An Authoring Tool to Develop and Display Courseware in a 3D Learning Environment

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Abstract. Authoring tools are becoming increasingly common, they make it easier and faster to create educational content. Normally, they are based on standard training practices, and the content usually is displayed in two-dimensions. A learning environment that contains a challenge manager to store exercises in a database has been developed as an authoring tool for a 3D educational game. The challenge manager allows teachers with no programming skills to design exercises and problems for the learning environment.

Keywords: Authoring tool, learning environment, courseware.

1 Introduction

An authoring tool is an application development environment for non-programmers, which has pre-programmed elements for the development of interactive multimedia software titles. According to Locatis [3], the term authoring tool refers to a range of software products having utilities for composing, editing, assembling and managing multimedia objects, whereas the term authoring system refers to a subset of these products allowing multimedia development without having to program.

These tools are classified from simple to advanced. The tool is simple when supporting utilities, for example, drag-and-drop facilities and wizard. Advanced tools require programming capabilities to build course material and need technical competency [2]. Some of them are unspecialized authoring tools, such as PowerPoint and Flash, FrontPage and Dreamwaver. For example, Wagner [8] uses PowerPoint as a scenario authoring tool in athletic training. Whereas examples of specialized authoring tools are Presenter, Engage, Quiz Maker, Course Lab and GLO Maker. Prensky [5] proposes to produce new types of training modules that are likely to draw interest from trainees in ways that the current authoring tools don't. For example, by trainees allowing orient themselves by walking around an accurate 3D representation to find clues and solve problems.

Venustiano Soancatl, María-Luisa Cruz, Lucina Torres, Andrea Herrera, Luis David Huerta, et al.

Courseware that is instructional material in an interactive mode facilitates and controls the individualized learning environment for students. It can be used to provide instructional material to a group of students or for the individual student. Courseware can be further subdivided into instructional methods, such as drill and practice, tutorials and problem solving which supplement or enrich the learning environment. The success of developing the courseware is governed by three major factors: the content and pedagogical quality of the learning materials, the amount and character of faculty support in the overall learning situation [1], and the motivational quality of the learning materials

Drill and practice is an author-controlled approach to develop courseware. The aim of this approach is to assume the main responsibility for developing the students skill in the use of a given concept. This involves leading the students through a series of examples where they can practice the material already learned or have it repeated. The assumption with a drill and practice system is that the students have already had the concept presented to them, that the material has been seen before, and the purpose now is to gain and develop familiarity with the ideas. Since the purpose of drill-and-practice is to increase learning effectiveness through repeated practice based on a stimulus-response theory of behaviorism, the frequency of repetition should have a direct effect on achievement. Research suggests that drill and practice-based lessons can be an effective means of teaching students of varying learning styles.

As with many approaches, courseware has some advantages and disadvantages. An advantage is the ability to individualize the instructional process so that multimedia content involves students actively in the learning process. It is impossible for the students to be passive in the situation, therefore the activity and their involvement facilitate learning. Courseware offers fast feedback so students are kept informed of their progress through immediate feedback, presentation and achievement summaries. The learning reinforcement is immediate and systematized. Instructions while developing courseware can be systematically prepared, sequenced, tested and revised. There is the possibility to create generic teaching strategies that can be used with different instructional content to represent abstract pedagogical entities and to design at the pedagogical level. For example: "give a hint" or "teach the prerequisites" [4]. An additional advantage is that courseware frees teachers for other necessary work and thereby increases educational productivity.

The major limitations to the widespread use of multimedia courseware and authoring systems in the educational systems are: 1. a lack of knowledge among the educators as how to effectively use the computer in an educational setting, 2. an insufficient quantity of high-quality courseware, which is closely related to the use of an inefficient authoring tool, 3. problems associated with the amount of time needed to develop materials and the difficulty of finding qualified and experienced instructional designers and computer programmers.

Some of the main features that an authoring tool should have are: 1) a user-friendly interface that projects usability, simplicity and ease of use. The user simply has to select the button to load the media object visible on the template

and use separate media editors to import the media files. 2) a database that is able to store, retrieve, update, sort and delete records. It makes it easy to improve content that has already been prepared for a specific use.

This paper describes authoring tools that can be used to easily develop courseware by teachers and domain experts with no programming skills by following the drill-and-practice approach. However, it also can be used for problem solving as described in [7]. Additionally, the content is presented in an attractive 3D learning environment to engage young students.

2 System Design

The 3 main components of the system are, a database, the Challenge Manager and the 3D learning environment. The database is shared between the Challenge Manager and the 3D learning environment, as shown in Figure (1). The Challenge Manager is mainly designed for teachers and domain experts, and the 3D environment for junior high or middle school students. The database stores information about the challenges, which can be questionaries, quizzes or step-by-step solved problems.
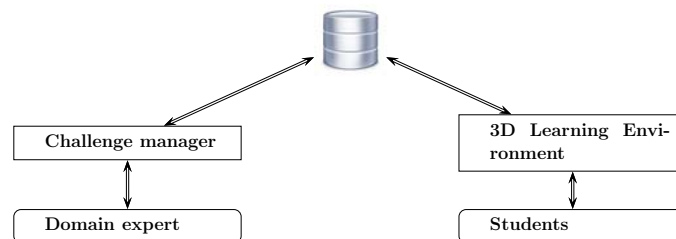

Fig. 1. System main components

2.1 Database

There are three main entities in the database: challenges, objects and users. A challenge is composed of a main statement, a figure linked to the statement, a time limit, a hint or recommendation, points, difficulty level, and a set of steps that lead the students to find the way to solve the challenge. A step is composed of a multiple choice question and if necessary a recommendation. A tip can be represented by text, a formula or an image. In this way, challenges can be questions or problems from any domain, such as math, history and even foreign languages. Challenges can be designed by teachers or domain experts and each challenge is linked to an object in the 3D environment.

Objects are fixed elements in the 3D environment and can be 2D images or 3D models. There are about 60 objects in the scenery which can not be

modified nor changed. Each object has a stored description and a position in the 3D environment. 2D images are famous philosophers or mathematicians and famous archeological places, such as, Teotihuacan, El Palenque and Machu Pichu. Additionally, architectural structures like the Big Ben in London and the Eiffel Tower in Paris are included to stimulate interest and interaction between the students and virtual environment.

In order to navigate in the virtual environment each user must have an account with a nickname and password. For each user, the database stores their name, age and gender. Also, it stores statistical information about the users such as the number of sessions in the system, how long the users use the system, number of conquered challenges, number of mistakes, number of attempts to conquer a challenge and scored points.
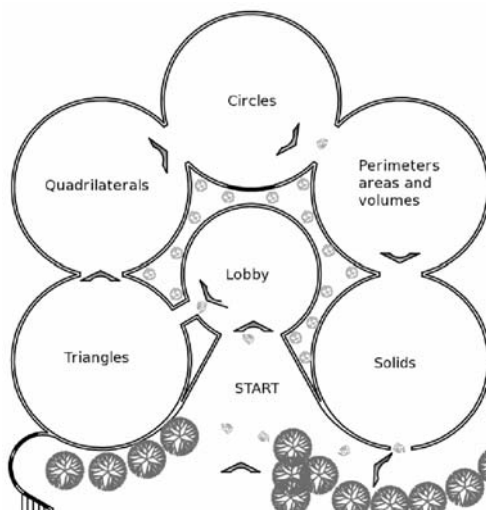

Fig. 2. Five main museum rooms

2.2   3D Learning Environment

The 3D learning environment is specially designed for students who like to play video-games focusing on the Game Based Learning approach as described in [6]. It is designed as a museum and the domain or main theme chosen to give examples is geometry. The museum has five rooms (Figure 2) and is called Geometry Virtual Museum (GVM). The GVM loads the challenges stored in the database and displays them as mentioned above. Each challenge is linked to an object and can be associated with multiple challenges. These objects can be images on the walls or 3D models such as platonic solids.

Figure (3) is a screenshot of the GVM showing elements taken from the database, such as pictures, the player nickname and score, the challenge, a

chronometer, the multiple choice question and the possible answers floating as balloons in the scenario. Users can navigate all around the GVM just as in a first person shooter game, but instead of a gun, users have a laser pointer and instead of projectile weapon-based combat, users interact with pictures and geometric challenges in the scenario. Every time users point on a picture, a short description of the picture is displayed on top of the screen. A click on a picture makes the system display a challenge step by step.

Fig. 3. Geometry Virtual Museum

The process of displaying a challenge, quiz or a problem is very simple, once a picture is clicked. The system displays the first challenge which starts with the main statement at the top of the screen and a chronometer begins. After a few seconds, the first multiple choice question is displayed at the bottom of the screen and choices are displayed in the 3D environment. If the correct choice is made by the user, the system displays a congratulating message and displays the next question (step). However, if the choice is incorrect, then a "try again" message is displayed on the screen. A recommendation can also be added to aid finding the correct solution. Also, to make the user think twice before making a wrong choice, they can be sent back to questions to refresh their memory. This process continues until the last multiple choice question is done, which increases the users' point score. Then the user can look for the next challenge to conquer. Additionally, when a challenge is displayed, it is stored in the database whether

it is overcame or not. Every mistake and the time taken to conquer the challenge is recorded for teacher reference. Thus, the question difficulty and effectiveness can be analyzed and adjusted.

2.3 Challenge Manager

The Challenge Manager (CM) allows teachers and domain experts to design instructional content to be included and displayed in the GVM. The process to design and integrate this content is very simple. The first step is to select the domain and five main themes, since the GVM has five rooms. For each main theme, it is possible to add as many subthemes and subsubthemes as the domain experts need. Figure (4) shows a schematic with themes and subthemes.
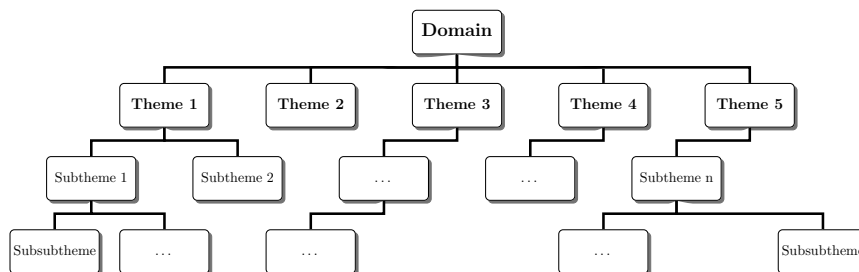

Fig. 4. Themes and Subthemes

The second step is to save the main theme names in the database using the CM. As mentioned above, each main theme corresponds to one room in the GVM. Every room has at least 10 objects on the walls. The third step is to design the challenges for each theme and subtheme, which can be quizzes or problems including multiple choice questions. The choices can be text or images. Challenges can be done using a simple text editor or a word processor. Figure (5) shows the structure of a challenge.

The fourth step is to add the challenges in the GVM using the CM. Since it has been designed to be used for non programmers, it is very easy to add instructional content into the GVM. It is necessary to choose one of the main themes saved in the second step, then the CM selects only the objects in that room. The domain experts can move through the objects and select one to link a challenge. Once an object is selected, it is possible to add a challenge to be displayed in the GVM.

Figure (6) shows a screenshot of the CM that is divided into three main vertical sections. The left section allows the domain expert to add five main themes and their subthemes. This allows them to select an object in the GVM in order to attach a challenge. The middle section permits the addition of a main statement of the challenge, a 2D image or figure associated to the challenge, a recommendation and points. It also permits the ability to update and delete
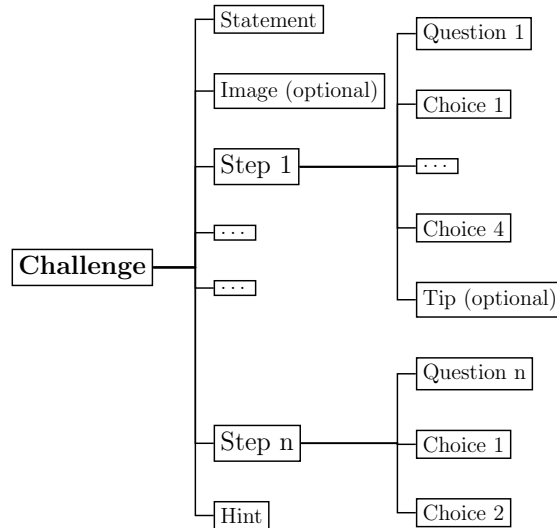
Fig. 5. General structure of a challenge

a challenge or to move through the challenges linked to the object. In order to delete a challenge from the database and GVM, it must not have any steps associated. The right section allows the addition of challenge steps (multiple choice questions) and a recommendation can be added if necessary. Choices can be text or images and for each challenge any number of steps can be added. It is recommended not to add too many steps since it can be tedious for the students. It is also possible to update and delete steps. The CM was developed using the programming language C# and SQL Server Compact Edition was used as the database manager.

2.4 Challenge Requirements

The design of challenges for the GVM has some requirements and limitations, for example, with the multiple choice questions, the first choice must be the correct answer. It makes it easier for teachers and domain experts to validate and review the correct answers and since choices in the GVM appear in a random order, students will not know the correct answer beforehand. The maximum number of words for a challenge statement is 40 or the maximum number of characters is 200. The maximum number of words for a step statement is 30 or the maximum number of characters is 125. The maximum number of characters for a text choice is 15. These text length restrictions allow the GVM to display text clearly in the scenery otherwise the text will be unreadable. The proportion between width and height or height and width of an image in the GVM should be 1.33 for aesthetic purposes.
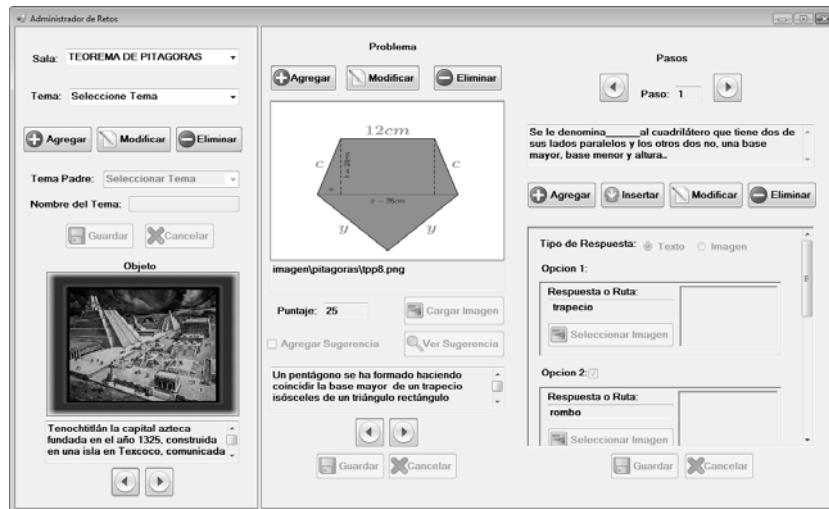
Fig. 6. Challenge Manager.

3 Examples

A possible challenge to be included in the GVM is the following: compute the volume of the building (Figure 7). Keep in mind that the side of each square is 5 meters.
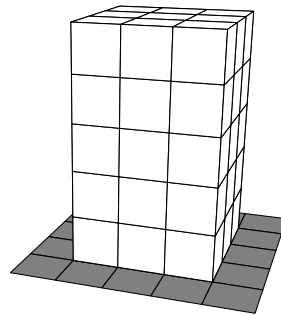

Fig. 7. Building

1. The formula to compute the volume of a quadrilateral prism is

(a) $V = L \times W \times H$ (c) $V = L^3$
(b) $V = L \times W$ (d) $V = W \times H$

TIP: Remember, the volume of a quadrilateral prism is the area of the base × the height.

2. The area of the base is

   (a) $225m^2$ (b) $125m^2$ (c) $325m^2$ (d) $225m^3$

3. The height of the building is

   (a) $25m$ (b) $15m$ (c) $25m^2$ (d) $45m$

4. The area of the base multiplied by the height is denoted by

   (a) 225×25 (b) 225×15 (c) 225×35 (d) 215×25

5. Solving the problem, the volume of the building is

   (a) $5625m^3$ (b) $5625m^2$ (c) $5625m^4$ (d) $5625m$

The above example is very simple and guides the student step by step through the process of solving the challenge, but more complex challenges can be designed. Additionally, different approaches can be used, for example, the problem solving Polya's method, question-led learning, action learning, learning by mistakes and others. The next example shows a challenge designed for non English speakers that can be included in the MVG

Challenge: Respond to the following questions about Chichén Itzá, which is one of the principal archeological sites on the Yucatán peninsula.

1. This is a photo of a

   (a) pyramid   (b) house   (c) monument

2. The base is a

   (a) square   (b) circle   (c) triangle   (d) rectangle

3. How many sides does the pyramid have?

   (a) four   (b) three   (c) forty

4. What is in the sky?

   (a) clouds   (b) rain   (c) snow

4   Conclusions and Future Work

This paper describes an authoring tool that is designed to be non-technical and uses a familiar interface that increases usability. The tool is designed to provide assistance to teachers and students in putting together simple courseware. It displays content in a dynamic 3D learning environment where students can learn the content and get feedback immediately. Furthermore, domain experts can use multiple teaching strategies to develop courseware and the drill-and-practice is an approach that can be easily integrated in a courseware using this tool.

In the future we intend to add artificial intelligence to the GVM in order to increase flexibility and the speed in adjusting the exercises according to the users' responses and skills. By adjusting the level of difficulty and preventing the use of questions that are either too difficult or too easy, user interest will increase by avoiding boredom. Further work to the system will allow the reproduction of video and audio recommendation and will make the 3D learning environment work in network in order to allow many users surf at the same time.

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