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INTEGRATING SERIOUS GAMES INTO E-LEARNING PLATFORMS: PRESENT AND FUTURE

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***Abstract**: Simulations and Serious Games (SGs) are very promising educational tools as they include new powerful characteristics such as learner engagement or authentic environment for learning. Moreover SGs are highly interactive applications that can provide valuable information about the in-game students' interaction. Educators can take advantage of this information with different purposes such as students' assessment, evaluation of the game design or for learning analytics purposes. But there are several open issues that should be addressed related to the fully integration of games into e-Learning platforms. This paper presents our experience integrating SGs into existing e-learning platform using the SCORM standard. This paper also discusses how the current e-learning standards trends will affect SGs integration on the existing and future educational platforms by exploring the possibilities of the next SCORM generation.*

***Keywords:** serious games, eAdventure, e-learning standards, SCORM, LMS, Moodle,*

I. INTRODUCTION

Serious games are a very promising educational content in e-learning as they can improve the interactivity, increase user engagement and provide a more authentic learning experience [1], [2]. Therefore SGs offer to educators an innovative and interactive instrument that can be used to support new models of teaching [3]. Currently, there is a discussion about what are the contexts and educational settings where SGs can be more adequate and cost-effective. But it is clear that the interactions of students while playing SGs can generate a tremendous amount of valuable information. If this interaction data is available and presented in an coherent way it can be used with different purposes such as learner assessment, evaluation of the usefulness of the game in the curricula or discovery game design errors [4]. But to obtain all these benefits some open issues should be address such as the full integration of the serious games with the e-learning platforms (a.k.a. Learning Management Systems – LMS) that allows for a better communication of user data. This will open the possibilities for new applications such as an automatic user/student assessment based on the performance demonstrated in the educational game. Nonetheless, there are some open issues that hinder the exploitation of the data that games can communicate: (i) *how is the SG delivered and how the learner access to it?*; (ii) *what data is gathered and how is stored?*; and (iii) *how this data can be used for learner assessment?*.

But as there are a great variety of SGs types and genders [5] there are no general models dealing with the integration of SGs into LMS. This same issue has been previously addressed with other educational contents by using standards (e.g. SCORM [6]), however these standards were not

conceived for communicating highly interactive content with LMSs. Hence, these aspects that are not fully covered requiring extra development effort.

The integration of any kind of SGs in any standard compliant LMS is too ambitious. In this paper we describe the integration of adventure games produced with the eAdventure platform [7] into a SCORM compliant LMS (i.e. Moodle). SCORM is the *de facto* global e-learning standard which includes some communication capabilities. eAdventure is an authoring environment designed for educators that allows for the creation of SGs without requiring any programming. eAdventure can pack and export SGs as SCORM compliant learning objects.

This paper is organized as follows. The section II revise the Learning Object model (LO) [8] and analyzes how the standards comprised in SCORM foster the interoperability of different factors such as delivery or communication and how the games created in eAdventure can be exported as SCORM packages. The section III illustrates how eAdventure games can be integrated in Moodle as SCORM packages by answering the open issues previously identified. In addition this section presents some of the pitfalls of SCORM when it is used for games' integration. In section IV we present the features of the Training and Learning Architecture (currently under development) focusing on how Experience Tracking (part of TLA) overcomes some of the problems related to SCORM presented in section II. Finally, we present the conclusions and future work.

II. E-LEARNING STANDARDS, LEARNING OBJECTS AND SERIOUS GAMES

The Learning Object (LO) approach is a wide accepted model for re-use, maintain and deploy educational contents in different LMS. Different organizations related to learning, education and training domains such as the Advanced Distributed Learning (ADL), the IMS Global Learning Consortium (IMS GLC), the ISO JTC 1/SC 36 committee, the CEN/TC 353 committee, etc., have been working in the definition of standards and specifications to ease the interoperability of LO. These standardization efforts are related to different aspects (i.e. tagging and packaging, communication, sequencing that affect the creation of educational contents and their deployment into LMS. Although these standards were developed without having in mind the high interactivity of SGs, they can be used with games to tackle the same issues.

In this section we first present how SCORM standard foster LO interoperability. Then some problems found when using SCORM to obtain games packing and interoperability are also presented.

2.1 SCORM components

ADL developed a Reference Model for Shared Content Objects (SCORM) composed of an application profile that uses different e-learning standards and specifications for LO packaging, tagging, communicating and sequencing.

For *content tagging*, SCORM include the IEEE Learning Object Metadata (LOM) standard [9] which establishes the data that are relevant while describing a LO, divided in a wide range of characteristics and organized in several categories. LOM includes additional information to simplify storage, searching and recovery to help when contents could be re-used. SCORM uses IMS Content Packaging specification (IMS CP) [10] which provides a way to *encapsulate LO* as zip files that include all required assets. This packages include a file know as "*manifest*" that shows the structure of the assets and the associated metadata. In SCORM, the *communication with the LMS* is handled by an application program interface (API) according to the IEEE 1484.11.1 [11], and the data-exchange model according to IEEE 1484.11.2 [12]. Finally, the *content sequencing* is based on registered activity is specified according to IMS Simple Sequencing [13].

2.2 Using SCORM for integrating games into a LMS

The success of the SCORM data model lies in its simplicity, but it has a number of limitations at the time of being used to integrate video games into LMS. This issue is mainly related to the fact that highly interactive contents such as SG, simulations, virtual worlds, etc. can generate a continuous stream of valuable data [14], [15] to be sent back to the LMS and this situation was not considered

during the development of standards. The emergence of SG as a new opportunity for learning require the development of solutions that address this limitation.

Regarding the tracked data format (i.e. data model) SCORM provides a fixed data model that may not fit well with the structure of the SG or simulation. Therefore, it is usually necessary to transform and aggregate the game data to fit the SCORM data model or to reduce that data because SCORM does not provide a means to extend the data model without losing interoperability [14].

In addition, the sequencing mechanism included in SCORM presents a number of limitations when applied to SG integration. One advantage of using games in LMS is to take advantage of the rich in-game data to make adjustments on the flow of the lesson. For this purpose SCORM only allows the use the completion of the activity and the completion of the objectives. Furthermore, SCORM inherits some of the limitations of IMS Simple Sequencing such as it does not consider the use of advanced sequencing algorithms, for example, using artificial intelligence or planning techniques. Furthermore, SCORM model is single-learner, which is a big limitation in a new e-learning arena where collaborative activities (including SG) are on the rise.

Finally, there is neither a set of good practices and/or clear instructions nor a mechanism to test and debug the communication between an SCO (a LO under the umbrella of SCORM) and a LMS. All these aspect hinder the use of richer content-LMS data communication.

III. INTEGRATING EADVENTURE SERIOUS GAMES INTO MOODLE LMS

In this section we describe how eAdventure serious games are integrated with the Moodle LMS. We address the aspects previously described from both technical and user perspective.

3.1 Simple eAdventure SG deployment in Moodle

The first integration model of an eAdventure game into Moodle is pretty straightforward. From the eAdventure editor, once the game has been created, it is possible to export the game as a LO. As part of this process the author can provide some meta-data (although it is not required) with an integrated meta-data editor (**Error! Reference source not found.**.a).

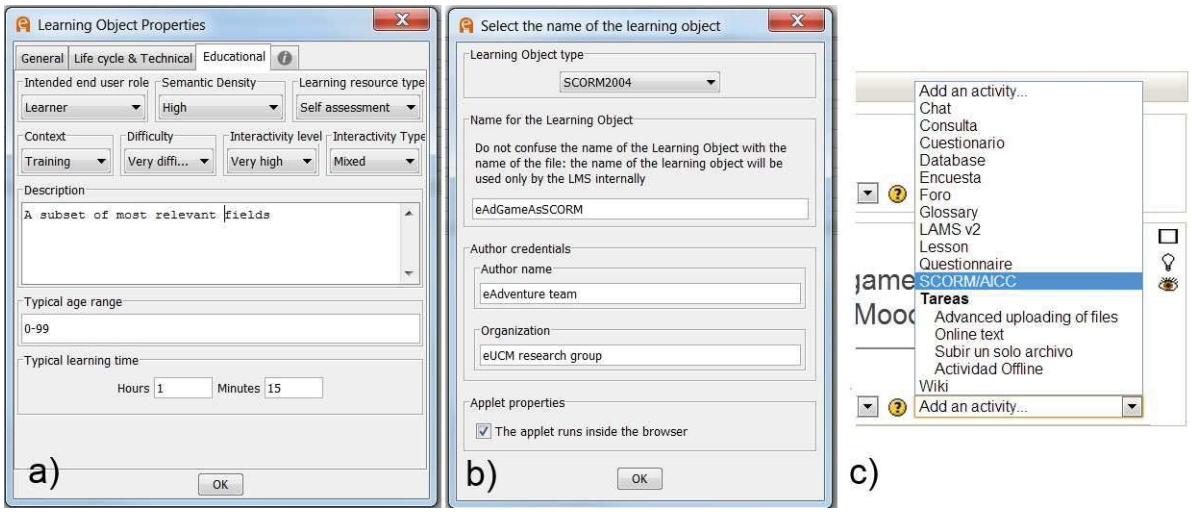

Figure 1. SG exportation in eAdventure and deployment in Moodle using the SCORM activity.

In eAdventure a sub-set of the most relevant fields in the LOM standard is supported in order to facilitate the games' cataloguing. In addition, the creator is assisted in the annotation process of games exported as LO, easing different aspects such as the need for specific vocabulary or the use of the needed data-formats [16]. After that, the game is exported as a SCORM compliant LO (**Error! Reference source not found.**.b) and it is ready to be deployed as any other SCORM content in

Moodle (**Error! Reference source not found.**.c). The meta-data of the exported games can be edited or repurposed with any other LO editor such as RELOAD Editor.

In this case, the educational game is deployed as a "black box" as no in-game information is communicated back to Moodle. This simple integration model is appropriate for courses where SGs are complementary activities or used for subsequent debriefing where the information extracted from the gameplay is not needed. User can access to the eAdventure game as they do to any other course content.

3.2 eAdventure SG deployment with communication to Moodle

To obtain a full eAdventure SG integration in Moodle it is necessary to define what game information is sent back and what is the meaning of this data in terms of the SCORM data model. That is, we need to establish what would be the relationship among the game state model (named flags and variables in eAdventure) and the fields of the SCORM data model [17].

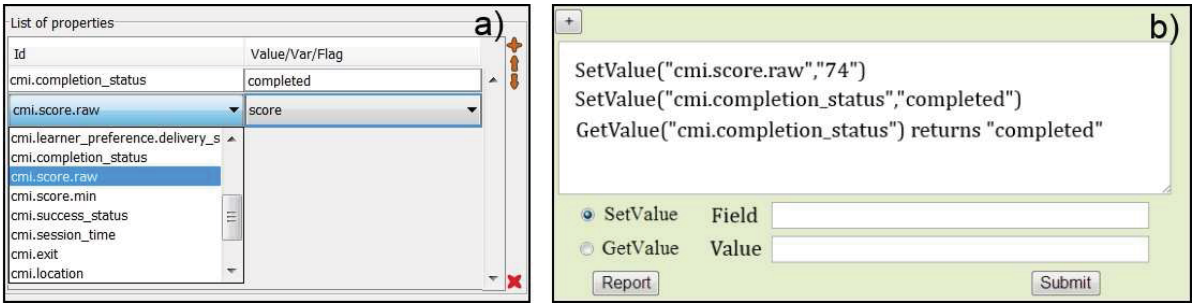

Figure 2. Details of the eAdventure assessment profile and debug console. a) depicts the linking between CMI data model and eAdventure variables and/or values; b) depicts how the communication between the game and Moodle LMS is sniffed.

The eAdventure platform includes a rule-based mechanism, used to define an *assessment profile*. An *assessment profile* comprises a set of rules, where each rule comprises a condition over the game state and a set of tracking actions. The tracking actions are executed when the rules are met, for example an effect can be used to present some kind of feedback or can set some of the SCORM CMI fields. For example, a game developer might want to send back to the LMS the game's score and notify that the game was finished when the user reaches some score/threshold in the game. One of the available assessment rule's actions allow to send the in-game score variable and set the value game status variable to the CMI fields created for that purpose ("cmi.score.raw" and "cmi.completion_status" respectively in SCORM 2004 4th edition) (**Error! Reference source not found.**.a) . In addition, eAdventure games can debug the communication between the games and any SCORM compliant LMS by using the debug console (**Error! Reference source not found.**.b) included with the games (done during the exportation process with the SCORM 2004+DEBUGGER profile). This way, the game authors can not only see what data are interchanged but also query the CMI model to ensure the data were sent properly.

In this case, the educational game is deployed as a "white box". This model is more appropriate for users without experience using ICT in education because the data model helps them to effectively take advantage of the information extracted from video games, so the game can be used as another course-based evaluated activity. More detailed examples of the use of CMI model and eAdventure for assessment purposes can be found in [18] and [19].

3.3 Access from Moodle to the eAdventure in-game data

Once the game has been played by the student, educators can use the gathered data for different purposes: learner assessment, evaluation of the usefulness of the game in the curricula or discovery of game design errors. In Moodle, educators can access the data sent by games having a complete report with details of all the CMI data fields were the game sent data (Figure 3). However, there is no standard Moodle reporting tool that helps educators consulting, filtering, shorting and comparing the data of the course students. Thus, educators' work-load increases drastically if they

want to perform a complex analysis as they have to extract the data manually and use an external tool (e.g. SPSS). The only information that educators can link to the Moodle Gradebook is the SG score or the success status, having a report of the results of the students along all the activities in a course. Nonetheless, the potential of the tracking presented in games not fully used due to the little information reflected in the Gradebook.

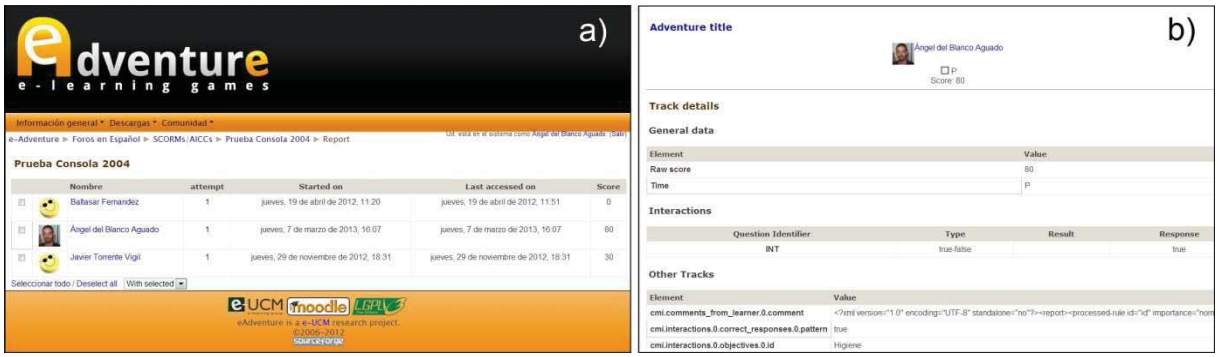

Figure 3. Accessing in Moodle the data sent back by eAdventure SG. a) depicts the global view of the SCORM activity where all a summary of all the students' result is shown; b) depicts the detailed report where all filled CMI fields appear.

IV. NEXT STEPS: TRAINING AND LEARNING ARCHITECTURE - EXPERIENCE TRACKING

The Training and Learning Architecture (TLA) is the name of the next generation of SCORM [20] proposed by ADL taking as starting point the work of done in the Tin Can project. TLA is a holistic solution for the LO interoperability which comprises: Experience Tracking, for tracking any learning experience; Content Brokering, for describing, discovering and delivering content; Learner Profiles, for user profiling; and Competency Networks, for objectives and competencies definition.

The Experience Tracking is currently being developed with the main aim of tracking the learning activity from any kind of learning experiences. The central element of the Experience Tracking is the Learning Record Store (LRS), which is responsible to gather all the information about the students' experience. The Experience Tracking is complemented by a runtime API and a data model (a.k.a. Experience API, XAPI) to exchange information between the Learning Activity (LA) and the LRS. This activity can be inside or outside of an LMS. Moreover, Experience API provides tracking information sharing between different LMS, servers, and web applications allowing developers to define who can access to the data. The LRS does not have to be tied to a LMS anymore, thus the student's information can be shared among different systems (e.g. LMS, other LRS, reporting tools, etc.). In addition, the LRS allows for devices with a non-permanent connectivity to send the information when they get access to the network (e.g. mobile devices). The XAPI presents flexible data model based on Activity Streams. This data model allows representing almost all learning simulation events as statements (e.g. I did this). In addition, the data model allows the creation of specific verbs definitions to be use for a stakeholder community (i.e. Serious Game community).

The potential of Experience Tracking for games resides in first place in the fact that it is being developed not only having in mind highly interactive learning activities but also taking into account the feedback from some SG initiatives. The flexibility of the data model allows tracking complex situations as games and simulations can include and also defining specific verbs if needed for adapting the statements to the specific field of SG. The fact that tracking data is not centralized in LMS opens a wide range of possibilities. First, e-learning systems can take advantage of the rich assessment data to make detailed adjustments on the lesson's flow. Furthermore, the tracking data can also be used by games to perform adaptation in the game content (e.g. difficulty level, extra content, etc.). Finally, educators are not tied to the LMS limitations anymore, they can benefit from reporting tools external to the LMS which best fit their needs.

V. Conclusions

This paper presents how SCORM has been used in eAdventure to address the integration and interoperability with LMS (in particular with Moodle). eAdventure include SG exportations profiles for creating SCORM compliant SG. Two eAdventure SG integration models are presented from a basic one without communication back to Moodle to a more complete one that includes the tracking of the students' activity during the game plays. Finally, it is briefly analyzed how the current movements in the standardization community, in particular the Training and Learning Architecture with the Experience API overcome most of the identified problems, in particular the restrictions of the students' tracking model and game deployment.

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