Easing Assessment of Game-based Learning with <e-Adventure> and LAMS

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ABSTRACT

The increasing acceptance of video games as learning tools has promoted new studies on how to include them in the teaching-learning process. An interesting trend is the use of modern web-based Learning Management Systems (LMS) as a delivery platform for games and the integration of the information that can be extracted from the game-play sessions into the already existing tracking and assessment tools of the LMS. However, while LMS are increasingly supporting advanced tracking and assessment features, current LMS and standards are not ready to track the students' activity in highly interactive content such as games. In this paper we present the integration of games created with the <e-Adventure> educational gaming platform into Learning Activity Management System (LAMS). This integration allows teachers to use the information gathered during a game-play session to conduct the student through different activities of the learning plan or simply to collect more information that can be used for further assessment and tracking purposes.

Categories and Subject Descriptors

K.3.1 **Computers and Education**: Computer uses in education – *distance learning, computer-managed instruction*;

K.8.0 **Personal Computing**: General – *games*.

D.2.13 **Software Engineering**: Reusable Software – *domain engineering, reusable libraries, reuse models*;

General Terms

Design, Economics, Human Factors.

Keywords

<e-Adventure>, assessment, educational video games, Learning Activity Management System, Learning Management System.

1. INTRODUCTION

Educational video games are gaining acceptance as a highly interactive multimedia content for distance education and as a complement to more traditional approaches. Several enhancements of the learning processes are attributed to educational video games, such as a considerable improvement of students' motivation and engagement [1, 2] or the potential to provide authentic learning experiences where students face open-ended real problems [3, 4].

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Nonetheless, the application of video games in education is not free of barriers [5, 6]. One of the most relevant challenges faced by teachers and instructors is how to evaluate the learning outcomes of the game-play sessions. Instructors need to rely on debriefing sessions, post-tests or debates to determine the achievements of the students [7]. Although the assessment of game-based learning experiences may be facilitated by using the tracking and assessment features present in modern Learning Management Systems (LMS) like *Moodle*™ [8], most LMS are not prepared to track the activity of students for highly interactive content such as video games.

In this paper we present our work to integrate the <e-Adventure> educational gaming platform and the Learning Activity Management System (LAMS), and discuss how the combination of both platforms facilitates tracking and assessment of game-based learning experiences. Both <e-Adventure> and LAMS are opensource tools, and they were chosen due to their increasing impact as research platforms for innovative learning solutions (as an educational gaming platform and as an adaptive learning platform respectively). Our solution allows the generation and processing of in-game assessment information to be used by the LMS to modify the learning sequence and provide further feedback for the instructor.

This paper is structured as follows: First in Section 2 we analyze some of the current approaches and open issues related to assessment of the students' performance in game experiences and LMS. Next, we describe <e-Adventure> and LAMS, focusing on their assessment capabilities (Section 3). After that, the integration of both e-Learning tools is described (Section 4). In Section 5 we analyze how game-based learning experiences can be tracked using the LAMS monitoring view. Finally, in Section 6 we discuss the advantages and drawbacks of our approach and outline future lines of work.

2. ASSESSMENT IN GAME-BASED LEARNING AND LEARNING MANAGEMENT SYSTEMS

Current LMS try to cover all aspects of the teaching-learning process from course creation to content management [9]. The assessment of student performance, as one of the key aspect in this process, is very present in these systems with special focus on tests and questionnaires, as well as in tracking the activity of each

individual student within the course. This does not only refer to the evaluation of the *knowledge* gained by the student but also to the evaluation of the whole *learning process*.

For instance, to evaluate the knowledge gain, modern LMS usually include online questionnaires and tests. In this sense, the IMS Question and Test Interoperability allows the definition of test and questionnaires and the storage of data about the assessment of the student in a standard way, fostering reuse [10]. Other standards, such as SCORM [11], allow storing information about the assessment of the students (e.g. score and completed) through their interaction with learning contents. In regard to the evaluation of the learning process, current LMS keep interaction logs that store information about what each student does in the system (e.g. the time spent by the students in each content/activity, the number of accesses, timestamps, etc.) that can be accessed by the instructor. These logs can be used as formative and summative assessment [12]. However, while these data logs can be used to evaluate the learning process [13], their reliability is conditioned by the kind of the content stored. When the LMS is populated with web pages, it is not feasible to know whether the student was really doing something or just went away for coffee. Current LMS and standards (e.g. SCORM) were not developed to track the actual interaction of the students with highly interactive content such as games and simulations (although this has been identified as a future direction for SCORM [14]).

Games are usually sold as closed products that are difficult to adapt and which do not allow extracting information from the user. Therefore when existing games (e.g. Civilization™) are repurposed for education it is difficult for instructors to gather information about what the student is actually doing in the game. As a consequence, the most common approach to evaluate students' performance in games is the organization of post-tests or debriefing sessions where the students fulfill surveys about their game experience and discuss the results with peers and the instructor in an open debate [15]. It also common to use pre- and post-tests where instructors can identify whether students improved their knowledge after the game experience.

Nevertheless, video games and simulations could implement further assessment mechanics that relieve the instructor of most of the tasks above described. Game and simulation technologies allow the implementation of tracking systems that record students' interaction. The interaction log produced could be used to evaluate the performance of the students and produce an assessment report that would be provided to the instructor. For example, some authors work in the direction of extracting user information indirectly to avoid introducing external elements to the game itself and thus maintain the flow [14].

Should future LMS include a mechanism to keep information about the execution of interactive content like video games, the task of assessing the learning process could be facilitated as more accurate information would be available for the instructor.

3. THE <E-ADVENTURE> AND LAMS PLATFORMS

The solution we propose is based on the integration of existing educational gaming tools and adaptive e-Learning platforms. We have chosen LAMS and <e-Adventure> as our reference platforms due to their opensource nature and their focus on the development of innovative web-based learning scenarios. In this section we describe both tools with special attention to their assessment capabilities.

3.1 About <e-Adventure>

<e-Adventure> [16] is an authoring platform for educational video games and simulations that requires no programming skills. The platform focuses on the *point-and-click* adventure game genre. Using this platform, educators can create their own educational video games from scratch, adapt existing games for their own needs, or edit and revise games to add educational value. In this sense, <e-Adventure> provides educational features that other popular game authoring tools (e.g. *Unity*™, *GameSalad*™, etc.) usually do not provide. We want to point out two of the most important educational features: the assessment reports and the integration with popular LMS through different exportation profiles for the games (e.g. *Moodle*™, *Blackboard*™ or *Sakai*™) [8].

The <e-Adventure> platform has a rule-based assessment engine which allows the identification of game states that are relevant from an educational point of view [16]. The assessment engine is configured through the assessment profile (Fig 1) where each relevant game state is mapped with an assessment rule using the <e-Adventure> conditions system (Fig 1.a). When the game reaches a state defined by a condition, the rule triggers an action that can write down a human-readable log line in the assessment report (Fig 1.b), assign values to user-defined variables (Fig 1.c) (e.g. setting "score" to "20"), or both.

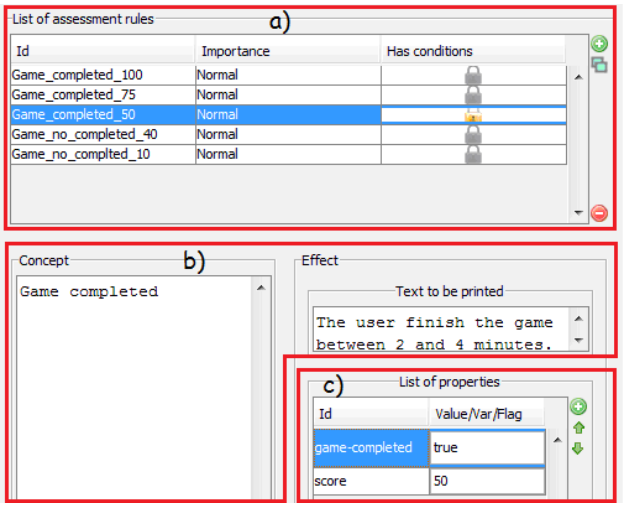

Fig 1. An extract of <e-Adventure> assessment profile edition panel. It allows (a) defining conditions over the game state, (b) adding text to the assessment report (c) and assigning values to variables.

The assessment data (i.e. the human-readable report and the final value of the variables) extracted during the game experience can be delivered to the teacher in different ways. When the game is deployed in a LMS, the variables can be attached to the student's profile by following the SCORM CMI data model [17] or an ad-hoc solution for the specific LMS. The <e-adventure> editor hides the technical difficulties related through the use of different exportation profiles, which allow exporting the same game for a variety of specific systems. In addition, the assessment report can

be sent to a specific e-mail account or saved to a local drive. Besides, <e-Adventure> can show this report to the student at the end of game for self-assessment.

3.2 About LAMS

The Learning Activity Management System [18] is an advanced LMS that provides three different views: an *Authoring View* (Fig 2), a *Learner View* and a *Monitoring View*. The *Authoring View* allows the design of teaching-learning plans based on the sequencing of different activities. The *Learner View* is in charge of the execution and orchestration of the designed sequences of activities. The *Monitoring View* allows tracking and monitoring of the students' progress through the activities sequences. While the *Authoring* and *Monitoring* views are oriented to the instructor, the *Learner View* is oriented to the student.

The LAMS *Authoring View* includes an intuitive visual authoring tool with an extensive library of activities (e.g. survey, mind maps, Q&A, wiki, etc.). Moreover, there are flow activities which allow modifying the execution order of the included activities. With these special activities educators can define alternatives paths (a.k.a. *Branching* Activity), optional activities, halt the sequencing until a condition is met (a.k.a. *Gates or Stop Point* Activity), group students or define activities outside the main sequence (i.e. activities that are always accessible, without going ahead or back in the sequence to access them). Educators can control automatically the sequence's flow by defining conditions using the student's outcomes of previous activities or using other criteria (e.g. select the time to open a gate, close gate until all students reach it, etc.). Besides, educators can optionally select the flow at runtime for each student at *Monitoring View*.

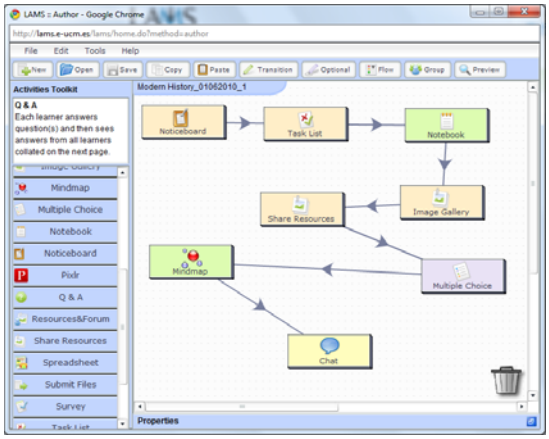

Fig 2. The LAMS *Authoring View*. We can see the sequence of a history lesson extracted from the LAMS sequences repository[1].

LAMS activities are grouped together taking into account their main characteristics. For example, the *Collaboration* group includes activities that require the joint participation of students and the *Content* group includes activities such as image gallery, content packages and files. There are two groups closely linked with the assessment of the educational gain in LAMS: the *Assessment* and *Response* groups. The *Assessment* group contains activities for evaluation and examination (such as a *Multiple Choice* and *Assessment* Activities). The *Response* group has activities to create surveys and questionnaires for the students. All these activities can generate information that can then be tracked by the teacher using the *Monitoring View*.

[1] http://lamscommunity.org

4. INTEGRATION OF <E-ADVENTURE> IN LAMS

The integration of <e-Adventure> in LAMS has required development on both sides. First, a new kind of activity has been implemented in LAMS to introduce <e-Adventure> games in a sequence of activities. We have implemented a *Tool* for managing a game activity within all LAMS views. Second, a new exportation profile has been created to configure games for the specific packaging and communication tasks required by LAMS. The <e-Adventure> Activity is added to the Assessment group due to the high amount of information that can be extracted for evaluation purposes.

Since version 2.0, LAMS adopted a modular architecture. In this new architecture, the core is responsible for managing services for the different LAMS views, controlling the contents and the activity flow and storing the structure of the learning design. The LAMS architecture uses a LAMS *Tool* (i.e. a wrapper) to manage the content of each learning tool present, which communicates with the LAMS *Core* to ask for services and responds to the *Core*'s request about expected behaviors. This architecture allows a separation between the learning design (*Core*) and content management (*Tools*). The main advantage of this design is the possibility of adding new LAMS *Tools* by following a set of requirements known as *LAMS 2 Tool Contract* [19] that has a different API for each LAMS view and one specific for general services.

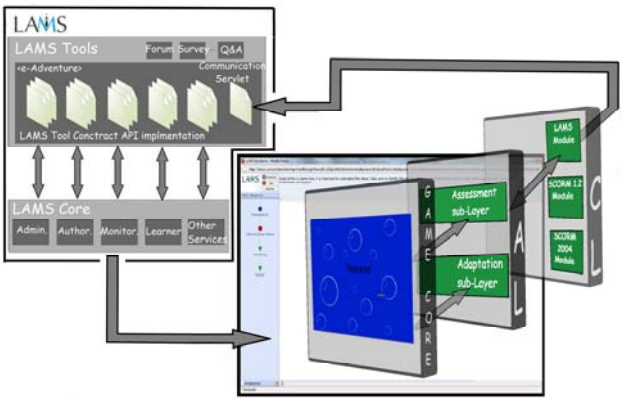

Fig 3. Diagram showing the architecture of the integration of <e-Adventure> in LAMS. The <e-Adventure> integration architecture and its connection with <e-Adventure> Activity in LAMS are showed.

On the other hand, the <e-Adventure> games are built with a flexible architecture that allows the integration with a wide range of LMS without demanding from the game author any kind of knowledge about standards or implementation details of the LMS [17]. This architecture is composed of two layers (Fig 3). The *Communication Layer* (CL) is responsible for managing the game communications from/to LMS. The *Assessment and Adaptation Layer* (AL) is responsible for interpreting the data received from

the CL. In addition the AL monitors the student interaction and uses the assessment profile that is embedded in the game to identify game states that are relevant from an educational perspective. When one of these states is reached, the AL notifies the CL to send the appropriate data to the LMS. The architecture allows exporting the same game for different environments by configuring both layers. The AL can be configured with the *Assessment* and *Adaptation* profiles by defining conditions over the game/LMS state and actions when these conditions are meet that changes the state of LMS/games respectively. The CL is configured by selecting one specific exportation profile when the game is packaged as a Learning Object.

We had to solve some technical issues to add the new exportation profile in the <e-Adventure> editor which allows deploying the games in LAMS. In this sense, we had to add a communication module implementing the related requirements of the *LAMS 2 Tool Contract.* The LAMS communication module in the *Communication Layer* provides support for RESTful calls. At exportation time the game is packaged following the IMS CP specification, adding an extra file which contains the assessment variables and their types (e.g. Boolean, Numeric) extracted from the assessment profile.

We also have followed the *Tool Contract* for each LAMS View in the development of the <e-Adventure> Activity. The <e-Adventure> *Tool* controls the game at sequence design, when it is executed and when it is monitored. Using the LAMS *Authoring View*, if a game is added in an <e-Adventure> Activity, the file with the game assessment values is parsed. The values extracted from this file are stored in the <e-Adventure> *Tool* to be used in the *Condition Tab* for defining LAMS conditions. The conditions defined can be used for automatic control of *Branching* or *Stop Point* Activities. The author also can select other features related to <e-Adventure> games, such as the name of the activity or the instructions to be shown in *Basic Tab* and *Instructions Tab.* The *Advanced Tab* allows configuring two options: whether the activity can be executed more than once, and whether the activity can be skipped by pressing the "finish button".

When the sequence execution reaches an <e-Adventure> Activity, the *Learner Module* asks the <e-Adventure> *Tool* for the game that needs to be launched. When the execution starts, the <e-Adventure> *Tool* sends information about the user, the session and the URL base to establish the communication. In our LAMS *Tool* we added a Servlet configured to hear a specific URL pattern (i.e. /eadventure/*). When an assessment rule is satisfied or the game ends, the *Assessment and Adaptation Layer* sends data to the Servlet through the URL received, adding the user and LAMS session identification received at game start to generate a Representational State Transfer (REST[2]) URL. For example, when the game sends a "completed" signal, the CL generates an URL with the value, such as:

*http://lams.e-ucm.es/learner.do**/eadventure/userId/session/id/completed***

The Servlet receives the data and stores the value with the user and session id read from the URL. This way the data are stored uniquely in LAMS databases for the <e-Adventure> Activity in relation to the user who ran the game in a particular session.

[2] http://en.wikipedia.org/wiki/Representational_State_Transfer

Finally when the execution reaches a *Branching* or *Stop Point* with a condition that depends on game variables, the LAMS *Core* asks the <e-Adventure> *Tool* to resolve the value of the variables. The conditions are evaluated on the tool side, returning a boolean value. Similarly, the teacher can check the assessment profile of each student in the *Monitoring View*. When the *Monitoring View* is opened for one <e-Adventure> Activity in a particular sequence, the LAMS core asks the <e-Adventure> *Tool* for the Assessment Report of all students who have started the sequence.

5. MONITORING OUTCOMES FOR <E-ADVENTURE> GAMES IN LAMS

The main aim of introducing <e-Adventure> games in LAMS is to provide a holistic learning solution that facilitates the use of games throughout the teaching-learning process, taking advantage of the synergy of both e-Learning platforms. On the one hand, <e-Adventure> allows educators to exploit the possibility of notifying the learning outcomes through an easy to configure assessment engine. On the other hand, LAMS eases the creation and monitoring of learning designs by educators, where the sequence flow and activity presentation can be modified by using the students' results in previous activities. Merging the assessment and flow control features present in LAMS with the evaluation of the game experience the educator can design sequences where the students' outcomes at game experience are taking into account as in other LAMS assessment activities.

5.1 General View

When educators decide to use a video game in a learning sequence, they can configure some features to enhance the use of video games within LAMS learning designs. The instructors can define complex conditions using the assessment variables defined in the <e-Adventure> assessment profile. On the LAMS side, for a *Branching* Activity, each condition can be mapped to one branch. For a *Stop Point* Activity, the sequence will be halted until the condition is met.

Whether the game has been developed by the educator or taken from a repository and adapted, the educator can use the variables from the <e-Adventure> assessment profile as LAMS conditions or use the <e-Adventure> Activity *Conditions* Tab to combine variables in order to express more complex states and combinations, and connect them into LAMS sequences.

In order to provide explicit support to common patterns, all <e-Adventure> games have four predefined variables: score, game-completed, game-time and real-game-time, although new variables can be defined. However, even with this small set several distinct situations can be expressed. For example, by combining "score" and "completed" the game author can express a set of game states where the main objective is achieved (e.g. completed is true) in different degree (e.g. with score = 100, score = 85, etc.). Also the variable "completed" can be connected with the "block finished button" at the *Advanced* Tab. If this option is selected, the LAMS button which changes to the next activity will be hidden until the <e-Adventure> game returns this special variable called "completed" set to true. This way the sequence can be halted without defining a *Stop Point* Activity.

In LAMS the educator can also control the flow at runtime if the selected flow activity is set to "Teacher Allocated" mode. The <e-Adventure> assessment reports gather as much information as

variables do, but present it in a textual way. Given that these reports are available for the instructors at monitoring, they can use them as formative assessment to decide the path manually for each student or to halt their progress until desired. Also, the assessment report can be used as summative assessment to add data about what the students know after the game execution into the collection of assessments gathered throughout all the activities in the sequence both in *Monitoring View* and into a single portfolio. Although the games are not assessment content *per se*, the information extracted from the games can be used to evaluate the accomplishment of the objectives established for the learning design.

5.2 Case Study

We have developed a LAMS sequence with an <e-Adventure> game as one of its activities in order to illustrate the ideas exposed in this paper. Following the LAMS philosophy that advocates for the reuse of learning designs, we adapted a preexisting learning design about the social movements in USA during the 50's and 60's, targeted at 11 years-old students extracted from the LAMS Community repository. We repurposed the sequence to teach about the historical events occurred in 1492 in Spain. We have followed the initial structure presented in the original sequence but we have changed the educational content to adapt it to the selected curricula. The main change in sequence's structure was to add a *Multiple Choice* Activity to evaluate the students' knowledge about the main events of this period in Spanish History: the conquest of Granada by the Catholic Monarchs and the discovery of America.

After these activities, the students play the 1492 game, an <e-Adventure> educational game set in the atmosphere of the Conquest of Granada[3]. The game is structured in three chapters, one for each main concept in the sequence where the students will have the opportunity to experience through an avatar the most important events. The game has an assessment profile which uses the predefined variables and generates an assessment report. The variable "score" depends on the student's answers in each in-game test. Therefore, the "completed" variable will not change until the student reaches the end of the game and has a basic knowledge of facts that took place in 1492.

This is precisely the key point of this case study. We want to condition the execution of the learning experience depending on the outcomes of the in-game tests. In order to illustrate the flexibility of the approach, we detail three alternative designs for this part of the sequence combining the <e-Adventure> assessment and LAMS flow control.

Approach #1: A first solution is to add a *Branching* Activity after the game with three branches (Fig4a). We have defined three LAMS conditions in the <e-Adventure> Activity using the "completed" and "real-game-time" variables. If the students achieve a high grade (e.g. score>=80) in less than 15 minutes, they will go to a branch with a summary of the main concepts. If the students achieve a medium grade (e.g. score>50 and score<80) spending between 6 and 20 minutes, they will go to a branch to reinforce the concepts, and with the same information as the first branch. If the students do not meet both conditions, they will go to a third branch with supplementary materials.

Approach #2: In the second solution we have added a *Stop Point* after the <e-Adventure> game (Fig 4b). We have mapped the second condition expressed in **Approach #1** with this flow activity, meaning that, while the student does not meet this condition, the *Stop Point* will be closed. This way the student will be forced to repeat the game to achieve the minimum requirements. In this case we have activated the option of showing the <e-Adventure> assessment report at the end of game execution in order to provide information to the student so that he/she can identify the main mistakes.

Approach #3: In the third solution we have used the "Teacher Allocated" option for the flow activity. We will analyze this solution for both designs, using the *Stop Point* and the *Branching*. When the students finish the game, the teacher can read the assessment report at *Monitoring View* and decides whether to force the student to repeat the game (*Stop Point*). For *Branching*, the teacher can decide which will be the next branch to follow.

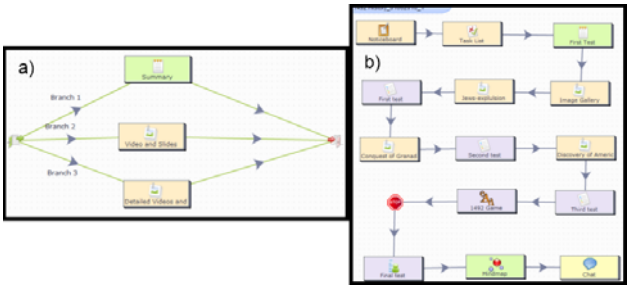

Fig 4. The learning design used for the case study. The initial design (Fig 2) has been adapted to the selected subject. This figure shows both design strategies: (a) using a *Branching* (detail of the structure of the branching, the design is the same for both alternatives but changing the flow activity) and (b) using a *Stop Point*.

When the sequence ends, the teacher can gather both the <e-Adventure> reports and the assessment information for each LAMS test in a portfolio.

6. DISCUSSION AND FUTURE WORK

Game-based learning is an educational approach with a great potential. However there are some barriers that hinder the adoption of educational games, including the difficulty of evaluating the learning process and the educational gain when video games are used. This issue could be addressed by integrating the games with assessment capabilities in modern LMS that include built-in assessment features. In this manner the back-end LMS that deploys the games could be used to store the results of the game, attach them to the students' profile just as any other questionnaire or online test, and allow the teacher to track the students using the features provided by the LMS.

In this paper we have presented how we have integrated the <e-Adventure> game platform into the LAMS LMS and how this facilitates the assessment of the educational gain. Besides, the integration of <e-Adventure> in LAMS opens new possibilities in the use of video games inside learning designs allowing that game outcomes can be used to modify the sequence flow. As we depicted in the case study, the use of the <e-Adventure> Activity in a design does not force teachers to follow any specific

[3] The first chapter is available http://e-adventure.e-ucm.es/course/view.php?id=18&lang=en_en_utf8

educational strategy so it is enough flexible to adhere to many different ones. One of the strong points of LAMS is the sequences' exportation to add them into a repository. Therefore educators can share and reuse not only a specific learning design for a particular subject, but also the underlying pedagogical design. Thus different examples about how use game into a learning sequence will be shared and discussed in order to improve the integration of video games into learning settings.

The flexibility of the sequences with <e-Adventure> games does not finish in the reuse or the modification of the pedagogical design but also it allows modifying the game itself to adapt to a new educational situation. The educators can modify the <e-Adventure> assessment profile or add a new one in an intuitive way. Thus, different in-game situations can be evaluated without the need of large development investments. This task is even easier if the original game developer used the predefined variables (i.e. score, game-completed, game-time and real-game-time), even if they are less expressive that customized profiles.

We want to emphasize that these games are not assessment elements by themselves and their main aim is neither to measure the students' knowledge nor to substitute other learning tools designed specifically for that purpose. However it is interesting to use their high interactivity in combination with the LAMS assessment and tracking features to modify the flow of the learning sequence, either automatically or through instructor intervention. In this sense, the information extracted from the games can be considered as summative and formative assessment.

Finally, our next research and development efforts will focus on giving support to the adaptation features offered by <e-Adventure> in LAMS. We expect the games to be able to modify their execution to adapt the game experience to each student taking into account the student's performance in previous activities. Other future lines of work are related to the development of specific modules that allow a further integration of <e-Adventure> in other LMS such as *Moodle*™ or *Sakai*™ going beyond the actual integration level of <e-Adventure> in these systems which is limited to the IMS-CP and SCORM specifications. Finally we are planning to develop a new exportation profile for IMS Common Cartridge.

7. ACKNOWLEDGMENTS

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