

Knowledge Assessment within 3D Virtual Worlds



María Blanca Ibáñez, José Jesús García Rueda, Diego Morillo, Carlos Delgado Kloos
Departamento de Ingeniería Telemática
Universidad Carlos III de Madrid, Madrid
Spain
{mbibanez, rueda, dmorillo, cdk}@it.uc3m.es

ABSTRACT: *Three dimensional virtual worlds can be used to model authentic learning environments in which knowledge might be applied and evaluated on its context. To date, very few papers have reported the design, deployment and evaluation of a 3D virtual assessment environment. The aim of this paper is to report on participants' attitudes toward assessment activities carried out in a 3D virtual world representing a fiction novel. The results of this pilot study suggest that participants felt immerse and engaged in the learning environment and were able to perform required activities. The paper also reports human and technical difficulties that appeared during the design process and provides recommendations to overcome them.*

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1. Introduction

Unique characteristics of 3D virtual worlds (3DVWs) which include representational fidelity and their interactive possibilities [1] have a great potential in the educational context as they engage learners and provide them with the ability of explore, manipulate and modify the virtual world by means of their avatars in a collaborative learning environment [2]-[5]. Instructional designers have taken advantage of learning affordances of 3DVWs to deploy learning strategies based mainly on constructivism [6]-[8].

First attempts to introduce assessment on 3DVWs have been done on serious games where studies highlight the importance of do not breaking the *flow* state induced by immersive games with invasive assessment activities [9], [10]. Recent works emphasize the benefits of using 3DVWs for assess knowledge and competencies [9], [11], [12]. Benefits stated derived from the capabilities of these environments to be cost effective, valid, and reliable as well as their potential for making adequate observations of student performance. Despite the relevance of assessment within the learning process, 3D virtual worlds which include assessment activities remain rare. Indeed, relevant reviews carried out on educational applications using 3DVWs [2], [13], [14] show that the assessment is done outside the 3DVW by using “*paper and pencil*” methods.

This paper describes the design and evaluation from a pilot study involving the implementation of assessment activities in a situated learning environment deployed on a 3DVW. A set of assessment activities were designed using the interactive capabilities of 3DVWs described at Section 3. Activities designed intended to determine the participants' knowledge of the novel “*The invention of Morel*” by A. Bioy Casares and were deployed on Open Wonderland [15], a multi-user 3D virtual world platform. The study, described at Section 4, evaluates participants' attitudes toward assessment activities in the 3DVW. The results of the

evaluation are presented at Section 5. While this study does not establish links between 3DVWs and learning outcomes, its results may nevertheless provide some useful insights for instructors who are considering the use of these learning environments to support assessment activities. The paper discusses at Section 6 both the successes and limitations found and concludes at Section 7 with recommendations in the use of 3DVW for assessment.

2. Related Work

Starting from the basic characteristics of 3D virtual worlds, several studies present the potential learning benefits of them as learning environments. Representational fidelity, immediacy of control and presence are emerging as the basic capabilities of 3DVWs to foster learning benefits [2]-[5], [8], [16], [17].

2.1 Representational fidelity

Three dimensional graphics allows for realistic and detailed representation of 3D landscapes populated with 3D objects and characters [8]. Realism also deals with mimic the physical properties of the real world and the possibility to include 3D sound for a more immersive sensation.

2.2 Immediacy of control

The rich interface provided by 3DVWs allows participants to perceive the world from different viewpoints and provides them with real time interactive capabilities to modify the state of the world [18].

2.3 Presence

The terms presence and immersion have been used interchangeably for some authors. However, a distinction can be made between a subjective sense of been in place and the technical capabilities to render sensory stimuli. The former is considered presence, the later immersion [2], [7].

Determining how these technological features in isolation or in combination could influence the learning processes is an active area of research. Indeed, the theoretical framework proposed by Dalgarno and Lee [2] states that representational fidelity and learning interaction could influence the construction of identity, the sense of presence and co-presence which in turn will produce learning benefits such as spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning. Furthermore, Lee et al. [5] present a theoretical model of the determinants of learning effectiveness in 3DVWs and stresses a causal path from virtual reality features to motivation, control and active learning, reflecting thinking. However, studies signals that factors such as learning contexts, personal goals, cognitive styles and computer attitudes might have also decisive influence on learning benefits and should also been taking in consideration [3], [5].

Reviews carried out on educational applications using 3DVWs [1], [13], [14], [19], [20] show that most of the applications use constructivist approaches and report success to foster enjoyment, enthusiasm, motivation and positive attitudes of participants toward learning activities. These studies recommend direct research efforts to exploit characteristics of 3DVWs and identify good practices of using instructional design techniques in 3DVW for specific learning contexts. Among the techniques more commonly used in 3D virtual learning environments are situated learning, role playing, cooperative and collaborative learning, problem-based learning, creative learning and simulation [6]-[8].

In particular, 3DVWs provide an opportunity for situated learning where students will be in authentic contexts that can be freely explored and where authentic activities can be carried out [2], [8], [21]. Indeed, representational fidelity of 3DVWs allows deploying authentic contexts that reflects the way knowledge is presented and used in real life. Students are immersed in an engagement environment which invites exploration [21]. Moreover, a situated learning approach should embody authentic assessment activities that allow students exploring an environment with material both relevant e irrelevant, with a level of uncertainty similar to the real world [22]. 3DVWs capabilities related to immediacy of control will potentially deepen learning benefits [8], [23].

Although the applications with assessment activities in 3D virtual learning environments are rare [13], [20], it is worth mention three of them dealing with different approaches. V. J. Shute's work [9] follows an analytic approach using Bayesian models to monitor actions, integrate evidence on learner's performance, and update the student model in relation to competencies. In River City [12], a multi-user virtual environment, the detailed records of students' actions are collected and stored to assess how learners detect and decipher pattern of illnesses in a town besieged with health problems. Their main concern is in a situated an

experiential learning environment assess participants skills. Finally, QuizHUD [11] represents the first attempt to integrate a computer assisted assessment tool to a 3D virtual world. QuizHUD includes both classical multiple choice and exploration questions. Classical multiple choice questions are included into the virtual world as it would be in a web-based learning environment. For the exploration questions, students should click on 3D objects to state their choice.

For the purposes of this research, an authentic context was designed representing the main landmarks of a novel and a set of scenes dramatized by non-player characters (NPCs). In that context a series of assessment activities should be carried out by participants in order to demonstrate the knowledge acquired about the novel. Participants were expected to interact freely with the system both to receive as to transmit information that prove their knowledge using the set of interactions provided by 3DVWs that are presented at the next section.

3. Interactive capabilities of 3D Virtual Worlds and their uses in assessment

Typical assessment tests are composed of a set of questions with a pre-determined correct answer, a grading scheme and a possible feedback. A typical test question consists of the following parts:

1. A prompt to provide the question to students.
2. A response template with the list of choices.
3. A correct response.
4. Feedback and grades for different options.

When dealing with computer assisted assessment, elements (1), (2) and (4) are related to information that the assessment system must transmit to the students whereas element (3) corresponds to the information that student must provide to the assessment system.

In a 3DVW, students immersed in the environment perceive and act through their avatars. Perception comes from the senses of hearing and sight and can be very real in a 3D immersive system that can be explored freely. Although is technologically feasible, the haptic perception is not typically included in 3D virtual environments. On the other hand, the assessment system can monitor and log any interaction carried out by avatars within the virtual environment in order to interpret any student answer.

3.1 Interaction of an assessment system with participants

3DVWs can transmit visual information to users through text, pictures, video fragments, 3D objects and the 3D scenario where the learning scenario is deployed. Audio information usually is transmitted in combination with visual information through video or actions carried out by 3D objects (including NPCs).

Prompt can be available to users through different ways:

- Text as it is usually done in a class or a web-based learning environment.
- Audio or video file.
- Dialogues and actions performed by one or more NPCs can transmit the question to learners.

It is also possible to adapt the system to students' preferences for receiving information. Besides, mechanisms should be provided to replay the information as many times as necessary for its full understanding.

Once students have received a typical test question, a list of choices is available for them. This list can take the shape of the 3D objects within the virtual world which includes NPCs or a set of different places in the virtual world.

Feedback can be received in the same way as the prompt. A feedback can also be the change of the 3D scenario or its elements. For instance, a correct answer to a question may imply that a song starts playing or a 3D object that represents a prize to appear or student's avatar is teleported to another place of the virtual world. Even a correct answer might imply the occurrence of all these actions simultaneously.

3.2 Interactions of participants with an assessment system

Avatars can perform a rich variety of actions that can be monitored by the system and thus can be interpreted as the answer of

a question:

- Displacement from one place to another either walking, running or via teleporting. The information to transmit can be either the destination point, the proximity to an object or the path followed. Time employed can also be recorded.
- Perform gestures to affirm, deny, waving, clapping and so on. Gestures represent a way of communication that has not been yet employed on traditional assessment.
- 3D object manipulation which includes the selection an object, the displacement of the object, the modification of its size or any kind of simulation.
- Interaction with NPCs. NPCs can have simple conversations with students thanks to the simple artificial intelligence techniques currently used by chat bots.

3.3 Question types included in the system

Nowadays, the assessment system for 3D virtual worlds developed can work with three types of questions: “*multiple choice*”, “*order*” and “*essay*”. “*Multiple choice*” and “*order*” follow the typical test structure previously mentioned, and might survey a broad range of topics. “*Essay*” questions are easier to construct and allow assessing in-depth understanding of a few content areas.

3.3.1 Multiple choice

Users have to select the correct answer, there is only one correct answer, among several possibilities. In a 3D world, these answers can take the shape of 3D objects or characters, multimedia fragments, areas in the world, etc., and the way to select them can be by clicking on them, or coming closer to them, or entering some building or area, or moving the object to some specific location.

3.3.2 Order

Users have to put in order a set of elements according to some specific criteria, like relevance, proximity, etc. The range of elements to be put into some order in a 3D world is very wide: you can put in order some 3D objects or characters, some areas in the world, etc.

3.3.3 Essay

By using this type of question evaluators have the chance of asking their students to answer freely to some open question, by writing a short text. In a 3D world any element suitable for writing, like blackboards or panels, can be used as a means for submitting an answer. For this kind of question, automatic correction is not possible.

This reduced set of available questions was carefully selected out of the typical lists of test questions, taking especially into account the types of questions available in Question & Test Interoperability (QTI) [24], according to three criteria: relevance, adaptation and extensibility.

The selected question types had to be relevant, i.e. widely used in assessment and easily adaptable to any subject. Multiple choice, for instance, is probably the most commonly used test question, so including it in our system was a must. As in many occasions evaluators need to complete multiple choice based assessment with some more subjective input from the students, essay type questions had to be included, also.

The question types offered by our system had to be well adapted to the very nature of 3D virtual worlds, i.e. they should have a role to play especially interesting for this kind of environments. Putting staff in order, apart from being quite relevant from the point of view of assessment, is an opportunity to manipulate 3D content, to make students reason on the very spatial distribution of the 3D world, to move around and change things and compare elements in the world.

4. A Case Study

The study was conducted on an extracurricular activity among undergraduate and graduate students at the University Carlos III of Madrid. Participants were immerse in a 3D simulated setting of the science fiction novel “*The Invention of Morel*” by A. Bioy Casares with the aim of carry on assessment activities to show participants knowledge about the novel. To this end, a

discrete representation of the island where the actions of the novel takes place enhanced with assessment activities was built using Open Wonderland (see Figure 1).



Figure 1. A student within the 3D virtual world

4.1 Research Questions

The purpose of this research study was to identify the advantages and limitations of 3DVWs as situated learning environments where assessment activities are deployed. The research questions were:

1. Do students feel immerse into the 3D virtual assessment environment?
2. Do students are engaged in the assessment activities?
3. How does assessment occur in the 3D virtual environment?

4.2 Participants

Thirty-three individuals agreed to take part in the study, 2 professors, 2 3DVWs developers and twenty nine participants: 8 undergraduate students, 21 graduate engineering students. Participants were highly skilled Web and Web 2.0 users with limited knowledge on 3D virtual worlds. In the study participated 11 males and 18 females students; 1 male and 1 female professors and 2 male developers.

4.3 Research Design

Prior to taking part in the study, a text document was provided to participants outlining the purpose of the research and their right to withdraw at any moment. Informed consent was obtained from every participant. To ensure anonymity of the process, avatar names and other potential identifiers were removed.

Authors and developers had several work sessions with two professors of the course “*Humanities and Informatics*” offered at the University Carlos III of Madrid in order to define assessment activities adapted to a 3D virtual world that mimics the novel “*The Invention of Morel*”. Professors were informed about the functionality and technical limitations of the system, participated in the design of the activities, supervised the artwork and finally evaluated the learning environment.

In an initial face-to-face learning session, participants and instructors discussed the main issues of the novel related to plot, characters and setting. Then in a tutorial session, an instructor taught participants how to customize their avatars, navigate and interact in the 3D virtual world. Finally, participants login at the 3D virtual learning environment, were divided in three groups and each group received a different test with three questions. In order to solve the test, participants had to identify some of the characters of the novel based on their appearance, the place they used to act of the dialogues performed; to choose the right object for a character and, to go to a location where an event happened. Questions had to be answered on the three main landscapes of the simulated island and covered the different types of interactions that a user can experiment in a 3DVW.

4.4 Measurement

After the assessment session, participants were invited to fill a questionnaire of 15 items to measure their attitude toward the 3D virtual learning environment. The questions were evaluated using 5-point Likert-scale items were numerically coded (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree). The questionnaire included items to examine how participants perceive three distinctive properties of 3DVWs; items to measure motivation toward the assessment activities deployed in the island setting and items to determine participants' perception of the ease of interactivity with the system (see Table 1).

<i>Measurements</i>	<i>Category of Items</i>	<i>Source</i>
Perceived properties of 3DVWs	Representational visual fidelity Immediacy of control Presence	Dalgarno & Lee, 2010; Zelter, 1992
Motivation	Attention Perceived usefulness Confidence Satisfaction	Keller, 1987
Perceived ease of interactivity	Perceived ease of getting information from the system Perceived ease of transmitting information to the system	Burdea & Coiffet, 2003

Table 1. Summary Of Selected Measurements

5. Results

After the data collection phase, three cases with missing answers were deleted from the data. The frequencies of each of these responses, along with item means, for each question are reported in Tables 2 to 4.

5.1 RQ1 Do participants feel immerse into the 3D virtual assessment environment?

Table II shows that participants felt a moderate sense of immersion through the study. The majority of participants (57% to 73%) agreed or strongly agreed on having had a feeling immersion thanks to the control possibilities offered by the environment. 3D sound was also considered a positive factor of immersion by 63.3% of participants. However, the quality of images of 3D objects and feeling of presence due to avatars were considered as factors with neutral or moderate influence on immersion feeling by 63.3% of participants.

Results showed by Table 2 were corroborated by our observations and participants' comments. Indeed, participants indicated they expected a higher visual quality of the environment; some of them compared with commercial games and were disappointed. Whereas they were able to identify the main landmarks and characters of the novel, they claimed for more visual and audio details. Participants were especially careful on the customization of their avatars, all of them tried to build a character reflecting their main traits which was not always possible. Nevertheless, they were very pleased with the possibility of effecting changes on the environment through object manipulation.

- *“The objects appear a bit cartoonish, they do not have to many details. However, I like to observe them from my point of view.”*
- *“This door is too small for me; I have difficulties to get into the building.”*
- *“Each landmark is populated with enough elements, all relevant to the activities.”*
- *“It is funny to change of landmark when I go across the portal.”*

- *“I noticed that the sound gradually grew louder when I approached the characters, which gave me a feeling of realism.”*
- *“I missed hearing the sea when I was at the beach.”*
- *“I’m trying to customize my avatar as short and fat and I do not find how to do it!”*
- *“I have the feeling of been in a vivid place with other students and the characters in the novel.”*

5.2 RQ2 Do students are engaged in the assessment activities?

Table III shows that participants were moderate to high motivated to participate in the assessment activities, being the highest scores for confidence and satisfaction factors (88.4% and 84.6% respectively). Attention and relevance factors were also highly rated (69.2% and 65% respectively).

We observed participants highly concentrated during the study. Unfortunately, minor technical problems appeared once or twice on each of the sessions and participants claimed that they were disturbing factors. They also commented that it was an interesting challenge for them to solve a test in an unusual way. In this regard, participants commented:

- *“Being in context helped me to think deeply on the activities. All the elements that surround me had to do specifically with the questions to answer”*
- *“Each time I got to an island landmark, I was curious about which would be the new challenge”*
- *“The feeling of being in the novel helped me to concentrate better on the activities”*
- *“I only lost concentration when my avatar had problems to move”*
- *“It was easy for me to navigate and interact with the system”*
- *“This was an interesting challenge exploring the island to solve situations, before starting I was not sure of being able to do it”*

5.3 RQ3 How does assessment occur in the 3D virtual environment?

Does the environment facilitate or hinder assessment activities? Table 4 shows the measures of perceived ease of perform assessment activities within the 3D virtual environment developed. Participants were highly satisfied with the variety of ways of receiving information (76.9%). They neither had problems to discover the prompt (69%), to know how to answer it (88.4%) or to understand the feedback provided (61.5%). Similarly, they had no problems to handle 3D objects and 2D blackboards to answer the questions. In both cases a 92.3% of participants found easy or extremely easy the interaction with the system.

We observed that participants had no problems to move around the simulated island either walking or using placemarks. Participants were pleased with the diversity of activities available but suggested integrating them within a meaningful story similar to those found on video-games. They also remarked the lack of clues to help them on where to go or what to do. The interaction with the system was carried out with no difficulties.

Participants pointed out some advantages of this kind of assessment over a paper-and-pencil test. However, they stressed the need to complement the assessment mechanisms in order that students may develop their answers in more detail.

Finally, we observed that participants developed a supportive climate to help each other to overcome difficulties related to the interaction with the system. They preferred to communicate with their peers broadcasting messages through the chat rather than talking directly to them. Some of the participants’ comments were:

- *“At the beginning I was lost; I was not sure where I had to go or what I had to do. I would like to have more clues.”*
- *“I had to pay attention to notice which object or character had a new prompt but was not difficult to find.”*
- *“When I did not understand the prompt, I listened to the talks again”*
- *“Now I understand why it is important the information about the tides in the novel”* – referring to one of the assessment activities-
- *“I liked to see who was around me doing similar things. I found it supportive”*
- *“It was fun to do this kind of exam”*

• “I prefer this kind of test rather than paper-and-pencil assessment but I think that it is necessary to complement it with classical assessment activities”

Measurement	Item	Mean
1. Representational Visual Fidelity	1.1 The realism of the 3D images helped me to feel immerse in the novel	3.5
2. Immediacy of Control	2.1 The ability to change the view position of 3D objects brings a high degree of immersion	3.7
	2.2 The stereophonic sound brings a high degree of immersion	3.8
	2.3 The ability to manipulate objects in real time brings a high degree of immersion	4
3. Presence	3.1 My avatar allowed me to have the feeling of being on the island simulated	3.5

Table 2. Mean Ratings For Evaluation Of Immersion Into The 3D Virtual Assessment Environment

Item	Mean
4.1. The assessment activities helped me to concentrate on the novel	3.8
4.2. Assessment activities helped me to understand better the content of the novel.	3.8
4.3. As I worked on the assessment activities, I was confident that I could finalize the test successfully.	4.2
4.4. Completing the assessment activities gave me a satisfying feeling of accomplishment.	4.2

Table 3. Mean Ratings For Evaluation Of Motivation

5.4 RQ4 What lessons can be learnt from the development and deployment of the 3D assessment environment?

This study started by eliciting requirements for the assessment activities to be carried out in a 3D virtual world with the aid of two professors of the course “*Humanities and Computers*” from the University Carlos III de Madrid. Whereas professors centred their request on the contextualization of meaningful activities that help students to assess the expected learning outcomes, developers were concerned about the performance of the system.

Professors asked for a 3d setting reproducing the main landmarks of the novel and the representation of the main characters with their distinctive features. The first requirement was only partially satisfied. The 3D models were imported from Google 3D Warehouse website due to the lack of graphic designers. Furthermore, the performance limitations of Open Wonderland forced to include a limited amount of graphical objects made up of few polygons. Regarding the characters of the novel, they were created using Evolver, a sophisticated tool for 3D avatar modeling. Professors were very pleased with the visual quality of non-player characters.

Professors agreed to focus on the assessment of the knowledge of the causal and logical structure of the novel which connects events. After a demonstration of the functionalities of the system, professors were invited to design the assessment activities. However, they had serious difficulties to design the activities and finally they developed classical questions such as:

- How does the Fugitive show his love for Faustine?
- Identify the character that used to work with a video-camera
- Where did Morel describe his machine and his experiment to his friends?
- How does the Morel's invention work?
- What is the purpose of the ship that arrives at the island?

Then, professors and developers worked together in order to design tasks in the 3D virtual environment related to the given questions. Those questions that were difficult to deploy as multiple-choice, or order questions were implemented as essay questions.

The design of the environment was not a difficult task once the 3D objects and NPCs were available. Open Wonderland platform allows construction of the setting with simple drag-and-drop of digital objects followed by their resizing and positioning. An authoring tool developed for the system simplified the deployment of assessment activities once the digital information required was available.

6. Discussion

The results of this pilot study demonstrate the advantages and limitations of using 3DVWs for assessing the comprehension of a novel. The results include the lessons learned designing and deploying the assessment activities and the perception that a group of participants had toward using 3DVWs to assess knowledge.

The visual quality of the 3D virtual world was a major concern of professors and developers aiming to achieve the better contextualization possible of assessment activities.

Measurement	Item	Mean
5. Perceived ease of getting information from the system	5.1. I liked to receive information under different multimedia modalities	4.1
	5.2. I always knew how to get the question prompt.	4
	5.3. I always knew what I had to do to answer the questions	4
	5.4. I always understood the feedback provided	3.8
6. Perceived ease of transmitting information to the system	6.1. I had no difficulties to interact with the 3D objects to answer the questions	4.4
	6.2. It was easy to write my answers	4.5

Table 5. Mean Ratings For Perceived Ease Of Assessment Activities

Nevertheless, the trade-off between visual quality and system performance forced developers to deploy a reduced amount of 3D simple objects to ensure at least a minimum level of performance. The decisions taken at this stage had three main learning implications. First, the low quality of images was identified as a barrier to achieve high immersion levels and a complete sense of presence in the virtual environment. Fortunately, both professors and participants found that the environment had enough objects, details and characters to contextualize the activities. Finally, as technical problems were not suppressed completely, they acted as disturbing factors of participants' concentration.

Developing meaningful activities in the 3D virtual worlds to assess knowledge was not an easy task. Professors had difficulties to imagine how to use the interactivity possibilities of 3DVWs to build relevant assessment tasks. Thus, they had to work closely with developers in order to design such activities. The self-imposed restriction on working with multiple-choice and essay questions with the limited capabilities of interaction of 3DVWs facilitated the task of deployment of the activities designed. Participants reported to understand and work with no difficulties in each of the assessment activities. However, they perceived the tasks as isolated and claimed for meaningful assessment activities sensibly structured. Structuring a narrative around each of the three sequence of assessments deployed requires professional-game-writers skills that were beyond the goals of this work. A possible solution to this problem could be to guide participants through the activities with hints given for example by NPCs. Finally, both professors and participants agreed on the need to complement the test with more open questions or promote discussions in the virtual world. Technology was helpful to achieve several learning benefits. First, participants reached from moderate to high levels of immersion in the learning environment. The two factors that favoured the feeling of immersion were the interactivity capabilities added over 3D objects and the navigational possibilities offered by avatars as vehicles to perceive 3D visual and audio changes. Secondly, participants reported feeling attracted to do the assessment activities while exploring the virtual island and felt curiosity toward the different situations enacted. They were confident on their skills and knowledge to perform the activities and were satisfied with their achievements. Thus, assessment activities were perceived as motivating. Finally, a supportive climate of collaboration helped participants to overcome technical difficulties and help them to low their anxiety level.

7. Conclusions

In this work, 3D virtual worlds' features have been used to design a pilot-learning environment where to assess student knowledge about the novel "*The invention of Morel*" by A. Bioy Casares. We have tried to take full advantage of the capabilities of these worlds to recreate real or imaginary places to be explored by the students, using these 3D settings as working places where the evaluation is done in the context of the contents of the novel. This contextualization includes the creation of a narrative to structure the evaluation tests, providing kind of a small story to the evaluation process by means of the interactive elements available in 3D virtual worlds.

We have involved real teachers of the subject under evaluation in our study. As a result, we have found how difficult it is for non-technical teachers to conceive evaluation activities that make the most of the 3D environment's possibilities, especially interactivity. Thus, when putting teachers to the task of creating evaluation activities for this kind of environment, it is highly advisable that they have had previous direct and intense experience with them. Teachers also insisted on the need of including essay questions to complement the rest of assessment activities. This can be done easily and can be enhanced by recording the voice and gestures of the avatar for a more engaging activity.

Increased motivation in the students was identified, caused by the immersion capabilities of these environments, mainly. However, the activity flow and the immersion illusion are very sensitive to technical flaws in the system (connectivity problems, bandwidth, performance, responsiveness, etc.) and to weaknesses in the design of the interaction mechanisms included in the user interface, both constituting serious barriers for concentration. The graphical quality of the environment is another element to be taken into account, but its importance is not so significant, according to the results of our experiments. In this regard, several alternatives can be handled depending on course requirements. The setting might be minimized and simplified in order to ease the work of the rendering engine. The assessment activities could be done asynchronously thus lowering the server load. A more expensive solution is to split the setting in several worlds and assign each one of them to a different server. And finally, do not neglect the acoustic immersion, it does not have serious implications in performance and it is helpful to contextualize situations.

Participants found necessary to include more clues to help them to understand the test narrative, to help them to find where the next question to answer is. In this regard, the clues might be provided visually, by means of NPCs or through list of remaining

test topics.

In general, students were observed to be very engaged with the evaluation process, and very willing to collaborate and help each other even in the context of an exam. It is thus advisable to design collaborative-assessment activities in these environments.

We are currently working to improve the technical reliability of the system, to include new question types, to increase the functionalities and straightforwardness of the authoring tool and to increase the collaboration level in the evaluation activities, being our next objectives to facilitate the creation of these activities for non-technical teachers and to set up evaluation processes with a deeper constructivist nature.

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