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ADDRESSING SERIOUS GAMES INTEROPERABILITY: THE eADVENTURE JOURNEY

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Abstract: *Serious games are gaining acceptance by the educational community as evidence of their attractiveness, engagement and educational effectiveness increases. Now that serious games are reaching a mature state, new concerns are emerging about the interoperability of serious games across e-learning systems. Games are effective but expensive to develop and the need to protect the investment is high. eAdventure is a game authoring platform created with the aim of bringing serious games development closer to the educational community. Interoperability has been one of the main characteristics of the eAdventure platform since its inception in 2005. This paper presents how different serious games interoperability aspects such as deployment, tagging, discovery, assessment and adaptation have been addressed in eAdventure applying some of the available e-learning specifications and standards. Also this paper discusses how current trends for data tracking open a new perspective for SGs integration.*

Keywords: *serious games interoperability, eAdventure, SCORM, Experience API*

I. Introduction

Serious games (SGs) and educational simulations are becoming a new educational tool due to their powerful characteristics, such as their ability to effectively engage students or the creation of *authentic* interactive learning experiences [1]. Moreover, SGs support new teaching methodologies [2] and are being used in both, traditional curricula and continuous education. Among many different educational fields, SGs are well suited to learn procedural

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knowledge that is particularly useful in health, science and engineering [3], [4] where complex (and sometimes tedious) critical processes can be rehearsed on a daily basis in a risk-free environment, with the ability to modulate the general pacing and the frequency of rare (but relevant) events. Leaving aside the rich set of engagement features that SGs offer, in essence SGs can be considered as a particular case of highly interactive educational content.

The interoperability of educational contents is a critical aspect in the e-learning field that has been studied from the very beginning of the Computer Based Training [5]. The Learning Object (LO) model [6] is a widely accepted approach that addresses the reusability and maintainability of educational contents and has been successfully used in Learning Management Systems (LMSs) to deal with learning materials. Related to the reusability of LOs there have been different standardization activities to facilitate LO interoperability across different systems (e.g. authoring tools, LMSs, etc.). These standardization activities are related to different content aspects such as packaging and distributing, tagging and discovery, tracking interactions, and content sequencing, all of them features that affect both the creation of educational content and its deployment (for instance in a LMS).

We think that SGs can be seen as a particular type of LO where its granularity can be as simple as a *gamelet* (a SG that covers a particular or a small set of learning objectives) or a full SG covering a whole course topic, therefore offering different levels of reusability. Hence, we decided to explore whether it was possible to apply the LO approach (i.e. available standards and the know-how) to SGs in to order address the same issues.

The paper is structured as follows. Section 0 provides a brief introduction to the eAdventure platform and its adoption of e-learning specifications and standards to address interoperability. Section 0 offers a detailed description of the different phases of the platform's evolution covering different aspects of LO interoperability and which e-learning specifications and standards were chosen to tackle the issues described above. Finally section 0 provides a summary and some conclusions and describes some future lines of work.

II. The eAdventure Platform

Serious games are a tendency on the rise but are still far from general adoption because of different issues. The high development costs and uncertain return of investment are some of the most relevant aspects hindering the adoption and the creation of SGs, hence new models based on tools that simplify the creation of SGs and simulations are needed [7].

Beginning in 2004 the eAdventure platform [8] was conceived as a tool to ease the creation of educational 2D point-and-click adventure games that were very

popular in the 90's, like the Myst© or Monkey Island© saga. The design goals for the eAdventure platform were:

- The development cost of the game should be affordable and cost-effective.
- No programming should be needed to create an educational game or simulation. Educators should be able to create or to modify a game.
- Games should be easy to deploy and maintain.
- Games should be interoperable with other educational and e-learning tools (i.e. LMSs).

The eAdventure platform provides an easy-to-use graphical authoring tool that allows users without a technical background to create SGs (see Figure 1). eAdventure games do not require any programming and are based on the creation of a virtual world by defining multiple scenes, and then adding interactive elements such as characters and objects, as well as the game rules and game story [8] [9].

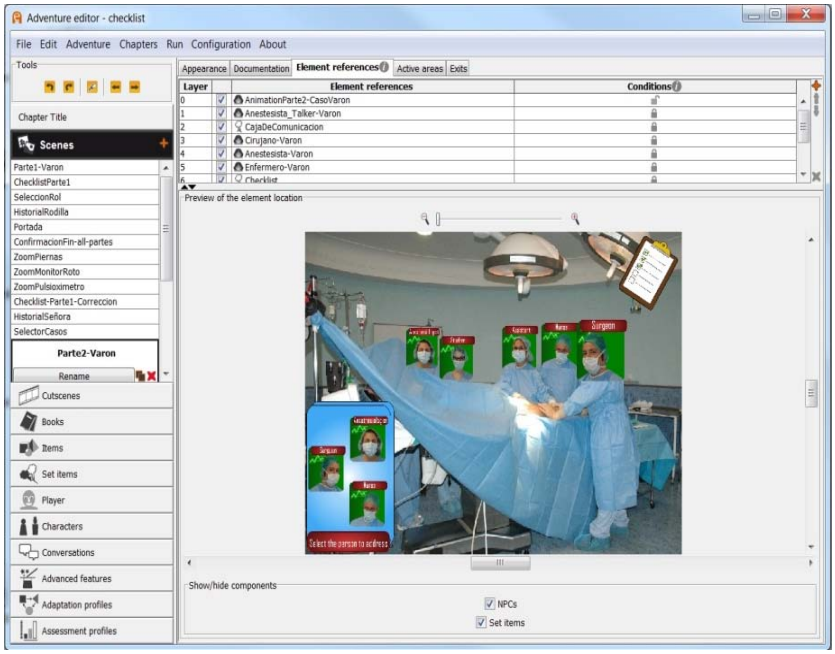

Figure 1. Screenshot of the eAdventure editor showing the authoring of a game scene

The eAdventure platform is complemented with an iterative methodology for videogame development based on fast prototyping [10] to ease the active participation

of educators in the process and the communication among all the stakeholders. In this methodology the knowledge has to be centralized in documents (specification document and game script) that are used to sketch early prototypes for being evaluated by educators in the early stages of development.

During each iteration, a full prototype is created including the final assets generated by graphic designers and refining the mistakes founded, modifying also the documents if required. In addition to the creation of cartoon-like adventure games in third-person (where the player's avatar is visible on the screen) eAdventure allows for the creation of first-person photorealistic environments where the needed resources can be extracted using a digital camera, thus significantly reducing the costs [11].

Therefore eAdventure allows educators to actively participate in the game design and development playing a key role in the way of including the educative content in the games, or even creating the whole SG by themselves [10], all while moderating the development costs. In addition, eAdventure games can be reused by modifying existing games to adapt their content to different learning scenarios.

a) b)

Figure 2. a) Screenshot of the third-person "Adventure games for English teaching: Hospital" game. b) Screenshot of the first- person "HCT Game" game-like simulation

The eAdventure platform includes a set of educational features to maximize the educational potential of the games. First, eAdventure allows evaluating student performance with a mechanism for identifying which user actions are relevant from an educational point of view. The system tracks and logs

these interactions, generating reports that can be presented to the student for self-assessment or to the instructor for insight into how a play session developed [8]. Finally, eAdventure has been designed to be integrated in the e-learning platforms ecosystem, as described in the following section.

III. Addressing Serious Games Interoperability in eAdventure

Digital learning resources are usually delivered through LMS because of their wide adoption in educational organizations. In particular, in an e-learning or blended-learning scenario the LMS is the central hub in the teaching and learning process. But there are a wide range of different LMSs available with different features. A simple game integration approach would involve the development of a particular eAdventure game integration module in each LMS. But this approach does not scale well due to the large number of LMSs. eAdventure addresses this issue by adhering to e-learning standards and specifications. In addition, learning resources can also be gathered from LO repositories [12], [13] where educators can access different learning tools and resources.

This section describes our work adopting different specifications and standards in eAdventure in order to allow integrating the developed games into LMS and repositories. The different subsections describe different aspects of SGs and how they were implemented in eAdventure not only from the user point of view and the technical details.

3.1. Distributing Serious Games

One of the problems that teachers must face when creating SGs is to distribute them to the students. The IMS Content Packaging specification [14] deals with packaging, structure and distribution of LO and it is widely supported by authoring tools and LMSs [15]. An IMS-CP package contains a *manifest* that describes the (possibly hierarchical) structure of the e-learning content. In particular, the *manifest* allows the definition of several organizations (hierarchical structure descriptions) and, therefore the definition of different views for the same content. This flexible approach to structuring content it is particularly useful for SG, because of it is possible to present different paths or starting points.

The eAdventure editor allows exporting the developed games as LOs following the IMS Content Packaging (IMS-CP) specification. In this method, eAdventure games are generated as a Java Applet embedded in a web page that will be displayed at the LMS. The Java Applet contains all the libraries that form the eAventure engine, as well as the game content. By default, a LO exported with

the eAdventure editor contain just one simple content: the game (although more complex aggregations are also possible).

3.2. Discovering Serious Games

In addition to LMSs, LO repositories [12] [13] appear as pools of educational resources for educators. These repositories provide a search facility in order to discover the resources that the teacher needs. However, to implement this search facility, the LO repository needs to index the educational resource. In some cases (like text, HTML web pages, etc.) it is possible to index the content itself, but there are some types of content, such as SGs, where it is not possible to automatically index the contents to be discovered by a search engine. Furthermore, sometimes a full-text search may not be useful because the same keywords can appear in different educational resources not necessarily useful for the teacher. Therefore, to address these two issues, we can add some metadata describing the content using a standardized vocabulary.

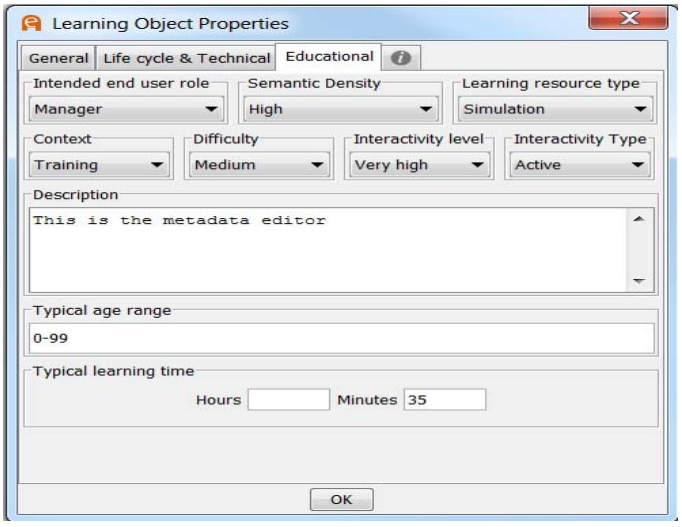

Figure 3. Screenshot of the eAdventure LOM editor

The IEEE Learning Object Metadata (IEEE LOM) standard [16] aims to facilitate the descriptions of e-learning content. IEEE LOM defines a set of categories and vocabularies that can be used to described an e-learning content from different perspectives to describe, for example, versioning (*lifecycle* in the IEEE LOM vocabulary), the technical requirements to use the content and the

intended audience (e.g. high school, university, primary school, etc.), complexity, etc. The eAdventure editor offers a simple LOM Editor that supports a significant subset of the most relevant fields in the IEEE vocabulary (see **Error! Reference source not found.**). It also provides automatically some default values to describe some elements that can typically be automated (like the technical category) as well as filling some other fields with generic placeholder texts that can be modified if more details are required to describe the particular game more precisely. These default values facilitate the cumbersome task of adding metadata to the SG. In addition, the eAdventure editor supports the LOM-ES (UNE-71361:2010) that is the Spanish application profile (customized version of IEEE LOM) [17]. In those cases where a developer may need to fill some less typical advanced metadata can open the game in a LOM editor (e.g. RELOAD) to complete those fields that do not appear in the eAdventure metadata editor.

3.3. Experimenting with Assessment and Adaptation

A big amount of valuable information about the students' performance can be extracted while they play the games. If this interaction data is available and presented in a coherent way it can be used with different purposes such as learner assessment, evaluation of the usefulness of the game in the curriculum, discovering game design errors and allowing the LMS to adapt and personalize content depending on each individual student's performance [18], [19].

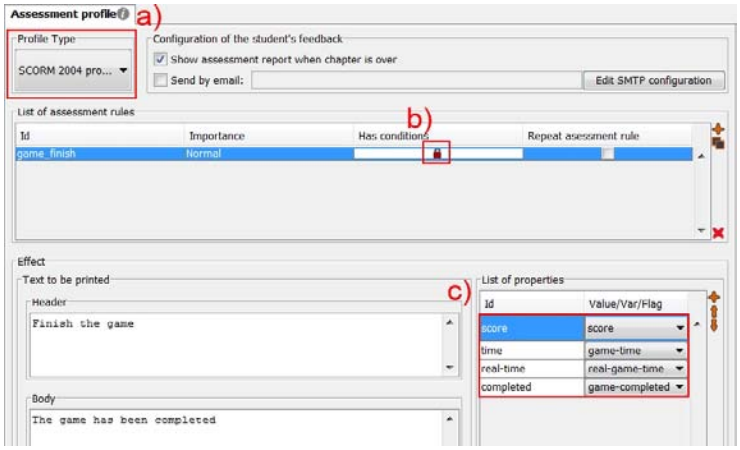

Figure 4. Screenshot of the eAdventure editor showing an assessment profile with some assessment rules. a) The area that allows selecting the compliance profile type. b) The area for defining assessment rules. c) Area for defining what data will be set in LMS

The eAdventure editor allows the definition of an *assessment profile* (see **Error! Reference source not found.** b), which is a means to define a set of rules that track the accomplishment of goals inside the game, based on the user interaction and the game state. As a result these rules may write a textual description of the evaluated situation in an *assessment report* or transmit attribute-value pairs to the LMS. The *assessment report* gathers all the rules that have been triggered during game play and can be displayed at the end of the game to students as self-assessment. To minimize the requirements of the LMS or e-learning platform used to distribute the game, the assessment report is accessible only from the same machine that is running the game. However, it is also possible to configure the game to send the report to the LMS or to an email address to facilitate the teachers' task of collecting the individual student assessment reports.

Although the aim of this assessment report is mainly to be human readable, a more advanced behaviour can be defined if the backend e-learning platform takes advantage of these assessment data. For example, the initial versions of the assessment and adaptation profile were tested embedding an eAdventure SG within an IMS Learning Design (IMS-LD) [20] unit of learning (UoL), that is, a course that use the IMS-LD notation to allow the creation of an adaptive course. The adaptation was achieved in both directions, driving the learner through a different learning path depending on the outcomes during the game play and starting the game in a different starting point depending on the learner outcomes in the previous activities of the UoL [21].

3.4. Maximizing Assessment and Adaptation Interoperability with LMSs

Regardless of the opportunities that an advanced LMS implementing IMS-LD could offer, the adoption of IMS-LD is scarce mainly due to the scarcity of easy-to-use authoring tools and that IMS-LD has not been widely implemented in LMS [22]. However there are other initiatives with a similar approach that, although not supported by any standardization organization, have gained a lot of attraction from the educational community such as the LAMS LMS [23]. Since version 2.3.5, LAMS provides an eAdventure learning activity included in the default distribution to exploit the assessment and adaptation possibilities [24].

The LAMS LMS central element is the authoring tool that allows educators to create an *activity sequence* or lesson that comprises a set of activities. LAMS offer a comprehensive set of predefined activities that can be divided in two categories: learning activities and control activities. Learning activities include common learning tools (forum, video, wiki, etc.) that fulfil a learning objective and control activities allow modifying the lesson flow at both per-learner and per-

course levels taking into account the students' performance in previous learning activities.

Figure depicts an activity sequencing that includes two eAdventure learning activities: The first one is the input of the branching activity that includes two paths, one that reinforces the learning objectives covered by the activity sequence and other that only shows a summary of the learned concepts [25]. The second one is the same game that appears again in this reinforced learning path (presented in the pop-up windows that appear when exploring the branching activity).

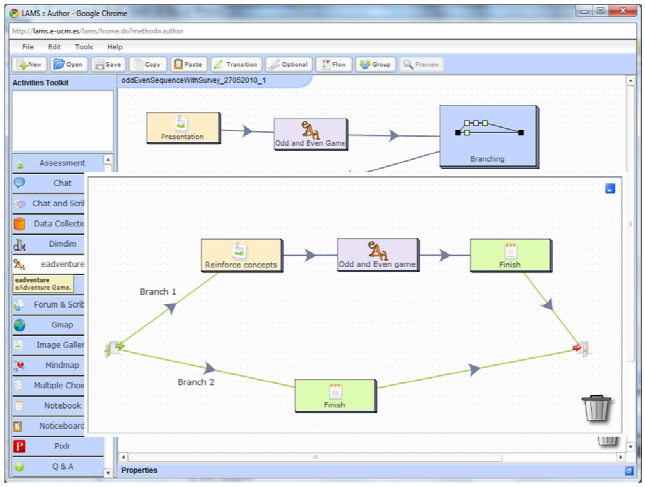

Figure 5. Screenshot of the LAMS activity sequence editor showing a branching activity based on the eAdventure outcomes

eAdventure SGs have four predefined variables to simplify the use of the assessment and adaptation SG features. This simplifies the use eAdventure SGs versatile modules in activity sequences because it is simple to communicate in-game data to LAMS:

- **score**. Store the player achieved score. This variable must be explicitly configured using the eAdventure assessment rules.
- **game-completed.** Store if the game has been completed or not. This variable must be explicitly configured using the eAdventure assessment rules for the correct final states.

- **game-time.** Store the time that the player has been actually playing. This variable is automatically established by the eAdventure game.
- **real-game-time**. Store the time that the player has been playing (including pauses). This variable is automatically established by the eAdventure game.

In addition, it is possible to add custom variables for sending other meaningful data that can be used not only to control the learning flow but also to add information about the students' performance in the gradebook. Furthermore, a more detailed assessment report produced by eAdventure assessment rules can be sent back and stored inside LAMS, allowing an easy review of the students' activity through the tracking feature of the LAMS platform.

The integration of eAdventure into LAMS [24] provides a great potential for the development of courses where SGs outcomes are used to drive the adaptation of the lesson. However, the integration effort done in LAMS is specific for this system, and cannot be trivially scaled for other available LMSs. To address this integration problem in a cost effective way, we would need a specification or standard that covers most, if not all, the eAdventure use cases for assessment and adaptation. The standard ADL Shareable Content Object Reference Model (ADL SCORM) [26] is a good approach because it provides assessment and adaptation features, and it is widely supported by the most common LMSs.

SCORM is a standard based on other specifications, including IMS-CP and IEEE LOM. Moreover, SCORM also includes two specifications specifically suited for the assessment and adaptation of SGs. These specifications provide a data model and a communication Application Program Interface (API) that can be used to interchange data between the LMS and the SG. The SCORM data model includes a set of fields that satisfy some of the SGs needs in terms of tracking the students' performance. First, there is a set of fields created with the aim of gathering general information about the degree of progress in the activity. These fields are "completion status" (*cmi.completion_status*) and "success status" (*cmi.success_status*). Both fields can be filled by SGs (using the assessment rules in eAdventure) to inform the LMS when the SG has been finished and whether the student has "won" (the student has achieved a successful result) respectively. In addition, the data model allows storing an overall grade of students' performance (*cmi.score.raw*) comprised in a range of values (*cmi.score.min* and *cmi.score.max*).

A characteristic with special interest from the instructional design point of view is the mapping between the achievements of goals inside the SG and the

learning goals. The "objectives" field (*cmi.objetives*) can be used for that purpose. This field includes information related to the degree of completion, success and measure of progress. The description of these objectives is defined using the IEEE LOM metadata, particularly using the categories "Classification", "Purpose", "Taxonomy" and "Description". It is possible to define different objectives and to structure the student's progress in the SG according to different skills or knowledge areas, thus deciding how each one affects the main SG goal.

SCORM also defines a composite field that contains a set of records labeled "interactions" (*cmi.interactions*) to store detailed information about student performance in the game. Using the "interactions" field SGs can track a set of player responses to specific questions or to specific student actions inside the SG. For each record included in the "interactions" field, the following data can be included: i) the type of interaction (true-false, relationship between groups elements, matching, etc.); ii) patterns of correct responses; iii) the weight of every interaction over the final grade; iv) student response; v) the result of the interaction (i.e. if the student was right or not). To provide "interactions" with more expressiveness, SCORM allows defining multiple possible correct answers using an integer to indicate the degree of correctness of each answer. In addition, each "interactions" field can be linked with a set of objectives to indicate their relationship. SGs can benefit from this field to map specific actions. In this case it is important to provide a significant identifier and filling the documentation field with an explanation of the specific game event to be registered.

An important feature to consider when using "interactions" fields is the way the interactions are stored (journaling or state). In journaling mode, each interaction is stored as a new record in the interactions set, although the same interaction was previously inserted. In state mode only a copy of each interaction is stored, thus multiple insertions of the same interaction update its state instead of adding a new record. The first mode allows storage detailed tracking of the actions taken by the student while the second can store the final state of the relevant interactions from an educational point of view. Thus, when using SCORM with SGs is important to select the most appropriate level of detail for each game, storing all interactions occurred or just recording the final state for each kind of interaction.

Finally, the SCORM data model can also store information about the state of the SG so it can be resumed from the point where the student left the activity, using the “location” and “suspension data” fields. The "location" field (*cmi.location*) can store a string with the point where the student must retake activity. The "suspension data" field (*cmi.suspend_data*) is used store the state of

the SG when the execution is suspended. Finally, SCORM includes a field to collect user comments (*cmi.comments_from_learner*) with intended to be used as feedback on the posed educational experience (e.g. structure and content design). This field can be used with eAdventure SGs for storing the assessment report.

The eAdventure editor assists game creators on exporting the developed games in compliance with two versions of SCORM: 1.2 and 2004 3rd Edition. In order to communicate data with the LMS, games exported as SCORM objects include an ECMAScript file which acts as a bridge between the Java Applet and the SCORM LMS's ECMAScript API endpoint calls (for both SCORM versions). When a SCORM assessment profile is selected, the eAdventure editor assists game creators on selecting the data model fields where sending data. This way educators have only to focus on identify the relevant actions in the game. Furthermore, the eAdventure platform includes a SCORM debugger to check the expected behavior of the game in terms of sending and receiving information [27].

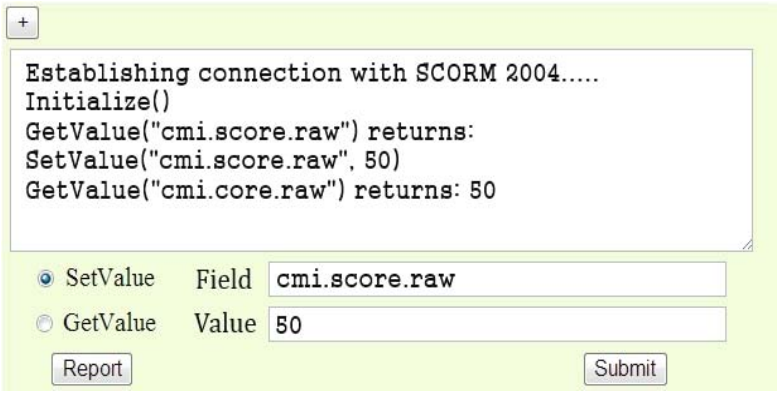

Figure 6. Screenshot of the SCORM console. This console is embedded in the HTML file that launches an eAdventure SG, allowing to debug the interchange of information between the SG and the LMS

The success of the SCORM data model resides in its simplicity. However it presents some limitations when it is used to integrate video games into LMS, mostly because during its definition highly interactive contents were not taken into account [28]. The SCORM data model does not allow storing the potentially vast amounts of data points that SGs could produce from observing the users' interaction with the required detail and specificity. In addition, SCORM does not

include a mechanism to extend its data model without losing data interoperability [29]. In other words, there are limitations preventing the reflection of a specific game model or simulation environment in the data model. Although "interactions" can be linked to almost any game situation, the process is manual and not standardized, and this limits most forms of automatic processing for evaluation and/or adaptation.

The sequencing (adaptation) mechanism included in SCORM also presents a number of weaknesses. In order to make adaptation decisions, SCORM only allows using the completion information of the activity and the completion information of the objectives. The information about the student is reset on each attempt, thus the tracking information can only be use to adapt the content of game if execution is resumed, but not across attempts.

3.5. Facing old barriers: the new families of standards

The main assumption in the previous sections is that the SGs are web based and SGs are launched through the LMS. However, what happens if the settings are different? For instance, what happens if educators want to track experiences from (non web-based) tablet/smartphones games? That is not possible with the previously proposed approaches because they not were envisaged for these new models of content distribution. However, there are other specifications such as ADL Experience Tracking [30] (formerly known as TINCan API) that can be used to address this new scenarios. ADL Experience Tracking provides:

- **Data model flexibility**: statement-based data model (e.g. I did this).
- **Decoupled content distribution model**: the content is not tied to the e-learning platform, thus it is possible to track data from almost any kind of educational activity.
- **Decoupled storage system**: the data can be stored and shared among learning tools, reporting tools, e-learning systems, etc.
- **Occasional connectivity**: learning activities can send information when the connectivity is available.

ADL Experience Tracking is a work in progress that tries to gather information about the students' performance coming from almost any kind of learning experience. This specification is being developed taking into account highly interactive learning activities and receiving feedback since the early stages of development from some SG initiatives. The Learning Record Store (LRS) is the central element being responsible to collect all the information.

ADL Experience Tracking also includes a runtime API and a flexible data model (a.k.a. Experience API or xAPI) that allows representing almost all SGs events as statements. This flexibility is complemented by the possibility of defining

a custom vocabulary (specific verbs) for SGs experiences adapting the statements to the specific field of SG. These features open a lot of new opportunities, for example, it is possible to track data, with different granularity levels, that can be used to adapt the game behaviour to the specific user (e.g. difficulty level, learning preferences, etc.). In addition, the tracked data is not tied anymore to a particular activity (or to a specific tool), so it is possible to reuse the tracking information between play sessions or even across SGs. For example, if a SG is a sequel of a previous one already played by the user, some of the initial steps (e.g. intro and basic levels) may be skipped. In addition, xAPI allows for new interactions models where the SGs can be the entry point or the central piece in the learning process (instead of the LMS as was the case in the previous approaches).

Conclusions and Future work

This paper has summarized the evolution of the eAdventure platform since its inception in 2005 from the interoperability point of view. We have chosen a development model based on e-learning standards to maximize the interoperability of eAdventure. This is an advantage in terms of deployment, but also a contribution towards eAdventure's goal of reducing development costs, by facilitating the use of the same games in different scenarios.

As result, different e-learning standards and specifications (conceived without taking SGs into account) haven been evaluated, tested and even pushed to the limit in order to take the most advantage from them. Our experiences with eAdventure,, particularly using SCORM, have shown that this approach is feasible and simplifies the development process.

However, with the current standards it is still difficult to take the full advantage of the SGs (i.e. tracking) and the approach has limitations with the new scenarios and interaction models (e.g. mobile platforms).

We are currently working with the draft versions xAPI (the 1.0 version is expected at the end of April 2013) to adapt the eAdventure communication module. In addition, xAPI only defines the requirement between the LRS and the e-learning content, but leaves open other aspects such as the relation between the e-learning content and the LMS, the deployment model and the actual vocabulary (xAPI verbs) to be used.

Taking advantage of our previous experiences with the integration of eAdventure with LAMS and providing support for SCORM, we are currently working in the context of the European Games and Learning Alliance Network of Excellence, in the analysis and proposal of a set of xAPI verbs to track SGs interactions and in the definition of a set of use case scenarios that shows how xAPI can be used with the context of SGs.

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References

[1] L. A. Annetta, J. Minogue, S. Y. Holmes, and M. Cheng, "Investigating the impact of video games on high school students' engagement and learning about genetics," Computers & Education, vol. 53, pp. 74–85, 2009.

[2] A. Amory, K. Naicker, J. Vincent, and C. Adams, "The Use of Computer Games as an Educational Tool: Identification of Appropriate Game Types and Game Elements," British Journal of Educational Technology,30(4), pp. 311–321, 1999.

[3] Arnab, S., Dunwell, I., & Debattista, K. "Serious Games for Healthcare: Applications and Implications". 370. 2012.

[4] Mayo, M. J. "Games for science and engineering education". Communications of the ACM, 50(7), 30-35. 2007

[5] N. Friesen. "Interoperability and Learning Objects: An Overview of E-Learning Standardization". Interdisciplinary Journal of Knowledge and Learning Objects. 1. pp23-31. 2005

[6] P. Polsani, "Use and Abuse of Reusable Learning Objects," Journal of Digital Information, vol. 3, no. 4, 2003.

[7] FAS. "Summit on Educational Games: Harnessing the power of video games for learning". In: Federation of American Scientists. 2006

[8] J. Torrente, Á. Del Blanco, E. J. Marchiori, P. Moreno-Ger, and B. Fernández-Manjón, "<e-Adventure>: Introducing Educational Games in the Learning Process," in IEEE Education Engineering (EDUCON) 2010 Conference, pp. 1121–1126. 2010.

[9] E. J. Marchiori, J. Torrente, A. del Blanco, P. Moreno-Ger, P. Sancho, B. Fernández-Manjón. "A narrative metaphor to facilitate educational game authoring". Computers & Education 58(1), 590–599. 2012.

[10] E. J. Marchiori, A. Serrano-Laguna, A. del Blanco, I. Martínez-Ortiz, B. Fernández-Manjón (2012). Integrating domain experts in educational game authoring: a case study. In proceedings of the 2012 Fourth IEEE International Conference On Digital Game And Intelligent Toy Enhanced Learning (DIGITEL 2012), pp. 72-76, 2012.

[11] Moreno-Ger, P., Blesius, C., Currier, P., Sierra, J. L., & Fernández-Manjón, B. "Online Learning and Clinical Procedures: Rapid Development and Effective Deployment of Game-Like Interactive Simulations". Lecture Notes in Computer Science, Transactions on Edutainment I, 5080, 288-304. 2008.
[12] Lehman, Rosemary. "Learning object repositories". New Directions for Adult and Continuing Education. Volume 2007(113). pp 57–66. 2007.
[13] Filip Neven and Erik Duval." Reusable learning objects: a survey of LOM-based repositories". In Proceedings of the tenth ACM international conference on Multimedia (MULTIMEDIA '02). ACM, New York, NY, USA. 2002
[14] IMS Global Consortium, "IMS Content Packaging Specification, Version 1.2 Public Draft v2.0," 2007.
[15] Torrente, J., Moreno-Ger, P., Martínez-Ortiz, I., & Fernandez-Manjon, B. "Integration and Deployment of Educational Games in e-Learning Environments: The Learning Object Model Meets Educational Gaming". Educational Technology & Society, 12 (4), 359–371. 2009
[16] IEEE, "IEEE Standard for Learning Object Metadata ." 2002.
[17] AENOR. LOM-ES Perfil de aplicación LOM-ES para etiquetado normalizado de Objetos Digitales Educativos (ODE). UNE 71361:2010. 2010.
[18] Á. del Blanco, J. Torrente, Á. Serrano, I. Martínez-Ortiz, and B. Fernández-Manjón, "Deploying and Debugging Educational Games Using e-Learning Standards," in IEEE EDUCON 2012 Conference, pp. 1113–1119. 2012
[19] A. del Blanco, J. Torrente, P. Moreno-Ger, Baltasar Fernández-Manjón. "Enhancing Adaptive Learning and Assessment in Virtual Learning Environments with Educational Games". In Quin Jin (Ed.) IJDET - Intelligent Learning Systems and Advancements in Computer-Aided Instruction: Emerging Studies, pp.144-163. 2011
[20] IMS Global Consortium, "IMS Learning Design Specification, Version 1.0 Final Specification." 2003.
[21] D. Burgos, P. Moreno-Ger, J. L. Sierra, B. Fernández-Manjón, Rob Koper. "Authoring Game-Based Adaptive Units of Learning with IMS Learning Design and <e-Adventure>". International Journal of Learning Technology, 3(3), 252-268. 2007.
[22] I. Martínez-Ortiz, J. L. Sierra, B. Fernández-Manjón. "Authoring and Reengineering of IMS Learning Design Units of Learning. IEEE Transactions on Learning Technologies". 2 (3). pp. 189-202. 2009.
[23] A. del Blanco, J. Torrente, P. Moreno-Ger, B. Fernández-Manjón. "Towards the Generalization of Game-based Learning: Integrating Educational Video Games in LAMS". In Proceedings of the 10th International Conference on Advanced Learning Technologies (ICALT 2010), 2010.
[24] A. del Blanco, J. Torrente, B. Fernández-Manjón. "Integrating educational video games in LAMS: The <e-Adventure> Experience". In proceedings of the 5th International LAMS & Learning Design Conference "Sharing Great Ideas", December 9th, Sydney, Australia. 2010.
[25] A. del Blanco, J. Torrente, E. J. Marchiori, I. Martínez-Ortiz, P. Moreno-Ger, B. Fernández-Manjón. "Easing Assessment of Game-based Learning with <e-Adventure> and LAMS". In proceedings of the ACM International Workshop on Multimedia Technologies for Distance Learning (MTDL 2010), pp 25-30. 2010.
[26] ADL, "Advanced Distributed Learning Sharable Content Object Reference Model 2004 v4," 2009.
[27] A. del Blanco, J. Torrente, A. Serrano-Laguna, I. Martínez-Ortiz, B. Fernández-Manjón. Deploying and Debugging Educational Games Using e-Learning Standards. In Proceedings of the IEEE Engineering Education Conference (EDUCON), pp 1113- 1118, Marrakesh, Morocco, April 20-22., 2012.

[28] Z. Madrigal and A. de Antonio, “Estándares actuales para el elearning : SCORM ¿ Se pueden incluir simulaciones en la actualidad ?,” VII Simpósio Internacional de Informática Educativa – SIIE05, pp. 183-88, 2005.

[29] V.J. Shute and J.M. Spector, SCORM 2.0 white paper: Stealth assessment in virtual worlds., 2008.

[30] J. Poltrack, N. Hruska, A. Johnson, and J. Haag, “The Next Generation of SCORM: Innovation for the Global Force,” in The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC), 2012 (1), 2012.