Teaching radiology in the "Second Life" virtual world

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VIRTUAL WORLDS AND SECOND LIFE IN EDUCATIONAL ACTIVITIES

A virtual world is a three-dimensional space reproduced on a computer through a specific viewer, in which the user, represented by an avatar, can move, interact with different objects, or communicate with others in a real time environment [1,2]. Due to their potential use by multiple users, virtual worlds are also known as multiuser virtual environments [2,3] or multiuser virtual worlds (MUVWs) [4]. Virtual worlds can promote the learning of real-world knowledge and skills by imitating real-world environments and practices. They are an emerging method used both in traditional classrooms and in distance education, and have been used in disciplines such as teacher training [5], language development [6] and health education [1].

Second Life, created in 2003 by Linden Research Inc. (San Francisco), is one of the most well-known virtual worlds used in healthcare education [4]. Second Life is a virtual world with more than 1500 million square meters, where recreational, social, cultural and educational activities are developed by the users themselves. There are many activities in Second Life dedicated to the training of health professionals [4], and interesting experiences in training areas such as emergencies [7], nursing [8], primary care [9] or medical undergraduate [3,10].

TECHNICAL CAPABILITIES OF SECOND LIFE FOR LEARNING RADIOLOGY

Second Life is organized in multiple virtual regions. Most of them are square plots of 256m X 256m that reproduce the real world, with water, earth and sky, so resembling an island. In 2011 we developed such an island, named "The Medical Master Island", which had the appearance of a university campus, and included several academic buildings and other more imaginative spaces such as underwater stages (caves, palaces and submerged basements) or aerial locations (floating platforms and auditoriums, etc.) [11,12]. The whole island is dedicated mainly to the development of educational innovation projects in radiology, and can be visited at: *https://maps.secondlife.com/secondlife/Medical%20Master%20Island/119/90/22*.

A simulated case presentation by medical students

Communication between avatars can be done through voice chat, written chat and note cards.

Voice chat gives an important sensation of presence, facilitates activities such as conferences, debates or discussion groups. Voice chat also makes it possible to put questions to the speaker or to someone else in the audience and is thus very versatile in enabling opinions to be expressed.

The **written chat** option is more suitable for putting "short answer" questions (such as yes/no, true/false, etc.) to the audience and allows attendees to communicate with the presenter without interrupting the presentation.

Note cards are messages that are sent in Second Life and are stored in the inventory of the avatar that receives it, with the date, time of sending and avatar of origin being registered. Note cards are very useful for collecting information from students, for example, recording who is attending the session or collecting the results of a task or

A radiological workshop on radiological anatomy

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Users feel more comfortable speaking in public and asking questions in Second Life than in face-to-face situations, perhaps because of the "protective effect" of the anonymity of their avatar.

an exam, with the note card being sent to the teacher's avatar.

All objects in Second Life are composed of primary objects or "prims", whose faces are covered by textures that give them a particular appearance (metal, wood, brick, grass, etc.). The prims can have images associated with one or several of their faces, which is very helpful to show radiographic images in a permanent way. Objects can perform functions through internal programs in Linden Scripting Language, when the user interacts with them. They can also play videos or web pages on one of their faces. We have used this last effect to create presentation panels, through PowerPoint presentations saved as images and integrated into a simple Web page with forward and backward buttons. They can be used as projection screens in a conference or to host content that the user can view on-demand. The quality of the images shown in Second Life is excellent, which is a major advantage for radiology education, since the contrast and details of medical images can be optimally displayed for teaching purposes. The designing and setup of asynchronous tasks, as well as the design and implementation of synchronous sessions are easy. All that is needed is the creation PowerPoint presentations, a skill in which all modern university professors and teachers are highly experienced. The presentations are then saved as images and simple Web pages created.

PRACTICAL EXPERIENCE OF RADIOLOGY EDUCATION WITH SECOND LIFE

Since 2011 we have carried out various training activities with different objectives, methodology and content, involving a total of more than 800 users, who all completed individual satisfaction questionnaires after carrying out the respective activities. The questionnaires were designed to determine the users' evaluation of the environment, the teaching contents or the usefulness for their training, and other aspects.

We began in October 2011, with a 4-week voluntary course on the fundamentals of radiology (for 20 students in 1st to 3rd year medical school) and on the interpretation of radiographs in the second cycle (for 26 students in 4th to 6th year). All of them attended four 2 hours real-time synchronous sessions and performed 4 asynchronous tasks, sending the results to the teacher by means of a note card.

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The student attendance level was 83% in the sessions; and 92% of them completed the tasks. The students rated the organization, the contents, the usefulness for their training and the teacher as having more than 9 on a scale of 1 to 10. This initial experience thus demonstrated that the teaching of radiology using Second Life was feasible and well perceived by medical students [11].

This motivated us to further investigate the possibilities of Second Life for radiology training.

Thus, we later carried out various training activities in radiology, some of which had an academic format, such as lectures on advances in radiology for master students, radiological interpretation workshops for medical students and primary care physicians, or bibliographical search workshops on Google and PubMed for doctoral students. Other experiences, such as meetings of clinical sessions for residents in radiology, or exposure sessions and discussion of radiology topics presented by students of biomedical engineering, were focused on improving oral communication skills. More recently, we have developed a competitive multi-user game for third-year medical students on the island named "The League of Rays", divided into 6 weekly blocks on anatomy and radiological semiology. In this, participants had to study the educational content on their own for the first 4 days and sit a test involving 15 questions over the remaining 3 days. Students who obtained lower scores were eliminated and the remaining participants were classified into five categories depending on their results. (In a reference

Lecture presentation by a team of bioengineering students

to radiological densities, the categories were air, fat, water, calcium and metal). A voluntary session involving 91 students was held in 2015, and two compulsory sessions, with 191 and 182 students were held in 2016 and 2017, respectively. The game was highly appreciated by the students (average scores ≥7.9 out of 10 points), although in the compulsory experiences there were somewhat lower ratings, probably due to the participation of a less motivated student sector. These experiences have been summarized in a recent paper in Spanish [12]; full results are pending publication.

THE FUTURE OF RADIOLOGY EDUCATION IN VIRTUAL WORLDS

Second Life allows synchronous remote participation of students and teachers, thus avoiding the need to travel and offering a versatile and attractive environment for younger generations. The excellent graphic representation of the images is ideal for carrying out training activities in diagnostic imaging. The sensation of being present allows the development of synchronous activities such as conferences or practical workshops, with active and enthusiastic participation of the assistants.

Second Life is also an ideal tool for the development of effective oral communication skills [13], although it does not include non-verbal communication or visual contact with the audience. It is a very efficient tool for training and improving the ability to communicate in public or to participate actively in debates, as users feel more comfortable speaking in public and asking questions in Second Life than in face-to-face situations [9], perhaps because of the "protective effect" of the anonymity of their avatar.

Second Life also allows the development of asynchronous activities. In this context, we have used panels with radiological cases for asynchronous tasks in several courses, or with educational contents for "The League of Rays" game, that the students had to use during a given period. The training contents can also be permanently housed in Second Life, so that the users can review them on-demand, as in a 3D multimedia virtual library.

We are currently exploring radiology team-based learning for medical students, and interpretive skills training for radiology residents, but the possibilities of Second Life for radiology education also include other, more elaborate formats, such as the simulation of virtual patients,which can develop learning based on role-playing in clinical situations, emulating radiology OSCE stations. These kinds of projects however require a considerable work in editing objects to give enough plausibility to virtual scenarios to engage participants. Other possibilities that we are currently studying are: the development of automated multiuser learning games, where the events that happen in-world are controlled from a server located outside, in real life; the configuration of virtual X-ray, CT or MRI equipment with which the users could interact by performing virtual explorations to their avatars explaining how such equipment works. Both projects require a deep knowledge of programming and many hours for development and testing, but could lead to highly interesting results in radiology education.

Medical students in the game "League of Rays"

Residents in a clinical discussion session

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