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LONG PAPER

Evaluating User Experience in Joint Activities between Schools and Museums in Virtual Worlds

Viviana Barneche Naya. Luis Antonio Hernández Ibáñez

Abstract: The use of virtual worlds in the school is an extraordinary tool to engage the children in the process of e-learning. Although one can find many examples that describe the use of such a technology in teaching regular educational contents, very few examples replicate other classical outdoor educational activities such as a visit to a museum, including the remote interaction with the docents of the visited institution. In this work, the results of a study of the user experience of three groups of children within a flexible virtual space that connects schools and museums are described and evaluated. This integrated educational space not only includes the exploration of exhibition areas but also the 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 an entire city.

Keywords: User experience, Virtual worlds, Learning environment, Open source, Virtual museums.

1 Introduction

Among all 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 [1-3]. The innovative aspects of this technology constitute a terrain for investigation, experimentation, and one of the great contributions in the use of digital technology as applied to education.

Many studies have shown that virtual world (VMs) vast capabilities can promote learning [4,5] including such aspects as the sensation of immersion in an inhabitable learning space, a 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 of the design of educational activities in virtual worlds developed for higher education using the platform *Second Life* as their foundation [6-8]. 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 children through the age of 12, the amount was 19% for secondary and only 12% for primary school children [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 purposes as places to meet and engage 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 different styles of learning and capacities of concentration.

Viviana Barneche Naya
videaLAB – University of A Coruña
Campus de Elviña s/n. 15071 A Coruña, Spain
e-mail: luis.hernandez@udc.es

Luis A. Hernandez Ibáñez
videaLAB – University of A Coruña
Campus de Elviña s/n. 15071 A Coruña, Spain
e-mail: luis.hernandez@udc.es

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 these of the Suffern Middle School [17], DigiTeen Project [18], and Children's Art at the National Virtual Arena of Scotland [19] (CANVAS) 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 other outside educators that may guide the visit, give talks, etc. Within the virtual world, this type of experience has been studied very little up to now [20].

The design of an integrated educational experience of this type that 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, in the virtual world, to becoming 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 also 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. This includes not only the exploration of exhibition 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 [21], which all users, students, and educators would access simultaneously from the different institutions involved in the experiment.

2 Objectives

The experiment presented here has the general and specific objective of testing the viability of the virtual world as a platform for educational activities which connect schools and museums in a deeper way than that of the user merely exploring a virtual exposition. For this purpose, the experience also involved the museum personnel in the development of activities of the same reach and scope as those developed 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, other aspects should also be considered for both school and museum contexts in terms of functionality and quality, as well as the degree of education and learning. This evaluation may be carried out by means of interviews with those in charge of the schools and the museums and by surveys of students.

This set of collected results should serve in studying 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 11-12, drawn from two different schools. Two groups, composed of 25 and 22 students, were drawn from a private/state sanctioned and private/state-assisted school, (Colegio Esclavas Del Sagrado Corazón de Jesús), for the purpose of this paper "Class A" and "Class B". The third group, composed of 20 students, was drawn from a school in the public education system (Colegio Sanjurjo de Carricarte) and will be called "Class C". Both schools are located in the city of A Coruña, Spain.

The Science Museums of A Coruña, (Museos Científicos Coruñeses), institutions 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 was the extraordinary contribution by the museum that provided a talk covering 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 authors' team had experience in the design of educational activities in virtual worlds although this experience was primarily in work focusing on adult students or in communicating with professors familiar with primary education via telepresence in virtual worlds. However, this experience was based upon the more powerful equipment and a proprietary platform such as Second Life. Those platforms are often more robust but can be costly which often limit or prohibit access by children. [22]

This experience would be very different in many aspects compared to all cases that the authors were able to find in literature. The students would be children and, as they declared, many of them had already played 3D video games, but none had previously experienced 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 OpenSim was utilized 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.

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

3.4 Contents

The experiment would last about 2 h, 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, avatars with the appearance of young people of the age of twelve were created by customizing publicly available adult avatars (Fig. 1). Other adult avatars were used for the teacher and the museum docent. The latter was dressed with glasses and the lab coat commonly associated with science laboratory.

The students would devote part of the experiment to personalizing their appearance in the virtual world. To enable this personalization, twelve patterns of avatars for girls and eight for boys were prepared, patterns on which they could build their avatar's appearance.

Fig 1 Students customizing their avatars

3.4.2 Lecture Attendance

In the lecture hall, the museum docent presented for 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 Mayas 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. (Fig. 2).

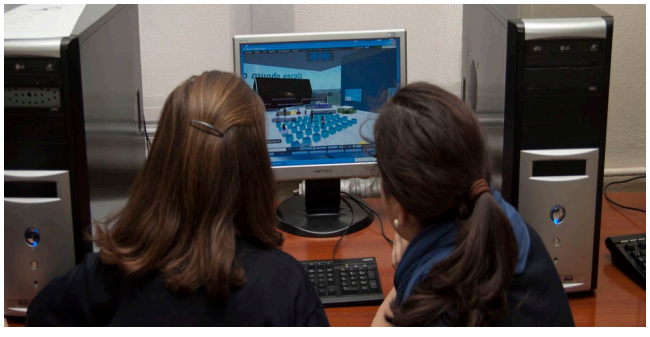

Fig 2 Students attending the virtual talk

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 exact 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. (Fig. 3).

Fig 3 Exploring the Mayan pyramid

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. 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 [23,24]. To illustrate this, a virtual planetarium was modeled and explained to the students the phenomena of stellar expansion. This phenomena were 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. (Fig. 4).

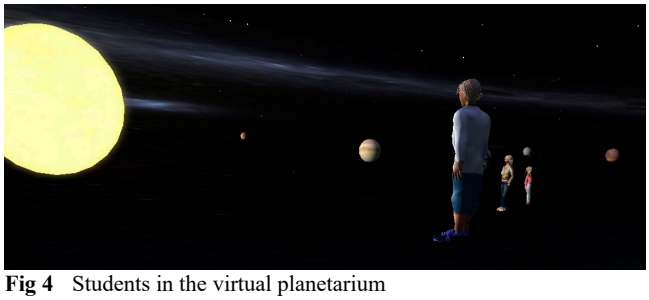

Fig 4 Students in the virtual planetarium

3.4.6 Virtual quest

The virtual world also included a hall in which an 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 was exhibited. The idea of searching for clues was proposed to children. Throughout the interaction with the models of the planets, they could find information about the planets. (Fig. 5). Their quest was facilitated with a printed questionnaire about the solar system containing the following questions:

1- *What is the Sun's surface temperature?*
2- *What is the duration of a day in Mercury?*
3- *Does the sun rise in the east or west on Venus?*
4- *What percentage of Earth's surface is covered by water?*
5- *What year did man first walk on the moon?*
6- *How many Martian days are in a Martian year?*
7- *How many of Jupiter's satellites did Galileo discover?*
8- *How many rings does Saturn have?*
9- *Which planet rotates "on its side"?*
10- *What is the higher wind speed in Neptune?*

From a selection of answer, students could extract a secret numerical 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 carrying 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. The students kept their questionnaires to include them in their personal coursework files.

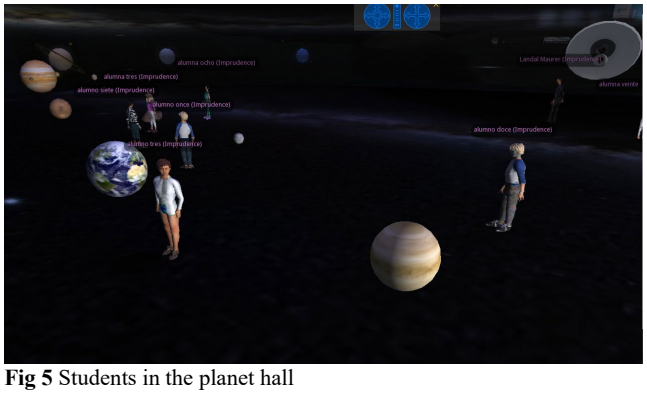

Fig 5 Students in the planet hall

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; therefore, it was decided to utilize a mixed model of telepresence and immersive activities.

A 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.

The virtual world viewer was installed on all computers in the information laboratory where the computers were identified by number.

User accounts were created 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. A stage of avatars' personalization followed in a zone with samples of prefabricated appearances that the students modified as they pleased.

Activity 2. Presentation of the lecture.

The students' avatars 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 on 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 to arrive at the Mayan pyramid. During the free exploration and the ascent to the top of the pyramid, the students received contextualized, scientific information from the docent concerning the sights they experienced.

Activity 4. Presentation at the planetarium.

The group came together in the virtual planetarium and either followed the docent 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 engulfing 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 while maintaining his avatar near the lecturer or focusing his camera on the lecturer or the 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 the ambient microphone.

Afterward, several laptops were enabled with a 3G connection from 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 was monitored by a teacher in the classroom.

5 Evaluation of the experiment

For the evaluation of the experiment, information was compiled through a survey of the children, collecting data to work with in the days following. From these data, questions arose relevant to three aspects: usability, presence, and learning. Other questions such as regarding the perception of the activity in relation to activities carried out in life as well as satisfaction in general were also expressed.

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

5.1 Analysis of the results

All the questions could take quantitative values between 1 (poor/little/bad) and 5 (better/much/good). (See Table 1) Noteworthy results are provided below.

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: Children in their first experience with this type of educational platform, which used an original interface designed for persons of greater age, had no significant problems. Even the personalization of the avatar, being a process somewhat more complex, did not present 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 were considered by the children as

high/very high (4.12/4.24). (Fig. 6), as was the sense of presence of the conference as compared with that of a teacher in a real class (3.92/4.29). It is worth noting that the data regarding the sensation of presence of the remote lecturer in the class were 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).

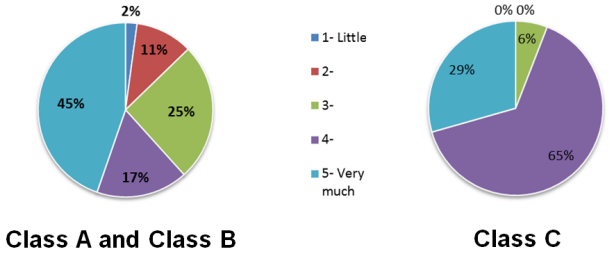

Fig 6 Sense of presence and company within the group

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 video game	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

It can be argued 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 on the talk in comparison with 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 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). (Fig. 7) 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 thus not negligible.

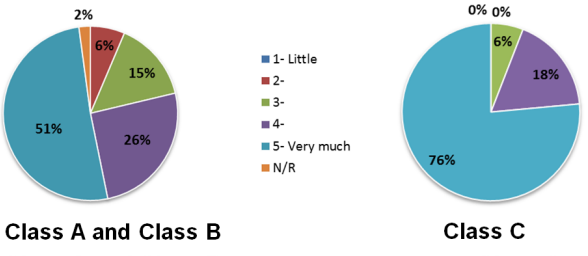

Fig 7. Degree of understanding of the lecture.

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.

For the question regarding the experience of having learned something new, the value was very high (4.24/4.71), particularly in Class C, which was more attentive to the conference. Still, the results of Classes A and B were also high. (Fig 8)

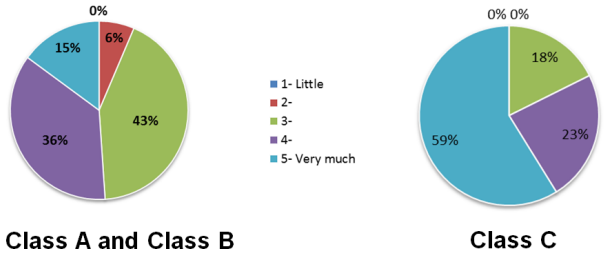

Fig 8 Sense of having learned something new

5.1.4 Comparison with real world activities

The students' responses expressed that the experience seemed little like a traditional class (2.57/2.94), somewhat more like watching 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 (Fig. 9)

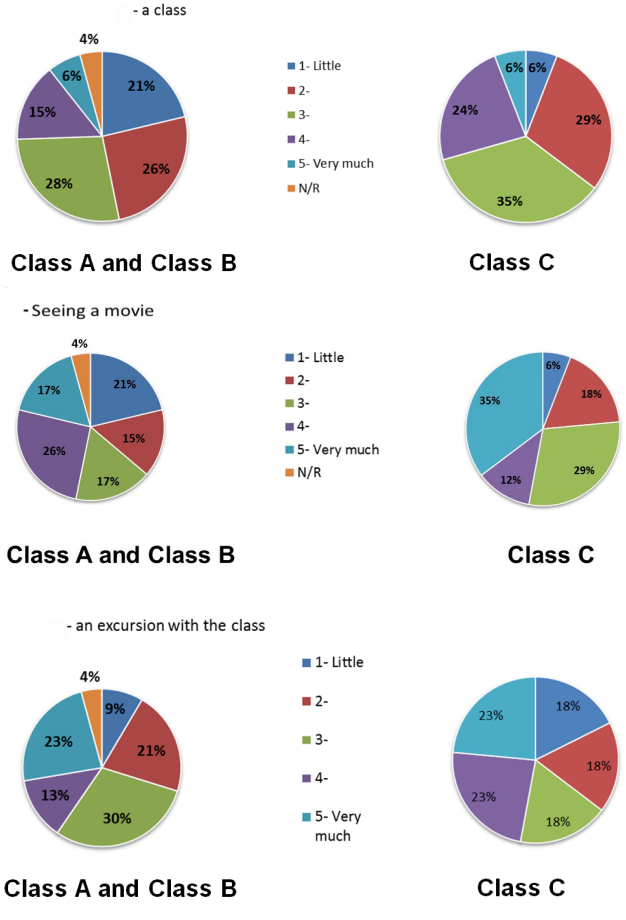

Fig 9 Comparison of the experience with a) a class b) seeing a movie and c) an excursion with the class.

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). (Fig.10)

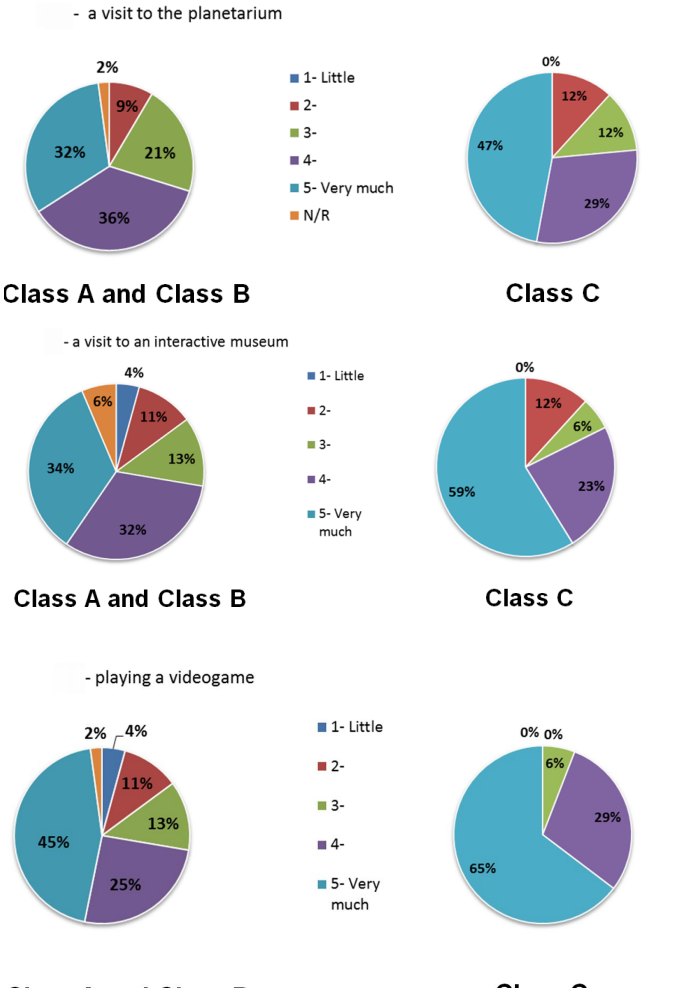

Fig 10 Comparison of the experience with a) a visit to the planetarium b) a visit to an interactive museum c) playing a videogame

5.1.5 Satisfaction

Turning to measuring the satisfaction of the students in view of this educational experience, two questions were addressed: desire to repeat with another subject, which was overwhelmingly positive (5/5) with a standard deviation of 0, and the general impression of the experience, which 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 the 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 the opportunity for more in-depth study.

5.1.7 Issues and challenges

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

The students demonstrated different levels of concentration throughout the 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.

No gender differences were observed during the completion of the experience by the students. Nevertheless, it is noteworthy that students were grouped in pairs and gender was important in the composition of each pair. Children felt uncomfortable with the possibility of using an avatar of different gender. Students generally chose a partner of the same gender in all cases for the experience. In the few cases, when it was not possible, the students were allowed to participate in the experience individually.

The possibility of experimenting with the functions of the visor in ways not intended for the experiment or with a use restricted to only one part of the experiment caused them in some cases to become distracted while carrying out other activities such as chatting. In addition, various cases were detected of students who would amuse themselves by modifying their appearance when they should have been more attentive to the docent.

However, the teachers of the center noted that such attitudes are also common in a visit to a real world museum. Nevertheless, in future experiments the aim is to improve the survey design in that respect 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

Everyone involved in the experiment, described in this paper, agreed that 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 observation of the children's behavior and attitude during the experience, their responses to the questions in relation with the difficulty of completion of the tasks, and their comments after the experience suggest that the playful approach to education that this particular platform facilitates and 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 was also notable. It is relevant to note that the simple projection on a screen of the remote docent avatar in the virtual hall; gave better results in terms of understanding of the lecture than those obtained from a configuration with all students inside the virtual world This constitutes 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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