Joint Spaces between Schools and Museums via Virtual Worlds. A Case Study

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ABSTRACT
In this work, we describe the results in the study of the user experience of three groups of children within a flexible virtual space that connects school and museum. This integrated educational space includes not only the exploration of exhibition areas but also includes telepresence talks on the part of museum personnel, simulations, educational work in the form of virtual quests, all within a multi-user virtual environment based on *OpenSim* and simultaneously accessible from the different institutions involved in the experiment. The results obtained could serve as a starting point for a future implementation of this platform for connecting educational institutions and museums across the entire city.

Categories and Subject Descriptors
H5.2. **[User Interfaces]:** Evaluation/Methodology.

General Terms
Design, Experimentation, Human Factors.

Keywords
User Experience, Virtual Worlds, Learning Environment, Open Source.

1. INTRODUCTION
Among the different technologies utilized in the field of Computer Supported Cooperative Learning, the virtual, multi-user environment as platform for e-learning is a tool extensively accepted worldwide [1,2,3]. The innovative aspects of this technology constitute a terrain for investigation, experimentation, and as one of the great contributions in the use of digital technology as applied to education.

Many studies recognize in Virtual World (VMs) vast capabilities that can promote learning [4,5] including such as the sensation of immersion in an inhabitable learning space, the great degree of interactivity, and the discovery of new and creative solutions for problems which emerge in the designing of educational content in a context of cooperation and exchange.

There are many examples developed for higher education of the design of educational activities in virtual worlds using the platform *Second Life* as their foundation [6,7,8]. The greater part of the studies and publications covering the relative performance between these collaborative, virtual environments and their equivalent situations in the real world have been carried out primarily for the age range corresponding to the higher education level with 69% of the studies and publications at this level. While those for the age range corresponding to K through 12, the amount was scarcely 19% for secondary and only 12% for primary [9].

An analysis of available sources and data covering this technology [10,11] lays out an encouraging panorama in the amount of scope, potential and degree of adoption by the "digital natives", the "V Generation", who naturally take up uses of virtual worlds for such uses as places of meeting and engaging in activities with their peers. So there is a need for increased empirical investigation focused on the user experience of subjects in this younger age range in the different categories of curricular activities which can be carried out on these platforms.

In contrast to traditional ITC systems, the application of virtual worlds in "e-learning" for young children yields a more natural and accessible system [12] as such systems enable the linking of effective methods of formal education with the informality of play, bringing knowledge closer in a more direct form. Also, the experiential aspect, the playful aspects, and the forms of participative work within an immersive, tridimensional environment permit a balance for students with differing styles of learning and capacities of concentration.

The virtual worlds for children grow day by day. Yet there exist few studies done about the use by children of these worlds [13]. If there are few documented cases covering user experience in VWs as applied to higher education [14], even more limited are those focused primarily on children [15,16]. Nevertheless, there exist a number of blogs and wikis with impressions and road maps of experiments such as *Suffern Middle School* [17], *DigiTeen* Project [18], and CANVAS [19] (Children's Art at the National Virtual Arena of Scotland) which is part of the GLOW education program, the online community of Scottish schools.

Furthermore, while in the real world, part of the learning activities for primary education involve other institutions such as museums, where children and teachers may interact with outside educators

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that may guide the visit, give talks, etc., within the virtual world, this type of experience has been little studied up to now.

The design of an integrated educational experience of this type, which connects the school to other institutions within a virtual space, permits a new focus on the user experience of children and evaluation of the efficiency of the design in the educational process. In this context, the museum evolves from being merely the classic exposition and simulation space, becoming, in the virtual world, an active part of a more complex space where educators may design, coordinate and lead various activities via telepresence.

In line with the previous, this paper seeks to analyze the user experience of young students in a group activity, a "field trip", of a virtual visit to *Escola*, a flexible space that combines school and museum, including not only the exploration of exhibit areas but also telepresence talks by museum personnel, simulations, virtual quests, educational activities, etc., all within the *Escola* world. This being achieved using a multi-user, virtual environment based on *OpenSim*, which all users, students, and educators would access simultaneously from the different institutions involved in the experiment.

2. OBJECTIVES

The experiment we present here has the general objective of testing the viability of the virtual world as a platform for educational activities which connect school and museum in a deeper way than that of the user merely exploring a virtual exposition. While also involving the museum personnel in the development of activities of the same reach and scope of those which develop in real world visits of school classes to museums.

In line with attaining a quality evaluation of the viability of the technology and the logistics of the experiment, we should consider the various aspects for both school and museum in terms of functionality and quality, as well as degree of education and learning. This evaluation may be carried out by means of interviews with those in charge of the schools and the museum and by surveys of students.

This set of collected results should serve in the study of the development of the experiment on a large scale, across 29 schools throughout the city, raising the possibility of the establishment of a permanent municipal educational structure based in the virtual world.

3. PREPARATION OF THE EXPERIMENT

The experiment involved three classes from the sixth year of education, ages 11 to 12, drawn from two different schools. Two groups were drawn from a private/state sanctioned and assisted school, (Colegio Esclavas del Sagrado Corazón de Jesús) Here we will call them "Class A" and "Class B". The third group was drawn from a school in the public education system (Colegio Sanjurjo de Carricarte) and will be called "Class C".

The Science Museums of A Coruña, (Museos Científicos Coruñeses), an institution comprised of three museums of science were collaborators in this experiment.

3.1 Topic of the Experiment

The topic of the experiment was the solar system, selected in coordination with the directors of primary education of the respective schools and the docents of the museum and comprised both appropriate educational units and associated tasks. Included were the extraordinary contribution by the museum which provided a talk covering the the astronomy of the Mayans, the prophecy of the end of the world in 2012, and the authentic end of the solar system after 5,000 million years.

3.2 Design of the Experiment

The team's producer had experience in the design of educational activities in virtual worlds although this experience was primarily in work meant for adult students or in communicating with professors familiar with education via telepresence in virtual worlds. However, this experience was on more powerful equipment and a proprietary platform such as Second Life. Which platforms are often more robust but can be costly and which often limit or prohibit access by children. [20]

This experience would be totally different in all aspects from previous cases. The students would be children and would be encountering for the first time a world of such characteristics. The docent of the museum received training in the system's operation to facilitate the preparation of his speech, rehearsal of his talk, and to enable him to assist with the design equipment in the construction of the models built in the virtual world.

3.3 Technical Aspects

As the supporting platform we utilized *OpenSim* for several reasons:

- Being an open source platform, it was possible to establish a private grid with excellent access control.

- There were no limitations in the quantity and types of content that could be used except as constrained by the technical limits of the OpenSim software.

- There were no minimum age requirements. This ruled out the use of commercial solutions which may be more robust but which restrict access by children.

- Ease of creation of tridimensional in-world settings, afforded programming via scripting, as well as supported multimedia and VoIP.

We put into service an *OpenSim* server that supported a virtual island to accommodate the experiment, this server accessible both to the schools as well as the museum, creating a private grid for the occasion. We created user accounts for the organizers as well as accounts with generic names for the students. For access to the program, we customized the open source viewer Imprudence for simplicity and robustness, this viewer was installed in the existing equipment of the school of Class A and B and on several laptops from the team in charge for the experiment in Class C.

3.4 Contents

The experiment would last about two hours, similar to a real world museum visit and would be able to contain, despite the limited duration, activities of various types drawn from the categories described in existing literature [3] as support for instruction and learning in virtual worlds:

3.4.1 Role Playing

The avatars which would represent the participants would reflect their roles in the real world. Hence, we created avatars with the appearance of young people of the age of twelve as well as adult avatars for the teacher and the museum docent. The latter dressed with glasses and the lab coat commonly associated with science labs. The students would devote part of the experiment to

personalizing their appearance in the virtual world. To enable this personalization, we prepared twelve patterns of avatars for girls and eight for boys, patterns on which they could build their avatar's appearance.

3.4.2 Lecture Attendance

In the lecture hall, the museum docent presented the class a lecture prepared for the upcoming experience in the virtual world. A video was shown covering the formation of the solar system along with supporting and related images. Following the theme of the exposition, the docent also displayed a model of the stela used in support of the rumor attributed to the Maya concerning the end of the world late in 2012, explaining the shortcomings of this idea but without disparaging the astronomical knowledge of the Mayan civilization. (see Figure 1).

3.4.3 Free Exploration

The virtual world contained a replica of the Mayan pyramid Kukulcán of Chichén Itzá. The pyramid served not only for discussions of the architecture of the Maya but also for relating the exacting orientation of the building to the cardinal points achieved with Mayan knowledge of astronomy. This orientation was displayed in the virtual world by the simulation of the dusk. The children, from a view at the top of the structure, were able to contemplate the setting of the sun, seeing the sundown perfectly aligned with the steps of the principal temple. (see Figure 2).

3.4.4 Assisted Exploration

The students were able to travel the planets, in a directed scientific exploration, arriving finally at Saturn and its moon Titan and were led in a discussion of the moon as a possible future home for humanity.

3.4.5 Simulation

The world did not end in December--or at least not in December of this year. However, it is true that current science understands the Earth will be destroyed by the sun when it becomes a giant red star after some 5,000 million years. To illustrate this, we modeled a virtual planetarium and explained to the students the phenomena of stellar expansion. This phenomena was simulated by way of augmenting the size of the sun, showing the engulfing of the interior planets of the solar system, including the Earth and extending approximately to the orbit of Mars. (see Figure 3).

3.4.6 Virtual Quest

The virtual world also included a hall in which was an exhibited interactive model of the various objects of the solar system such as the sun, the planets, the moon, and a replica of the Voyager II probe. We suggested to the children the idea of searching for clues. Throughout the interaction with the models of the planets, they could find information about the planets. We facilitated their quest with printed questions about the solar system. From a selection of their answers they could extract a secret code which could be entered on a keyboard displayed when the probe was clicked. If the code was correct, they were rewarded with a prize consisting of an image of a gold disk that carried illustrations meant as a message to civilizations of other worlds, an idea inspired by the "Sagan disks", also known as the "golden records", placed on the Voyager probes.

After completing their task and obtaining the prize, the children exited the virtual world.

Figure 1. Students attending the virtual talk.

Figure 2. Exploring the Mayan pyramid.

Figure 3. Students in the virtual planetarium.

4. SCENARIOS

As Internet access was different in the private school verses the public school, the experiment was adapted and carried out in two scenarios.

a. Immersive Experience: The activities of Class A and Class B were able to be carried out totally in the virtual world.

b. Blended Learning: The existence of a firewall in the public education system did not permit utilization of necessary ports and disabled access to the virtual world from the computers of Class C. This limitation was known so we decided to utilize a mixed model of telepresence and immersive activities.

Comparison of the results obtained in the different scenarios, which were seeking identical objectives with the various types of activities, yielded interesting conclusions.

4.1 Scenario 1: Classes A and B.

We installed the virtual world viewer on all computers in the information lab where the computers were identified by number. We created user accounts utilizing generic avatars of both boys and girls and user names composed of generic names and the computer number. For example, a girl using computer 14 would use the name *"girl14"*.

One of the authors of the simulation, present in the classroom, directed the activity and also acted as monitor of the group in the class and in the virtual world via his avatar.

Activity 1. Personalization of the identity.
After the initial login, brief guidelines were given on the operation of the system that were more than sufficient for the children to be able to maneuver in the virtual world with ease. After this, we moved to a stage of personalization of the avatars in a zone with samples of prefabricated appearances to start from that the students modified as they pleased.

Activity 2. Presentation of the lecture.
The avatars of the students gathered in a virtual hall with the docent who was using an avatar in the image of a scientist. The lecture to the class covered the planned scientific theme utilizing video, images, and a 3D replica of the Mayan stela. The entire experience was projected a screen in the classroom, replicating the computer of the lecturer. Students were offered the option of following the talk on their own computer or on the screen. The talk could be heard via speakers, as opposed to using individual headphones, and questions could be asked through the ambient microphone.

Activity 3. Excursion to the pyramid.
The group traveled through the island until arriving at the Mayan pyramid. During the free exploration and the ascent to the top of the pyramid, the students received from the docent contextualized, scientific information concerning the sights they experienced.

Activity 4. Presentation at the planetarium.
The group came together in the virtual planetarium and either followed tdocent or aimed their camera at him while he moved among the planets and presented the demonstration of the conversion of the sun into a giant red star which engulfed the inner planets.

Activity 5. The celestial quest.
The group gathered in the virtual exhibition. The scientist made his goodbyes and the docent explained the objective of the quest. The students carried out their search for information in the models of the celestial bodies, keeping records on paper in their respective classrooms. After finishing the search and collecting their prize, they handed in their records, exited the virtual world, and broke for recess.

Throughout the event, the children were making comments and asking questions via the chat function of the system

4.2 Scenario 2: Class C.

In this case, the event was carried out in two parts. First the students listened to the lecture, which was projected onto a screen, without entering the virtual world. This included the explanation of the Mayan pyramid and the virtual planetarium. For this part, one of the authors of the system acted as guide, accessing the virtual world via laptop with a 3G connection and maintaining his avatar near the lecturer or focusing his camera on the lecturer or elements referenced in the talk. The lecture was heard via speakers in the classroom and the children were able to ask questions at the end by way of ambient microphone.

Afterwards several laptops were enabled with a 3G connection on which the students--in groups of two per computer--accessed the virtual world in order to carry out the activities of personalization, exploration, and the quest, their progress monitored by a teacher in the classroom.

5. EVALUATION OF THE EXPERIMENT

For the evaluation of the experiment, we compiled information via survey of the children, collecting data to work with in the days following. From this data arose questions relevant to three aspects: usability, presence, and learning. Also other questions such as perception of the activity in relation to activities carried out in life as well as satisfaction in general.

Questions that arose--cast in language amicable and typical of children of the age range studied--are transcribed here in more concise terms.

Table 1. Survey results.

Question	Class	Mean 1- worst 5- best	Standard deviation (σ)
Ease of exploration	A-B	4.28	1.04
	C	4.41	0.91
Ease of avatar customization	A-B	3.74	1.25
	C	3.94	1.21
Degree of understanding of the lecture	A-B	3.60	0.81
	C	4.41	0.77
Sense of presence of the lecturer as a teacher in a real world class	A-B	3.92	1.15
	C	4.29	1.13
Sense of presence and company within the group	A-B	4.13	0.90
	C	4.24	0.55
Ease of solving the quest.	A-B	3.96	1.25
	C	4.18	0.98
How does the experience compare to "real world" activities…			
a class	A-B	2.57	1.17
	C	2.94	1.00
a visit to the planetarium	A-B	3.93	0.95
	C	4.12	1.02
an excursion with the class	A-B	3.21	1.28
	C	3.18	1.42
a visit to an interactive museum	A-B	3.86	1.15
	C	4.29	1.02
watching a video or a movie	A-B	3.03	1.42
	C	3.53	1.29
playing a videogame	A-B	3.98	1.19
	C	4.59	0.60
Desire to repeat with another subject.	A-B	5.00	0.00
	C	5.00	0.00
Sense of having learned something new.	A-B	4.24	0.93
	C	4.71	0.57
General impression of the experience	A-B	4.74	0.52
	C	4.63	0.48

5.1 Analysis of the Results

All the questions of the survey could take quantitative values between 1 (poor/little/bad) and 5 (better/much/good). Noteworthy results by category are as follows:

5.1.1 Usability

The operation of the interface and the actions taken with it--such as walking, flying, focusing the camera--obtained very high

marks (4.28/4.41). The observation of those monitoring the children corroborated a surprising facility in the children. In their first experience with this type of educational platform, which used an original interface designed for persons of greater age, they had no significant problems. Even the personalization of the avatar, being a process somewhat more complex, did not raise great difficulties for them (3.74/3.94).

5.1.2 Presence

The sensation of presence in the virtual world and the company of the group was considered by the children as high/very high (4.12/4.24), as was the sense of presence of the conference as compared with a teacher in a real class (3.92/4.29). Here it is worth noting the data regarding the sensation of presence of the remote lecturer in the class was greater for the students who viewed the talk on the screen in the classroom (Class C) than for those who viewed the talk within the virtual world (Classes A and B).

We believe that this was due to various reasons: on the one hand, the fact of sitting, watching the conference on the screen without distractions possibly increased concentration in the talk (such also would reaffirm a previous question about the comprehension of same) in comparison to Classes A and B in which the children had more possibilities of amusing themselves with other actions inside the virtual world, similar to what can often happen in real world lectures in classrooms when the students believe no one is watching. On the other hand, the projection of the avatar on a large screen approximated the real size of a professor. Nevertheless, both Class A and B both reported a high level of presence of the lecturer.

5.1.3 Learning

Related to with the above, the students of Class C responded more positively to the question of degree of comprehension of the lecture (4.41) than Classes A and B (3.60). This seems to indicate that the virtual world can be used for telepresence without total immersion for some instructional activities such as lectures. The use of virtual worlds in this respect may be limited yet still powerful and not negligible.

With respect to the questions answered through the virtual quest, the facility in finding the solution was qualified as medium high (3.96/4.18). In the opinion of the educators of the schools, the difficulty of the test could be considered high for that age range. Some examples given included the specificity of numbers such as temperature of the sun's surface, length of the Martian day, number of moons of other planets. However, the motivation, means, and mechanism of gamification for obtaining the answers engendered a perception in the students that the task they were carrying out was not difficult but, instead, enjoyable.

To the question regarding the experience of having learned something new, the value was very high (4.24/4.71). Especially in Class C which was more attentive to the conference. Still, the results of Classes A and B were also high, comparing favorably.

5.1.4 Comparison with real time activities

The students' responses expressed that the experience seemed little like a traditional class (2.57/2.94), somewhat more like seeing a movie (3.03/3.53) and a class trip (3.21/3.18) although to these two questions they responded with high values of standard deviation (1.28/1.42), marking divergences in their opinion in this point

The comparison with the visit to a planetarium (3.93/4.12) and the visit to an interactive museum (3.86/4.29) received very high responses, although in that sense there was a clearly noteworthy comparison with playing a video game (3.98/4.59).

5.1.5 Satisfaction

Turning to measuring the satisfaction of the students in view of this educational experience, we posed two questions: desire to repeat with another subject, that was overwhelmingly positive (5/5) with a standard deviation of 0, and the general impression of the experience, that was described very positively (4.74/4.63) with a standard deviation of only 0.5.

5.1.6 Impressions of those in charge

Both directors of the two schools expressed a high level of satisfaction with the experience, which was new for them, offering to repeat the experiment in the future with more groups. With respect to those in charge of the museum, they highlighted the potential of this technology for carrying out with great facility their objectives of working more closely with the schools and offering more in-depth study.

5.1.7 Issues and challenges

Although the general results of the experience were highly satisfactory, we have identified some potential weaknesses.

The students demonstrated different levels of concentration throughout the different various activities, tending to scatter when the objective was not clearly stated such as in the case of the excursion to the pyramid, where considerable effort of organization was required in regrouping them.

The possibility of experimenting with the functions of the visor in ways not intended for the experiment or with a use which should be restricted to only one part of the experiment caused them in some cases to become distracted doing other activities such as chatting. Also we detected various cases of students who would amuse themselves modifying their appearance when they should be attentive to the docent.

However, the teachers of the center noted that such attitudes were common in a visit to a real world museum. Nevertheless, in future experiments we will endeavor to improve the design in these aspects and utilize more of the possibilities of the system to better focus the students on the activity that they should carry out and to avoid distractions.

6. CONCLUSIONS

All involved in the experiment described in this article agreed good results were obtained, which suggests the suitability of the virtual world as a vehicle for museums and schools to stage joint educational activities.

The playful approach to education which this platform facilitates permits the children to acquire knowledge with little sensation of effort, the naturalness with which the young students perceived the presence of remote professors and engaged them in this type of experience being notable.

The use of virtual worlds for the education in this age range allows utilizing various formats, among those are simple projection of the avatar of a remote docent in a virtual hall, constituting a simple and effective method for enabling the giving of remote talks, even to different classes simultaneously.

Among future lines of investigation in this field, the authors are working in experimentation with activities that involve the collaboration between various distant school groups and the carrying out of educational activities coordinated with participating museums for even younger groups.

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