Integrating Gamified Educational Escape Rooms in Learning Management Systems

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Abstract

Escape rooms offer an immersive and engaging learning experience that encourages critical thinking, problem solving and teamwork. Although they have shown promising results in promoting student engagement in the teaching-learning process, they continue to operate as independent systems that are not fully integrated into educational environments. This work aims to detail the integration of educational escape rooms, based on international standards, with the typical central component of an educational setting - the learning management system (LMS). In order to proof this concept, we present the integration of a math escape room with the Moodle LMS using the Learning Tools Interoperability (LTI) specification. Currently, this specification comprises a set of Web services that enable seamless integration between learning platforms and external tools and is not limited to any specific LMS which fosters learning interoperability. With this implementation, a single sign-on ecosystem is created, where teachers and students can interact in a simple and immersive way. The major contribution of this work is to serve as an integration guide for other applications and in different domains.

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1 Introduction

Escape rooms are interactive and immersive entertainment experiences in which participants are locked in a room. The goal is to solve a variety of puzzles, riddles, and challenges within a set time limit to ultimately find a way to escape from the room. Escape rooms often have a specific theme or storyline which can be integrated into many academic disciplines such as mathematics, computer science, STEM subjects, physics, biology and many others [4].

These escape rooms, typically used for entertainment games, have been adapted for educational purposes as a way to engage students in learning in an interactive and playful way. This approach has received attention from educational researchers, who have investigated how Educational escape rooms (EER) can be used to promote learning and develop skills such as teamwork, problem-solving, decision-making, and critical thinking [3].

While EER have proven highly effective in terms of student engagement and active learning [6], it is important to recognise that interoperability with learning environments, such as Learning Management Systems (LMS), is crucial to create a unified ecosystem where teachers and students can easily access and exchange information with each other through two-way communication [5].

This work aims to address the integration of educational escape rooms into learning management systems. Although escape rooms have shown promising results in promoting student engagement and learning, they continue to operate as independent systems that are not integrated into educational environments. The objective of this study is to demonstrate the integration of an educational escape room – for learning Maths – with Moodle LMS using an international specification called IMS LTI [1]. This standard includes a set of services that enable seamless integration and is not limited to any specific LMS. By implementing this approach, a single sign-on ecosystem is created, where teachers and students can interact seamlessly. Teachers can expose links to specific escape rooms within the LMS, and students can access and solve the challenges. Additionally, teachers can monitor students' performance in these rooms through the LMS's gradebook without the burden of manually collecting data from the escape room, reducing the potential for errors and saving valuable time.

The rest of the article is structured in three sections: the second section presents related work on EER and integration frameworks. The following section present the integration architecture, followed by a detailed explanation of its components and the steps needed to integrate the two components using the IMS LTI specification, more precisely, the integration between Moodle LMS and a Math escape room. Finally, the contributions of this article to the scientific community are presented as well as the future work.

2 Related work

EER are a type of learning activity where students are placed in a simulated environment where they must solve a series of puzzles and challenges in order to escape within a given time limit. While solving challenges, students learn a variety of subjects and skills, from critical thinking and problem-solving to content-specific concepts and knowledge. At the same time, they promote collaboration, communication, and creativity. However, in order to maximize the benefits of EER, it is important to integrate them with other learning tools and platforms, such as learning management systems.

2.1 Integration of LMS with EER

Integration of EER with LMS allows for a seamless transfer of data between the two systems, making it easier for teachers to manage student progress and for students to access and engage with the content with a single sign-on environment. The following are some examples of the integration between these two types of systems:

- **Schoology** - Schoology is a popular LMS that offers integration with EER, such as Breakout EDU [2]. This integration allows teachers to assign escape room challenges to students directly through the Schoology platform, and students can complete the challenges and submit their results back to Schoology for grading and assessment.

- **Canvas** - Canvas is another popular LMS that offers integration with EER, such as Escape Classroom and Breakout EDU. With this integration, teachers can easily embed Escape Classroom challenges into their Canvas courses, and students can complete the challenges and submit their results directly through the Canvas platform.
- **Moodle** - Moodle is an open-source LMS that offers integration with EER through several plugins and modules. For example, the "Escape Room" module allows teachers to create and manage escape room challenges within their Moodle courses, and the "Breakout EDU" plugin allows for integration with Breakout EDU escape rooms.
- **Blackboard** - Blackboard is a widely used LMS that offers integration with educational escape rooms through the "Breakout Room" tool. This tool allows teachers to create and assign escape room challenges to students within their Blackboard courses, and students can complete the challenges and submit their results back to Blackboard for grading and assessment.
- **Google Classroom** - Google Classroom is a free LMS that offers integration with EER through various third-party tools and platforms. For example, the "Escape Room Extension" for Google Chrome allows teachers to create and manage escape room challenges within Google Classroom, and the "Escape Room Digital Locks" tool allows for integration with various types of digital escape rooms.

2.2 Integration specifications

The IMS LTI specification [1] defines a set of standard messages and protocols for communication between the LMS and external tools or applications. This ensures that different tools and applications can work seamlessly with different LMS platforms, making it easier for educators to use a variety of tools to enhance the learning experience.

In its 1.3 version, the specification integrates the LTI Advantage as an extension to provide additional services that aim to enhance the interoperability, security, and user experience of the LTI platform. The main services provided by LTI Advantage are:

- **Deep Linking** - allows educators to link directly to specific content items in an external tool, such as a specific quiz or assignment. This enables users to access specific content items without having to navigate through the external tool interface.
- **Assignment and Grade Services** - allows the exchange of assignment and grade data between the LMS and external tools. This enables educators to create and grade assignments directly within the LMS, using external tools to provide additional functionality or content.
- **Names and Role Provisioning Services** - allows the exchange of user and role data between the LMS and external tools. This enables external tools to customize the user experience based on the user's role or other user data.

There are several alternatives to IMS LTI that provide similar functionality for integrating external learning tools with LMS, such as:

- SCORM (Sharable Content Object Reference Model) - a set of standards and specifications that define how e-learning content can be packaged and delivered to learners through an LMS. SCORM includes a runtime environment (the SCORM player) that enables the communication between the content and the LMS.
- xAPI (Experience API) - a newer specification that allows for more flexible tracking and reporting of learning activities, beyond what is possible with SCORM. xAPI enables the collection and analysis of data about a wide range of learning experiences, including informal and social learning.

- Common Cartridge - a standard for packaging and sharing e-learning content, including multimedia, assessments, and other interactive learning objects. Common Cartridge aims to provide a more portable and flexible way of sharing content across different LMS platforms.
- AICC (Aviation Industry Computer-Based Training Committee) - A specification for integrating external learning tools with LMSs, primarily used in the aviation industry. AICC provides a set of communication protocols and data structures for exchanging data between the LMS and external tools.

From all these alternatives presented, the xAPI (Experience API) specification is one of most promising specification. xAPI, also known as Tin Can API, is a specification for tracking and recording learning experiences in a standardized format. It is designed to capture data from a wide range of sources, including mobile devices, simulations, and virtual environments, among others. The xAPI specification enables the collection of a wide range of data, including learning experiences that occur outside traditional LMS, such as informal learning experiences or on-the-job training. This data can include a variety of information, such as learning objectives, assessment scores, and even learner emotions.

The xAPI specification is closely related to a Learning Record Store (LRS). An LRS is a database that stores learning experience data in the format specified by xAPI. It is the system responsible for collecting, storing, and retrieving xAPI statements, which are the standardized format for recording learning experiences. The LRS can also provide analytics and reporting capabilities that enable organizations to gain insights into learning experiences and improve learning outcomes. By recording learning experiences, organizations can gain a more complete understanding of how their learners are interacting with learning content, and can use this information to improve training programs and support individual learning needs.

It's worth noting that each of these alternatives has its own strengths and weaknesses, and the choice of which to use may depend on specific use cases and requirements. However, IMS LTI is currently the most widely adopted and supported standard for integrating external learning tools with LMSs.

3 Integration framework

This section outlines the process of integrating a learning platform (Moodle LMS) with an external tool (Math Escape Room). Firstly, the integration architecture is presented, followed by a brief explanation of one of its components (the escape room). Finally, the steps to integrate the two components, using the IMS LTI specification are listed.

3.1 Integration architecture

An integration architecture refers to the overall structure and design of the framework that enables different software applications or systems to communicate with each other and exchange data seamlessly. Figure 1 illustrates the integration architecture for the communication between the learning platform and the external tool.

The LMS serves as the entry point for both teachers and students. Teachers can add links to access the external tool (either as a whole or for a specific room), while students can access these links and enter the escape room to solve challenges. All performance results are then sent back to the learning platform, specifically to the LMS gradebook of the corresponding course. All these interactions are done implementing the IMS LTI 1.3 (with Advantage services). Meanwhile, all student activity, such as academic performance, behavior patterns,

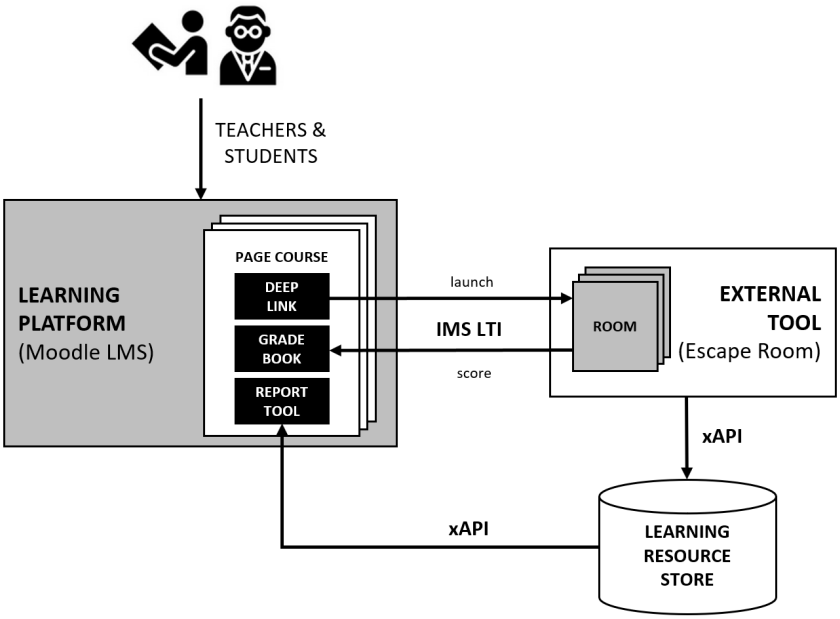

Figure 1 Integration of the learning platform and the external tool.

and social interactions, among others, is sent to special databases called LRS and then forwarded to reporting tools for analysis. All this communication is guaranteed by the xAPI specification. By analyzing student data, educators can gain insights into how students learn, identify challenges they face, and determine the most effective strategies for promoting learning. They can use this information to customize instruction to the needs of individual learners, identify students who may be at risk, and improve overall course design and delivery.

3.2 Math Escape Room

A math escape room is a type of interactive game where players are presented with math problems and puzzles that they must solve to progress through a series of challenges or rooms. The ultimate goal of the game is to "escape" from the room by solving all of the puzzles before time runs out. Math escape rooms can be designed for a variety of skill levels, from basic arithmetic to advanced calculus. They can be used as a fun way to reinforce math concepts in a classroom setting, or as a team-building activity for a group of friends or colleagues.

For this proof of concept, we choose a math escape room from the Math-Digger European project[1] – MATH-DIGGER project - MATHematics Digital Escape Rooms platform – which aims to provide a free tool to maximize students' enjoyment, engagement and motivation in their math learning process. Students will face exciting math exercises and problems as micro-games in Geogebra, developed for Linear Algebra and Analytical Geometry, Differential and Integral Calculus courses, mostly based in real world problems, and solve them in a virtual reality framework.

Despite its usefulness, it is implemented as a separate web platform to which a student can log in to solve math challenges served in a gamified form (e.g., as challenges and quests rewarded with points and badges, etc.). This means that the student must leave the LMS

[1] `https://www.ipp.pt/mathdigger/`

platform to solve the challenge(s), and his/her achievements are not transferred back to the LMS platform. Therefore, the instructor also must log into the Escape Room platform and, somehow, to see the students' individual progress and, finally, to combine this data with the LMS-based student activity data to produce the final grade. The goal of this integration work is therefore to fill the gap between interactive learning environments and popular LMS platforms using an LTI-based approach, in specific, to open the Escape Room ecosystem to educational environments. This is much more flexible and sustainable compared to writing plugins for popular LMS platforms, i.e., by providing an LTI-compliant interface to Escape Room platform, any LTI-compliant LMS can be connected to it. Using the plugin option, every LMS would require a dedicated plugin written only for it and any updates to LMS code could render older plugins incompatible. Furthermore, the LTI, as an established standard, it is expected to stay for a considerable time.

4 Integration steps

This section presents a guide with all the steps to allow the integration of a math escape room (the external tool) with Moodle LMS (the learning platform) using the IMS LTI specification.

It is expected that this section can be useful in other domains by replicating all the steps contained herein to link other environments (new LMS platforms and new external tools) into an educational setup. The main steps are:

1. Adding the external tool into the learning platform;
2. Registering the learning platform in the external tool;
3. Adding course activities in the learning platform.

4.1 Adding the external tool into the learning platform

In this section we detail the steps needed to add the math escape room as an external tool in Moodle LMS. To this end, sign into Moodle as an administrator and select manage external tools to configure a tool manually. This opens the external tool configuration form where the administrator should fill the following fields:

1. Tool name, URL (the URL of the escape room) and description;
2. Specification: LTI 1.3
3. Public Key type: RSA key
4. Public key: leave this field empty. This will be filled out later when we register the LMS (Moodle) as the platform in the escape room.

After saving changes, the Client ID will be filled in automatically which will be necessary for the next step.

4.2 Registering the learning platform in the external tool

The LMS platform needs to be registered in the external tool (the math escape room) to get a Public Key, which allows signatures of incoming messages and service requests to be verified. At the moment, there isn't a User Interface (UI) form to facilitate this process. Therefore, the register code is stored in an index.js file of the web app deployed in a server platform (Heroku).

Listing 1 Main code.

```
// Register platform
const platform = await lti.registerPlatform({
  url: MOODLE_URL,
  name: "MD",
  clientId: process.env.LTI_KEY,
  authenticationEndpoint: "{{MOODLE_URL}}/mod/lti/auth.php",
  accesstokenEndpoint: "{{MOODLE_URL}}/mod/lti/token.php",
  authConfig: {
    method: "JWK_SET",
    key: "{{MOODLE_URL}}/mod/lti/certs.php",
  },
});
```

This JavaScript object contains several properties. Each property contains a key and the respective value. The most important keys are: url - the URL for the platform; name - the name of the external tool configuration in the platform; clientid - the id generated after the creation of the external tool instance in the platform. Please add LTI_KEY as an environment variable in the server platform where the Web app is deployed (in this case in Heroku); endpoint - a set of URLs that defined platform endpoints. When we launch for the first time the escape room it will log the public key. The obtained public key should be added to the external tool in Moodle.

4.3 Adding course activities in the learning platform

After fully configuring the external tool, teachers may add an external tool activity by:

1. Select the added tool (in this case, the escape room) in the preconfigured tool;
2. Add a name and a description to the activity;
3. Select new window as Launch container
4. Enable all options, in the privacy section, namely Share launcher's name with the tool, Share launcher's email with the tool, and Accept grades from the tool;
5. Set Completion tracking, in the activity completion section, to show activity as complete when conditions are met and enable the Require grade option.

5 Conclusion

This paper presents a guide with all the steps needed to allow the integration of a learning platform (Moodle LMS) with the external tool (math escape room) using the IMS LTI specification. The expected impact is significant, as it removes the limitation in the adoption of external tools in a typical educational setting where the LMS plays a central role. Apart from satisfying the needs described above, it also addresses the psychological barrier of instructors being reluctant to add yet another platform to the portfolio of their educational IT tools. The major contribution of this work is to serve as an integration guide for other applications and in different domains.

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