SG-LOM as Metadata Description for Serious Games to Benefit from LMS Monitoring Features

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Abstract—Compared to the conventional approach of e-learning, serious games are playing an increasingly important role in the educational sphere and reached a certain maturity to become a possible alternative to traditional methods of learning that is often seen as restrictive and boring sometimes by learners. This is due to the fact that young people today are familiar with new technologies and virtual worlds outside schools as part of their leisure. A habit that enable these young people to be immediately in the heart of the matter since they already have a video game culture (gameplay) that allows them to focus on the main message. However, the integration of serious games in the learning process still limited since they don't provide efficient features for monitoring and assessing learner (player) interactions and decisions without breaking the nonlinearity of the game in order to show them the consequences of their decisions, a limit that has been proven in a previous comparative study [1]. In this paper we address the aspects of serious games (Robocode as example) integration and deployment into LMS (Dokeos as example) based on the automatic packaging and exportation of serious games as reusable learning objects (LO) that can be easily distributed through any LMS. This integration uses the ADL SCORM data model that defines how content may be packaged as a Package Interchange File (PIF), and the IEEE LOM Application Profile "SG-LOM" [2] as metadata description to describe every level of SCORM since the standard LOM doesn't meets the particular needs of serious games.

Keywords—serious games, SG-LOM, LMS, learning object (LO), assets, monitoring, application profile

1 Introduction

The "serious gaming" is a recent approach for conducting "serious" activities such as communication, awareness and learning, using the techniques used in video games. Serious Games are the social arm of video games, they are rooted in the great family of playful learning mechanism. This current called "Serious Game" that Gathers games whose primary purpose is other than simple entertainment allows to video games to

reach new sectors such as professional training, medical, advertising ... even in politics, today they make a massive and noticeable entrance in the educational field.

However, despite the contribution and potential of serious games in education, their integration into the learning process remains limited because it is difficult to monitor and evaluate the knowledge acquired by the learner/player, this is due to the lack of tracking tools offered by serious games allowing to track and monitor learner / player progress, except perhaps an overall score far enough to reflect sufficiently the learning of the player, thus preventing us from assessing the impact of learner choice.

This work tries to meet this issue. It is interested in integrating serious games into LMS in order to benefit from their tracking and monitoring features. This can improve the integration of serious games in the educational field and guarantee their effectiveness during the learning process. This effectiveness can be seen in assessing learner (player) interactions and decisions without breaking the nonlinearity of the game in order to show them the consequences of their decisions. The integration and deployment of serious games into LMS (Dokeos as example) is based on the automatic packaging and exportation of serious games as interactive reusable learning objects (LO) that can be easily distributed through any LMS. Our integration approach uses the SCORM data model that defines how content may be packaged as a Package Interchange File (PIF) and the Application Profile "**SG-LOM**" as metadata description to describe every level of SCORM since the standard LOM doesn't meets the particular needs of serious games.

This paper is divided as follows; we first present a brief overview on the importance of monitoring concept especially for serious games. Then we address the e-learning standards that we use in our approach and the application profile "**SG-LOM**" introduced in a previous work. The third part named "our approach" will be devoted to the detailed explanation of the aspects of serious games integration and deployment into LMS. We conclude with a synthesis that resumes the essential of what we saw in this paper.

2 Tracking learner / player progress, an essential challenge for serious games

Monitoring means to follow (literally "pursue") the progress and activity of the learner in the learning path. This monitoring is organized from significant data stored during training, according to the program and frequency integrated in the design of educational resources. These data reflect the working method of the learner, the difficulties encountered, acquisitions, periods of looseness [3].

In education "Monitoring" is a method for classifying students in relation to their skills in a learning experience or a homogeneous class, it allows the systematic collection and analysis of information as well as the progression of learner and assessment of his skills. Tracking also gives us an overall summary of the activities of the learner and an overview of the modules or tools most frequently consulted or just used as a point of entry / exit of the course.

The challenges of tracking in serious games:

- **The Player**: motivation and thus promote learning by providing him advice to advance in the game
- **The Tutor**: give visibility of knowledge acquired through the use of game
- **The Designer**: improve the game in its subsequent versions by detecting common errors players
- **The Game**: adapt the proposed content for the player based on his performance

In a previous comparative study we introduced an assessment and analysis grid which aims to assess the quality level of the serious games intended to be used in education. This grid that allows us to make an overall or specific assessment was applied on a set of serious games used to help student learn computer programing. As a result we were able to find the side of weakness or strength of each game assessed as well as its ability to be integrated into education. The result of the assessment of each of these games shows that each one has its own weak and strong points. But they all have unmet needs in the educational side especially the side that is interested in the assessment method adopted in the game also none of those games does allow tracking the learner/player during his progress.

The problem here is that there was a lack of monitoring and evaluation tools in serious game for situating the learner in terms of results. The tutor that uses these tools only see the end result and an overall score, far enough to reflect the learning of the player and not at the method with which the learner has achieved its goal or not. So our problem is in particular to find ways with which serious games can be integrated with LMS (Learning Management Systems) in order to benefit their features that we talked about.

3 E-learning standards

The scope of this section is to present an overview of existing standards efforts for the portability of educational resources and interoperability of virtual training environments.

3.1 IEEE LOM

LOM (Learning Object Metadata) is a description schema of learning resources. The LOM standard was published in 2002 by the "Learning Technology Standards Committee (IEEELTSC). It aims to index educational objects for reuse in curricula. It is based on the principle of "Share and Reuse". The 1484.12.1 version of the IEEE LTSC is structured into nine categories including total sixty elements describing an educational purpose (1.General, 2.Life Cycle, 3.Meta-Metadata, 4.Technical, 5.Educational, 6.Rights, 7.Relation, 8.Annotation, 9.Classification) [4].

The IEEE LOM was the first of the learning standards to become an officially endorsed standard. It also was widely accepted from the very beginning and thus it was integrated into almost all further e-learning standards, which in turn also helped to further establish IEEE LOM as the backbone of the e-learning standardization.

3.2 ADL SCORM

The SCORM (Sharable Content Object Reference Model) was born of an initiative of the Department of Defense US in 1999 (ADL - Advanced Distributed Learning), which generally aimed to modernize education and training using technologies information and communications. SCORM is not a standard in itself but rather a collection of standards and specifications for web-based e-learning. It enables communications between client side content and a host system called the run-time environment, which is commonly supported by a learning management system. SCORM also defines how content may be packaged into a transferable ZIP file called "Package Interchange Format"[5].

Based on XML, SCORM uses IMS Content Packaging to store and deliver content. Support for metadata is provided through the use of the IEEE LOM (Learning Object Metadata) specification, it can be determined for each level in SCORM including: Assets, SCO, Lesson, Course and Organization or as a separated file. It can be also embedded by using a space named XML [6].

Currently SCORM meets several needs and has significant capabilities to the structuring of the learning object into several levels, as well as its operations in different distance learning platform regardless of the diversity or heterogeneity of LMS (s).

3.3 The SCORM manifest file

Every SCORM content packages contain an XML manifest file that describes the package and its contents. The manifest file is a structured inventory of the content of the package. The name of the manifest file is always “imsmanifest.xml” and it must appear in the root of the content package [6].

This Manifest is an XML document that describes the contents of a course and how a learner may move between each SCO and sub-aggregation in the course.

Each component found within the SCORM Content Model is represented in the manifest, and the manifest provides you with the means to associate metadata to these components:

The manifest file is structured in four categories: Metadata, Organization, Resources and Sub-Manifest (Figure1):

Metadata. The metadata section can contain the metadata describing the package as a whole. SCORM suggests the use of IEEE Learning Object Metadata (LOM) (IEEE, 2002) to describe the package.

Organizations. The organization section is the solution for the interoperability within SCORM Content Packaging. It describes the structure of learning resources. A learning resource specifies either a structure of other learning resources or refers to a set of resources. Each learning resource can be used on its own and thus represents reusable content.

Resources. This section lists the physical resources used by the CP. It is in this section that the SCORM ® type activities (Asset, SCO) will be found. All the files in the CP must be reported in this section.

These files may be media files, text files, assessment objects or other pieces of data in electronic form. Conceptual groupings and relationships between files can be represented within the resources component.

Sub-Manifest(s). Currently, ADL and IMS working on new specifications for the (sub) manifest. It is therefore recommended by ADL not to use the (sub) manifest (s) in the SCORM Content Package ® profile.

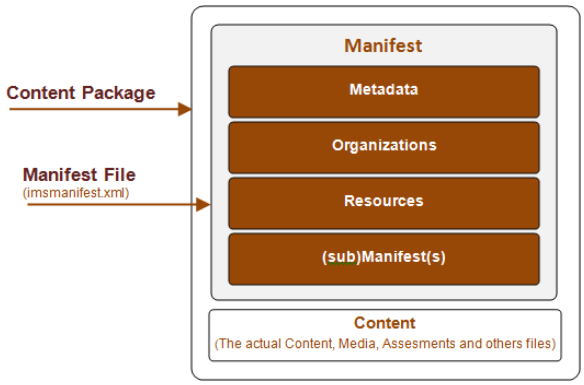

Fig. 1. SCORM content package [6]

3.4 The "SG-LOM" application profile

In order to improve the integration of serious games in education, we adopted in a previous study a new approach that aims to meet the particular needs of serious games in terms of metadata description so they can be described, indexed and capitalized. The development of an appropriate metadata scheme can greatly facilitate search and indexing of serious games as well as the description of learning objects outcome of these games, which gives us the possibility of integrating these games with learning management systems and therefore they can take advantage of monitoring and assessing features proposed by these systems.

To this end, we introduced one of the first serious games metadata schemas. The scheme is based on the IEEE LOM metadata schema, incorporating fields to describe the game not only in a technical sense but also by examining pedagogical and Playful criteria [2].

The Metadata schema is therefore termed as "**SG-LOM**" application profile, specified for serious games based on the LOM standard in which we adopted a methodological approach that focuses on the study of the main components of serious games taking into account the classification studies and evaluation have been done before. It adopts many of the elements of LOM, specializing several of them in order to best match the needs of the serious games, as new elements have been added and other items were eliminated because they are not considered appropriate for our context of use or simply deemed unnecessary or too subjective. This application profile was developed in accordance with Guidelines and support outlined by European Committee for Standardization in [7].

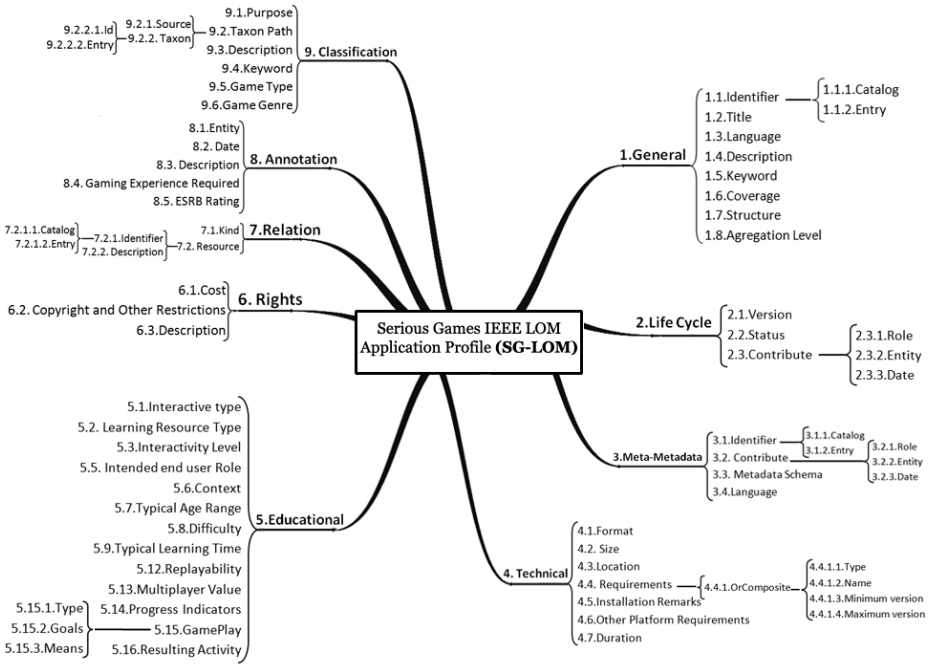

Fig. 2. An overview of the proposed SG-LOM application profile [2]

To meet specific needs of serious games, it was necessary to add new elements specific game features. This addition does not present a problem from the viewpoint of compatibility with the LOM. Indeed, the LOM is a metadata set open, that is to say in which it has been foreseen the possibility of extension. We proposed to add specific fields to the characteristics of the game to the elements 9. Classification, 8.Annotation, 5.Educational and 4.Technical of LOM [14]:

Table 1. New fields that have been added in category 9.Classification [2]

Nr	Name	Explanation	Size	Value Space	Data Type	Obligation
9.5	Game Genre	Means a set of video games characterized by a similar gameplay	Smallest permitted maximum: 10 items	▪Action ▪Simulation ▪Adventure ▪Puzzle ▪RolePlaying ▪Strategy	Vocabulary (Enumerated)	Recommended
9.6	Game Type	The game type allows us to classify the games by their narrative content.	Smallest permitted maximum: 10 items	▪ Drama Crime ▪Fantasy ▪ Horror ▪ Mystery ▪ Science Fiction ▪War&Espionage ▪Western/ Eastern / frontier	Vocabulary (Enumerated)	Optional

Table 2. New fields that have been added in category 8.Annotation [2]

Nr	Name	Explanation	Size	Value Space	Data Type	Obligation
8.4	Gaming experience required	It gives an idea on the level of experience required to play this game	1	▪ Novice ▪ Beginner ▪ Intermediate ▪ Experienced ▪ Advanced ▪ Senior ▪ Expert	Vocabulary (Enumerated)	Optional
8.5	ESRB Rating	A system to ensure clear labeling of contents games for the age group to which they are best suited.	1	▪ EC ▪ E ▪ E10+ ▪ T ▪ M ▪ AO ▪ RP	Vocabulary (Enumerated)	Optional

Table 3. New fields that have been added in category 5.Educational [2]

Nr	Name	Explanation	Size	Value Space	Data Type	Obligation
5.12	Replayability	The replayability is used to describe the entertainment value of playing a game more than once.	1	- Yes - No	Vocabulary (Enumerated)	Optional
5.13	Multiplayer Value	The Multiplayer value lets us know if the game authorizes more than one person to play in the same game environment at the same time	1	- Single player - Multi player	Vocabulary (Enumerated)	Optional
5.14	Progress indicators	Progress indicators can provide the player an estimate of how far the game has progressed or to evaluate the success of a particular activity.	Smallest permitted maximum : 30 items	▪Score ▪Speed ▪Time ▪Completion ▪Appreciation ▪Success ▪ Failures	Vocabulary (Enumerated)	Optional
5.15	Gameplay	A description of game plays type as new classification.			Vocabulary (Enumerated)	Recommended
5.15.1	Type	Games type according to their use/lack of rules.	1	▪ Game-based ▪ Play-based	Vocabulary (Enumerated)	Optional
5.15.2	Goals	Goals to achieve previously designed which the player must react with it.	Smallest permitted maximum : 10 items	▪ Avoid ▪ Match ▪ Destroy	Vocabulary (Enumerated)	Optional
5.15.3	Means	Define the means and constraints for reaching the goals.	Smallest permitted maximum : 10 items	▪ Create ▪ Manage ▪ Move ▪ Select ▪ Shoot ▪ Write ▪ Random	Vocabulary (Enumerated)	Optional

5.16	Resulting activity	Activity proposed for players	Smallest permitted maximum : 30 items	▪cooperate ▪create ▪exchange ▪simulate ▪observe ▪organize ▪ produce	Vocabulary (Enumerated)	Optional

4 Our approach

Our approach is based on the production and deployment of serious games as reusable learning objects (LO) so they can be integrated in different learning environments such as LMS. This integration uses the SCORM data model that defines how content may be packaged into a transferable Package Interchange File (PIF). The metadata description of the package is provided through the IEEE LOM application profile "SG-LOM" that meets the particular needs of serious games since existing standards for describing learning resources are incomplete when it comes to describing serious games. The automatic packaging and exportation of serious games as interactive reusable learning objects (LO) that can be easily distributed through any LMS allows to serious games to take advantage of tracking and monitoring features offered by these systems by tracking learners (players) progress and assessing their interactions and decisions without breaking the nonlinearity of the game. Therefore, the achievement of this integration could allow improvement of the whole learning process.

4.1 Production of serious games as reusable learning objects

Learning Object (LO) is the distribution of larger content into smaller pieces of information that accomplishes a single learning outcome. The smaller piece of content is incorporated with multimedia elements to promote meaningful learning [8]. The idea of breaking content into smaller chunks of information is a new approach to content creation, which is just right and uses the lowest possible size to accomplish a single learning outcome. The chunk of content attributed to be highly reusable in various learning contexts. A learning object can be integrated for a single lesson unit or several independent learning objects can be integrated for a single lesson which might carry various skills or content [9].

The learning object concept is widely adopted by several institutions and environments because it is able to: [10]

- Develop and deploy learning content efficiently and quickly
- Deliver content between LMS (Learning Management System) and LCMS (Learning Content and Management System) or other E-learning platforms
- Reduce content development, maintenance time and delivery costs.

The Learning Object (LO) approach is a wide accepted model for re-use, maintain and deploy educational contents in different LMS. That's why we use the same concept to incorporate serious games in LMS, since integrating a large serious game that can be

used to learn an entire domain will usually be difficult. The serious game can simply substitute one of the learning objects included in the course, as long as it covers the same materials and behaves externally the same way. Serious games can be produced as self-contained distributable Learning Objects (LO) in support for the principles of the LO model that deploys the learning contents as small self-contained objects that can then be combined into larger units. However, particular challenges exist when considering games, this challenge is mainly related to the fact that highly interactive contents such as serious games can generate a continuous stream of valuable data to be sent back to the LMS and this situation was not considered during the development of standards.

Generating a SCORM package for LMS import. In this section we describe the process of generating an ADL SCORM Package using the SCORM and metadata editor "Reload Editor[1]". It allows the automatic packaging and description of serious game content (web pages, images, flash animation java applets etc.) to be ready for storage in content repositories as reusable learning objects (LO).

Reload provides the following functions: [11]

- Packaging content created by other tool.
- Repurposing existing content through reassortment and reorganization
- Preparing content for storage in repositories
- Delivery of content to end users using 'the save content Package preview 'facility.

As example of use, we intend to import the serious game Robocode[2] that aims to help student learn computer programing into Reload editor in order to create a SCORM Package from its content with an SG-LOM metadata description. Robocode is a programming serious game, where the goal is to develop a robot battle tank to battle against other tanks in Java or .NET. The robot battles are running in real-time and on-screen [12]. The choice of this serious game is not arbitrary but it based on a previous work in which we presented a comparative study to develop a tool for the qualit assessment of Serious Games intended to be used in education by examining pedagogical, playful and technical criteria of the serious game [1].

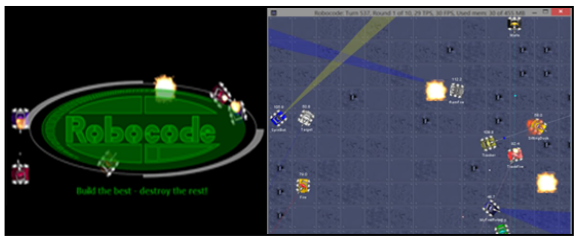

Fig. 3. The serious game Robocode

[1] http://www.reload.ac.uk/
[2] https://www.ibm.com/developerworks/library/j-robocode/

To create a new ADL SCORM package using Reload Editor, you will be asked to select a new folder to store your package in. At the moment the Content Package contains no content, before we add any content, we should add some metadata, or rather, a placeholder then we will add the metadata schema later.

Since we will use our own metadata description that meets the particular needs of serious games called "SG-LOM", we should edit the existing metadata structure and change the tree view of the metadata to be conforming to the SG-LOM structure. So, the process begins by right-clicking on the Manifest node in the Manifest pane and chooses Add Metadata, then, on the metadata node we are interested in and click Add Schema. Right-click on the Metadata node again and this time we will click Edit metadata. In the edit metadata section, we can import and export metadata files that are intended to describe the package.

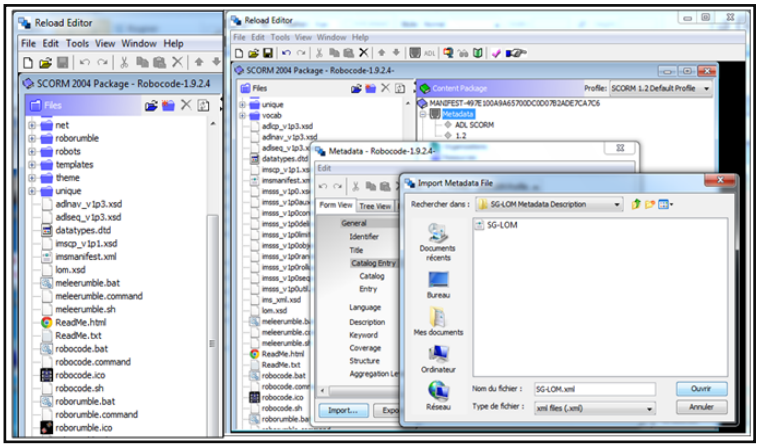

Fig. 4. Import Robocode content & SG-LOM Metadata file

One of the chartered activities of the IEEE LTSC is to develop an XML binding for LOM that define how LOM records should be represented in XML. The standard LOM uses naturally a specific namespace LOM that allows identifying the LOM instances. When using this LOM namespace in XML file, we engage to somehow respect the standard that is the LOM.

The SG-LOM extends / restricted in the LOM by:

- Proposing new elements / attributes,
- Offering new vocabularies,
- Mandating / unique elements / attributes,
- Deleting some elements / attributes,
- Deleting some vocabularies

In a SG-LOM instance, the SG-LOM namespace is used in conjunction with the LOM namespace. The elements and attributes from LOM must naturally be declared in the LOM namespace elements and attributes from the SG-LOM must be given in the SG-LOM namespace.

In order to validate an XML file as an instance SG-LOM, it requires two successive validations that are complementary: xml-schema then Schematron[3].

- XML-schema: An XML Schema describes the structure of an XML document. It specifies how to formally describe the structure of an xml document. This description can be used to verify that each item of content in a document adheres to the description of the element in which the content is to be placed. This first validation formalism adopted (sg-lom.xsd) is organized according to the recommendations of IEEE LOM schema extension. It validates XML LOM documents and SG-LOM then it shows the conceptual organization and vocabularies of the SG-LOM and enforces compliance with the order presented in SG-LOM.
- Schematron: is another formalism for specifying the structure of an XML document. It differs from most other XML schema languages in that it is a rule-based language that uses path expressions instead of grammars. Instead of creating a grammar for an XML document, a Schematron schema makes assertions applied to a specific context within the document. If the assertion fails, a diagnostic message that is supplied by the author of the schema can be displayed. The schematron validation formalism (sg-lom.sch) allows validating the correspondence source-value of LOM vocabularies and SG-LOM, also the presence of the mandatory elements and the effective absence of the elements and vocabularies in the LOM not included SG-LOM. [13]

It is common to use both formalisms together. An XML schema defines the overall structure of the document, a schematron complete this structure by adding additional constraints that must meet the document to be valid. There are also mechanisms to include a schematron within a schema such as the Schematron editor <oXygen/>[4].

Once the content imported in the reload workspace, the files imported now appear in the tree view on the left hand side of the reload workspace as well as the supp folders containing the images, stylesheet etc. As we have seen previously, a SCORM content Package consist of one or more organizations of content. By default the CP we create has no organization. So it has to be added first. Finally we create the structure for our content package by adding items to an organization. Adding items to the organization can be carried out by using menus or just 'drag and drop' content from the tree pane to the manifest pane.

After adding the metadata to the content Package which will create information that can be searched by users of the database. The content Package is now fully functional and ready for the final export. It has to be save it and stored as ZIP file by using The 'Zip Content package Icon'. Now, the content Package can be imported into software (Learning Management Systems or repositories) which interpret information held within the manifest and create a navigational structure for the content.

[3] http://www.schematron.com/

[4] www.oxygenxml.com

4.2 Integrating serious game (Robocode as example) into e-learning platform (Dokeos)

Serious games offer an innovative and interactive tool that can be used to support new teaching models. Currently, there is a discussion about what are the contexts and educational environments where serious games can be more adequate and cost effective. But it is clear that the interactions of the players while playing serious games can generate a huge amount of valuable information, if such interaction data are available and presented in a consistent manner, it can be used for different purposes such as monitoring and tracking learners or assessing learning activities in the game. But to get all these benefits some pending issues should be overcome such the full integration of serious games with the e-learning platform (Learning Management Systems - LMS).

So, in this section we describe how serious games (Robocode as example) can be integrated in Dokdeos as SCORM packages by answering the open issues previously identified. Dokeos[5] is an e-learning and course management web application. It provides all the features needed for e-learning and blended learning management: From Authoring to Reporting [14].

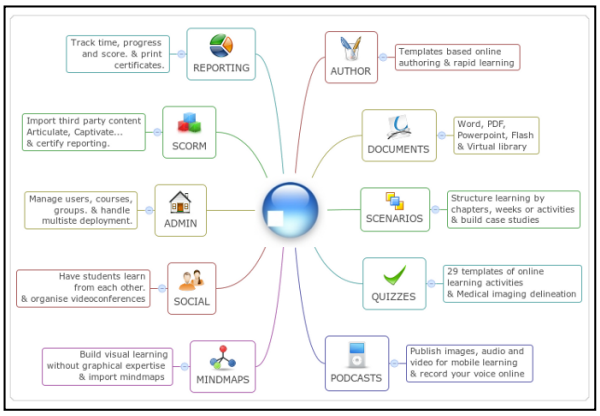

Fig. 5. Dokeos features [14]

Dokeos deals with SCORM contents by providing a JavaScript API (a library that can be called) to enable SCORM features. Dokeos is an open-source e-learning system where one of the components is the SCORM component, used to import learning content conforming to standard SCORM (Sharable Content Object Reference Model) which has the form of a compressed file. This file not only contains all the course resources, but it also contains the information structure of the game such as the articulation of the various stages. In addition, SCORM content is able to "dialogue" with the platform on which it is played. So in order to enable communication between Dokeos JavaScript API and the SCORM contents, the serious games content must be packed in

[5] http://www.dokeos.com

a SCORM package included an XML file (called imsmanifest.xml) to give a list of all elements of our package as was done previously.

Fig. 6. Authoring tools offered by Dokeos

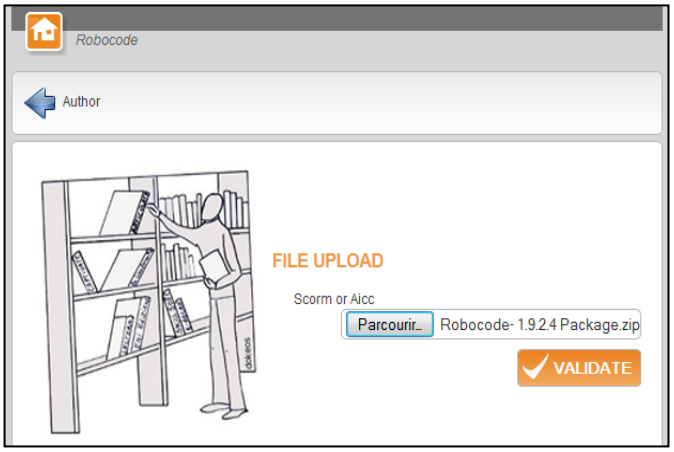

Fig. 7. Importing robocode package into Dokeos

Once the SCORM package opened in Dokeos it send a LMSInitialize() call to the Dokeos SCORM API. Which is done, using APIWrapper.js file, by calling doLMSInitialize().

Since the serious game (Robocode as example) is opened in Dokeos and it can be played so it send a LMSSetValue('cmi.core.lesson_status','completed') after the end of each part of the game. Finally, the package calls LMSFinish() to finish the process of SCORM. Technically, it calls LMSCommit() first (to save changes to the Dokeos database). There are multiple other calls that can be done to get or set other values.

Fig. 8. Robocode battle played in Dokeos

The Robocode serious game offers a set of statistics that reflect the relevance of the robot built. These statistics can be in the form of scores that determines each robot's rank in the battle. Other statistics concern robot survival such as Survival Score and Last Survivor Bonus and many others.

Results for 10 rounds

Robot Name	Total Score	Survival	Last Survivor Bonus	Bullet Dmg	Bonus	Ram Dmg * 2	Bonus	Survival 1sts	Survival 2nds	Survival 3rds
1st: sib.Nightwasp	3128	1400	50	1488	143	45	0	1	0	2
2nd: sib.SideSteppingBot	3087	1650	150	1156	88	43	0	3	0	2
3rd: sib.Turminator	2858	1500	200	1009	72	76	0	4	0	1
4th: sib.SmartBot	2381	1500	100	690	64	26	0	2	0	3
5th: sib.JTWbot	2021	950	0	985	34	51	0	0	0	2
6th: sib.AIBot	624	500	0	104	0	20	0	0	0	0

Fig. 9. Statistics offered by Robocode after a battle of 10 rounds

Despite these statistics offered by Robocode, learner/player profiling remains a problem in order to monitor its progress and control its access to the game. The integration with Dokeos platform allowed us to determine the profile of each learner/player who accesses the game by generating a set of statistics and indicators reflecting its progress.

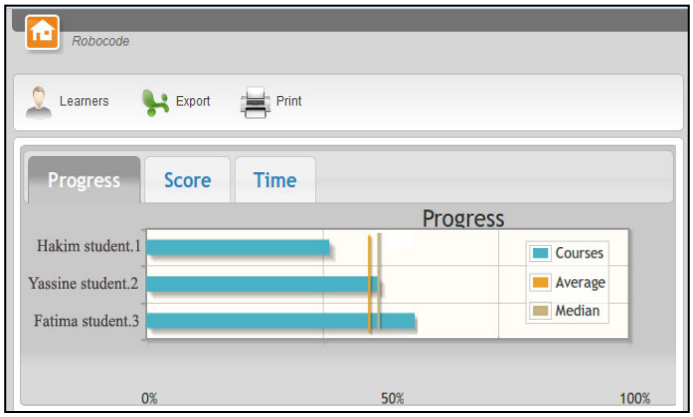

Fig. 10. Progress indicators in Dokeos

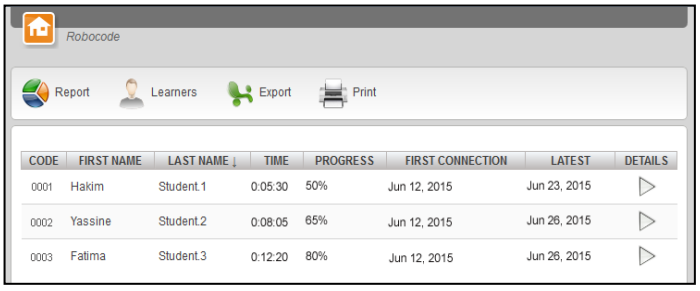

Fig. 11. Detailed statistics on each learner/player subscribed to the Robocode module

5 Conclusion

The main objective of this paper is to enable serious game to benefit from tracking and monitoring features offered by other virtual environments. Starting from this approach, we addressed the aspects of serious games (Robocode as example) integration and deployment into LMS (Dokeos as example) based on the automatic packaging and exportation of serious games as reusable learning objects (LO) that can be easily distributed through any LMS. We used the ADL SCORM data model that defines how content may be packaged as a Package Interchange File (PIF), and the IEEE LOM Application Profile "SG-LOM" as metadata description since the standard LOM doesn't meets the particular needs of serious games. As a result of our proposed approach, the integration of the serious game Robocode with Dokeos allowed to generate a set of statistics and indicators reflecting the progress of each learner/player. Through these statistics we can do a learner/player profiling by giving a detailed view of its activities.

6 References

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