Assessment of the Efficacy of Second Life, a Virtual Learning Environment, in Dental Education

Maha M.A. El Tantawi, Ph.D.; Mona K. El Kashlan, Ph.D.; Yasmin M. Saeed, B.D.S.

Abstract: This study assessed the efficacy of Second Life (SL) in delivering lectures and demonstrating clinical procedures. Sixteen students in a dental school in Alexandria, Egypt, volunteered to participate in SL to learn about topical fluoride through lectures and YouTube videos demonstrating the application of fluoride gel. This was followed by face to face (F2F) sessions about pits and fissures sealant including lectures and F2F demonstration. Knowledge improvement was assessed by pre- and posttests; practical skills were assessed by a checklist; and percent scores were calculated. The relation between these scores and some background variables was assessed. Students' satisfaction with and perceptions of SL were also assessed. Knowledge improved significantly after both SL and F2F experiences (p<0.0001 for both). There were no significant differences between SL and F2F in knowledge improvement or skills percent scores (p=0.16 and 0.26, respectively). Knowledge improvement was significantly related to previous experience with SL and previous year grade (p=0.02 and 0.007, respectively) but not to gender. Practical skills scores were not related to any of these three variables. Satisfaction with SL experience was high and not affected by any of the three variables, and the experience was perceived positively. This study suggests that SL can complement traditional F2F teaching, especially for underachieving students and in higher education institutions with problems of increasing numbers of students and limited space.

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The generation born after the 1980s grew up surrounded by digital media. Compared to previous generations of learners, this generation is easily bored and impatient and expects instant feedback and rewards.¹ These characteristics emphasize the need for changing the ways of delivering education to these students. Virtual Learning Environments (VLEs) offer online learning and are considered applications of Web 2.0 in the teaching/learning process. Three-dimensional Multi-User Virtual Environments (3D MUVEs) are VLEs that can be shared simultaneously with more than one user. They are networked desktop virtual reality systems in which users move and interact via a graphical representation of themselves called avatars. Avatars allow multiple users to interact with each other synchronously and with virtual objects and places that are graphically represented in three dimensions to resemble real life.² 3D MUVEs provide opportunities for real-time simulation and collaboration in a virtual environment that does not require participants to be in the same physical or geographical location.³ They do not have rules for game-play, a storyline to follow, or a set of tasks to accomplish for rewards.⁴ 3D MUVEs have attracted the attention not only of individual users but also of schools and universities. Live education events, including research seminars and international conferences, are regularly occurring in virtual environments.⁵ Any educational institution can hold virtual classroom hours, and students from around the globe may listen to invited guest speakers,⁶ hence eliminating the necessity for the student or professor to travel.⁴ They can also enhance social presence and engagement, thus promoting student attention and engagement through providing real-time virtual student-instructor and/or student-student interaction.⁷

The largest and the most popular 3D MUVE in use today is Second Life (SL), developed by Linden Research Labs in 2003.⁸ Users of SL are called residents, and they can customize their own avatars with features. These avatars can meet and socialize with other residents (using text, images, voice, and gestures).³ Social interaction is more realistic by using
gestures such as sitting, bowing, clapping, laughing, dancing, and making other movements characteristic to humans, all of which can all be performed through avatars in SL.

In dental education, there have been several reports of dental schools using SL for educational purposes. Case Western Reserve University School of Dental Medicine in Ohio built a virtual replica of its campus to develop communication skills with a real-life actor’s avatar. In this replica, students’ participation was found to be more efficient, and less faculty instructional time was needed for SL simulation compared to face to face (F2F) interaction. The University of Maryland School of Dentistry created a virtual school with a dental hygiene clinic in SL to evaluate students’ knowledge of infection control and behavioral skills such as dealing with angry patients. The Medical College of Georgia School of Dentistry (now Georgia Regents University School of Dental Medicine) designed the “Virtual Dental Implant Training Simulation Program” to help students in diagnosis, decision making, and treatment protocols. Students’ reviews were positive, and they reported that the experience added to their understanding. The Dental School at Aristotle University in Greece developed a 3D educational simulation called “Virtual Child” that used SL. It aimed at assisting dental students in developing skills related to child behavior management, and the researchers reported their intention to expand the simulation by adding more scenarios. Finally, when the University of Kentucky established a virtual laboratory in SL to teach gross anatomy to predoctoral dental students, the students indicated that the instantaneous feedback from instructors and the anonymity in the use of avatars allowed for free exchange of ideas.

Although reports of SL use in dental education thus exist, formal studies designed to assess its value are not common. Our search of PubMed using the term “Second Life virtual” retrieved a number of articles. However, when this search was limited to the subset of dental journals, a review by Phillips and Berge was the only one retrieved. This search indicates the scarcity of studies assessing the effectiveness of SL in dental education. More research is required to evaluate the application of these new technologies in the field of dental education. These applications can be especially useful as possible solutions to problems of physical space limitations, increased student to space ratio, and limited resources that face higher education in general and dental education in particular. This is especially true in countries with limited resources that need to devise unconventional solutions for these problems. Compared to the cost of building real lecture halls and rooms to present the didactic part of dental courses, the cost of purchasing suitable land parcels in SL seems minimal. The cost is also considerably less than that needed to establish virtual learning environments in custom-made commercial software. The aim of our study was to assess the effectiveness of SL in delivering lectures and demonstrating a clinical procedure compared to traditional F2F methods and also to assess the perceptions and satisfaction of students participating in the SL learning experience.

Materials and Methods

Senior dental students studying in the Faculty of Dentistry, Alexandria University, Egypt, were invited to participate in the study. Calls for volunteers took place in practical sessions and through a Facebook (FB) group “Second Life: New E-Learning Tool.” Students were recruited with the following criteria: not having studied the course of applied preventive dentistry (including the use of topical fluoride and pits and fissures sealant that were to be in the study), willing to donate time to the study, having adequate computer skills, having access to a high-speed Internet connection, and having access to a computer that met SL requirements.

Sample size was set to ten to fifteen participants to match the explorative nature of the study: since group dynamics inside SL were unknown, it was not known whether a larger group of participants would find it difficult to get acquainted and interact with each other in SL. Similarly, it was not known if the available Internet connection would accommodate synchronous interaction of a greater number of students. In addition, Linden Lab recommends that a land parcel of the size used in the study can accommodate up to fifteen to twenty concurrent avatars at one time. The approval of the Ethics of Dental Research Committee, Faculty of Dentistry, Alexandria University was obtained.

The study used a within-subject quasi-experimental design to compare participants’ learning outcomes in a Second Life classroom to that in a traditional face to face classroom so that the subjects would act as their own controls. Subjects went through the SL experience where a series of sessions about topical fluoride was offered, followed by the F2F experience where another series of sessions about pit
and fissure sealant was offered. The study involved planning of the learning experiences, implementation of the experiences, and outcome assessment.

Planning SL and F2F Experiences

Two series of lectures were designed: one about the use of professional topical fluoride (for SL) and the other about pits and fissures sealant for caries prevention (F2F). These were designed following the respective lectures taught in the Dental Public Health course for fourth-year students in the dental school. Intended learning outcomes (ILOs) included development of knowledge and practical skills. Course content was defined to meet the ILOs. A subject expert not involved in the study reviewed and finalized the contents. Five sessions were planned for each experience, with each session planned to last about an hour. Teaching methods included lectures supported by educational aids (PowerPoint presentations or videos) followed by discussions in which students had the opportunity to ask questions.

For SL, educational materials included PowerPoint presentations in addition to illustrations and diagrams. Videos were selected from YouTube to demonstrate topical fluoride gel application to be used in SL lectures; this was the only demonstration available in SL. For F2F, on the other hand, educational materials for lectures were based on PowerPoint presentations illustrated with diagrams. F2F demonstration of pits and fissures sealant application was carried out in the Pediatric Dentistry Clinic in the Faculty of Dentistry, Alexandria University.

To prepare SL learning space, an account was created through the SL website. The avatar of the instructor was customized, and her name was selected from a list of surnames offered by SL. Her appearance was customized to portray a female with professional conservative clothing. Different SL islands were explored to find a suitable land parcel for the learning space. A prepaid developer designed and built the learning space, which consisted of a video hall with two screens linked to YouTube videos and a lecture room with four screens to display PowerPoint presentations (Figure 1). The screens were kept in place so that students could check the lectures and revise them asynchronously out of sessions. A script was created to allow students to raise their hands when they needed to ask questions in order to prevent distractions.

For the F2F experience, a lecture room was selected that would be comfortable for delivering the lecture. The room was 6m x 5m, large enough to accommodate all participating students and allow them to move freely. The room was quiet and free from distractions, was air conditioned, and had suitable lighting. In addition, it was technology-supported with a laptop, data show projector, and a 4” x 3” screen to deliver lectures.

Implementation of Learning Experiences

To implement the SL experience, students were advised through the FB group to visit the SL Orientation Island, which is the first island where new residents begin and where they find on-screen tutorials to guide them through SL basic skills. An orientation session was scheduled in which study objectives were explained and responsibilities outlined, including answering the pre- and post-study tests, reviewing the educational materials supplied in SL, attending lectures at the assigned time, and preparing their headphones and microphones. Students were asked to create their own avatars and post the avatars’ names to the FB group, so that it would be possible to add each other to the SL contacts list. Camstudio screen recording software (http://camstudio.org/) was downloaded before the SL lectures commenced and tested to confirm its usefulness to videotape and record the lectures.

Five lectures were delivered through SL with the instructor speaking through a microphone and students responding to her questions and asking for clarification by typing in local chat (a text messaging option that sends instant messages, is available to visitors of the island in SL, and can be read only by visitors in the same location or within a limited distance of it). Several trials were made during the five sessions to overcome the problems of two-way voice communication through using SL voice chat, Skype, and Yahoo Messenger with limited success. However, during the last session, voice chat software (Inspeak communicator) (http://www.inspeak.com) was used for two-way communication and showed success with good voice quality. For practical demonstration, students watched videos demonstrating fluoride gel application in an SL video hall after the technique was explained with an illustrated PowerPoint slideshow during one of the lectures.

For the F2F experience, lectures were scheduled through the FB group. Five lectures were delivered followed by discussion. Students were given F2F demonstration of chemically cured pits and
Outcome Assessment

Assessment of learning gains. Two tests of thirty multiple-choice questions each were prepared to assess students’ knowledge before and after SL lectures as well as before and after the F2F experience. A correct answer was given one point, whereas the wrong answer received no points.

fissures sealant application at the pediatric dentistry clinic. All required equipment and instruments were prepared before students’ arrival including dental towels, disposable mirrors, probes and tweezers, plastic cups, cotton, saliva ejector, disposable cotton brush tips, mixing pads, and sealant material kit. In both SL and F2F experiences, a lecture lasted approximately ninety to 120 minutes.

Figure 1. Learning space for study

a. Video hall area

b. Classroom area

c. Overview of lecture room during session showing students and instructor
At the end of the study, students were divided into three groups (five or six students/group), and dates and groups members’ names were confirmed on the FB group. Patients (≥6 years of age with fully erupted, noncarious, first permanent molars) were referred from the output clinic. Two checklists were prepared to assess the competence of the students in applying topical fluoride gel and pits and fissures sealant, with each checklist dividing each of the two procedures into eight steps. The steps were evaluated as achieved or unachieved correctly (one and zero points, respectively).

**Assessment of satisfaction with SL.** A questionnaire based on a previous SL study\(^{20}\) was given to students to assess their satisfaction with SL quantitatively. It contained eleven closed ended statements categorized into three aspects: satisfaction with technical aspects (four statements), satisfaction with interaction (four statements), and satisfaction with education in SL (three statements). Responses were on a six-point Likert scale (fully agree=5 to fully disagree=0). The points for each statement were summed, producing a subscore ranging from 0 to 20 for the first two aspects and 0 to 15 for the last aspect. The three aspects’ subscores were summed to produce an overall satisfaction score ranging from 0 to 55.

Qualitative assessment of satisfaction and perception of SL was done using five open-ended questions in which students were asked about their opinion of SL, its advantages, its disadvantages, their expectations for its use in education, and their suggestions to improve the experience. Responses to the questions and related comments were analyzed and categorized using thematic analysis.\(^{21}\)

**Statistical Analysis**

Quantitative data were analyzed using SPSS 16.0. Significance was set at 5 percent. Data analyzed included knowledge percent and percent improvement, practical skills percent score, satisfaction aspects percent subscores, and total satisfaction percent score. Percent knowledge score was calculated as (knowledge score * 100)/30. Knowledge score percent improvement was computed as (posttest score-pretest score)/pretest score * 100. Practical skills percent score was computed as (skill score * 100)/8. Satisfaction aspects percent subscores were computed as (aspect satisfaction subscore * 100)/20 for satisfaction with technical and interaction aspects or 15 for satisfaction with educational aspect.

Knowledge score percent and percent improvement were normally distributed, and a paired t-test was used to compare knowledge score percent before and after each experience as well as percent improvement between SL and F2F experiences. A t-test was used to assess the relation between knowledge percent improvement and gender (males/females), previous experience with SL (yes/no), and previous year grade (≥ and <very good). Practical skills percent score was not normally distributed, and Wilcoxon signed-rank test was used in place of paired t-test and Mann Whitney U test in place of t-test for the previously mentioned comparisons and relations.

The percent subscores of the three satisfaction aspects and the overall satisfaction percent score were normally distributed. Repeated measures analysis of variance was used to assess differences between the three aspects satisfaction percent subscores, and pairwise comparisons were made among them with Bonferroni adjustment. To assess the relation between the three percent subscores of the satisfaction aspects and overall satisfaction score on the one hand and the students’ characteristics (gender, previous experience with SL, and previous year grade) on the other hand, a t-test was used.

**Results**

Twenty-six students who expressed interest in the study joined the FB group and were screened for eligibility. Of those, four students had computers incompatible with the minimal system requirements set by Linden Labs, and four were not willing to donate time to the study. Therefore, eighteen students met the eligibility criteria and answered the pre-study test. Two students dropped out after the first SL lecture because of sickness and family issues, leaving sixteen students to complete the study of whom only thirteen attended the assessment of practical skills. All sixteen students answered the posttests and the satisfaction questionnaire. Figure 2 shows the sequence of activities in the study and the subjects flow in each step. Of the sixteen students, six were females, and ten were males. Their ages ranged from twenty-one to twenty-two years with a mean age (SD)=21.6 (0.5). All were third-year students. Six students reported having experienced SL before as users, whereas ten were completely new to SL.

Table 1 shows the knowledge percent score and percent improvement and practical skills percent score in the SL and F2F learning experiences. There were no statistically significant differences in mean knowledge percent before or after the experi-
Table 1. Knowledge percent score and percent improvement and practical skills percent score after Second Life (SL) and face-to-face (F2F) learning experiences

<table>
<thead>
<tr>
<th>Variable</th>
<th>SL</th>
<th>F2F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent score before experience</td>
<td>47.91 (9.50)</td>
<td>55.81 (12.45)</td>
<td>0.06</td>
</tr>
<tr>
<td>Percent score after experience</td>
<td>83.97 (10.40)</td>
<td>84.28 (11.74)</td>
<td>0.94</td>
</tr>
<tr>
<td>Percent improvement</td>
<td>83.41 (45.76)</td>
<td>58.50 (46.76)</td>
<td>0.16</td>
</tr>
<tr>
<td>Practical skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent score after experience</td>
<td>100 (75-100)</td>
<td>100 (62.5-100)</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*Statistically significant at p≤0.05

ences (p=0.06 and 0.94, respectively)—although after both experiences, knowledge percent scores increased significantly (p<0.0001 for both). There were no statistically significant differences in mean knowledge percent improvement or median practical skills percent score between SL and F2F (p=0.16 and 0.26, respectively).

Table 2 shows the relation between different variables and knowledge percent improvement as well as practical skills percent score after the SL and F2F experiences. After the SL experience, knowledge percent improvement was significantly affected by previous experience with SL and previous year grade (p=0.02 and 0.007, respectively): students with previous experience with SL and those with <very good grades in the previous year had greater percent improvement. None of the studied factors was significantly related to knowledge improvement.
after the F2F experience or to practical skills percent score after the SL or F2F experiences.

Figure 3 shows the median scores for students' satisfaction with different aspects of SL. The highest median scores (5) indicated that students totally agreed they were satisfied with dealing with their colleagues' avatars and that education in SL was fun and useful. The overall satisfaction percent score ranged from 67.3 to 92.7 with a mean (SD) of 83.8 (6.9).

Table 2. Relation among gender, previous SL experience, and previous year grade and percent improvement in knowledge score as well as practical skills percent score after SL and F2F experiences

<table>
<thead>
<tr>
<th></th>
<th>Percent Improvement in Knowledge Score</th>
<th>Practical Skills Percent Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SL</td>
<td>F2F</td>
</tr>
<tr>
<td></td>
<td>Mean (SD) p-value</td>
<td>Mean (SD) p-value</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>93.85 (46.30) 0.25</td>
<td>55.31 (35.55) 0.74</td>
</tr>
<tr>
<td>Female</td>
<td>66.02 (42.90)</td>
<td>63.81 (65.04)</td>
</tr>
<tr>
<td>Previous SL experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>111.93 (6.55) 0.02*</td>
<td>65.49 (41.66) 0.30</td>
</tr>
<tr>
<td>No</td>
<td>66.30 (50.97)</td>
<td>54.30 (51.26)</td>
</tr>
<tr>
<td>Previous year grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥very good</td>
<td>63.45 (45.96) 0.007*</td>
<td>53.62 (49.41) 0.33</td>
</tr>
<tr>
<td>&lt;very good</td>
<td>116.68 (18.80)</td>
<td>66.63 (45.13)</td>
</tr>
</tbody>
</table>

*Statistically significant at p≤0.05
staff discussed the ability of SL to facilitate communication and interaction. One student noted, “You are free to ask whatever questions you have in mind without being shy that anyone would laugh at you. You are free to interact.” Another advantage related to communication and interaction was the ability to listen to the instructor during the lecture without interruptions from other students since each student directly asked the instructor after being granted the permission to do so. One student commented that the SL experience helped to “avoid the distraction of some students.” However, another student found that SL did not allow for interaction, saying that “It doesn’t provide enough interaction between the lecturer and my colleagues.” Apart from the educational use assessed in the study, one student proposed another use for SL to enhance interaction and communication between students and instructor, suggesting that “it can be used for meeting with students regularly like twice a week.”

The third category was educational aspects. Most students reported that they joined the SL experience to discover a new method of education. “I loved the idea because it is new in our society and I have the honor to be one of those to try this experience for the 1st time in our university,” commented one. Another student saw its value as avoiding boredom caused by the traditional lecture-based method of education: “I’m excited because otherwise I’m really bored with our traditional teaching method, every day’s routine, old method of teaching. It causes me to fall asleep during lectures or even skip some.” Some students addressed the advantage of flexibility so that they can attend class without actually being in class because of reasons such as sickness. One said, “[SL allows me to] attend lectures while I am anywhere, especially in cases of sickness, travel, or any other circumstances that prevent the attendance of lectures in the lecture hall.” Another student valued the experience because it allowed him to listen to lectures while enjoying the comfort of home: “I love the thought of all of us in one place, while in real life we’re at home sitting comfortably learning.” Others pointed to the advantage of saving time; as one commented, “I think it saves time as there is no need to go anywhere to listen to lectures, just a few steps towards your computer.” Another student commented that SL contributed to the solution of lecture halls that were overcrowded...
Discussion

In this study, SL was used in dental education as a representative of 3D MUVEs. SL is the most popular virtual world platform and is increasingly used among higher education institutions. This is why it was chosen for this study. The study utilized within-subjects, quasi-experimental design to compare participants’ learning outcomes in SL classroom to that in a traditional F2F classroom. In such designs, there is no randomization and/or no comparison group. These designs are particularly useful for experimental research because of increasing number of students, noting that “I think that it will be a solution for the problem of increasing number of students by allowing better opportunities to learn and share in the progress and development of my faculty.”

SL also made it possible to avoid the need to commute to and from the school in crowded streets: comments on this point included that SL allows “learning at home, at convenient times, no concerns regarding traffic” and “the attendance of large number of students at the same time.” Another student recommended that the real potential of SL needs further testing, commenting that it “can be used only after repeating the experience on a larger scale by accommodating a greater number of students and their distribution at different times.”

Two particularly interesting aspects of using SL in dental education were raised: merging play and learning. “I never expected that I can use a game as SL in education,” one commented. “I like this combination of entertainment and education.” Another student mentioned the value of immersive experiences: “Clinical experience with SL would be much easier with the possibility of simulating a complete set of patients ahead of real students also encouraged the use of SL in education in the future after developing the use of SL in education in Egypt. One noted that “it is difficult to apply ICT and e-culture in SL in education, one commented, “like this combination of entertainment and education.”

Another student recommended the real potential of SL needs further testing, commenting that it can be used only after repeating the experience on a larger scale by accommodating a greater number of students and their distribution at different times.”

Because students enjoyed the experience, they considered it smart to use SL in education although not so pervasively as to completely replace traditional F2F lectures. One commented, “I should be smart enough to benefit from it. Seriously, I loved these lectures, and they were so fun and never boring,” while another added, “It can’t be a substitute for face-to-face lectures.”

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Table 3. Relation among gender, previous SL experience, previous year grade, and percent subscores for satisfaction with technical, interaction, and educational aspects as well as overall satisfaction percent score with SL experience

<table>
<thead>
<tr>
<th></th>
<th>Satisfaction with Technical Aspects</th>
<th>Satisfaction with Interaction Aspects</th>
<th>Satisfaction with Educational Aspects</th>
<th>Overall Satisfaction</th>
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<tbody>
<tr>
<td></td>
<td>Mean (SD) p-value</td>
<td>Mean (SD) p-value</td>
<td>Mean (SD) p-value</td>
<td>Mean (SD) p-value</td>
</tr>
<tr>
<td>Gender</td>
<td>Male 79.50 (6.85) 0.49</td>
<td>84.00 (8.43) 0.31</td>
<td>88.67 (8.92) 0.32</td>
<td>83.64 (5.62) 0.94</td>
</tr>
<tr>
<td></td>
<td>Female 82.50 (10.37) 0.71</td>
<td>78.33 (13.29) 0.31</td>
<td>93.33 (8.43) 0.32</td>
<td>83.94 (4.44) 0.84</td>
</tr>
<tr>
<td>Previous SL experience</td>
<td>Yes 81.67 (10.33) 0.71</td>
<td>83.33 (15.71) 0.68</td>
<td>88.89 (9.11) 0.61</td>
<td>84.24 (10.00) 0.84</td>
</tr>
<tr>
<td></td>
<td>No 80.00 (7.07) 0.71</td>
<td>81.00 (6.58) 0.68</td>
<td>91.33 (8.92) 0.61</td>
<td>83.45 (5.03) 0.84</td>
</tr>
<tr>
<td>Previous year grade</td>
<td>≥very good 80.50 (8.32) 0.94</td>
<td>83.00 (5.37) 0.60</td>
<td>90.00 (9.03) 0.82</td>
<td>84.00 (4.98) 0.86</td>
</tr>
<tr>
<td></td>
<td>&lt;very good 80.83 (8.61)</td>
<td>80.00 (16.43)</td>
<td>91.11 (9.11)</td>
<td>83.33 (10.05)</td>
</tr>
</tbody>
</table>
Marked improvement in knowledge was observed after the SL experience. This is consistent with the SL PCR lab study,\textsuperscript{20} in which students’ knowledge was assessed before and after the experience and test scores were found to increase significantly across the study. Another study\textsuperscript{5} used SL to deliver a continuing medical education program about diabetes to primary care physicians and found an increase in the percentage of participants providing a correct insulin initiation plan and mealtime insulin initiation plan, although the increase was not statistically significant possibly because of the limited number of participants (n=10). The results in our and these previous studies suggest that 3D MUVEs can be considered as useful educational methods to improve students’ knowledge and learning skills.

No difference was found in our study between students’ SL and F2F experiences in either knowledge improvement (p=0.16) or practical skills (p=0.26). This is similar to the findings of a study\textsuperscript{28} that examined the effectiveness of a virtual Emergency Department (ED) created in SL. In that study, thirty trainees were enrolled in the study as a part of a crisis management curriculum at Stanford University and were randomly assigned to either a Virtual ED or an expensive Patient Simulator (PS). There was no significant difference in trainees’ performance after ED and PS. These findings indicate that 3D MUVEs can bring online education closer to F2F education. The equivalence of SL and F2F effects can be attributed to students’ feeling of presence via their avatars, sharing a common space and real-time communication with each other and with their instructor.\textsuperscript{29} In addition, the virtual classroom/clinic atmosphere might have helped students to feel real learning situations. Contrary to the above findings, the Genome Island project study\textsuperscript{30} found that the mean (SD) student scores on items learnt from SL activities were higher than on items learnt from other real laboratory activities (79.1 percent [13.6] and 60.5 percent [15.9], respectively). The researcher attributed this to the safe environment that SL provided for students to replicate F2F experiments and to the possibility of bringing conversation outside the formal classroom to a game-like environment that encouraged exploration. On the other hand, in another study,\textsuperscript{31} CPR training in OLIVE revealed that the mean (SD) values for knowledge dropped during the six months training period from 8.0/10 (1.6) to 6.25/10 (1.5) with a significant difference (p=0.002). The researchers’ explanation for the knowledge drop was that part of the knowledge tested was not explored in the virtual
In our study, no statistically significant difference was found between males and females in knowledge percent improvement or practical skills percent scores. These findings indicate that knowledge improvement was not a result of gender-related competence or preference of ICT. Lack of gender-related differences was also found in a study that explored learning in a “MOOsE-Crossing” virtual environment to teach programming. In that study, males had a slightly higher mean performance score than females (1.63 and 1.04, respectively), but this difference was not significant and was ascribed to prior programming experience. In a more recent study conducted among a group of high school Taiwanese students using an Internet-based virtual physics laboratory, there was no difference between males and females in how they appreciated the inquiry learning or the cognitive apprenticeship.

Our study showed a statistically significant difference in knowledge percent improvement, where the improvement was greater for previous users of SL compared to non-users. Students may be more interested in something they already know and consequently become more motivated. On the other hand, lack of prior experience can lead to loss of attention in an attempt to navigate the environment and master avatar controls. This is consistent with the findings of a study in which fifty-eight undergraduate students at the University of Pennsylvania were enrolled in an environmental science course that demonstrated green home construction. Results show that the length of time spent in SL and previous experience with SL had a significant correlation with higher posttest score (p=0.003 and 0.009, respectively).

In our study, there was significantly greater knowledge improvement for students with lower grades in the previous year (p=0.007), which might be attributed to the effect of entertainment on learning by improving the appeal to learn in a MUVE. This can be highly applicable to underachieving and undermotivated learners who have turned away from learning in the more formal system of education. This is consistent with Civilization III study findings, in which 25 percent of students who were underachievers developed new vocabularies and better understanding of geography and world history. The same findings were supported by a Science through Second Life (StSL) project, in which nineteen ninth-grade students were enrolled from a high school in Brooklyn, New York. These students learned science by investigating ecological problems through virtual simulations. Results showed that low performance students did significantly better and their grades increased 5.6 points. One student who was suspended from school due to behavioral issues logged-in to StSL from home during class time each day to work with his classmates and attend his class virtually. Whereas these findings are based on a much younger population than the students in our study, de Freitas proposed an explanation for the expected increased engagement of students in higher education in virtual learning environments. She attributed the increasing use of virtual worlds in education to two factors: one is the movement into tertiary education of young people who grew up accustomed to online gaming, and the other is the discovery by neuroscience of the involvement of the entire brain in users engaged in activities undertaken in virtual worlds compared to less involvement when they are engaged in more formal education. In this light, the generalization of findings from studies based on schoolchildren to students in higher education seems justified.

Students’ satisfaction in our study was high regarding technical aspects in SL. This can be explained by the ease of the procedures related to SL especially for neomillennial students who routinely register for Internet services. This agrees with the findings of a study that used SL to teach occupational psychology at Leicester University, UK. In that study, four students were trained in a virtual environment and visited an SL oil rig platform to experience an evacuation simulation plan. At the end of the study, all four reported that SL was easy to learn. However, the findings of that study cannot be generalized due to the very small sample size (n=4). Our findings are different from the findings of a study that utilized SL to teach a Master’s of Business Administration elective course at Iowa State University. Data collected from twenty-nine graduate students in that study indicated that they experienced a steep learning curve. Students believed that SL could be an education and communication environment if technical problems were solved. Another study assumed that these technical problems were due to special system requirements and the need for high-speed Internet connections. In that study, Internet speed-related problems were frequent, coupled with difficulty in using voice communication effectively most of the time—similar to what occurred in our study. In addition, a response lag time was frequent and most evident when all students’ avatars were
synchronously available, requiring the processing of a large volume of data and resulting in software crashes. Our study’s results are also in agreement with Cheal, who surveyed fifteen undergraduate students studying technology at Oakland University to assess their perception of learning in SL. The students reported facing technical problems, and 60 percent of them could not access SL from home or found it slow to operate. These problems have the potential to waste students’ time off task in an attempt to resolve them.

Students in our study expressed an interest in communicating with their instructors. The animated avatars and 3D space make MUVEs different from other online chat platforms in which interaction with others is limited to text increasing user satisfaction. This is in agreement with results of Melás-Palazón et al., who assessed the suitability of SL as an educational tool among seventy-six primary health care professionals from nine health centers in Spain. After the participants attended two training workshops in SL, 68.42 percent thought SL was an adequate interactive method, while 85.53 and 43.42 percent were satisfied with interaction with teaching staff and colleagues, respectively. The authors explained the difference between the last two percentages by the way the sessions were set up, in which individual access to all health care personnel could not be provided simultaneously. Therefore, one person logged into SL from a single computer, and image and sound were projected on a screen for the other participants to see. One other aspect that can explain enhanced interaction in MUVEs is the anonymity of users in the classroom so that avatars can remove the social and emotional barriers in an F2F classroom. Avatars allow shy students to interact in a way they would not normally do in a regular classroom. This is consistent with another study that reported a greater degree of student participation in virtual classrooms especially for shy students who rarely participated in F2F classes.

The SL learning experience was reported by students in our study to be free from distractions caused by other students. This is similar to another study that assumed students’ full immersion in MUVE is due to the sense of isolation and selective attention via their headsets and camera controls so they can focus on slides and instructor. This left no chances for distractions away from learning and allowed students to be totally focused. This was opposed by another study that assumed there was a potential for distraction during lectures due to avatar customization, lack of constraints on student avatars, and exploring interactive objects misplaced in classroom, in addition to random avatars not related to the class who may interrupt a lecture. This can be avoided as in our study by building the learning space on a private land parcel.

Our students admired the fact that in SL there was no need to travel and they could participate from their own homes. This advantage can be associated with other e-learning tools, but SL differs as it adds the sense of social presence afforded by an avatar. This is in agreement with results of another study in which students were satisfied with the flexibility offered in 3D MUVEs so that they can meet in non-classroom settings, making the learning environment less stressful and more relaxing.

In our study, satisfaction with education was greater than satisfaction with technical or interaction aspects in SL. MUVEs are widely perceived as vehicles for fun and enjoyment, which, when associated with learning, can enhance students’ understanding and retention of the material being taught and can keep students interested. Other researchers have agreed with the potential of video games for education. On the other hand, Boulos and Toth-Cohen warn that too much fun and fantasy would not reinforce and serve the educational message and might negatively affect the learning process by acting as distracters.

Education in MUVEs is closer to F2F education than other online education methods that are based on asynchronous communication and are two-dimensional. MUVEs provide options for a variety of communication tools (voice, chat, gestures, space) that can make learning fun. The surrounding atmosphere in virtual environments can be felt as real, comfortable, and emotionally safe. MUVEs are not expected to replace F2F education, but they can be used as a supplement to the traditional classroom, thus providing new opportunities for enhancing interactions, provided that recurrent technical problems are controlled. In view of the financial and time investment usually required to successfully implement educational experiences in SL, it may be advisable to prioritize SL activities for students with lower academic achievement who need additional support to perform better and for students in crowded settings and to restrict these educational activities to lectures more than demonstrations of practical or clinical procedures. Studies with larger samples selected randomly with a control group included would allow stronger conclusions to be drawn.
REFERENCES


