Simplifying serious games and analytics deployment in a virtual campus using LTI and xAPI

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***Abstract*—Effective deployment of Serious Games into the classroom is a challenging task that adds extra administrative burden to educators and researchers, hindering the generalization of the use of games in the class. This paper presents how elearning standards such as IMS LTI and xAPI specifications can be used to simplify this deployment. This approach has been tested in the context of the Erasmus+ project IMPRESS, using serious games to teach software engineering.**

Keywords*— *serious games, analytics, virtual campus, external tools, IMS LTI

I. Introduction

Virtual Campuses (VCs) are a key element used to organize the educational activities of many higher learning institutions. VCs not only provide access to educational content and communication and collaboration tools; increasingly, they also include learning analytic capabilities that can take into account students' interactions to provide insights to teachers on students' progress through the educational activities in a specific course.

Due to the diversity of needs that they address, VCs are not monolithic and closed systems; instead, they are built to be highly customizable, and extensible through addons and extensions that provide additional tools. The number of built-in tools found in a specific VC, however, is always limited; teachers often need to incorporate external tools that are better suited to their educational scenario. Depending on the kind of tool, its use in the VC may require significant additional work for the teacher. This effort usually implies at least the initial setup and configuration of the tool; but, when the tool is loosely integrated in the VC, it can also require recurrent additional tasks every time the tool is used, such as copying the students roster from the VC into the tool, sending results from the tool to the VC, or even distributing the tool itself and/or its access codes, into students' devices. In particular, integration of gamified learning activities and Serious Games (SGs) as external tools into VCs generally incurs many of these extra burdens.

In controlled scenarios, these issues have been addressed with tools that implement interoperable educational standards [1]. For instance, a SG can be packaged as an Open Educational Resource (OER) - and then deployed on VCs which support this packaging. However, packaging presents several limitations: first, it can only be used to deploy web-based tools; and additionally, the type of information that packaged tools can send back to the VCs severely hampers gathering of analytics. For example, a packaged serious game would not be able to send back detailed information on student interactions while playing it to the hosting VC.

Fortunately, there are emerging new interoperable educational standards such as LTI or xAPI that can be used to address some of these previously identified issues. We have used those standards to simplify SG game deployment in VCs at the university level. This has been done in the context of the Erasmus+ Project IMPRESS to facilitate the usage of a serious game that teaches software validation concepts (FormalZ) to improve the learning experience on a software engineering course. Section II of this paper describes FormalZ in the context of the IMPRESS project, focusing on how analytics were integrated, how the evaluation was carried out, and limitations of this approach. Section III describes how we addressed those limitations in FormalZ and other SGs. Finally, section IV provides some conclusions and future lines of work.

II. The IMPRESS Project, Initial Situation and Limitations

The EU Erasmus+ Project IMPRESS aims to explore the use of gamification and SGs in educating software engineering at the university level. The objective has been to develop a toolset that can help to improve students' engagement, and hence their appreciation, for difficult subjects such as software testing and specifications.

One of the activities that are considered more daunting and boring by computer science students is learning formal specifications. To help this problem, one of the results of the IMPRESS project is the FormalZ SG (see fig. 1). FormalZ allows teachers to formulate exercises on writing formal specifications and deploy them as a game in their class. Students can have some fun in playing the game and, while doing so, learn the basics of writing formal specifications. FormalZ takes a rather radical approach, namely deep gamification, where playing gets a key central role in order to generate student engagement [2].

Moreover, teachers can take advantage of the analytics capabilities that are integrated in FormalZ to follow the students' progress or proactively support students that get stuck during the activity. To provide useful insights for the teacher about the students' game we created a teacher dashboard (see fig. 2) on an improved version of the RAGE-Analytics platform customized for the specific needs of the IMPRESS project [3].

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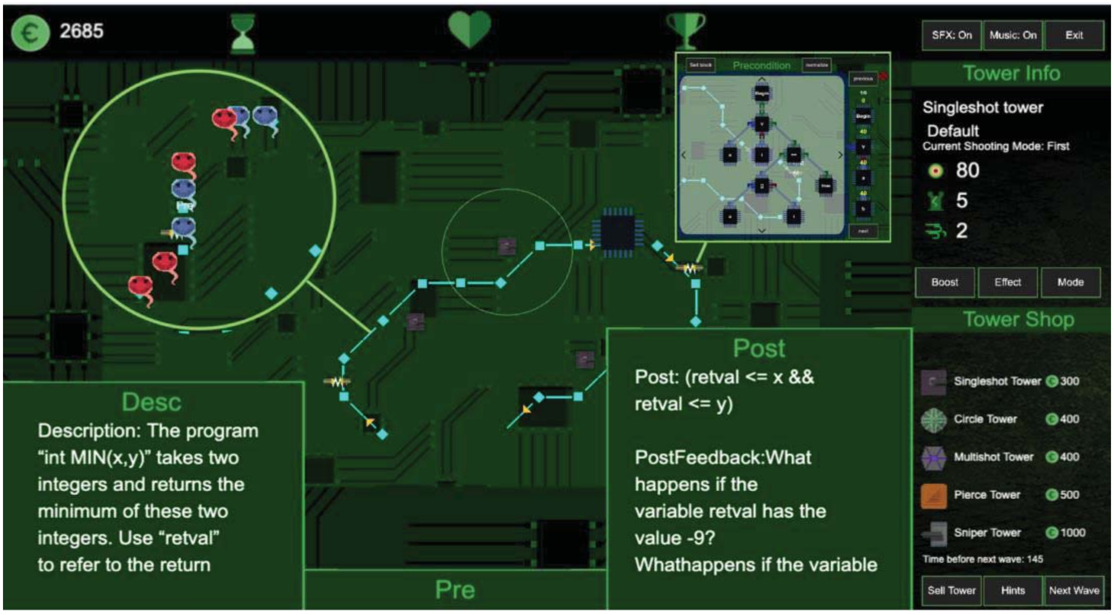

Fig. 1: FormalZ game screenshot. Source: Self-made.

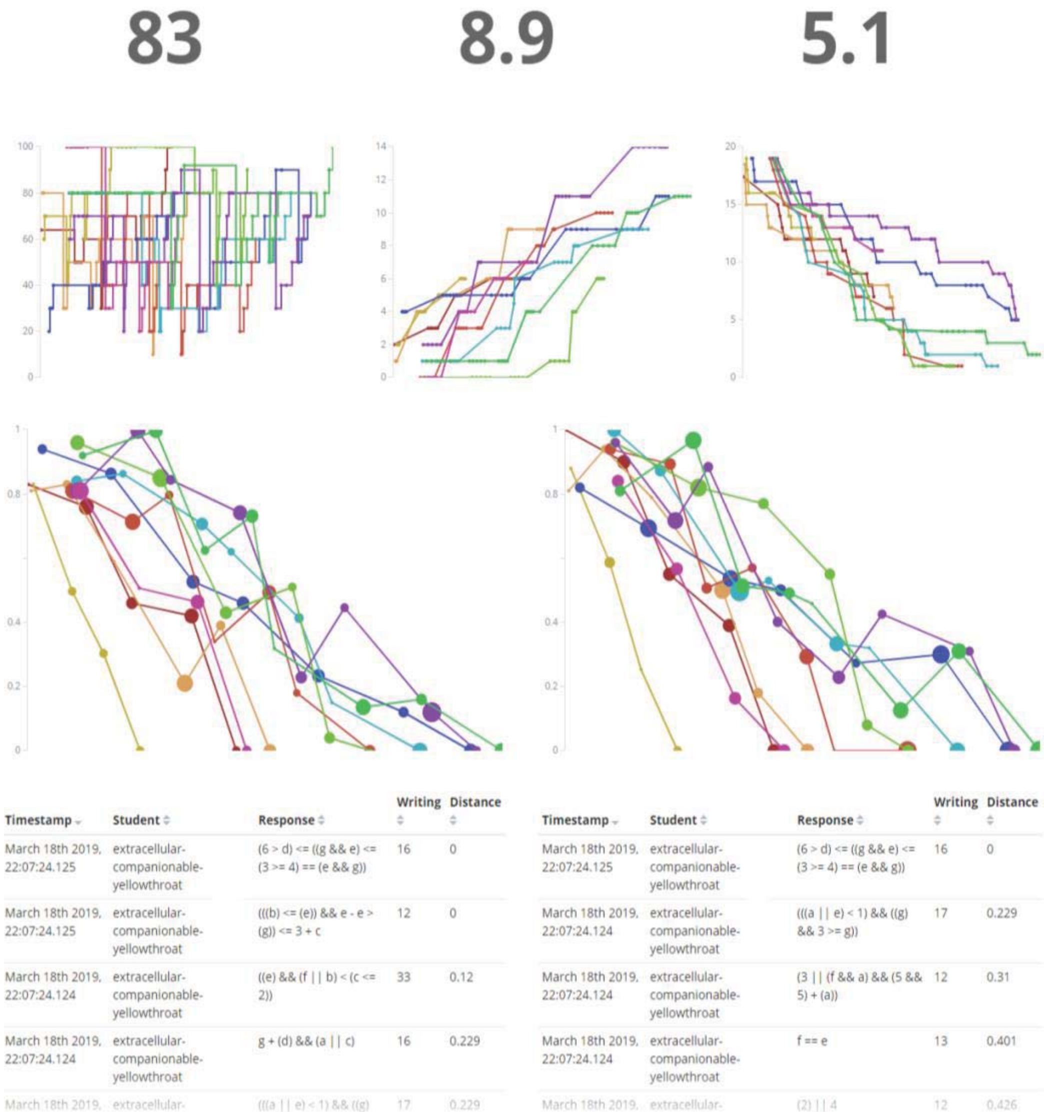

Fig. 2 FormalZ analytics dashboard. Source: Self-made.

Currently FormalZ supports three different roles:

- Administrator, managing all teacher accounts.
- Teacher, managing one or more *rooms* (a group of students and a teacher), and *puzzles* within the rooms (the problems to solve through the game).
- Students, who enter rooms to play its puzzles.

Thus, the usual workflow with FormalZ in a specific course, consists on the following steps:

1. If not previously done, the Administrator invites the teacher to the FormalZ platform to create a new account.
2. The teacher creates a specific Room in FormalZ and either invites each of the students by sending invitations to create accounts; or posts a link (with a password) in the VC so students can enroll themselves to create an account inside the Room.
3. The teacher creates a Puzzle within a specific Room. Each puzzle takes the form of an informal description of the pre- and post-condition of a hypothetical program and with a model solution. The teacher then posts a message about it in the VC so that students know where to find it
4. Students enter the room to play and solve the puzzle.
5. In addition to the analytic the teacher gets from the associated dashboard, if he/she wants to use the score as a course metric for the activity, the teacher must copy the student's scores back to the VC.

In addition, feedback about FormalZ was gathered using Google Forms questionnaires. However, a more formal and scientific validation of FormalZ (e.g., full system validation, to validate a specific puzzle, or to validate two versions of a specific puzzle) requires a more systematic approach [4].

III. FormalZ VC Integration and Validation With SIMVA

To alleviate the burden of the management and to improve the usability for both teachers and students we decided to integrate FormalZ with the specific VC used for our experiments (Moodle). However, instead of doing an ad-hoc integration of FormalZ as a specific Moodle Activity plugin, we decided to extend the FormalZ Management component to support IMS LTI 1.3 [5], integrating FormalZ as an LTI Tool. This enables not only integration with Moodle, but also with any other LMS compatible with IMS LTI, such as SAKAI, Canvas, Brightspace or Blackboard.

Based on the experienced acquired through IMPRESS and the development and validation of other SGs like Conectado [6] or First-Aid [7] we distilled the steps required to validate a SG and we build a tool called SIMple Validation tool (SIMVA) to help with this process [8]. SIMVA seeks to provide an all-in-one evaluation tool for serious games and other activities (see fig. 3). It automates significant parts of the experimental setup, participant management and grouping, analytics, questionnaires, and experimental design; together with activity deployment and monitoring. Finally, data collected by SIMVA is designed to be easily accessible from external analysis tools.

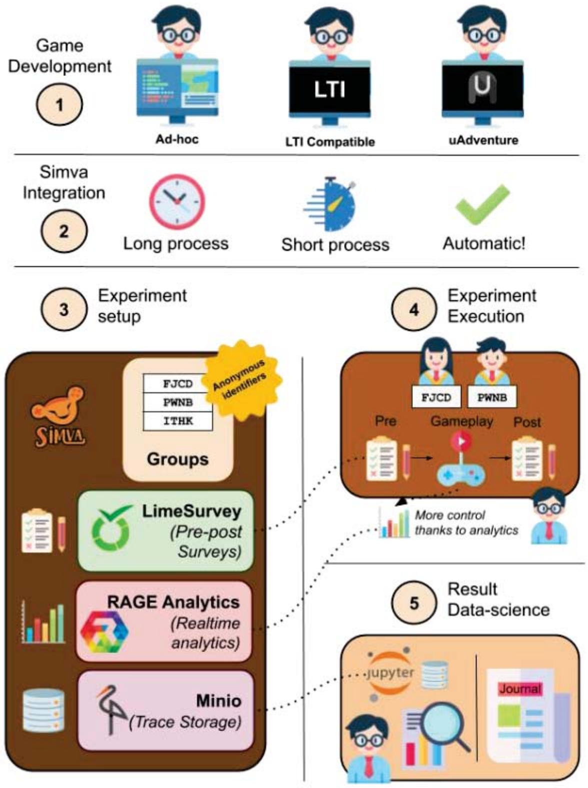

Fig. 3: SIMVA simplified game validation process. Source: Self-made.

SIMVA's "case studies" are a sequence of activities. While additional activities can be added, SIMVA already includes all standard activities commonly used when scientifically validating a SG:

- Gather and store analytic data so it can be analysed afterwards. We provide a simple means to give access to the collected data through an API compatible with AWS S3 API, so it is easy to integrate with analytics and data science tools like Jupyter Notebooks.
- Relay analytic data to an analytics back-end (RAGE Analytics) for real-time analysis.

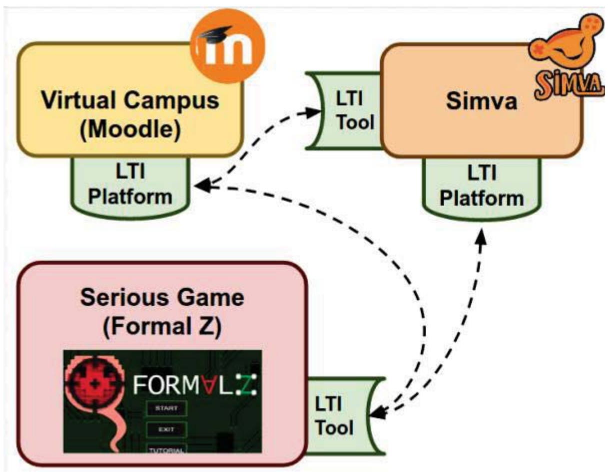

Fig. 4 *Left*: SG integration as an LTI Tool within a VC; *Right*: SIMVA's integration approach as a Platform for other LTI Tools and as an LTI Tool inside the VC. Source: Self-made.

- Pre-post questionnaires. SIMVA integrates an already established survey tool called LimeSurvey. Teachers/researchers can use this tool to create surveys to simplify user feedback or to define more formal pre-post surveys to validate the SG.

SIMVA manages the state of the case study / experiment for each of the participants providing a unified and integrated tool. SIMVA allows users to smoothly transition between the activities (even if managed by different tools) that correspond to their group in a particular case study.

However, with SG like FormalZ, or in fact any other similar interactive tool, we need to perform an integration between the tool and SIMVA. To take advantage of the work done in FormalZ, and to minimize the effort of integrating another tool with SIMVA we decided to add IMS LTI support to SIMVA too. Thus, SIMVA acts both as an LTI Platform and as an LTI Tool (see fig. 4). SIMVA as an LTI Platform simplifies the integration of external tools such as FormalZ, while at the same time SIMVA as an LTI Tool allows easy integration an external tool inside any LTI compliant VC.

IV. Conclusions and Future Work

Applying emerging e-learning standards such as IMS LTI and xAPI greatly simplifies the deployment of SGs and other interactive tools in VCs. We have described how their application in the Erasmus+ IMPRESS project has smoothed the process of integrating FormalZ SGs in a Moodle VC and how the standards support of SIMVA helps to generalize the process, including support for SGs learning analytics.

Our work also has some limitations. Currently both FormalZ and SIMVA implement IMS LTI v1.3, which appeared in 2019 and is only supported in recent versions of the LMSs that provide the VCs. This imposes a restriction in educational organizations that are still running older versions. Moreover, certain LTI Tools do not support LTI 1.3 yet. To provide support for these systems, we are planning to add support for LTI v1.1.2 in newer versions of SIMVA.

As future work, we are exploring these new opportunities combining SIMVA with our SG authoring tool called uAdventure (https://www.e-ucm.es/uAdventure). This will allow a native SG created using uAdventure to be seamlessly launched as an activity within a VC.

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