

ASSESSMENT IN 3D VIRTUAL WORLDS: QTI IN WONDERLAND

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ABSTRACT

The number of users and platforms of 3D virtual worlds has grown in the last years. This growth is due to the hardware performance and software development that increase the features of these worlds.

3D virtual worlds are a powerful media for instruction and education. They can be used both to create an environment where students can learn or where they can be assessed. The features of a 3D virtual world make it possible not only to assess knowledge, but also skills and competences. Nowadays, this new type of assessment is desired, because with the new generation of students the traditional educational methods are not sufficiently effective.

In this paper, a solution that enables automatic assessment in a 3D virtual world is presented. The implemented assessment engine supports embedded assessment by combining Open Wonderland, a virtual world platform, with the newAPIS engine that manages test and questions-items that are formatted following the IMS Question & Test Interoperability (QTI) specification.

Categories and Subject Descriptors

H.5.1 [Information interfaces and presentation]: Multimedia Information System – *artificial, augmented, and virtual realities.*

General Terms

Design, Standardization.

Keywords

Virtual worlds, assessment, IMS QTI, Wonderland.

1. INTRODUCTION

3D virtual worlds are a genre of online community that takes the form of a computer-based simulated environment in which users are represented by an avatar visible to others. In these worlds users, by means of their avatar, can interact with other avatars and objects.

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Since its origin, in the early 90s, with the advances in hardware performance and software development, virtual worlds have evolved to the present, where Second Life [1], the more famous 3D virtual world, has more than 20 million users. Some analysis published in 2007 [2] [3] predicted a great success of these worlds and their adoption in the education in the followings years. Although the prediction, 80 percent of active internet users will use virtual worlds at the end of 2011, seems to be difficult to achieve, the use of these platforms has grown to exceed the 800 millions of virtual worlds registered accounts at the end of 2009 [4], more that the 40 percent of internet users [5].

3D virtual worlds are a powerful media for instruction and education because they provide a shared, realistic and immersive space where users can explore, interact and modify the world, in addition to allow communication and collaboration among users. These features make virtual worlds a possible solution to the problem of student motivation, according to the results that have been reported by some researches [6] [7] using River City [8] or Quest Atlantis [9]. For example (as seen in [7]), in a classroom that uses a virtual world, the 75% of the students completed optional activities although they were activities for no credit, while in a traditional classroom only 4% did similar activities despite the benefit of the extra credit.

Virtual worlds have many features that can be used to improve learning environments. However, these worlds lacks of some necessary learning elements: learning objects; instructional design; intended learning outcomes; management of roles; and assessment.

The aim of this paper is to describe the architecture of an assessment engine in a virtual world implemented over Open Wonderland [10], and using the assessment specification IMS QTI [11].

This paper is organized as follows. In section 2 the possibilities that virtual worlds bring to the assessment are discussed, as well as an introduction of some works in this area. Section 3 presents the different interactions that can be monitorized in the virtual

world. Next, in section 4, the assessment engine is described. Finally, conclusion and future work are discussed in section 5.

2. 3D ASSESSMENT

Traditional learning is based on knowledge transfer, which is not enough nowadays. The implementation of new mechanisms for the acquisition and assessment of knowledge and competences are necessary.

In this new educational context, 3D virtual worlds are promising environments to assess *knowledge*, the outcome of the assimilation of information through learning; *skills*, the ability to apply knowledge and use know-how to complete tasks and solve problems; and *competences*, the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development [12]. For example, a virtual world provide a new interface and elements that can be applied to change the way in which the users interact with the assessment elements to answer questions instead of interacting with textual question-items; or an environment in which different situations or tools can be simulated, and where all the actions of the students can be monitored.

The assessment mechanism implemented in virtual worlds should be as immersive as possible to maintain what is commonly called flow [13], the state of optimal experience, where a person loses track of time and is absorbed in the activity: embedded assessment (or stealth assessment). A virtual world can help to capture and sustain attention, which has a central role in the education. The use of an embedded assessment allows obtaining information about students' progress without students divert attention of the learning activities.

Currently, different serious games (games designed for a primary purpose other than pure entertainment) and virtual worlds have been used to assess students, highlighted among them:

River City, a multi-user virtual environment (MUVE), is a city, set in the late 1800's, where the students have to detect and decipher a pattern of illness that is sweeping through the virtual community [14] [15]. In this MUVE, the detailed records of student' actions are automatically collected and stored in a server-side database, and offer a great potential for assessing the behavior of the student while they try to diagnose and solve the problems. The number and level of detail in these records is impossible to replicate in a classroom-based experience.

Quest Atlantis is an educational computer game for children. In this game the students are immersed in a 3D virtual world for completing educational activities. The aim of this game is not only to assess lower level skills or memory. It uses a portfolio assessment [16]. In this game each student has a homepage that serves as an online portfolio of their activities in the world and teacher feedback of these activities.

The previous games, based on the Active Worlds platform [17], have a disadvantage compared to other virtual worlds, like Second Life: content creation tools are not available to all users, only for administrators or developers, not allowing certain learning or assessment task where students are required to create content.

Sloodle [18] is a project which is working on integrating learning and teaching across Second Life and Moodle, a popular Web-based Virtual Learning Environments (VLE). QuizHUD [19], a

side-project of Sloodle, has the aim to harness the benefits of web-based learning and assessment while incorporating the benefits of virtual worlds. This tool is present in the students' screen and shows information and questions in the form of specially created web-content. This content is created by the educators using their web browser, instead using the virtual world's tools. QuizHUD has the "Quiz mode" in order to assess students' progress in the same environment in which the learning takes place. This operation mode has two main questions types available:

- *Multiple Choice Questions*, where the questions and the available answers appear in the quizHUD and students have to choose the correct one. This type of questions uses the virtual world to give information that the students can need to give a solution, but does not use virtual world elements in any part of the questions.
- *Explore Questions*, where the question is showed in the QuizHUD and the students have to answer it by clicking on an object in the environment. This type of questions makes the students more active in the learning process, and incorporates "environment awareness skills": students not only have to choose an element to answer a question, they also have to look for it in the world. This type of questions allows the assessment of knowledge using mechanism inherent to 3D virtual worlds, not only traditional text-based questions.

After all the above, the aim of the implemented assessment engine presented in this paper is the creation of a mechanism of embedded assessment in which: 3D virtual world elements could be used in any part of a question (prompt, response template or feedback); and the students can create new content or modify the existing one if it is necessary.

Despite the advantages provided by virtual worlds, they have certain drawbacks such as the complexity that can result from the use of a new tool and the additional workload that may involve the creation of new educational content. To reduce the impact of these drawbacks in the adoption of this new tool in education, the following features have been implemented in the created assessment engine: the assessment content is loaded in the world from external resources, like XML files, therefore, once the world is created, educators can create new tests, or modify the existing ones, in an easy and quick way; the second feature is the use of a specification for the creation of the assessment content, so as educators can adapt their existing assessment test and assessment items without the necessity of creating new ones. The selected one is the IMS Questions & Test Interoperability Specification that proposes standard XML language for describing questions and test to allow the interoperability of content within assessment systems. This specification has been selected for being the closest to a standard that exist, since the rest of specifications are related to a particular VLE.

The intrinsic characteristics that the QTI assessment specification has (such as its interoperability, flexibility and XML format) enable its use within a virtual world.

As a first approximation, multiple-choices questions have been chosen between the different types of questions defined by the

IMS QTI specification to be implemented in this assessment engine because they are the most common questions.

3. INCLUDING ASSESSMENT IN OPEN WONDERLAND

3.1 Actions in the virtual world

The different types of actions that a user can do in a virtual world are suitable to be monitorized and can be considered in the design of each part of a question. The following subsections explain the actions that have been taken into account in the implementation of this assessment engine.

3.1.1 Prompt

There are several actions that users can do to get the instructions of a question, and they can receive them in different ways.

An NPC (Non Player Character) is a character that is part of the world and it is not controlled by a human. It can give the instructions playing a pre-recorder audio file, simulating that this character is talking to the students. The reproduction of the audio file can begin when students are close to the NPC or when they select it. A button appears in the lower right corner of the wonderland client window when an NPC can be selected and the user is near to it.

There is another way in which an NPC can give the instructions to the users: using the AIML language [20], a XML-based programming language that relates linguist patterns with templates that contain the response to a user input. Student can talk with the NPC, and if the things that they say are which the NPC waits, it gives the instructions to them (see Fig.1 to see a student speaking with an NPC). The simplest example of this type of interaction is when the NPC asks to the users if they want to receive the instructions: if they say “yes”, they receive them.



Figura 1. A student speaking with an NPC

Other action that users can do in the world is the selection of an object, by a click over it with the mouse. The cursor shape of the mouse change when it is over a clickable object (the typical arrow is replaced by the symbol of a hand).

In this case, students can receive the instructions of two different ways; in a textual way, a window with the instructions of the question is displayed in the world; or listening to an audio file.

Students also can receive the instructions when they access to a particular zone in the world. These instructions are given using one of the two ways explained in the previous action, the selection of an object.

Students can request the instructions of the questions as many times as they want. In the case of the second action explained, the use of the AIML language, they only have to speak with the NPC one time, the next times they request the instructions the NCP gives them directly.

3.1.2 Choices

Once the student has received the instructions, the different options of answer are available in the world. The elements of the virtual world that represents each of the possible options can be visible only after students receive the instructions, and they can disappear when students give their answer.

Students may have to choose one between several elements in the world. In this case there are three possibilities: (1) they have to choose the NPC that they think that is the correct answer; (2) they have to choose the correct object; (3) or they have to go to a determinate zone.

To identify the elements that students can choose, a button appears when they are near to an NPC (if it can be selected), or the cursor shape changes if the mouse is over a selectable object.

All the options are represented by the same type of element. It means that if the correct answer is an NPC, all the available options are NPCs.

There is other way in which students can give an answer, using the AIML language. They have to talk to an NPC, and it can finish the conversation using different sentences. Each of these sentences is one of the different options of answer, so, if what students say to the NPC is correct, they receive the correct answer.

3.1.3 Feedback

There are several ways in which the feedback can be given to the students; even teachers can indicate that there is not feedback at the end of a question.

The simplest way in which students can receive the feedback of their answer is displaying a window that contains it (textual feedback).

The modification of the world can be used to give this information. An object, or an NPC, can appear in the world once students have answered. In the same way, an object can disappear of the world.

An audio file can be played when the answer to the question is given. In this case, the element that the student chose is the source of the audio in the virtual world.

The last possibility to give the information is importing an image in the world. This image is included in the world with a security component that avoids that the rest of students could see it (only the student that answers the questions can see it).

Besides the feedback of a question, when users finish the last question, a window is displayed in the world. This window shows the feedback of the complete test and the final score.

3.2 Help system

One of the disadvantages that students can find answering question in a virtual world is the time that they spend between the answer of a question and the beginning of the next one. This disadvantage can be very important when students have a maximum time to complete the test. In a traditional test, students have all the questions in the same paper, so when they complete a question, they can begin the next one immediately, but in a 3D virtual world, when they answer a question, they have to look for the element that gives the instructions of the next one.

Educators can add a track in every question to guide students toward the element that gives the instructions of the question.

A new element has been added to the menu bar of the Wonderland client window. This new menu allows students to access these tracks.

When students request a track, a HUD (Head-Up Display) appears in the lower right corner of the window (Fig. 2). The content of this HUD is the track of the next question, or the QTI prompt if students received the instructions of the question previously.



Figura 2. HUD with the track of the next question

4. THE WONDERLAND-QTI ASSESSMENT ENGINE

4.1 Architecture

The assessment engine proposed in this paper is formed by two main components: Open Wonderland, a toolkit engine to deploy collaborative virtual world where students are assessed; and newAPIS, a QTI engine that exchange information with the virtual world to check and store the students' progress.

4.1.1 NewAPIS

NewAPIS [21] is an updated version of the work done in a previous project called APIS [22] (Assessment Provision through Interoperable Segments). NewAPIS has been developed by the Universitat Pompeu Fabra to make the engine compliant with QTI 2.1 and support the management of complete tests.

NewAPIS is a modular item-rendering engine that is in charge of interpreting QTI v2.1 XML files. These files have to be previously created by a compliant authoring tool (e.g. Recourse [23] among others). NewAPIS manages the QTI XMLs and

creates the XHTML of the test which is visualized by the users through a web player. The engine computes the interactions of the users when answering the questions. It stores all the assessment data, checks the answers of the students and calculates their scores using the information contained in the QTI files.

Previously to the work presented in this paper, newAPIS has been combined with an external service in order to extend the possibilities of the QTI specification. The objective was to create new types of QTI questions and forms of user's interactions. An example is the work done by Navarrete et al in [24], where the authors combine QTI with Google Maps with the objective of extending the specification with new types of geographical questions. As a result a Middleware that communicates the newAPIS engine with the Google Maps service was implemented.

Considering this previous work newAPIS was selected as the suitable QTI assessment engine that could be combined with the open virtual world Wonderland in order to extend the QTI specification with 3D interactions.

4.1.2 Open Wonderland

Open Wonderland is a cross-platform, free and open source 3D virtual world that has been chosen for the "Immerse Education Initiative" [25] to integrate an ecosystem of platforms for virtual reality and game-based learning and training systems

The toolkit is written entirely in Java. Its main features are: it supports desktop application sharing, for example, a web browser can be executed in the server and it can be accessed by all the users of the virtual world; integration with external data sources, for example, the use of devices different to the keyboard or the mouse pad that allow move the avatar, as a SunSPOT [26]; it has spatial sound capabilities, it means that the sound has location, direction and intensity, so the user listens the sounds in the virtual world in a realistic way; and it allows the communication between the users using a text chat, that can be read for all people in the world, or talking directly through their avatars using a microphone that allow conversations between groups of users.

Two external tools are very useful to create avatars or to build objects and NPCs: the online Evolver [27] tool allows a great customization of the characters (avatars or NPCs), improving the immersion; and Google SketchUp [28], the tool used in the creation of the 3D models of the different objects of the world.

Wonderland is a distributed client-server architecture [29]. A *WebDav-based* content repository hosted in the Wonderland server. This repository stores the data common to all clients. These data can be accessed via the HTTP protocol.

The functionality of the virtual world can be extended developing new modules. Each of the different types of elements in the virtual world is managed by its own module. These modules manage the actions that users can do with the different elements. Other actions in the virtual world (play audio files, add images, and so on) are managed by their own modules too.

A new module, the Wonderland-QTI Player, is the core of the assessment engine: it is the union between Wonderland and newAPIS and it checks the students' actions in the virtual world to determine if they have to receive the instructions of a new question or they are answering another one.

Wonderland enables that an element in the virtual world can be hidden for some of the users. An object can have a security

component where is indicated the name of the groups, or users, that can access to the object, so, users only can see the object if they belong to one of these groups.

In Wonderland, a zone is defined adding a proximity listener to an object, so the zone is defined as a circle which has an object in the center. It is possible detect if a user is in the area of the circle.

4.2 The proposed extension of QTI proposed

The QTI specification uses the XML format to describe tests and questions and report results. Each type of question is identified by a tag (it describes a XML element) and contains all the necessary information to manage it.

Multiple-choice questions are defined in the QTI XML file using two elements: the “choiceInteraction” element that contains the “prompt” element and a “simpleChoice” element for each possible option in the questions; and a “modalFeedback” element for each possible option, storing the feedback that is given to the users when they answer each one of the different options.

3D Virtual worlds introduce new interactions that there are not considered in QTI, thus the specification cannot be used directly in Wonderland.

In order to enable the use of QTI to define questions in Wonderland two different XML files have been used: the QTI XML files that are managed by newAPIS (and could be used by any QTI player compliant with the QTI v2.1); and a new file, related with the QTI XML files, which contains all the information needed in the virtual world and that cannot be defined in QTI: the actions that students can do in the world to receive the instructions of a question or to answer it and the ways in which they receive the information. From now on this new file is called Wonderland QTI file (WL-QTI file).

The WL-QTI file is divided in four different XML elements (fig. 3), three of them related directly to any of the elements in the QTI file:

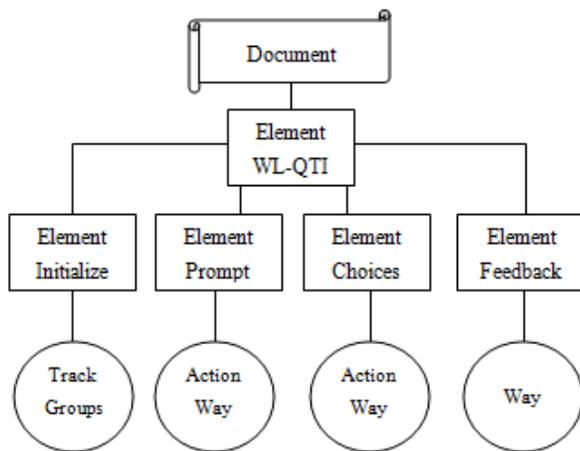


Figura 3. WL-QTI file structure

- The first one, the element *initialize*, is not related to the QTI file because the information that it contains is not used in any part of a question.

It includes information that is loaded by the 3D virtual world when users access to the world. This information is the track used to guide students in the world and the

groups in which users have to be added to see some of the objects of the world. For example if the feedback used in the question is the disappearance of an object.

- The second one, *prompt*, indicates the interaction that users have to do to get the instructions of the question and the way in which it is shown in the virtual world.

The XML element’s start tag identifies the action of the user, and a key word is used to identify the different ways to give the instructions. For example, the words *text* and *audio* are used to differentiate if a textual prompt is used or an audio file is played.

This element is related to the “prompt” element in the QTI file.

This XML element contains the name of the object, or NPC, that is used to give the instructions of the question. If an audio file is played, it also contains the path of the pre-recorder file. However, if a textual way is used, it is not necessary more information, because the text is contained in the QTI file.

- The *choices* element defines the action used by the students to select the answer to the question. It is identified using the XML element’s start tag. The same interaction is used for all the possible options.

Each “simpleChoice” element in the QTI file has an identifier to differentiate one option to another. In this assessment engine, these identifiers are used to relate each option in the QTI file to the element that represents it in the virtual world.

In this file are stored the name of each element in the virtual world together the identifier of the QTI simpleChoice that it represents.

This element includes the way in which the options are shown in the world. For example, the objects can be hidden until users get the instructions of the question, they can be visible all the time or they can disappear when students answer the question.

- The last XML element, called *feedback*, defines the way in which the feedback information of each question is shown in the world when the question is answered. The start tag is used to identify the way. This information is related to the “modalFeedback” element contained in the QTI file. The feedback of all the options is shown in the same way.

Like in the previous section, the identifier of the option is used to relate the information in the WL-QTI and QTI file.

This element is related only with the feedback of the different questions, not with the test feedback. It is shown in a textual way, showing a window with the final score and the content of the feedback element in the QTI test file, when all the questions have been answered.

This element contains: the name of the group in which students must be added or removed to make appear or disappear objects; the path of the audio file that is

played; or the path of the image that is included in the world.

4.3 Communication

The management of newAPIS is transparent for the students. The Wonderland QTI Player is the responsible for the exchange of information with the QTI engine.

Fig. 4 shows the communication between the two components, which has four steps:

1. This step is executed each time a student accesses to the world. NewAPIS is asked in order to retrieve the list of questions that the user has not yet answered. Students can complete a test in different moments, because newAPIS stores the information related to the questions that they have answered before.

NewAPIS uses a code number to identify each student. This number is assigned by Wonderland the first time that the user accesses to the world. It is stored in a file that relates the name of the students in the virtual worlds and their identifier number in the QTI engine.

The test's identifier is an element contained in the QTI test XML file. That is used by newAPIS to know the test that has to load. This parameter is included in a configuration file read by the WL-QTI Player. Different tests can be executed in the same world, modifying only the test's identifier in this configuration file.

2. Once the WL-QTI Player has the list of questions, it requests to newAPIS the information of each QTI question in the list. This information is the prompt (the instructions of the questions) and the response template (the choices to choose from in the case of multiple-Choices questions).

The questions' identifiers are received by Wonderland in the previous step.

3. The third step happens every time students answer a question in the virtual world The WL-QTI Player checks the action of students in the world and relates these actions with the selected choice's identifier, the parameter that newAPIS understands.

When newAPIS receives the selected choice's identifier, it is stored in its database, so, this question will be stored as an answered question.

The feedback of the questions is obtained by newAPIS after processing the received response. This feedback is sent in the reply to show it in the virtual world.

4. The final step is executed once the last question of a test is answered in order to obtain the final score and test feedback.

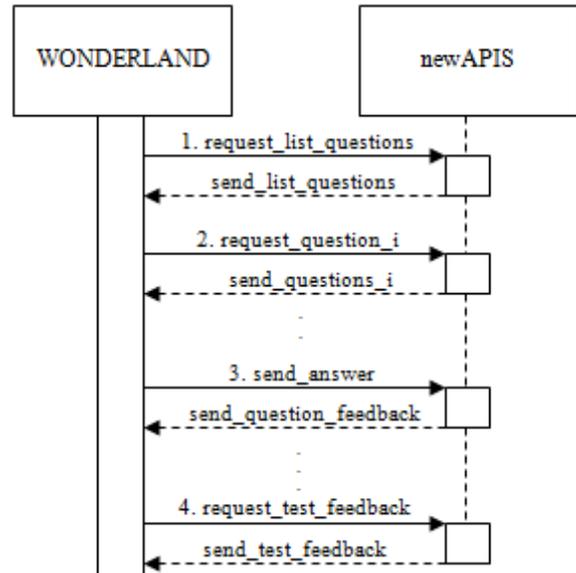


Figure 4. Communication between the components

NewAPIS has been adapted in order to enable the communication with the Wonderland client. Instead of showing the assessment information via XHTMLs, each step of the communication has a URL associated within the newAPIS server. From Wonderland, the get method is used to send the information to newAPIS, adding the needed parameters in the URL. The information from newAPIS is encoded in the response of the URL using a predefined XML format.

4.4 Configuration file

In the *WebDav server* there is an XML file that contains the configuration information of the assessment engine, so, it can be modified without changing the WL-QTI Player. The information in this file is:

- The test's identifier. Teachers can change the test that is displayed in the virtual world modifying this parameter.
- The path of the file that contains the identifiers of the users. This file is stored in the WebDav server.
- The path where the WL-QTI files are stored. These files can be stored in the WebDav server or in the newAPIS server together the QTI files. Teachers can change the location of the files, and they only have to change this parameter, without modify anything more.
- The URLs that are used to communicate Wonderland with the QTI engine. Storing this information outside of the WL-QTI Player, for example, change the address of the newAPIS server is possible, without change anything in Wonderland.

5. CONCLUSION AND FUTURE WORK

The use of virtual worlds allows the assessment of students in a richer way. Even using the same type of questions that many of the traditional tests use, for example a multiple-choice question, virtual worlds allow new types of interactions that facilitate the assessment of more than simple knowledge, as, for example the understanding of the environment.

The use of an assessment specification allows not only the reuse of existing assessment content, but also the use of an existing engine, newAPIS, that can manage the actions that are not directly related with the virtual world, as the processing of the answer.

As a future work our plans include to improve the management of the QTI question-items of the WL-QTI engine by allowing the use of other types of questions that are defined in QTI, not only multiple-choices questions. This improvement would involve the management of new types of actions in the virtual world, for example, the movement of the objects or adding a label to an object.

The WL-QTI assessment engine will be improved to manage the different options that can be included in a QTI assessment test, not only to get the list of questions. For example, to let students choose the questions, between all the available ones, that they want to answer in each moment; or to let the processing of all the answers when the last question is finished, and not make the processing of each question separately.

There are other areas where the expansion of the functionalities of the engine is desired: in the creation of the WL-QTI files and the world. When teachers create the world, they have to add the object in their correct position and must add the different capabilities that they have (for example, the object is the representation of a zone or the object can be selected). A new feature is desired in the engine that allows adding different capabilities automatically for objects by processing WL-QTI files. So teachers only have to put the objects in the world.

Now, there are different tools that teachers can use to create a QTI file with the description of a question, but the WL-QTI file must be created for them. An authoring tool that allows the creation of the QTI files and the WL-QTI file automatically at the same moment is desired.

Future work also includes evaluating the integration of this assessment engine in a real educational context in order to obtain results that would enable us to improve and extend the engine.

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