were then allocated into two groups at the beginning of the teaching session by the leading lecturer. The group who were going to use the Virtual Lab in Second Life (SL group) was formed of the first 50 students to arrive at the very beginning of the scheduled class as time was a pressing factor in this study. The non-SL group subsequently was formed in part by late arriving students, whereas the SL group were all prompt attendees. The SL group completed a pre(virtual) Lab quiz and then individually registered for Second Life to create an avatar under instructor supervision. Each student completed some orientation exercises on UEL Island to become adequately skilled in using the Second Life environment (e.g. flying, putting on clothing etc.). The student avatars then met in the Virtual Lab to perform the PCR experiment. This was initially demonstrated by a member of staff before each student completed the virtual experiment themselves. Throughout this teaching session the students received face to face and virtual communication from their instructor. The students in this group then completed the post-(virtual) prep test before undertaking the physical world laboratory practical. Meanwhile the non-SL (Demonstration) group completed the pre lab quiz then viewed a demonstration of the PCR experiment by a member of teaching staff, and then completed a post-preparation quiz.

Participants in both groups then completed the physical world PCR practical individually in the laboratory. During the physical world practical the number of questions asked of staff and demonstrators by students in each group was recorded. After the real-world practical all participants completed the in-class quiz once again as a measure of overall learning gain.

The flow of pre- and post- tests and teaching methods used in the study is in Figure 1.

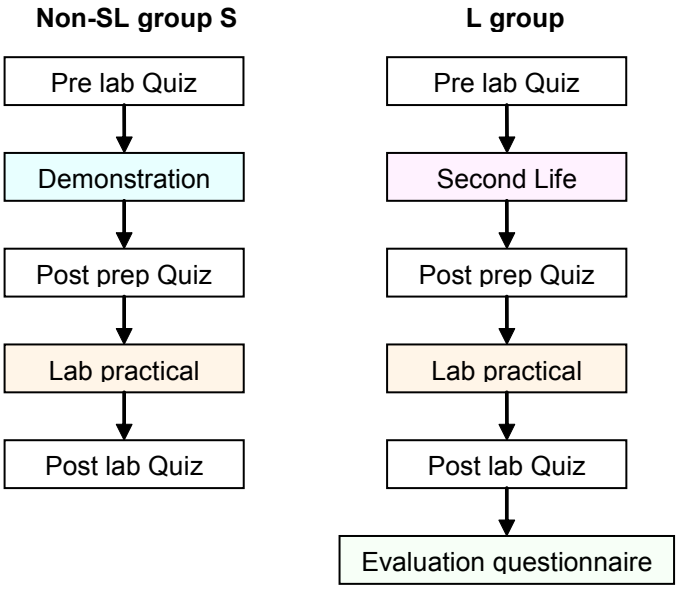


Figure 1: Design of the Second Life PCR lab evaluation. The flow diagram depicts at which point questionnaires, and pre- mid- and post-tests were used in relation to each teaching session for the SL and non-SL groups.

The Virtual PCR lab was evaluated by 50 students from the SL group. Each completed an anonymous questionnaire about their past experiences of Second Life, their demographics and course details. The questionnaire also consisted of 20 statements about Second Life, the Virtual PCR lab and computer usage against which students rated their agreement on a 5 point Likert scale. Several negatively scored questions were introduced to ensure that questionnaires were completed correctly by students. Some demographic information was also collect by means of the questionnaire. Students in the non SL group were given the opportunity to use the Virtual PCR lab after the evaluation had taken place.

A mixed (or split-plot) ANOVA was used to determine if there were any significant differences in learning gain between the SL and non-SL group over the three test periods (pre prep, post prep and post lab). A non-parametric Chi-Squared test was used to measure whether there was a significant difference in the practical knowledge (number of questions asked of demonstrators) of each group. Pearson's correlation was used to measure the relationship between overall satisfaction and ease of use with various other factors from the evaluation questionnaire. T-tests were also used to determined whether any significant differences were present between the opinions of males and females, re-sitters and first timers, those who had used Second Life before and those who had not and those who started the course in semester A and semester B.

Results

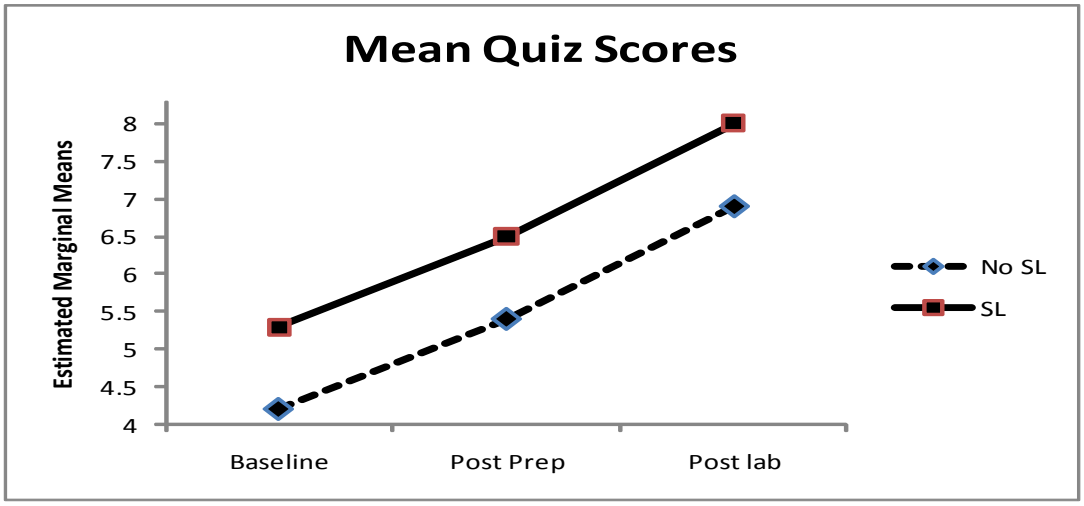
Demographic

Of the 50 students who took part in the evaluation 17 (34%) were female and 33 (66%) were male. This apparent disparity in male to female ratio reflects the ratio seen for this module which consists of 74% males and 26% females from a total of 104 students. One hundred of the 104 students in the study group are registered as international students, the majority coming from India. Ages ranged from 20 to 40 years with a mode and median age of 22 years. The majority of students had only registered for their programme of study two months before the evaluation (29 students). Of the 21 students who had been registered for more than two months prior to the evaluation, 11 of these students were re-sitting the module.

Learning gain

Pre-, mid- and post-tests were used to examine the learning gains seen in the students at each stage of the teaching process. The learning gains of each group at the three stages of testing are illustrated in Figure 2. Using a mixed (or split-plot) ANOVA there were found to be no significant difference between the learning gains achieved by the SL and non-SL groups, with both groups achieving the same mean increase in test score between the pre and post tests. Interestingly however, there was a significant difference between the scores achieved by students in the SL and non-SL groups overall (p<0.001), with the initial average pre-test score of the SL group being significantly higher than the initial average pre-test score for the non-SL group. Quiz scores increased significantly across the study for students in both groups (p<0.001).

Figure 2: Learning gains of SL and non-SL groups following the pre- mid- and post-tests conducted throughout the evaluation.



Practical knowledge

The number of questions asked by students during the physical world laboratory practical was recorded for the non-SL and SL groups. As can be seen in Figure 3, the non-SL group (Demonstration) asked significantly more questions (p<0.001) during the practical than the SL group. Furthermore, the staff supporting the practical sessions reported the SL group students to be more organised in their conduct during the class and appeared to take less time to complete the task.

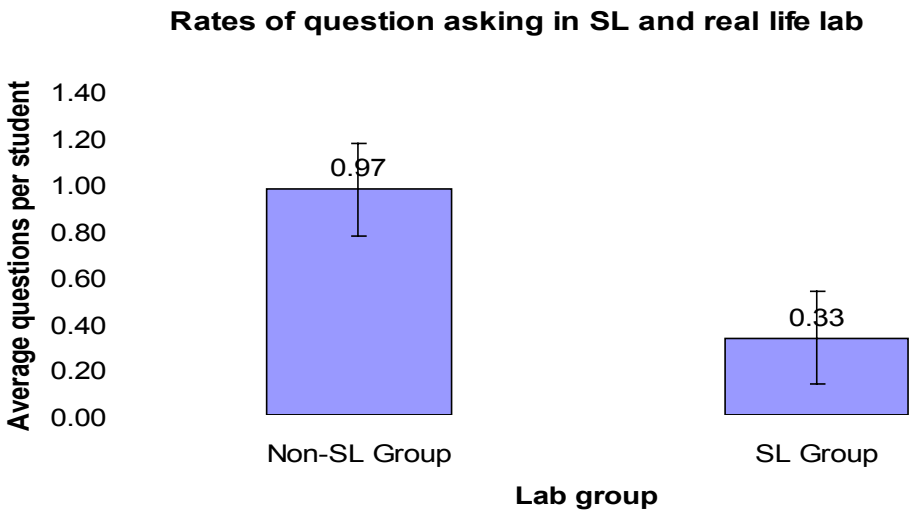


Figure 3 *The number of questions asked during the real-life (RL) practical by the SL and non-SL group. The p-value for the difference in the number of questions asked between the two groups is given.*

Evaluation

The SL group were asked to complete a questionnaire at the end of the teaching session. Students were asked their age, gender, date of course entry, whether they were re-sitting the module, if they had used Second Life before and would again, and the time it took them to complete the Virtual Lab experiment.

Table 1 *The statements used in the evaluation questionnaire. Statements are divided into those which were designed to assess IT competence and aptitude, perceptive ease of use of SL and satisfaction of the Virtual Lab.*

Ease of use of SL	Q1	I found registering for a Second Life account easy
	Q2	I found it easy to create my own avatar
	Q3	I learned how to move around quite quickly (e.g. walking and flying)
	Q4	I found it easy to get to UEL Island
	Q7	I found it easy to put on the clothes
	Q8	I found it easy to move around the lab
	Q9	I found it easy to use the apparatus
	Q10	I found using Second Life quite difficult (negatively scored)
Satisfaction of the Virtual Laboratory	Q5	I understood what I needed to do very well
	Q6	I found the instructions on the bill-board very helpful
	Q11	I received sufficient feedback during the experiment
	Q12	Using Second Life enhanced my understanding of the PCR experiment
	Q13	Using Second Life for lab practicals would increase my attendance
	Q20	Doing the PCR lab in Second Life made me better prepared for the real thing
IT competence and aptitude	Q14	I am confident using computers for basic tasks (e.g. email and word processing)
	Q15	I am confident that I can learn to use new software
	Q16	I play computer games quite often
	Q17	I feel apprehensive about using computers (negatively scored)
	Q18	I feel intimidated by the internet (negatively scored)
	Q19	The internet is a helpful and entertaining resource

In addition they were asked to rate a variety of statements listed in Table 1 as 1 = strongly disagree to 5 = strongly agree. Questions 1 to 4 and 7 to 10 related to ease of use of SL, Questions 5, 6, 11 to 13 and 20 related to satisfaction with the SL PCR lab and Qs 14 to 19 related to students confidence and aptitude using computers. The results of the evaluation questionnaire are summarised in Figure 4.

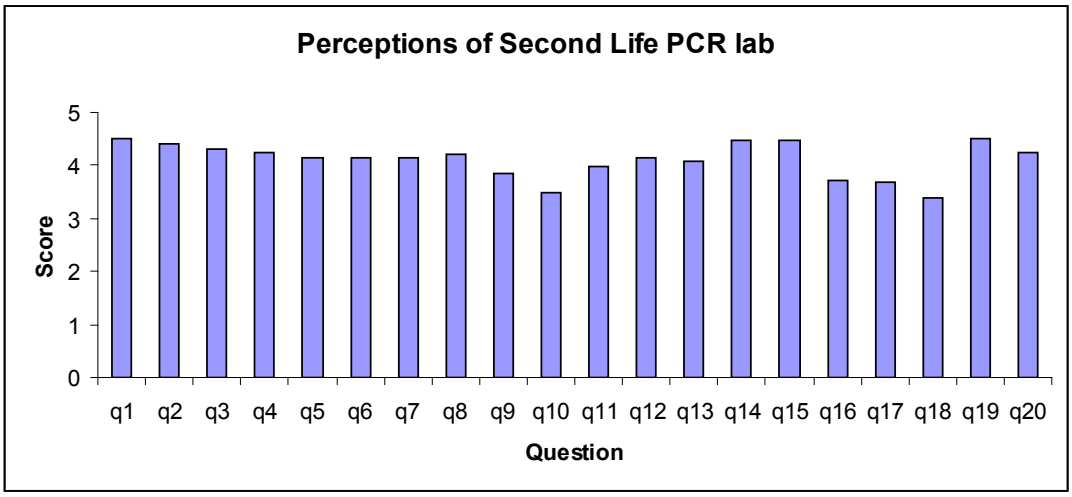


Figure 4 *Summary of responses from the evaluation questionnaire. The average response value obtained for each statement used on the questionnaire. 1 = strongly disagree; 5 = strongly agree.*

Overall, satisfaction with the Virtual Lab was high. Ninety-two percent of respondents said they would use Second Life again and many had commented during the teaching session that they would like to see other experiments in the Virtual Lab. There were no significant differences in opinion between the sexes and between those who are re-sitting the module (11 students) and those that were not. Students who had already completed one Semester of the course joining the programme in October 2008 (21 students) found the in world instructions on how to complete the Virtual Lab experiment more useful than those (29 students) who started in Semester B, February 2009 ($p<0.05$). Of the 21 students who started the programme in October 2008 only one (6.25%) rated Q6 (Table 1) with 3 or less whereas 5 (17.24%) of the 29 February starters answered 3 or less to this question.

Students' own evaluation of the Virtual Lab revealed a strong correlation between perceived ease of use and overall satisfaction ($r= 0.7$, $p<0.001$) and a weak negative correlation was found between time taken to complete the task and overall satisfaction ($r= -0.38$, $p<0.01$). Those who found Second Life easy to use were most satisfied with the outcome of the exercise. A moderate negative correlation was found between age and overall satisfaction ($r= -0.54$, $p<0.001$). Younger students were generally more satisfied with Second Life than older students. Those who took longer to complete the experiment were less satisfied with the system overall.

Those who had used Second Life before the study (16 out of 50 students) differed significantly in their expectation of in-world feedback whilst undertaking the Virtual PCR experiment from those who had no prior Second Life experience ($p<0.05$). Of the 16 students that had used SL before 6 students answered Q11 of the questionnaire (Table 1) with 3 or lower while only 4 students out of the 34 who had not used SL before answered Q11 in this way. Those who had used Second Life before thought that they had not received sufficient feedback during the experiment. Unfortunately the questionnaire was not designed to follow up on this finding.

Discussion

As expected no difference in learning gain between the SL and non-SL groups was found across the study. Students in both groups increased their knowledge equally and learning gains were unaffected by whether the students used the Virtual Lab in Second Life or saw a demonstration before the physical life practical. Surprisingly students in the SL group already had greater baseline knowledge of the theory and practice of PCR than students in the non-SL group at the outset of the study. This difference in baseline knowledge could be due to individual differences or the way the allocation to groups was conducted. As the SL group were chosen from the students present at the very beginning of the scheduled class, the non-SL group ended up being formed partially of late arriving students, whereas the SL group were all prompt attendees. It seems plausible that there may be a correlation between punctuality and the amount of preparatory work done prior to class which may explain the difference in the baseline knowledge levels. Regardless, the overall result was unaffected by difference in baseline knowledge as learning gains were similar in both groups.

Similar to our findings, numerous previous studies have shown that computer aided teaching does not reduce the learning gain seen following teaching by traditional methods (eg. Tvedten *et al.* 1993; Xakellis and Gjerde 1990). While the use of Second Life did not appear to enhance the learning gains of the students, there are other types of cognitive development and theoretical understanding enhancement which may not have been picked up using the methods employed here. Furthermore, as the whole study was conducted over the period of three hours, these finding say nothing of the difference in the long term learning gains that may exist between the two groups. Marcelle Siegel (2000) examined learning gains of students using computer based instruction verses tradition methods and found a greater increase in learning gains by the computer taught group following a delayed post-test. Further research into the learning gains from using Second Life by other methods is currently underway.

During the physical practical the students who had used the Virtual Lab first asked significantly fewer questions of the demonstrators than those who had seen a visual demonstration. Demonstrators also observed that students who had been through the virtual lab PCR experiment were quicker to get started and noticeably more organised when they completed the physical world practical. This is an encouraging outcome as burden on the laboratory demonstrators is decreased if students have fewer minor queries about the procedure. Furthermore, the increased organisation and reduced number of questions asked by the SL group suggests an enhanced level of understanding in this group in comparison to the non-SL group not detected by the pre-, mid- and post- tests.

The increased level of organisation and understanding seen in the laboratory practical undertaken by the SL group suggests that the use of the Virtual Lab prior to conducting real-life experiments makes students better prepared for the real thing. This offers numerous advantages in running these types of classes. For example, the students are less likely to make mistakes wasting costly reagents if they have a better understanding of the procedure at the outset, so may offer savings in terms of laboratory consumables. As the SL group students did not ask as many questions and were more organised in the laboratory, the demand on demonstrator time was also reduced. Furthermore, although students conducted the Virtual Lab experiment at the university under supervision in this instance, they are able to access and repeat experiments in the Virtual Lab as many times as they desire, enabling them to self direct their learning in this area until such a time that they feel comfortable with the procedure. Large class numbers and the costs of running physical world practicals make this level of repetition impossible in the physical world.

Students who had already completed one Semester of the course found the in-world instructions on how to complete the Virtual Lab experiment more useful than those who started in Semester B ($p<0.05$). It is possible that those students who have completed one semester of the course already have greater knowledge of the PCR procedure and therefore found the instructions more helpful. They may have also had more use of college computer equipment and therefore found the Second Life environment easier to nagivate. Overall, satisfaction with the SL PCR lab was high and many commented that they would like to see other experiments in the Virtual Lab. Second Life is said to be among the most challenging platforms for new users (Wood *et al.*, 2008) so it is extremely encouraging to see that our students rated their experience of the Virtual Lab so highly.

Those who had used Second Life before thought that they had not received sufficient feedback during the Virtual Lab experiment. This could mean that other places in Second Life give more extensive feedback than the UEL PCR lab. It might also indicate that those students have become more reliant on the technology they use to do some of the thinking for them. The design of the Virtual Lab experiment is that they cannot complete the task unless they have correctly undertaken the procedure. Incorrect attempts at, for example, setting the pipettes and adding the reagents is met with an error message and the opportunity to retry. It is intended that this setup would provide instant feedback to the user. Alternative feedback methods will be investigated in attempt to overcome this downfall. However, overall most statements relating to ease of use, usefulness of the experience and perceived enhancement of learning were rated as 4 (agree) or 5 (strongly agree).

There are potential benefits and problems associated with inclusivity which did not emerge from the group of students used in this evaluation. It is expected that students with certain disabilities (eg. Learning disabilities and some physical disabilities) may benefit greatly from the use of computer aided teaching in this context. For example students with social interaction deficits such as Asperger's Syndrome may benefit greatly from computer aided learning for numerous reasons (Emmons, 2008). Conversely, this type of learning will be of limited value to students of visual impairment or those with extreme physical disabilities preventing self directed use of a PC.

This study has provided important information about the use and value of Second Life in practical based science education at university level as evaluated by students and demonstrators. Use of UEL's virtual lab in SL did not reduce the learning gain in comparison to traditional teaching methods, and in fact appeared to enhance student understanding of the experiment as measured by their in class organisation and assistance required during the physical world experiment. Current research is underway to compare the effectiveness of virtual experiments in Second Life with an alternative Flash-based platform that may be more familiar to our students.

Corresponding author
Stephanie Henderson-Begg, School of Health and Bioscience, University House, University of East London, Romford Road, Stratford E15 4LZ email s.henderson-begg@uel.ac.uk

References

Atkinson, T. (2008). Inside Linden Lab: Second Life for Educators. *TechTrends: Linking Research and Practice to Improve Learning*, **52** (3), 16-18

Broadribb, S. and Carter, C. (2009) Using Second Life in human resource development*, British Journal of Educational Technology* **40** (3), 547-550

Bronack S, Riedl R, Tashner J. (2006) Learning in the zone: A social constructivist framework for distance education in a 3-dimensional virtual world. *Interactive Learning Environments* **14** (3), 219-232

Childress, M. and Brasswell, R. (2006). Using Massively Multiplayer Online Role Paying Games for Online Learning. *Distance Education*, **27** (2), 187-196

Emmons, J. (2008) Exploring the use of computer assisted instruction with autistic students, *Connexions module* **m16541**, retrieved from http://cnx.org/content/m16541/latest/ (Accessed 2nd April 2009)

Foss, J. (2009) Lessons from learning in virtual environments, *British Journal of Educational Technology* **40** (3), 556-560

Hewitt, A. M., Spencer, S. S., Ramloll, R. and Trotta, H. (2008). Expanding CERC Beyond Public Health: Sharing Best Practices with Healthcare Managers via Virtual Learning. *Health Promotion Practice*. **9**, 835-875

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

Salmon, G. (2009) The future for (second) Life and Learning, *British Journal of Educational Technology* **40** (3), 526-538

Siegel, M.A. (2000). Changes in student decisions with Convince Me: Using evidence and making tradeoffs. In M. Hahn & S. C. Stoness (Eds.), *Proceedings of the Twenty First Annual Conference of the Cognitive Science Society*, 671-676. Mahwah, NJ: Erlbaum

Stott, D. (2007). Learning the Second Way. *British Medical Journal*, **335** (7630), 1122-1123

Tvedten, H., Walter, G., Stickle, J., Henkel, K. & Anderson, C. (1993) Computer-based instruction versus instructor-based instruction of interpretive clinical pathology case analysis, *Journal of Veterinary Medical Education* **20** (3), 640-651

Wood, T. Solomon, M. and Allan, D. (2008). Welcome to the Matrix: E-Learning Gets a Second Life. *Marketing Education Review,* **18**, 47-53

Xakellis GC and Gjerde C (1990) Evaluation by second-year medical students of their computer-aided instruction. *Academic Medicine* **65**:23-26