e-learning Standards in Game-Based Learning?

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***Abstract*— Despite the proven benefits of Serious Games when compared to traditional e-learning, uptake of game-based learning in mainstream education is still very low. Increasing uptake requires making suitable games easier to deploy as an activity type in existing e-learning platforms, without compromising game quality or increase development cost; and leveraging data generated by players to improve their learning outcomes. We briefly discuss available e-learning standards to address these issues and describe our current standards-based approach to both game deployment and evaluation (including learning analytics).**

Keywords—serious games, e-learning standards, learning analytics, learning management systems

I. INTRODUCTION

Teachers that want to include game-based learning in their courses confront multiple challenges, including: i) finding suitable games, ii) providing access to students as activities integrated into their institutional Learning Management System (LMS), including grading and evaluation; and iii) leveraging the high degree of interactivity of games to enjoy the benefits of Learning Analytics. Ad-hoc solutions for these challenges are expensive to develop and maintain, and lead to vendor lock-in, compromising the institution's freedom to change platforms or manage the resulting data. The logical answer is to rely on open standards, which allow disparate systems to interoperate and fuel a thriving ecosystem of e-learning systems. This paper describes how current and upcoming e-learning standards can facilitate deployment of serious games in educational contexts while providing access to learning analytics.

II. E-LEARNING STANDARDS AND EDUCATIONAL RESOURCES

Table I provides an overview of some of the main e-learning standards and their features, with columns grouped into metadata, to describe and later locate relevant games; game packaging and access; and communication/analytics. Several standards cover multiple concerns at once.

A. Accessing activities: IMS CP, LTI and CC

IMS Content Package has been widely adopted by the most popular LMSs and is actively used for content/game packaging in learning environments. When packaging games or other highly interactive content, IMS CP is limited to web-based distribution, which is suitable only for technologies such as WebGL. IMS CP packages are self-contained, placing a significant load on LMS hosting infrastructure when delivering large games and complicating updates for deployed games.

The IMS Learning Tools Interoperability standard focuses on communications between LMS platforms and tools. It provides a mechanism to forward user authentication and authorization from the LMS to an external tool for the duration of a session. During gameplay, tools can report back completion and grades for tasks carried out by students. LTI is simple to use for teachers, which only need to provide a link to the LMS that can then automatically configure the corresponding activity. Nevertheless, on the developer side, it is a complex standard to implement and it cannot handle native applications by itself. LTI is currently adopted by most major LMSs.

Finally, IMS Common Cartridge (CC) is a specification by IMS similar to ADL's SCORM, using IMS CP as a packaging base, but with a more flexible approach. It provides better mechanisms to build packages from modules, greatly facilitating reuse of content within a package. It can also include LTI links as content, providing web-distribution and communicating activity with LMSs. However, there is a low adoption rate among the main open-source LMSs such as SAKAI and Moodle; additionally, supported versions tend to be outdated, and may lack support for LTI.

TABLE I. MAIN E-LEARNING STANDARDS AND THEIR FEATURES

E-L standard	Feature					
	Metadata	*Packaging*	*Delivery*	*Protocol*	*Report*	*L A*
LOM	X	-	-	-	-	-
CP	LOM	X	-	-	-	-
SCORM	LOM	CP	-	X	x	-
LTI	-	-	X	-	X	-
CC	LOM	X	LTI	-	LTI	-
xAPI	-	-	-	-	-	X
CMI-5	Basic	X	X	X	X	X

B. Communication & L.A.: SCORM, xAPI, Caliper and CMI5

The Shareable Content Object Reference Model (SCORM) is a web-based collection of standards and specifications for Learning Objects developed by ADL. It builds on IMS CP for packaging and IMS LOM for metadata, and then adds a simple communication layer. SCORM versions 1.4 and 2004 are well-supported and used for game-based learning. However, SCORM inherits several problems from IMS CP, provides a very constrained information stream which is mostly limited to result-score pairs, and only supports web-based platforms.

The xAPI specification is an activity stream data model for Learning Analytics that requires an external communication protocol to be implemented and relies on an external Learning Record Store (LRS) to store the information. Its focus is to provide a flexible format to trace all meaningful interactions,

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using simple statements that include an actor, an object and a verb, and can optionally include results, score and a set of customizable extensions. The xAPI model can be extended with *application profiles* that add more verbs, objects and extensions to describe specific domains, such as Serious Games when using xAPI-SG [1]. IMS Caliper is a related standard that also supports activity streams, using events instead of statements, each with an actor, action and object which align with xAPI's actor, verb and object. These events can also use specific vocabularies. However, adoption of Caliper is currently lagging that of xAPI in e-learning systems.

The ADL/AICC CMI-5 protocol is a packaging and communication standard for xAPI-based courses. It is the spiritual successor of SCORM, addressing most of its weaknesses. CMI-5 uses a specific xAPI profile to communicate with the LRS and describe the state of activities, using extensions for its outcomes. Launching a CMI-5 activity from an LMS transfers the user to the activity through a URL-based protocol. This allows native applications to be launched by using URI Schemes, supported in most operating systems. When launching activities, LMSs can provide authorization and user information as actors to the corresponding application, solving the task of identifying the user and gathering user information for activities. While CMI-5 was launched in 2016, it remains, as of this writing, unsupported by mainstream LMSs.

III. A Standards-Based Proposal

Our proposal (Fig.) focuses on the task of delivering games using standards that go beyond the limits of IMS CP and SCORM, providing support for native applications and better game distribution, while integrating grading, evaluation, and rich analytics with xAPI. Since CMI-5 is not yet widely supported, we use an alternative approach for hosting xAPI-based CMI-5 packages, using LTI to delegate the CMI-5 package launch to an intermediate xAPI-compliant tool that also contains an LRS to store the traces. With LTI, the LMS creates a bidirectional communication channel with the mediator tool. In one direction, it delivers the user's authorization session to the mediator platform, and in the other direction results from the activity are reported back to the LMS. Once activities finish, xAPI reports become accessible via LTI Submission Review.

User experience is also an important factor in this approach. Students enjoy a seamless experience with a one-click launch of the game by following a link presented by their LMS, since the CMI-5 launch is seen as a redirection. This gives developers freedom to choose where the game is hosted, and can boost the speed with which the game can be launched and simplify maintenance of deployed games. The teachers' task is also streamlined when game packages are managed by developers, teachers just have to include the appropriate LTI links in their LMS courses, instead of having to upload packages to the mediator tool to obtain the corresponding LTI links.

We have implemented most of this proposal as a proof of concept, using uAdventure (an authoring tool built on top of Unity 3D) for game development, packaging and xAPI support; and Simva (a multi-purpose validation tool that includes user management, experiment design, cloud storage, and data-science [2]) for LTI connection, a CMI-5 inspired launch, and to

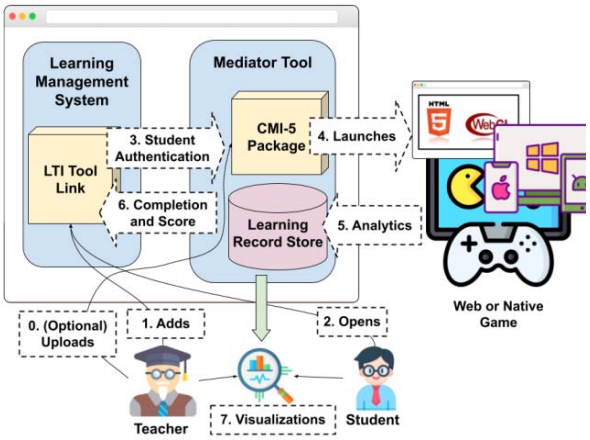

Fig. 1. Using games in the class with LTI and CMI-5 through a mediator tool that supports CMI-5 Launch for xAPI-Based analytics.

provide basic LRS-like functionality. This "proxy" approach can launch both online and native games and transparently handle player authorization during the activity. Our vision is for game developers to automatically package and export games to Simva, generating LTI links that allow teachers to include the resulting game in their courses, resulting in both interoperable games and simple-to-integrate game-based activities.

IV. Conclusions and Future Work

Game-based learning offers educators significant benefits compared to traditional methods. But to generalize its use, serious games should be easier to deploy in real setting. Upcoming e-learning standards such as CMI-5 could be a solution but are not yet supported by any major LMSs.

We propose an approach to integrate games in LMS courses that relies on the widespread LMS support of LTI to integrate a mediator tool that supports launching xAPI activities, packaged using CMI-5. We consider that our approach would result in more interoperable games that include rich learning analytics are simple-to-integrate with other e-learning activities.

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