GamiTool: Towards Actionable Learning Analytics Using Gamification

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ABSTRACT: Learning Analytics enable a better understanding of teaching and learning processes by identifying and monitoring indicators based on students' activity. These same indicators can also be used by reward-based gamification strategies as conditions that students should satisfy to earn rewards, with the purpose of increasing their engagement with the learning contents and activities. Hence, gamification systems must enable the digital representation and interpretation of indicators based on students' activity, similarly as learning analytics tools do. This position paper introduces GamiTool, a gamification system to support the design and the computer-interpretable representation of a wide variety of learning analytics indicators that can be configured by practitioners as gamification conditions. Additionally, the paper discusses five potential lines of work regarding joint research with GamiTool and LA.

Keywords: Learning analytics, gamification, reward-based strategies, indicators, practitioners.

1 INTRODUCTION

Nowadays, playing games is one of the most popular forms of worldwide entertainment (OppenheimerFunds, 2018). Games' entertainment has its roots on the human feelings (*e.g.*, curiosity, excitement, competition) that game designs can generate as part of the interaction with the players. Gamification aims at identifying and implementing in non-game contexts, game design elements (*e.g.*, leaderboards, maps) and techniques (*e.g.*, onboarding, increasing difficulty) able to motivate the users, hold their interest and/or challenge them to solve problems (de Sousa Borges et al., 2014; Simões et al., 2013). One of the contexts where gamification has attracted lot of attention during the last years is online education (Antonaci et al., 2019).

Previous literature reviews on gamification showed that rewards (*e.g.*, experience points) are the game design elements most implemented in online educational environments (Antonaci et al., 2019; Dicheva et al., 2015). These rewards are visual elements (*e.g.*, ribbon) or privileges (*e.g.*, unlock content) that are issued when conditions defined beforehand are fulfilled (Ortega-Arranz et al., 2019). For instance, students can get a deadline extension for a task (*privilege*) when submitting three optional course tasks before a configured deadline (*condition*). Literature has also reported the potential of these reward-based gamification strategies in online environments regarding the improvement of learners' motivation, engagement and learning outcomes, among other benefits (Domínguez et al., 2013; Ibañez et al., 2014; Anderson et al., 2014).

However, the inclusion of reward-based strategies implies a set of orchestration tasks (Prieto et al., 2014) which must be carried out by practitioners (*i.e.*, teachers, instructors, instructional designers).

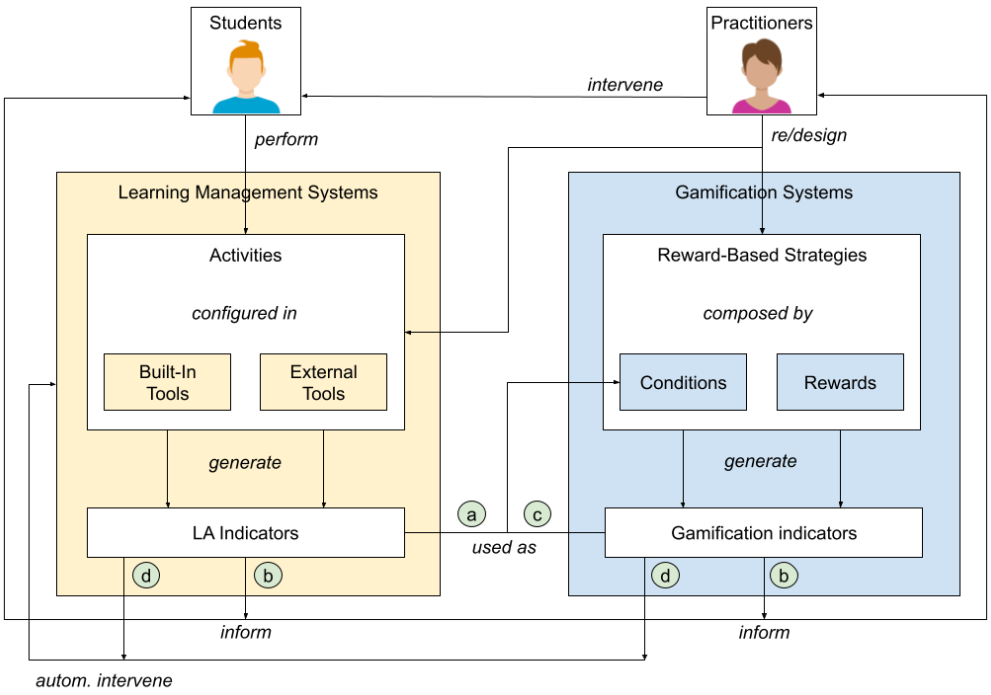

Figure 1: Association between LA and reward-based gamification in online learning environments.

For instance, the translation of practitioners' gamification purposes into reward-based strategies, the configuration of such strategies in the learning platforms, or their management during course run-time. Multiple gamification tools and systems have been created to support practitioners in performing such tasks and alleviate the associated workload such as OneUp (Dicheva et al., 2019), MEdit4CEP-Gam (Calderón et al., 2018) or Badgr[1]. In this situation, gamification systems are expected to provide automatic capabilities for orchestration tasks (*e.g.*, checking gamification conditions) and therefore, capabilities to computationally understand the different components shaping the gamification designs (e.g., course activities, conditions, rewards).

From the Learning Analytics (LA) perspective, reward-based strategies can be conceived as a form of making LA indicators actionable (Dichev et al., 2018), and gamification systems, as LA-design tools able to script, interpret and automate these actionable indicators. These gamification systems enable practitioners decide which indicators and thresholds will be used as conditions (e*.g.*, complete more than 3 peer reviews), and which actions will be taken once the conditions are satisfied (*e.g.*, unlock new learning contents). Usually, these conditions are based on students' behavioral data obtained from the system logs (see *(a)* in Figure 1) and represent students' actions considered beneficial by practitioners for the purposes for which gamification is used. For instance, counting students' posts to foster interaction in discussion forums (Anderson et al., 2014) or engage in practice by repeating exercises (Dicheva et al., 2019). These indicators can range from very simple information, close to raw data (*e.g.*, number of posts in forums), to more sophisticated ones, based on natural language processing or advanced analytic techniques (*e.g.*, thoughtful users) (Ruipérez-Valiente et al., 2015).

[1] Concentric Sky. Badgr: https://info.badgr.com/, last access: March, 2021.

This paper presents GamiTool (Section 2), a gamification system developed by the authors to support practitioners in the orchestration of reward-based strategies. This system supports: (a) the creation of flexible computer-interpretable gamification designs; (b) the automatic implementation and enactment of gamification designs according to the values and thresholds of LA indicators configured by practitioners; and (c) the real-time visualization of gamification indicators. Furthermore, Section 3 introduces some future lines of research considering GamiTool and the last advances carried out in the LA field. Finally, Section 4 outlines some conclusions obtained from this work.

2 GAMITOOL: SUPPORTING THE ORCHESTRATION OF REWARD-BASED GAMIFICATION STRATEGIES

GamiTool[2] is a gamification system implementing an adapter-based architecture to support the orchestration of reward-based strategies in multiple learning management systems (Ortega-Arranz et al., *under review*). GamiTool also incorporates a gamification-specific data model to support the flexible design of reward-based strategies (*i.e.*, conditions and rewards) as conceived by practitioners (see Figure 2). This flexibility in the design of gamification strategies aims at enabling practitioners to select a wide variety of LA indicators of their own choice to adapt their gamification conditions to their learning designs.

More specifically, GamiTool enables the computer-interpretable representation of gamification designs involving 10 different types of learning resources (*e.g.*, assignments, quizzes, content pages), and 30 different actions (*e.g.*, log in, submit, post) which can be further specified into multiple fine-grain rules (*e.g.*, before a specific date, several times). For instance, a gamification condition can be configured as *students must submit (action) the questionnaire located at Module 1 (resource) before the configured deadline (rule) and score higher than 90% (rule) in the first attempt (rule)*. This gamification condition shows the use of multiple behavioral indicators that can potentially inform about those students that are more engaged with the contents (first attempt, high score) at the envisioned course pace (condition deadline).

Apart from fine-grained conditions, GamiTool also supports the gamification of actions that must be satisfied by a specific percentage of group members (*e.g.*, at least 50% of group peers must contribute to the collaborative group glossary). Therefore, group activities can be also gamified to foster the individual accountability of group peers to achieve the reward. Additionally, since many learning situations are configured in distributed learning environments (Prieto et al., 2014), GamiTool was designed to interact with both LMS built-in and external tools, being able to retrieve behavioral indicators from both learning management systems (*e.g.*, Moodle, Canvas) and external tools (*e.g.*, Google Spreadsheets) in a same gamification design. In summary, all these features for the design of computer-interpretable gamified designs provide practitioners with a high flexibility when configuring LA indicators as gamification conditions (*e.g.,* conditions based on student individual actions, based on group actions, based on peer approval, based on previous earned rewards).

[2] Further information about GamiTool can be found at https://www.gsic.uva.es/gamitool/, last access: March 2021.

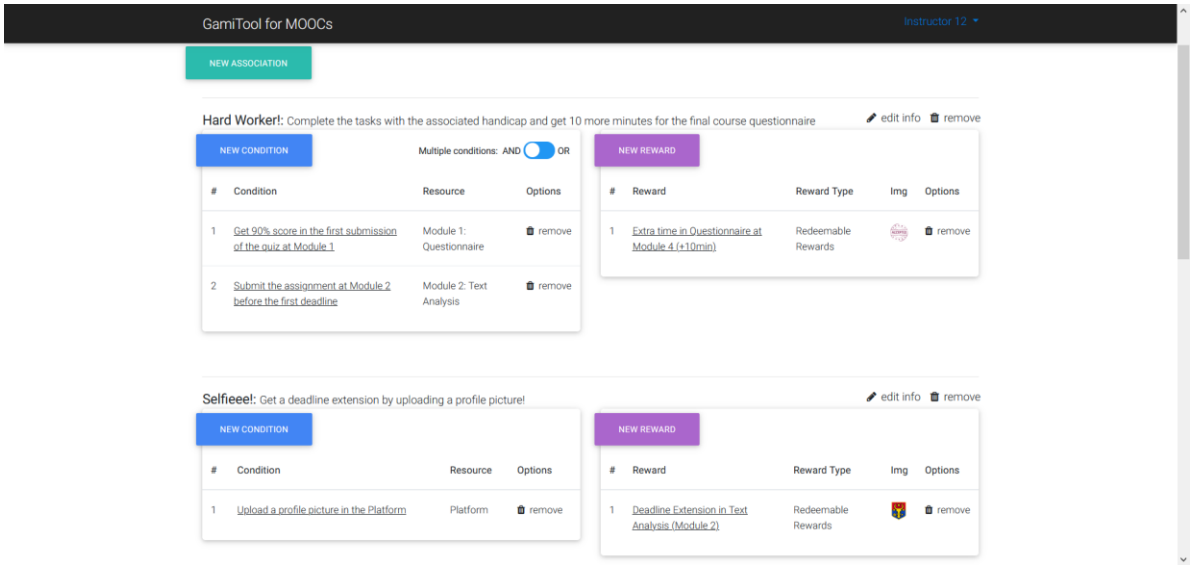

Figure 2: Screenshot of the GamiTool association page.

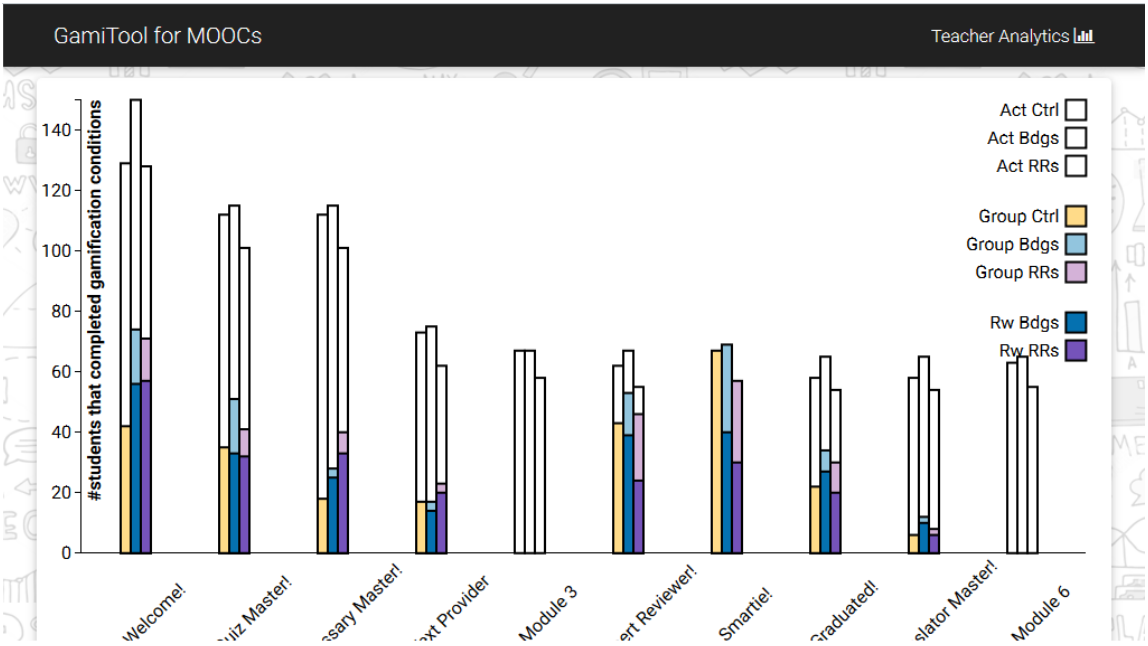

Figure 3: Screenshot of the GamiTool analytics page.

In addition, as represented in Figure 1, the interaction of students with the gamified activities, and therefore, with the configured reward-based strategies, generates multiple gamification indicators such as the number of earned rewards, the student positions in the leaderboards, the number of students that earned a concrete reward, etc. (Heilbrunn et al., 2017; Dichev et al., 2018). The gamification analytics strongly depend on the decisions taken during the design of gamification (*e.g.*, those designs including leaderboards can track the current position and the progress of the student in the leaderboard). These gamification indicators (see Figure 3) are potentially useful for monitoring and re-designing reward-based strategies, *e.g.*, a gamification condition is so difficult that only few students earned it (see *(b)* in Figure 1). Like the LA indicators, gamification indicators can be also used for the definition of new gamification conditions (*e.g.*, a new reward will be issued when student rank

first in the leaderboard or when students earn 100 experience points) and for automatic interventions in the learning design of the course (see *(c)* and *(d)* in Figure 1, respectively). This type of conditions based on gamification analytics are also supported by GamiTool.

A prototype of GamiTool has been developed supporting part of its functionality in two learning management systems (*i.e.*, Moodle, Canvas) and one external tool (*i.e.*, Google Spreadsheets). This prototype was used in a real MOOC hosted at Canvas Network (Ortega-Arranz et al., 2019), and was evaluated by 19 practitioners and gamification designers from multiple institutions (Ortega-Arranz et al., *under review*). In this last evaluation, among other features, practitioners were requested to create a gamification design with reward-based strategies over a given MOOC. Therefore, we could understand the extent to which GamiTool supports the representation of computer-interpretable gamification designs as configured by real practitioners and gamification designers (Ortega-Arranz et al., *under review*). Results showed that from all the configured gamification conditions (N=71), GamiTool can directly represent most of them (59.15%), including those involving behavioral indicators such as submitting quizzes, getting likes in discussion forums, or completing rubrics for peer review. On the other hand, results also revealed that a considerable percentage of conditions (39.44%) could be quantitatively supported by GamiTool but, ideally, they would require content analysis (*e.g.*, submit three economical terms to the course glossary) or more complex indicators (*e.g.*, active participation in the group task). Support to these two types of conditions has been outlined in the GamiTool roadmap agenda.

Another important feature of the evaluation was to understand the extent to which GamiTool helped practitioners to create gamification designs. In this situation, the GamiTool catalog of supported behavioral indicators that can be tracked for the different course activities was, in general, perceived as useful for the definition of new conditions, and showed a moderate positive correlation ($r(18)= -0.470, p= 0.049$) with the previous gamification experience of the users (Ortega-Arranz et al., *under review*). The evaluation also showed an "excellent" usability of the system (Brooke, 1996) according to SUS score ratings ($mean(19)= 84.61$), and a low perceived workload (Hart, 2006) for designing and implementing gamification designs according to the *Raw TLX* score ratings ($mean(19)= 31.57$).

3 EXPLORING SINERGIES BETWEEN GAMITOOL AND LA

LA (Siemens & Long, 2011) and gamification (Deterding et al., 2011) have been proposed to address similar educational drawbacks (*e.g.*, improving student learning outcomes, fostering self-regulated learning) by using similar indicators. However, both research areas created their own agenda separately. As a case of this separate trends, the research work leading the development of GamiTool was mainly inspired in the gamification-related literature and did not consider its connections with the learning analytics field. Consequently, we have made ourselves two questions: *How can GamiTool benefit from the LA field?* and the other way around, *What could be the contribution of GamiTool to the LA field?* These questions have led to five potential lines of work regarding the relation between GamiTool and LA.

Extending the Use of Gamification Analytics: As mentioned before, the student interaction with the reward-based strategies generates new variables that can be tracked by GamiTool (*e.g.*, time span for claiming rewards, number of earned rewards, position in the leaderboard, students completing a configured condition). These gamification analytics can potentially complement the traditional learning analytics provided by learning management systems for multiple purposes (*e.g.*, students that are most and least active, engagement level of tasks). Another envisioned purpose is the use of these variables as input variables of LA frameworks to model and predict student behaviors more accurately (Ranjeeth et al., 2020). Furthermore, modelling student behavior considering both learning and gamification analytics could help define personalized learner and player profiles more accurately, thus supporting the effectiveness of tailored gamification (Hallifax et al., 2020). As a future work, we plan to understand the relationship between these gamification variables and the student behaviors (*e.g.*, task submission, dropout) in our previous studies about reward-based strategies in MOOCs, and to propose their integration within existing LA models.

Complex Indicators as Conditions: GamiTool supports the configuration of gamification conditions based on indicators of student activity (*e.g.*, post a comment in a discussion forum) which can be further combined with other indicators to form more complex conditions (*e.g.*, upload a profile picture, post a comment in the discussion forum, and receive at least 5 likes in such comment from course peers). Currently, GamiTool supports a set of basic indicators which were shown to be the ones most frequently envisioned by practitioners in our evaluation. However, a considerable number of conditions proposed by the participants of the evaluation studies also involved content analysis (*e.g.*, "submit three economical terms to the course glossary") and more complex indicators (*e.g.*, "active participation in group work"). Therefore, considering the existence of LA tools able to obtain complex LA indicators (*e.g.*, Khalil & Belokrys, 2020), it seems interesting to study the connection of GamiTool with such LA tools and to assess their usefulness for practitioners.

LA Frameworks for Gamification Design: One of the outcomes of the evaluation performed with practitioners and gamification designers was the usefulness of GamiTool to inspire the design of new forms of gamification, thanks to the fact it displays all the supported indicators for every resource type of the learning design. In this same evaluation, practitioners also raised the potential usefulness of being supported in the design regarding the most suitable number of rewards (and conditions), and/or the most important resources to be gamified according to the purposes for which gamification is being implemented (*e.g.*, increase learning outcomes, foster participation). Given this context, there exist LA frameworks providing useful insights about how LA indicators relate to different learning purposes (*e.g.*, Gašević, et al., 2017). Therefore, it seems interesting to explore to what extent these frameworks can be transferred to the context of gamification, and if such frameworks also produce a meaningful support in the design of gamification conditions. As a future work, the conceptual elements of such frameworks could be combined with GamiTool-DM to explore their applicability and usefulness within GamiTool.

Gamification Across-Spaces: GamiTool currently supports the gamification of learning management systems and external tools, thus supporting the creation of gamification designs that involve multiple virtual learning environments and tools (*e.g.*, Moodle, Canvas, Google Spreadsheets). However, learning does not only occur in the digital space but also in the physical one. Gamification experiences in the physical space normally require the manual monitoring and management of student behavior.

Nevertheless, the rapid growth of sensors in the last decade (*e.g.*, smartphone sensors) enable their use to automatize data collection from the physical space. During the last years, there has been much research regarding this aspect in the LA field under the umbrella of the so-called "CrossMMLA" (Giannakos et al., 2020). Therefore, future refinement of GamiTool should leverage the current state of CrossMMLA to support reward-based gamification in across-spaces learning situations (*e.g.*, GamiTool-DM extension to support the gamification of actions performed in the physical space).

Ethics and Data Privacy: The collection and measurement of student information involves some ethical and private issues that are more aggravated when this information is not only used by learning management systems but also by third-party gamification systems. The ethical and privacy implications of tracking students' actions are been extensively addressed by the LA research field, including the development of educational systems (*e.g.*, Hoel et al., 2017). However, this does not happen in gamification. Further work is needed to understand whether the policies proposed in the LA area are transferable to the concrete case of gamification and gamification systems, including GamiTool.

4 CONCLUSIONS

This paper reflects about the (bi-directional) relationship between LA and GamiTool, a gamification system initially conceived under the frame of gamification-based research. GamiTool enables the definition of gamification conditions at design time, based on indicators of student activity, and which can represent goals expected to be achieved as defined by practitioners. The definition of indicators considering the Learning Design relates to the current efforts from the LA field to script actionable LA at design time (*i.e.*, rewards and privileges are given to the student according to conditions considered beneficial by practitioners).

On the one hand, latest LA advances can provide to GamiTool (and to other gamification systems) with design frameworks, tools, and policies, supporting the design of effective gamification strategies, the incorporation of more complex gamification conditions and the secure treatment of student personal data. On the other hand, GamiTool can provide to the LA field new gamification variables potentially defining the behavior of students with learning resources and activities. This information could be used together with traditional learning analytics to better understand and predict the learning processes happening in online courses and generate automatic interventions that can alleviate the associated orchestration workload to practitioners. All these lines point out to potential lines of future work combining the research fields of LA and gamification.

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