Perceptions of pre-service teachers about a Science Lab developed in OpenSim

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Abstract

With the integration of technology in the educational area, use of virtual learning environments has allowed the adoption of new practices and forms of learning. Areas like Science has an interesting field of research involving the use of Virtual worlds, being possible to integrate virtual tasks with the practical work carried out in the real world, providing features such as immersion, interactivity, virtual reality, collaboration and visualization of phenomena through animated 3D objects. This article presents a virtual world composed of three laboratories for teaching Science in elementary education, whose objective is to demonstrate how it can assist educators in the process of teaching, mixing activities of the real and virtual world. OpenSim was used for the development of the virtual world, which has several types of educational content in the format of videos, slides, texts, questions and 3D simulations of practical experiments. This prototype were tested and validated by pre-service teachers of Science in a federal institution, with the objective of evaluating the benefits and difficulty involving this approach and the resources available in this environment. The results demonstrated a wide acceptance and satisfaction in using this virtual world, showing that the users felt motivated to use in their pedagogical practice and believe that it can assist students in their learning process.

Keywords: learning environment, pre-service teachers, virtual world, OpenSim, Science;

1. Introduction

An initiative that has been adopted in the last few decades is Blended Learning, that is a hybrid way of teaching in an attempt of matching the existing advantages of distance education and activities performed in classrooms (Marsh, Mcfadden, & Price, 2003). Christensen, Horn & Staker (2016) explains that hybrid education is emerging as a sustainable innovation in relation to the traditional classroom, where educational spaces are being rethought and converted in more open and social spaces, in order to better

integrate leisure and study.

In line with this scope, new initiatives involving the use of virtual environments, such as Virtual Worlds, seeks to improve the performance of tasks that could supplement the activities developed in the classroom. Moreover, these initiatives aim to foster students to adopt a more active posture.

Jacka (2015) believes there is some common sense that virtual worlds are in a construction process, and there is a lot yet to be done before teachers, students and managers fully adopt virtual worlds as a learning space. Essentially, this is a challenge to be explored in this area, since researchers like Johnson, Vorderstrasse & Shaw (2009) and Nunes, Herpich, Paschoal, Lima & Tarouco (2016c) understand that immersive environments may offer a new type of approach, in which, users move from a state considered passive and observatory to become more active within the virtual world.

In this kind of environment, virtual labs are an alternative to the school labs in real life, where some experiences are unfeasible because of the chemical reagent required, that could be toxic, or because of the kind of residue generated by the practical activity, among other factors. Kozlovsky and Kravtsov (2011) explains that virtual labs can be considered like a virtual environment in which the possibility of research of conducts of models of objects, their sets and the derivatives, set with the certain stake of detailing in relation to the real objects, in a certain field of knowledge is organized.

The use of virtual worlds opens the possibility to create different types of virtual labs in that environment, which allow viewing different kinds of multimedia resources such as videos, slides, texts and simulations of phenomena's. In addition, it allows the communication and collaboration between users in the environment.

Is important to observe that exists some problems in this type of approach, as highlighted by Potkonjak et al. (2016). The authors explain that this type of environment has not be created by this kind of use and a training is necessary for the users, besides the requests that are imposed on computer resources (dynamic modeling and 3D CAD modeling of objects may be rather complex and requiring).

Besides these problems, the creation of virtual laboratories and simulations in the field of sciences, chemistry, and physics opens the possibility for students to perform the lab practice at any place, time and at reduced costs. Since these do not consume natural and human resources to support experiences and, finally yet importantly, reduce risks of human or environmental accidents from eventual problems during experiences.

Based on this motivation and its particularities that this article has the objective of present the development and validation of a virtual world created with OpenSim to teach basic sciences to students of the primary level. Tests were performed with pre-service teachers of a Science course from a federal university, in order to demonstrate their vision of the virtual world developed and how this environment can improve teaching and learning processes.

Different types of simulations were created in three virtual labs disposed at the virtual world, as a variety of multimedia resources was inserted to complement educational activities executed in these labs. Avila, Tarouco, Passerino & Guterer (2014) explains that virtual worlds can be considered as spaces for pre-service teachers establish the previous contact with the teaching practice, as at the same time to approaching the use of technologies in the educational scope. Therefore, further presenting the

development of the virtual world, this validation aims to demonstrate from in a pedagogical point of view of the teachers how the use of this kind of environment can help improve teaching and learning processes in the area of basic sciences.

2. Related Works

In order to provide a broader view of studies that promotes the use of virtual learning environments and virtual labs for the teaching of areas related to Sciences, like chemistry and physics, this section aims to describe some works founded in literature. The objective is to demonstrate the relations existing in these articles with the research present in this paper, highlighting the differences of this approach with the existing literature.

The survey developed by Limniou, Roberts & Papadopoulo (2008) presents a virtual lab that allows interacting with virtual representations of molecules and chemical reactions, enabling the simulation and experimentation of these phenomena in the microscopic dimension. The authors relate the chemistry contents in a CAVE using 3D objects written in OpenGL for graphic visualization. Results were positive since students were excited and felt like as if they were interacting with the objects in the environment.

The work by Shudayfat, Moldoveanu, Moldoveanu, Grădinaru & Dascălu (2015) proposes an approach oriented to educational games in the field of chemistry. It developed a game of several phases and integrated to the virtual world OpenSim, with experiments and activities related to different learning topics in chemistry, such as chemical elements, chemical reactions, and solutions. The results of the game were considered positive since the game format provides a more practical and playful character, where users can learn in a pleasant and challenging way the contents delivered in on-site classes.

The survey developed by Merchant et al. (2012) focused on the analysis of the impact of students using 3D virtual environments, and to which extent it improves the academic performance in chemistry among students starting the undergraduate course. Different types of variables related to space presence, usability and self-efficacy were analyzed using the structural equations modeling. The results achieved showed that teaching through the 3D virtual reality is efficacious to improve the students' performance.

Regarding the field of physics, several works were developed in the same way as proposed for the fields of chemistry and sciences, where the simulations of physical phenomena are a highlight in the virtual worlds. Surveys as that by Greis, Reategui & Marques (2013), Peachey, Withnail & Braithwaite (2014) and Wegener, Mcintyre, Mcgrath & Craig (2012) have as a main focus the evaluation of virtual simulations of experiments that occur in the real world, using 3D environments. Overall, the results of these works were positive and instigating, highlighting the advantages of visualizing simulations in a 3D environment.

Some main points can be extracted from this summary made, in which, the benefits relies on the use of simulations, being exposed that the critical thinking and change of behavior to a more active action by the students were observed, as for the facilities provided by the visualization of these phenomena's in a 3D view. These points are related to the project presented in this article, were the creation of simulations and support to different types of educational materials in virtual labs using a virtual world are one of the main arguments utilized for this research in the scope of basic sciences.

It is also crucial to present the differences in the proposal made herein. The contents approached in virtual labs are oriented to the teaching of basic sciences, differently from the other works presented. The OpenSim environment was used to build the virtual labs. In addition to simulations, several types of multimedia resources were inserted, such as videos, texts, slides, questions and links. This can also be considered to be a differential in relation to the other works presented.

3. Virtual Worlds

Virtual worlds may be considered as virtual environments that allow users to interact with 3D objects, multimedia resources, and communicate with the remainder participants in the environment. In a concept more centered on the educational light, Orgaz, Moreno, Camacho & Barrero (2012) understand that virtual worlds aim to provide 3D spaces where the student can transit and try experiences in a highly interactive environment.

Nelson and Erlandson (2012) explain that these three-dimension spaces simulated by a computer can be explored in the first or third person, through a graphic representation named Avatar. For users to transit in the virtual world, terrestrial spaces named regions are created, with standard size formed by a bi-dimensional matrix of 256x256 meters.

Nunes, Herpich, Tarouco & De Lima (2016a) affirms that the visualization of virtual worlds demands to install an application named "viewer". This software should be set up with the parameters of connection to the virtual world that users want to access. As examples of viewers, we have the Singularity, Firestorm, and Imprudence.

The virtual world also allows the creation of programming scripts in some languages such as the OpenSim Script Language (OSSL) that, among the different resources provided, allows assigning movements and pre-established actions to 3D objects and program virtual agents, named Non-Player Characters (NPC). In addition, it also allows an external connection with files in different formats, like in the extension Hypertext Preprocessor (PHP).

Data collected using scripts in the virtual world can be sent with HTTP Request to PHP files in the server. The data handled in these files can be saved or not in a database. Moreover, a response can be sent back to the virtual world using the HTTP Response protocol. This provides more flexibility to developers, because data from their interactions in the virtual world, in an educational activity, for example, can be saved externally, using these resources.

Pardo, Rosa & Camacho (2014) say that some characteristics of the virtual worlds, among which the easy use, collaborative nature, and attractiveness found in the 3D resources, which provide a new and exciting sense of immersion to users, are responsible for making the VW an interesting alternative to be used in different areas. The intensified use of this kind of environment in different fields allowed its incorporation to the educational scope. This brings about new perspectives of use of these computer resources as an element of support and motivation in the teaching-learning processes.

The use of different types of multimedia resources such as videos, slides, texts, images, questions and links, opens a wide range of possibilities to apply these resources to educational activities in the virtual world. The communication using the chat also fosters the exchange of information between users, and the

settlement of doubts.

Another great advantage of the virtual world is the possibility of building simulations to represent in an animated or interactive way a given phenomenon of the real world. The use of scripts and the modeling of 3D objects allow representing the simulation of a specific topic of teaching. Thus, users can view this experiment in a virtual world. Many times the experiment cannot be seen in the real world due to the costs of materials and human resources, or because of the dangers, it could entail. Addressing this scope, the next section presents a vision centered on the teaching practice and on education in sciences in the virtual worlds.

4. Teaching Practice in Virtual Worlds

Fullan (2013) states that schools are undergoing a push-pull effect, where both students and teachers are being pushed away from formal education and pulled into out-of-the-class technology. Some examples of that are found in the innovative approaches that have been proposed, like the application of Blended Learning and the use of Massive Open Online Courses. To Jacka (2015), the teachers that are implementing new pedagogical approaches using technology are extremely conscious of the countless problems that emerge when they try to change the traditional classroom.

The integration of technologies in the classroom recalls an emerging reality, where the use of technology as part of the teaching-learning process is increasingly necessary. Twining, Raffaghelli, Albion & Knezek (2013) approach this situation explaining that teachers being trained to play a core role in the introduction, development, and support to innovative teaching and learning processes, as part of the technology integration to meet the needs of the 21st-century students.

Therefore, the building of this kind of environment demands the pedagogical supervision to fully monitor the process. Therefore, the virtual world can have a higher degree of reality and reliability in relation to the real world. Avila et al. (2014) emphasize that, despite the pedagogical potential that is being found in these tools, teachers still miss skills to handle with and build such resources.

The authors explain that encouraging the authorship on virtual worlds is a huge challenge because resources of this nature still are considered to be highly complex for users that do not have advanced knowledge in the field of informatics. Here, the process of building the virtual world in the technological light is under the responsibility of developers that will play a core role in the development of the objects. However, the developers should be supervised and instructs by teachers of the field in question.

Chang and Law (2008) also explain that the use of simulations in virtual worlds has several characteristics particularly useful to the teaching of sciences, physics, chemistry and biology. Specifically, in the scope of this article, the field of sciences comprises a large number of teaching topics that have simulations to be presented to students, and that many times cannot be viewed in the real world because of the microscopic nature of the matter, and the chemical and physical phenomena involved. These simulations could also provide for the experimentation of laboratory activities, overcoming problems regarding the costs related to development, and the dangers inherent to this environment.

In this scope, the construction of simulations in the virtual world to the field of sciences ends up becoming an essential option to provide students with a reliable 3D representation of some real world

phenomena at microscopic and microscopic level.   The teacher in training should also fit into and try to get engaged in the use of technologies in the classroom, seeking for an adequate strategies and methodologies to apply virtual worlds in the classroom.

5. Methodological Procedures

This article presents the development and evaluation of a virtual world made up by several labs built to supplement the processes of teaching and learning in the field of basic sciences, integrating different resources and technologies. As for the research questions present in this study, they are addressed as follows:

- How was made the construction of virtual worlds in the area of basic sciences to allocate simulations and other types of educational resources?
- Is there the possibility of teachers' use these type of environment in their pedagogical approaches and integrate virtual and real activities in the area of basic sciences?
  - How is the adaptation and facility of teachers to use these type of environment and their acceptance to this kind of approach?

To that, the following subsections show the details and methodological procedures adopted to build this virtual world and perform the tests.

5.1 Experiment Design

First, the theoretical literature for teaching sciences in virtual worlds was surveyed and an analysis of pertinent works related to this field was carried out, being analyzed the main points related to this research and the differences in it. Further, the technological infrastructure required to perform this work was defined and implemented, as shown in Figure 1.

OpenSim in version 0.8.2.1 was selected. The Singularity viewer version 1.8.7, which allows inserting different types of media, such as videos, XML and Dae files, in the virtual world was used. The Wamp Server 2.4.9 was elected to host the applications required to run the virtual lab because it is a solution consolidated in the market and free. It is made up by three elements: MySQL, PHP and Apache. A local server that will host the MySQL database of the OpenSim and of the Moodle environment will be created in it. The database will be accessed through the Apache server, which is integrated with the Wamp Server.
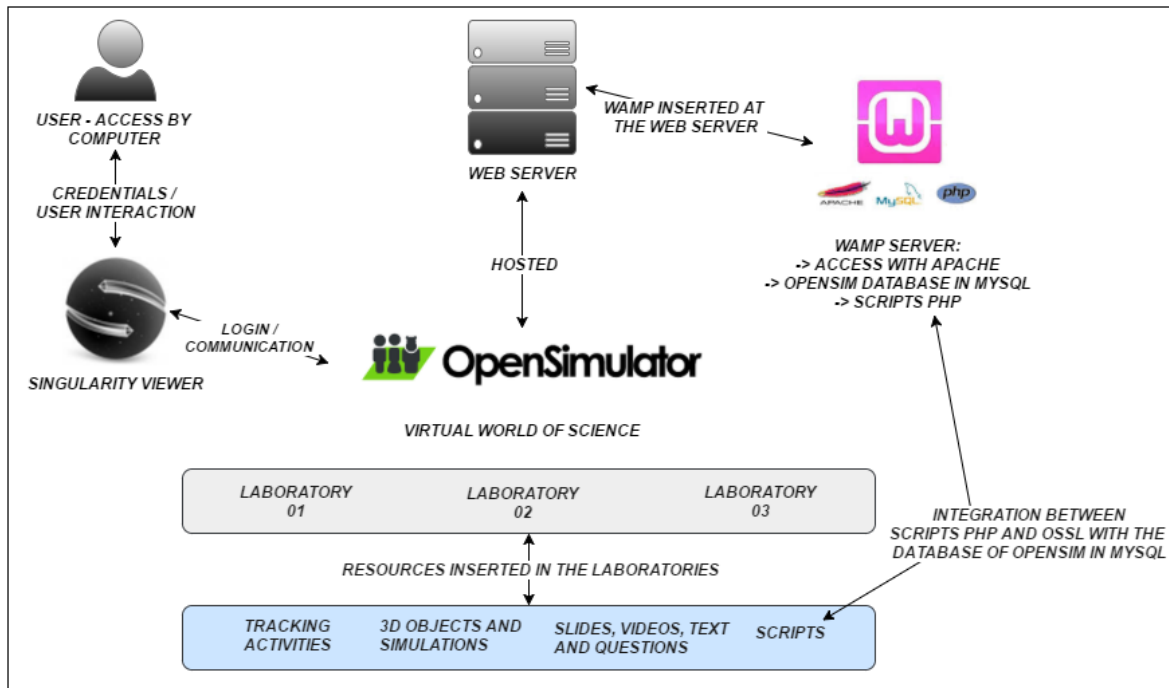
Figure 1. Technological infrastructure of the project.

Figure 1: After establishing the applications to be used, the practical stage of the study was implemented. In this stage, the Basic Sciences virtual lab was built in the OpenSim. To that, a teacher of the field actively participated in the design and construction of simulations referring to the contents approach, to ensure a degree of reality similar to that of the real world, and the proper representation of experiments.

The selected contents are part of the fundamental education curriculum, i.e., all contents worked on for two semesters in a year were digitally represented in the virtual world, through simulations, videos, slides, texts, images and multiple choice questions. In general, following were the contents approached:

- Constitution of the matter: Atoms and molecules;
- Physical and chemical phenomena;
- Sources of energy;
- Soil: Importance, components, formation, types, and erosion;
- Soil and health: Pollution and diseases;
- Water: Importance, composition, properties;
- Water: Physical states, water cycles;
- Purification and Treatment of Water and Sewage;
- Water and health: Pollution and diseases;
- Ecology: Study levels; Food chains and webs; Ecological relations; Balance and imbalance.

The description of the virtual world built and further details on the labs built therein are presented in section 5 to explain in a clearer and more detailed way how the resources were places in the environment, and to illustrate some experiments developed. The following subsection describes the information related to participants that tried this environment.

5.2 Participants

The validation of the contents inserted in the virtual world and their resources demands an evaluation in

the didactic light, i.e., with participants that could use the environment and issue their opinions about their impressions during the experiment. This way, 14 teachers of a federal university, who were taking in Nature Science teaching course, with specialization in Biology and Chemistry, were selected.

The group members were 79% female students and 21% male students. The prevailing age of the group is up to 24 years (57%), followed by 22% of the age 35 - 44 years, 14% of 25 - 34 and 7% of 45 - 54 years.

Approximately 79% of participants are taking teaching undergraduate course, while 21% work as teachers, but as beginners with 1 to 3 years of experience. They were asked about their mastering of and knowledge about the use of Educational Technologies. Half the participants (50%) said to have basic knowledge, while 42% consider having the intermediary knowledge, and one person said to have advanced knowledge.

Considering the 71% of the participants said to have never interacted with virtual worlds, while 29% said to have used some kind of environment similar to this, the objective proposed was to use all the resources in the environment to check how each content would be viewed, how teaching materials are presented and the use of simulations. This way, the participants could have an experience in the virtual world, where they could answer and evaluate the environment in a consistent and integral way. The following subsection presents details about the experiments performed with the participants.

5.3 Instrument

Participants attended two on-site meetings in a lab of informatics of the education institution. The meetings lasted one hour and forty-five minutes each. The in the first meeting, the participants were introduced to the virtual world, where they learned to use the basic commands of the OpenSim environment, customized their Avatars, and briefly visited the labs in the virtual world.

By the end of the meeting, a test was applied to the 14 participants, comprising seven multiple choice questions related to basic information about the participants and their first impression when using the virtual world, considered that none of them had ever used this kind of environment. The options were placed according to the model proposed in the Likert's (1932) scale, defined as follows: Fully disagree; Partially disagree; Indifferent; Partially agree; and, Fully agree. Is important to highlight that the creation of the formularies was made using Google Forms application.

The second meeting was characterized by the use of the three labs in the virtual world, where participants were instructed to interact with all resources present in the virtual world and check how these works and contents were presented. In this second meeting, only 11 of the 14 participants were present and responded an evaluation questionnaire about the interaction.

The questionnaire comprised nine multiple-choice questions and three narrative questions to gather information about their opinion on the use of the environment, difficulties and advantages identified during the experiment. Both questionnaires seek to collect information's about the first impression of the participants and their adaption in using the virtual world, how they pretend to use these type of environment in their pedagogical approach, the benefits and problems identified, as for the ideas of integration involving virtual and real activities for teaching basic sciences.

5.4 Data Analysis

To analyze data, taking into account that the number of participants is low to apply a statistical analysis using non-parametrical approaches, the results were described in a basic quantitative form, exploring more the qualitative analyses performed. The quantitative approach used was the calculation of Weighed Average to measure the Average Ranking and verify the responses from the Likert scale. In addition to this, a qualitative analysis of these results founded integrated was made, integrating also the observations performed by the authors of these article during the tests.

According to Malhotra (2011) and Laranjeiras, Albuquerque & Fontes. (2011), to find the Average Ranking of each variable surveyed, based on the Liker scale analysis method, the calculation considers the dividing of the weigh average to each category investigated (item Likert) by the Likert scale, respectively presented (sum of the responses to each Likert item).

In Figure 2, the Xn element refers to the value of each question choice, which ranged from 1 to 5 (Fully Disagree to Fully Agree), and Pn is the number of participants that checked the respective value. Therefore, we have the weighed average of the items of each category investigated divided by the number of participants. The final value is the Average Ranking and can vary from 1 to 5, as shown in Figure 2. Therefore, the Average Ranking shows the degree of agreement or disagreement to a given questionnaire and is related to the frequency of the participants' responses selecting that option.

$$\frac{P1 * X1 + P2 * X2 + P3 * X3 + \cdots + Pn * Xn}{P1 + P2 + P3} = \frac{\sum_{i-1}^{n}(Pi * Xi)}{\sum_{i-1}^{n} Pi}$$

Figure 2. The formula for the analysis of data collected.

Therefore, the degree of agreement (close or equal to 5) or disagreement (close or equal to 1) of the questions evaluated can be verified. Values below three are considered to be in disagreement, and higher than three as in agreement, considering a 5-point scale. The value three is considered "indifferent" or "no opinion" and is the "neutral point".

The Cronbach's Alpha (Cronbach, 1951) technique was applied to both questionnaires.   The Cronbach's Alpha was presented by Lee J. Cronbach as a way to estimate the reliability of a questionnaire applied in a survey. The alpha measures the correlation between responses to a questionnaire, through the analysis of the profile of responses selected by the respondents, i.e., it is an average correlation between questions (Hora, Monteiro & Arica, 2010).

As presented in Hora et al. (2010), using the same scale of measurement, the coefficient is calculated from the variance of individual items and the variance of the sum of items of each evaluator, through the following equation (Figure 3):

$$\alpha = \left(\frac{k}{k-1}\right) \times \left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_t^2}\right)$$

Figure 3. Formula to calculate the Cronbach's Alpha

Source: Hora et al. (2010)

Therefore, this formula is applied to verify the reliability of the questionnaires applied, to validate the questions asked to the participants in this survey and provide a higher degree of integrity to the survey.

6. Sciences Lab

To better understand how the virtual world was designed and built, the elements inserted in the environment to perform the activities should be described. Two regions were created in OpenSim, where two labs were placed on one region and one lab on the other, thus totaling there labs built in the virtual world.

Each region had an Avatar center. This is the place where users can select different clothes to customize their Avatar. This way, each participant has the possibility of building their own style and customizing their character according to their preferences.

Despite the different appearance, all labs strictly followed the same structure of composition of activities to be performed by students. It had five rooms: Video room; Slide room; Text room; Questions room; and, Practical activities room. It is worth emphasizing that the sequence of resources explored by users is not conditional to any pre-defined path. This gives freedom to users to run the pedagogical path proposed as they wished.

Following we present the resources present in each room. It is worth mentioning that these resources are equally used in the there labs created in the virtual world. The only difference is the topics presented in each lab resource, as previously presented in section four above, distributed along the three labs in the virtual world.

In the videos room, YouTube tutorials were made available to be watched directly in the virtual world, to provide a higher level of interactivity and immersion. Figure 4 presents an example of interaction in this room, where the Avatars are watching a video on the topic of water treatment.

Figure 4: Videos room

The viewer used (Singularity) provided the option of adding texture to an object in multimedia format, through an Internet address. Therefore, videos could be added directly from the YouTube to be watched by users.

In the slide room, theoretical presentations were available as short topics about the units comprised by this experiment, in the same format of exhibition used in presentation editors such as the PowerPoint. Figure 5 presents an illustration gathered during the experiment, where an Avatar is reading about atmospheric pressure and water pressure, directly in the Virtual World.

Figure 5: Slides room

This kind of resource can be implemented using scripts that allow creating actions on the next, back and home buttons. Another aspect is the format in which slides are imported into the environment, which must be conversed to an image format (jpg, png, etc.) and inserted one by one, through the viewer on the OpenSim, been allocated on the presentation panel in the desired sequence.

The texts room contains several articles for reading and operates similarly to the resources used in the

slides ROM. The images room also uses the same procedure to insert images in the virtual world. Text pages can be divided just like the slides. However, a negative aspect in this kind of operation is that it can damage the quality of some texts. Therefore, more care is required to select and converse text to image when it is inserted in the Virtual World.

In the questions room, several multiple choice questions are made available for users to answer. As shown in Figure 6, the user selects the option and then gets the feedback on the response. The objective of this resource is to practice the knowledge acquired for further evaluations.

Figure 6: Questions room

Multiple choices and short answer questions are allowed; in the last, the right answer is compared with the answer given by the user. This resource is implemented through scripts, where only the question wording, choices, right answer, positive and negative feedbacks need to be inserted in a text file on the panel. Before each of these items, a signal (exclamation mark, question mark, positive, negative, etc.) is inserted, showing what is each of them, to make the questions created available.

After describing the resources present in the five rooms in each of the three labs, it is necessary to describe the process of constructing the experiment rooms. Each of these rooms has a set of different simulations related to the topic of each lab. Figure 7 gives a general view of the different simulations referring to the study bout the chemical and physical properties of water.

Figure 7: Simulations of the water molecule

Simulations available can be presented in a static way, where users click on a Button to receive information about the experiment they are viewing or can be animated. In this last, when the user clicks on the button to start the experiment, several pre-defined actions took place to show the phenomenon in a practical way.   Figure 8 shows other examples of simulation.

Figure 8: Simulations in the other labs

Figure 8 shows an overview of the simulations contained in the other two labs, comprising contents related to atmospheric pressure, photosynthesis, pollution, sources of energy, physical and chemical phenomena, among other topics approached. After describing the resources present in each of the lab rooms, it is necessary to present a monitoring system on the users' interaction in the virtual world.

6.1 Monitoring of users in the virtual world

The monitoring resources in the labs are not visible to users. The process is entirely performed in the background to prevent interferences on the interaction of users in the virtual world. To capture data on the interaction of each user, several sensors programmed with scripts were inserted in each room of the labs. These sensors collected data and sent these through HTTP requests to PHP files in the server. These PHP files treated the data and inserted them in two tables created in the OpenSim database.

The first table was named "record_activities", and aimed to store the daily time spent by each user interacting in each lab room, and the kind of action they were performing. To that, the following data were stored in the table: User's name and code, lab and room where he/she was, as well as the type of

action performed and the time spent on the activity. Figure 9 shows part of the data collected during the interaction of users in this experiment.

Figure 9: Table "record_activities" with data on the interactions in this experiment

The sensor analyzes five different types of student's interactions (writing, absent, flying, walking or steady), storing the total time that each Avatar stayed in the position during the day. The illustration shows all data collected during the experiment and that, after the tests, can provide the teacher or manager with a detailed view on how each participant behaved during their interaction in the virtual world.

The second table created in the virtual world, named "touch_user_activity", aimed to provide detailed information about the users' interaction, and tried to identify with which objects they interacted. This table stores the user's data, the lab where he/she was and the respective room, as well as which objects he/she touched and where he/she touched the object.

Therefore, all objects in the virtual world have their own identifier to improve accuracy about with which object the user was interacting. It also records on which part of the object the user touched. The illustration shows the records from the simulations room, where we have different types of objects touched and which action was performed.

The objective of these records is to provide teachers with a more detailed view on how each user interacts with the virtual world, and thus visualize the kinds of actions performed. The data collected during the experiment will not be analyzed because it exceeds the scope of this work. The following section presents the results gathered concerning the questionnaires applied and data analysis.

7. Discussion of Results

This section presents, in a clear and detailed way, the results achieved by the experiment performed, which in the previous section was made the description. To that, it will present the data achieved from two questionnaires applied to participants. It will also describe the analysis of results using the Cronbach's Alpha technique.

7.1 Analysis of Questionnaires

The first questionnaire applied aimed to evaluate the students' impressions about their first access and use of the virtual world created. It was an attempt to understand their view, and compared these with the responses provided by the end of the experiment. To that, the Average Ranking analysis method was applied to evidence the trend of participants' response to each question. This method has already been explained herein. Table 1 presents the data achieved through the users' response to each of the five options, based on the Likert scale to each question, calculating and presenting the Average Ranking of each question.

Table 1. Average Ranking of responses to the first questionnaire

Questions	Frequency of Subjects in each response					
	1	**2**	**3**	**4**	**5**	**AR**
01. In your first access, you felt motivated to use the virtual world	0	0	1	3	10	4.64
02. You could customize the Avatar as you wished	0	3	1	6	4	3.79
03. The scenario was clear, with full view of the objects	1	0	0	5	8	4.36
04. The chat worked properly, getting in touch with the remainder participants	2	0	1	0	11	4.29
05. The environment helped to build a sense of immersion during my interaction	1	0	1	4	8	4.29
06. Navigation in the lab was intuitive and easy	1	2	0	4	7	4
07. You consider valid inserting an Avatar in the environment to help interaction and clarify doubts about the topics approached	1	3	0	0	10	4.07

The first question tried, in a broader way, to show the user's status in relation to motivation, asking if the user was motivated to use this virtual world for the first time. The AR of responses for the 14 respondents was 4.64, very close to 5, showing broad agreement with the statement. We could observe that during their first contact and access to the virtual world, the participants were anxious and curious to interact with the new environment because this was not a usual practice. Oliver, Allison & Miller (2009) explain that to keep the feeling of immersion, the system should react in real time and consistently with the interactions of users. This would avoid putting users off and making them have a negative experience when using a VW.

The second question is related to the basic actions performed in the first access of users and tried to learn

if participants succeeded in customizing their Avatars. The value of 3.79 is due to the fact that most of them have changed the look of their characters, but faced minor difficulties during this task, as some clothes that did not work well on the Avatar and putting off and changing these pieces.

Question 3 was about the full and consistent view of the objects in the virtual world, and scored 4.36 because all users could properly view the 3D objects in the environment. Some users had minor difficulties in the beginning, and report that resources took a time to be fully rendered.

Question 6 is in line with this question. It tried to find if navigating the lab was easy and intuitive. It ranked 4 because, although the lab rooms were described, as well as how users should interact with the objects in the room, other paths in and out of the lab had no information of support. This ended up by hindering the localization by users that had not much experience in the environment because this was their first access.

Trying to relate these issues, question 7 asked the participants if they considered valid the insertion of an Avatar in the environment to help the interaction and clarify doubts about the topics approached. The general acceptance was 4.07. This result opens the possibility to insert a virtual agent to help users during their interaction with the environment and could facilitate and improve interaction, besides clarifying general or specific doubts. Nunes et al. (2014) explain that the NPC can play an important role in the interaction with the student's Avatar, serving as a virtual guide or guardian, providing information, instructing the student in the environment to help with activities and respond their questions.

As regards question 4, the chat was used in a positive and satisfactory way, scoring 4.29. Users were instructed to talk in the environment and test this functionality. Only a few difficulties were reported regarding the understanding of some chats because this is shared among all and a large number of chats can hinder the comprehension sometimes. Nunes, Herpich, Zunguze & De Lima (2016b) explains that using the text or voice chat, navigating in different settings and interacting with elements can build an enabling scenario for more collaborative attitude among users.

Closing the analysis of this first questionnaire, question 5 also had an Average Ranking equal to question 4, where participants were asked about their sensation of being immersed in this environment. This question is contextualized into which extent the users felt concentrated, fully interacting with the environment. The result can be considered positive since the resources in the environment made users feel this way and want to keep on using the virtual world. Pardo et al. (2014) explain that the characteristics of the Virtual Worlds such as easiness of use, collaborative nature, and attractiveness of the 3D resources give users a new and thrilling sensation of immersion, making the virtual worlds an interesting alternative to be used in different areas.

After these remarks about the responses to the first questionnaire, we should analyze the second questionnaire applied by the end of the experiment. This questionnaire aimed to learn about the users' opinion on different specific points of the virtual world, and compare some responses with those for the first questionnaire. It used the same procedure previously adopted, using the Average Ranking analysis method. Table II presents the data achieved from the users' responses to each of the five options, based on the Likert scale to each question, and calculating and presenting the Average Ranking of each question.

Table II: Average Ranking of responses to the second questionnaire

Questions	Frequency of Subjects					
	1	2	3	4	5	AR
01. Was the scenario clear, with full view of the objects?	1	3	0	2	5	3.64
02. You have visualized the materials (slides, videos, texts, and questions) in an appropriate way	0	4	0	4	3	3.55
03. The presentation and interaction with materials (slides, videos, images, texts, and questions) were proper and easy	0	1	0	5	5	4.27
04. The simulations were proper and right in the didactic light	0	0	0	2	9	4.82
05. Do you believe the use of these 3D simulations in the virtual world could help the students' learning process?	0	0	0	1	10	4.9
06. As a teacher, you would use the virtual worlds in your didactic practice	0	0	0	4	7	4.64
07. In your opinion, the use of this virtual world will raise the students' interest in the subject approached	0	0	0	4	7	4.64
08. You believe the supplementary activities performed in the visual world could help learning the content delivered during the on-site classes	0	0	0	2	9	4.82
09. You felt motivated to continue using the virtual world after this experience	0	0	1	1	9	4.73

Trying to compare the visualization of objects in the virtual world in both meetings, the first question once again asked if the scenario was clear, with a final result of 3.64. This value is lower than that for the first questionnaire and could be justified by the problems involving the internet connection during the second meeting when the speed was much lower than in the first meeting. This problem can be considered natural, but has a significant impact on the interaction with the virtual world, since when the connection speed reduced, users said that moving in the environment was slower and crashed.

Question 2 is in this scope and scored 3.55. This lower value also results from internet-related problems, which partially hampered the interaction of participants with the slide, videos, texts and questions

resources. For example, some multiple-choice questions took a long time to be loaded and sometimes crashed. However, it is worth mentioning that resources have properly operated. In this aspect, Fernandes, Antonello, Moreira & Kamienski (2007) highlight some concerns involving data traffic, download and streaming during the user's interaction in the VW. For example, the use of voice, music, video and data in one single virtual world with a significant amount of users connected from different places can have negative impacts on the quality of services offered.

This fact can be observed in question 3, where the final result was 4.27. This result was considered positive, despite the difficulties identified and described above. Therefore, one can conclude that the didactic resources in the three labs have properly and functionally worked. This is of utmost relevance since the labs are where users can visualize the theoretical contents and practice the knowledge acquired. Tüzün and Özdinç (2016) explain that virtual worlds have potential to provide individuals with more significant and long-term data in comparison with the traditional interactive multimedia environments.

Question 4 approached specifically the simulations present in the virtual world labs, trying to investigate, in the educational light, the opinion of the teachers in training about the proper building and actions of each simulation. The result may be considered positive, since its value was 4.82, suggesting that participants have evaluated experiments as teachers, and considered these adequate and properly reflecting the phenomena that occur in the real world. Valente and Mattar (2007) say that these environments allow the inclusion and practice of activities for experimental learning through simulations, modeling of complex scenarios, among other possibilities, with the opportunity for collaboration among members and co-creation.

In this scope, question 5 aimed to verify the participants' perceptions on the use of 3D simulations in the virtual world to help the students' learning process. The result of 4.9 can be considered excellent. This shows that, for the teachers in training, simulations properly reflect, in a virtual way, the phenomena occurring in the real world, and are likely to positively contribute to the students' learning process.

The sixth question tried to learn if, in the pedagogical light, the participants would use the virtual worlds in their didactic practice. The result of 4.64 showed the participants' acceptance. This shows that they felt motivated and confident to use this kind of approach in the classroom, to assist the students' teaching and learning process. This is an important aspect to be considered in this evaluation of the environment. According to Sgobbi, Nunes, Bos, Bernardi & Tarouco (2014), the virtual worlds are a new step in this pedagogical proposal. In this space, students now only interact with the object of study, but also experience a virtual process that leads them to an immersion in the teaching and learning situation, ensuring deeper engagement in the activities proposed.

In this context, the seventh question tried to learn their opinions about the use of the virtual world and if they believed this would raise the students' interest   the subject approached. The result for this question was 4.64. This average can be considered positive and evidences the teachers' acceptance of the environment since, based on their expertise, they believed that this kind of application can instigate students and be used during their learning process.

The 8th question tried to learn if participants consider that supplementary activities in the virtual world can help learning the content delivered in the classroom. The final result was 4.2. This can be considered

positive and instigat, since one of the main objectives of the construction of this prototype is to assist, in a supplementary way, both teachers and students to practice and fix the contexts learned on-site or at distance.

Finally, the 9th question is a comparison with question 1 of the first questionnaire, asking the participants' opinion about keep on using the virtual world after this experience. The final result was 4.73. This result is comparable with that of question 1 in the first questionnaire, showing that users, from the beginning to the end of the experiment, were motivated to use the environment. This fact was also observed during the experiment. The users' excitement was clear when interacting with the virtual world, as well a by the end of the experiment, when they said to be willing to continue using the environment.

After the analysis of the responses to the two questionnaires applied during the experiment, the narrative responses of the participants were also analyzed. The first question aimed to understand the problems and difficulties during the participants' interaction. One of the highlights here was the initial difficulty in adapting to the system, as could be expected since users had not the previous contact with the environment. Another issue mentioned was the eventual slowness to interact with the Avatar and remainder objects in the virtual world, mainly by the time of practicing the exercises. This problem is justified by the variations in the internet connection speed during the experiment.

Finally, by the time of viewing the simulations, a text is displayed on the chat explaining what is happening. Some participants said to face some difficulty to follow the simulation and simultaneously read the text. According to the cognitive load theory (Sweller, 1994), when the instructional material is presented in a complex or inconsistent way, they can produce strange cognitive load. This reduces the pupils' capacity of properly processing the learning activities (i.e., the relevant cognitive load) and hampers the learning process (Merchant et al., 2012). It is important to try to balance this aspect to improve the user's assimilation of the content.

After describing the main difficulties faced by participants, the second question approached the differences perceived by users between the virtual world and a file manager environment, considering that they use the Moodle. Among the main issues raised, there is the fact that the virtual world is more visual, instigating, interactive, dynamic, pleasant and promotes more active learning. This is in line with the characteristics of this environment, and this evaluation comparing with the Moodle can be considered positive. Students have also highlighted that both environments should not compete with each other. Rather, they should be used together to supplement the students' learning about the subject. According to the authors of this study, it should also be adopted as a teaching method.

The last question tried to learn the students' overall opinion about this experiment and the environment. Here, they emphasized that the virtual world can be considered instigating, motivating and educational in the context it was applied. It is a form of learning that can be used at the time of delivering the content to students or after it, so they can individually interact in this environment with the contents they were   to explore deeper. They also emphasized the problems to be corrected in the environment, like better signaling and guidance for users to interact with objects.

Aft the analysis of the results of this experiment, we should apply a final instrument to verify the validity of the responses to the objective questions of the two questionnaires applied. The next section presents

the results achieved when the Cronbach's Alpha was applied.

7.1 Cronbach's Alpha

The Cronbach's Alpha verifies the questionnaire applied to users to validate its reliability and ensure more trustworthiness to the results achieved. Based on this, this technique was applied to both questionnaires used in this experiment. The results are presented below.

In the first questionnaire, made up of seven objective questions, the calculation presented in the methodological section of this article was applied. The results are presented in Figure 10. One can see that the Cronbach's Alpha result is 0.905319 that, according to the values-based classification scale proposed by George and Mallery (2003) can be considered Excellent.

Question / User	Q1	Q2	Q3	Q4	Q5	Q6	Q7	$(\sum x)^2$	$\sum x^2$
User 1	3	5	1	1	1	1	1	13,00	169,00
User 2	5	3	5	5	4	5	5	32,00	1.024,00
User 3	5	4	5	5	5	4	5	33,00	1.089,00
User 4	5	4	4	5	5	4	5	32,00	1.024,00
User 5	5	4	4	5	4	5	5	32,00	1.024,00
User 6	5	4	5	5	5	5	5	34,00	1.156,00
User 7	5	4	5	5	4	5	4	32,00	1.024,00
User 8	5	5	5	5	5	5	5	35,00	1.225,00
User 9	5	4	5	5	5	5	5	34,00	1.156,00
User 10	4	2	4	5	3	4	5	27,00	729,00
User 11	5	2	5	3	5	2	4	26,00	676,00
User 12	4	2	4	1	4	2	4	21,00	441,00
User 13	5	5	5	5	5	5	5	35,00	1.225,00
User 14	4	5	4	5	5	4	5	32,00	1.024,00
Variance	0,37	1,17	1,09	2,06	1,2	1,71	1,11	174.724,00	12.986,00

Sum of Variance (S^2i) = 12,6   N= 12 α = 0,905319

Figure 10: Cronbach's Alpha applied to the first questionnaire

Question / User	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	$(\sum x)^2$	$\sum x^2$
User 1	5	5	5	5	5	5	5	5	5	45,00	2.025,00
User 2	5	5	5	5	5	5	5	5	5	45,00	2.025,00
User 3	4	4	5	5	5	5	5	5	5	43,00	1.849,00
User 4	1	2	4	5	5	4	4	5	4	34,00	1.156,00
User 5	5	4	5	5	5	5	5	5	5	44,00	1.936,00
User 6	2	2	2	4	4	4	4	4	3	29,00	841,00
User 7	4	4	4	4	5	5	4	5	5	40,00	1.600,00
User 8	5	4	4	5	5	4	5	5	5	42,00	1.764,00
User 9	2	2	4	5	5	4	5	5	5	37,00	1.369,00
User 10	5	5	4	5	5	5	5	5	5	44,00	1.936,00
User 11	2	2	5	5	5	5	4	4	5	37,00	1.369,00
Variance	2,23	1,52	0,74	0,15	0,08	0,23	0,23	0,15	0,38	193.600,00	17.870,00
Sum of Variance (S^2i) = 5,71				N= 12					α = 0,886707		

Figure 11: Cronbach's Alpha applied to the second questionnaire

In relation to the second questionnaire, made up nine objective questions, the Cronbach's Alpha was 0.886707, considered to be Good, as shown in Figure 11. The values and classifications of both questionnaires can be considered positive and instigating since they provide sounder guarantees that the questionnaires applied to the group of users were valid, and the values inserted by them can be considered reliable regarding the environment evaluation.

8. Conclusions

The increasingly use of new technology resources in the educational area has provided new pedagogical techniques and increase the use of virtual learning environments to support teachers and students. In this context, the virtual worlds can be perceived as a way to supplement the contents delivered in the classroom or remotely, in different fields of education, as is the case of Sciences, which has a large scope of possibilities to be explored using this kind of environment.

In face of that, this article presented the development and validation of a virtual world created with OpenSim to support the teaching of Sciences to the elementary school. Different types of experiments were developed in three labs, and a variety range of multimedia resources was inserted to supplement the resources present in those labs.

The experiment was described and validated with the support of a group of pre-service teachers from a course of Sciences: Specialization in Biology and Chemistry of a federal university. The results show an overall acceptance by participants regarding the use of the virtual world to support sciences teaching, classifying the system as instigating, motivating, educational, pleasant and promoter of active learning.

Some difficulties and problems were also identified during the experiment, such as problems related to interaction with the environment due to the internet connection speed, learning curve to learn using the virtual world, and lack of clarity and signaling on the rooms and resources in the environment. These are important problems that can be solved.

Finally, it is worth mentioning related to the research questions proposed that, this article could provide detailed information about the process of construction of this environment in the area of sciences. The tests proved the possibility of teacher's use this virtual world in their pedagogical practice, in which, they affirm their interest in integrating activities in the real and virtual world. As for the adaptation, in general, the virtual world was evaluated as positive and consistently validated to be used in the next stages of this project.

Therefore, future initiatives should correct the problems found and perform tests involving students in the field of basic sciences to try to analyze the likely impact of the use of this system as a supplement to the students' learning process. It also provides for the use of an educational theory to ground and guide the pedagogical project proposed, to better meet the needs and preferences of teachers and students.

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