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RESEARCH ARTICLE

GamiTool: Supporting Instructors in the Gamification of MOOCs

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ABSTRACT Reward-based gamification strategies are proposed as a promising technique to increase student engagement in Massive Open Online Courses (MOOCs), following its success in other small-scale educational settings. However, these strategies imply a number of orchestration tasks (*e.g.*, design, management) that are usually carried out by instructors, and which may hinder their use and adoption. Furthermore, some MOOC distinctive features (*e.g.*, scale, 24/7 availability, etc.) have considerable implications on how these gamification strategies are orchestrated, resulting in an unmanageable instructors' workload in cases of manual operation. Therefore, an eventual adoption of gamification in MOOCs calls for automatic systems capable of decreasing the additional workload of instructors. The limitations identified in the current solutions (*e.g.*, non-usable graphical interfaces, inflexible gamification designs) led us to propose and develop a new gamification system named *GamiTool*. An evaluation with 19 MOOC instructors and gamification designers showed the high design expressiveness, usability and potential for adoption of GamiTool. Hence, GamiTool can be used by instructors to improve students' engagement, and also, by researchers to keep understanding the effects of gamification in MOOC settings.

INDEX TERMS Gamification, instructors, MOOCs, rewards, system, workload.

I. INTRODUCTION

Massive Open Online Courses (MOOCs) are consolidated as a complement or alternative to other forms of teaching and learning (*e.g.*, flipped-classrooms, microcredentials) [1]. This consolidation can be attributed to benefits such as free access to structured education on demand, certification from prestigious universities, etc. [2]. Especially, these benefits have been highlighted during the COVID-19 outbreak, in which MOOC platforms have registered a drastic growth in the number of new users, and a higher interest on these courses [1]. However, these courses still present symptoms of low student engagement and lack of motivation to complete course tasks [3]. Given this context, gamification is regarded as a promising strategy to help overcome this problem, according to the positive results observed in other educational settings [4], [5].

Gamification is usually defined as the application of elements and techniques (*e.g.*, stages with increasing difficulty) that frequently appear in games, into non-game contexts [6], [7]. Previous literature reviews on gamification in education have identified rewards as the game element most used in online educational environments [8], [9], generating the so-called *reward-based gamification*. In this type of gamification, students are awarded with *rewards*, containing a *signifier* (*e.g.*, name, image) when a predefined *completion logic* (*i.e.*, condition) is fulfilled [10], [11]. Reward-based strategies have been proved to be beneficial in educational environments, MOOCs included, regarding student engagement [12], [13], [14], [15], learning outcomes [14], [16] and task participation [15], [17].

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However, despite the potential benefits of reward-based strategies to help overcome the aforementioned MOOC drawbacks, their use increases the burden of the already complex MOOC orchestration[1] for instructors[2]: video recordings, activities, learners' doubts and problems during course runtime, etc. On the other hand, some examples of gamification orchestration tasks are: gamifying the course according to the desired purposes of instructors (*e.g.*, selecting the rewards, defining the thresholds for conditions); integrating the gamification design into the learning platform; or, monitoring the evolution of gamification strategies during course runtime. All these gamification-related activities imply an additional time and effort [19], on top of the already high workload needed to produce and orchestrate a MOOC, which may imply a strong barrier in the use and adoption of gamification strategies in MOOCs. Existing literature reviews show a limited research regarding instructor-related issues in MOOCs [20], and gamification is not an exception [21].

Therefore, the underlying research question that guides this work is *How can instructors be supported to keep the orchestration workload of reward-based strategies in MOOCs manageable?* To address this question, we have proposed GamiTool, a gamification system implementing a data model (GamiTool-DM) and an adapter-based architecture (GamiTool-ARCH). While the data model aims at supporting the computer-interpretable representation of gamification designs, the architecture aims at reducing the orchestration workload of reward-based strategies in MOOCs. This paper presents GamiTool, and its evaluation with MOOC instructors.

The structure of the paper is as follows. Section II identifies and analyzes the current MOOC platforms and gamification systems supporting the orchestration of reward-based strategies in virtual learning environments. Section III describes in detail the proposed system (*i.e.*, GamiTool), including its architecture and data model. Afterwards, the evaluation study of GamiTool is explained (Section IV) and its results are presented (Section V). Then, the findings are discussed regarding the posed RQ (Section VI). Finally, some conclusions are outlined from this work (Section VII).

II. STATE OF THE ART

A. GAMIFICATION SYSTEMS AND MOOC PLATFORMS SUPPORTING REWARD-BASED STRATEGIES

In order to identify the current systems providing support to the orchestration of reward-based strategies in MOOCs, we performed a systematic literature review, following the guidelines proposed by [36]. Table 2 presents a summary of the decisions made during the literature review planning phase. The first search string aimed at finding gamification systems and MOOC platforms supporting reward-based strategies in MOOCs. However, we realized that some potential gamification systems not originally intended for MOOCs could be used in these massive environments. Therefore, we complemented the initial search with a second search string, applying the same inclusion and exclusion criteria (see Table 2). The first string resulted into 3 gamification systems: Gametize, MyMOOCSpace and SBGF; and 2 MOOC platforms: iMOOX and OpenHPI, described in 8 different publications (see Table 3). The second string resulted into 3 integrated learning environments with gamification capabilities, described in 7 different publications: MEdit4CEP-Gam, INDIeAuthor and OneUp (see Table 3). Further information about this literature review can be found in [37]. In the current paper, we present an analysis of such systems from the perspective of the instructors' support, the associated workload and their potential for adoption.

B. CAPABILITIES AND CONSTRAINTS OF CURRENT GAMIFICATION SYSTEMS AND MOOC PLATFORMS

All gamification systems and learning environments identified in the previous section provide instructors with tools for designing and handling reward-based strategies. However, many of these systems do not tackle the associated orchestration workload for regular instructors (*iMOOX, Gametize, MyMOOCSpace, SBGF, INDIeAuthor*). More specifically, the lack of graphical interfaces and automatic capabilities supporting the authoring and monitoring of reward-based strategies could hinder their use and adoption in MOOCs *(Limitation 1)*.

Additionally, we observed that, in some of the identified systems, the gamification conditions (*i.e.*, the student actions under which the rewards will be issued) that can be computationally represented for automatic support are restricted to quiz-related activities such as multiple-choice or poll questions (*OneUp, iMOOX, SBGF, MyMOOCSpace*). Therefore, instructors can only gamify quizzes, and not other frequent MOOC tools such as discussion forums (*e.g.*, conditions involving posting in forums), content videos (*e.g.*, conditions involving the visualization of videos) or peer reviews (*e.g.*, conditions involving the submission of a given number of revisions), thus restricting their application in real contexts *(Limitation 2)*.

Furthermore, we realized that the gamification of multiple activity types is usually carried out in two different forms. First, by developing ad hoc gamification capabilities for a specific MOOC platform (*OpenHPI, iMOOX*) *(Limitation 3)*. Therefore, these gamification capabilities cannot be employed by instructors using other MOOC platforms (decision usually imposed by institutional agreements). And, second, by inserting into the MOOC platforms external tools with the same functionality as those tools provided by the MOOC platforms but with gamification features (*INDIeAu-*

[1]The orchestration metaphor refers to *"the process of coordinating a teaching/learning situation from the point of view of the teacher"* [18].

[2]For simplicity, we refer to *MOOC instructor* as any person involved in the design and orchestration of gamification strategies in MOOCs, including instructional designers, teachers and teaching assistants.

TABLE 1. Design requirements to support orchestration and adoption of reward-based strategies in MOOCs.

Parameter	Decision
Databases	ACM Digital Library, IEEE Xplore, Digital Library, Science Direct, Scopus, and Springer Link. These databases have been previously considered for literature reviews about gamification in education [7], [22], [23].
1st Search string	"gamif*" and "*MOOC*" ("gamification" and "MOOC" if restriction).
2nd Search string	"gamif*" and ["editor" or "authoring tool"] ("gamification" and ["editor" or "authoring tool"] if restriction).
Search fields	Title, abstract and keywords (metadata or abstract if restriction).
Time restrictions	No time restrictions (until April 2019).
Screening	By reading title and abstract first. Then, if needed, the text body.
Inclusion criteria	[I1] Manuscripts describing platforms, editors or authoring tools that could be used by instructors to orchestrate reward-based gamifications in online learning environments.
Exclusion criteria	[E1] Prefaces of conferences, workshops, books and chapters. [E2] Publications dealing with the use of games or treating the word gamification as a full game. [E3] Publications written in other languages different than English or Spanish. [E4] Publications reporting platforms intended for other purposes different than teaching or learning. [E5] Publications describing gamification systems for a specific learning topic (*e.g.*, programming). [E6] Publications describing gamification systems without a developed prototype.

TABLE 2. Summary of the literature review planning phase.

System	References
Gametize	[24]
MyMOOCSpace	[25], [26], [27]
SBGF	[28]
iMOOX	[29]
OpenHPI	[30], [31]
MEdit4CEP-Gam	[32]
INDIeAuthor	[33], [34]
OneUp	[23], [35], [19], [15]

TABLE 3. Technological systems supporting the use of gamification in MOOCs.

Tag	Design Requirement
DR1	**Provide usable interfaces and automatic capabilities:** The system should make the orchestration workload of reward-based strategies (*e.g.*, authoring, configuring, managing) manageable for instructors. To this end, gamification systems should incorporate usable graphical user interfaces and provide automatic capabilities for such tasks.
DR2	**Provide a high expressiveness for gamification designs:** The system should provide enough flexibility in the creation of computer-interpretable gamification designs to restrict as little as possible the gamification decisions conceived by instructors.
DR3	**Support multiple MOOC platforms:** In order to reach out to a broader number of instructors, the systems should provide orchestration capabilities for multiple MOOC platforms.
DR4	**Track student actions in built-in MOOC-platform tools:** The system should have access to the actions performed by students in the built-in tools of MOOC platforms, in order to provide a seamless experience.
DR5	**Track student actions in external tools:** The system should have access to the actions performed by students in third-party tools used together with the MOOC in a learning experience.
DR6	**Adapt to students' preferences:** The system should provide students with the capability of deciding whether to participate in the course gamification or not.

thor, MEdit4CEP-Gam). Consequently, these systems force instructors to replace the MOOC platform built-in tools by external ones, and to learn how to use them, thus contributing to a higher orchestration workload that might hinder their adoption *(Limitation 4)*.

In other cases, instructors need to extend the functionality of MOOC platforms' native tools with third-party tools such as social networks (*e.g.*, Twitter, Facebook) or collaborative tools (*e.g.*, Google Spreadsheets, Padlet) [38]. Nevertheless, none of the identified gamification systems and learning

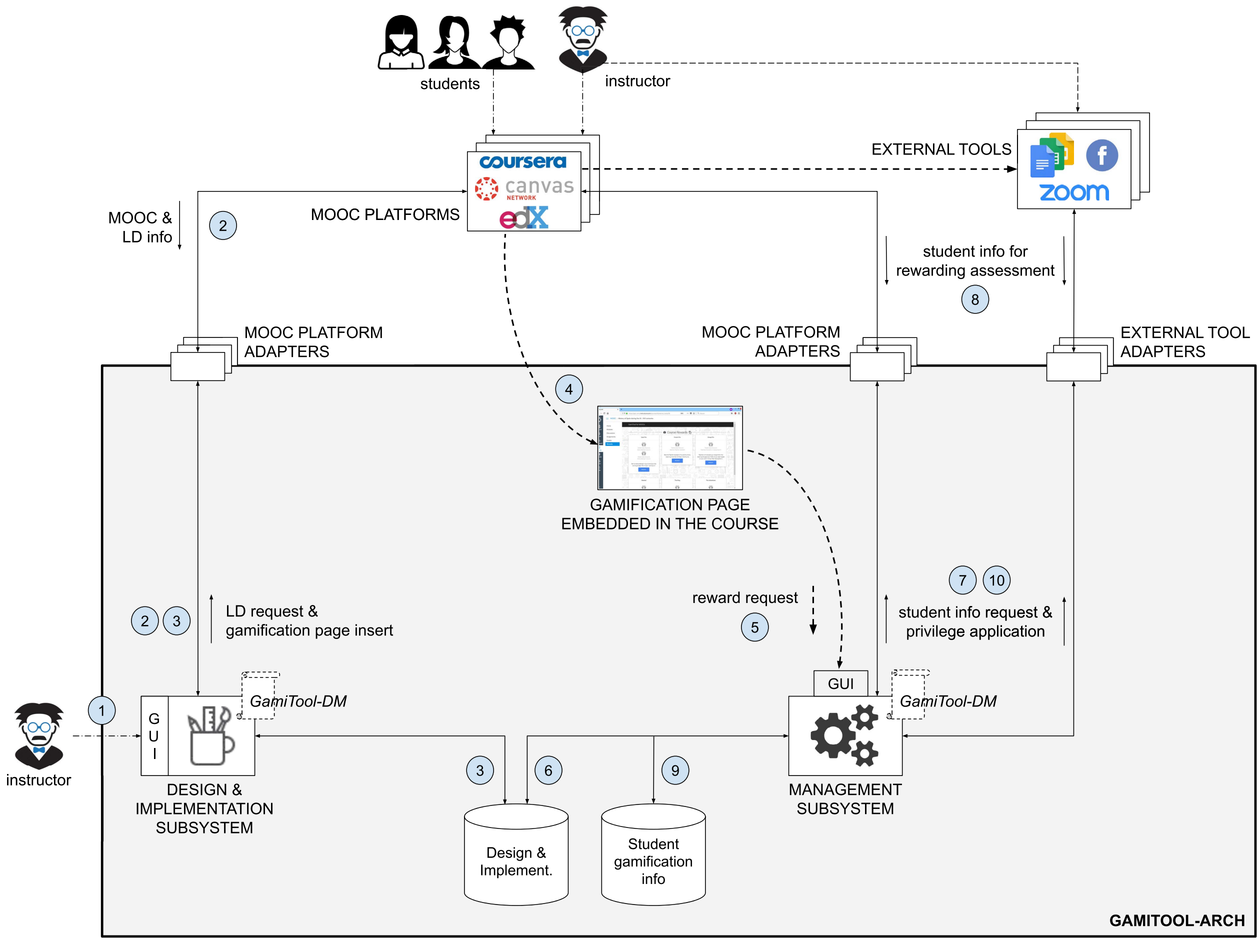

FIGURE 1. Conceptual summary of the GamiTool architecture.

environments provide capabilities to gamify mainstreamed third party tools, forcing instructors to exclude the activities supported by these tools from the gamification designs *(Limitation 5)*.

Another limitation of MOOCs is related with the enrollment of thousands of students with different backgrounds, profiles and learning goals in the same course. While some learners feel motivated by the attainment of rewards, some others do not, and forcing them to participate in gamified activities could have a negative impact on their engagement [39]. Therefore, it seems desirable to provide MOOC participants with the capability of deciding whether to participate in the gamification or not (*e.g.*, activating or deactivating gamification or claiming the rewards they are interested in). Nevertheless, this feature was only observed in two of the identified systems (*OneUp, iMOOX*) *(Limitation 6)*.

From the limitations identified in this section, we derived a list of Design Requirements (DR, see Table 3), supporting the development of a gamification system for the manageable orchestration workload of reward-based strategies in MOOC environments. The next section presents such gamification system.

III. GamiTool

GamiTool is a gamification system designed and developed by the authors, aimed at supporting MOOC instructors to design and orchestrate reward-based gamifications in a manageable way. GamiTool has been developed considering the design requirements described in the previous section. This section presents its architecture (*GamiTool-ARCH*), data model (*GamiTool-DM*) and developed prototype.

A. GamiTool-ARCH: THE ARCHITECTURE

GamiTool-ARCH implements a two-layer structure with loosely-coupled adapters to facilitate the integration with multiple virtual learning environments and external tools (see Fig. 1). GamiTool-ARCH is composed of two main subsystems:

The **Design & Implementation subsystem** allows instructors to configure reward-based strategies on top of MOOC learning designs through its graphical user interface (see (1) at Fig. 1) (compliant with DR1, see Table 3). To reduce the workload of the design process, this subsystem enables the automatic importation of learning designs from MOOC platforms (*e.g.*, structure of the course, modules, resources), over which reward-based strategies are configured by instructors

(DR1). This feature allows the automatic retrieval of the tasks and tools configured in the course and their identifiers in the platform ②. Therefore, the student actions during course run-time can be tracked, and can be computed to understand whether gamification conditions are satisfied or not.

Once gamified MOOC designs are fully defined, this subsystem also enables the automatic deployment[3] of the gamified design and its storage in the *Design & Implementation* DB ③ (DR1). In order to provide these automatic functionalities to multiple MOOC platforms, GamiTool-ARCH incorporates a set of adapters (DR3). These adapters are responsible for: (a) converting the information coming from the different MOOC platforms to the data model supported by GamiTool; and, (b) deploying the gamification design in the target course.

During the course enactment, the **Management subsystem** manages the visits to the gamification interface embedded in the course ④, providing different contents depending on the visitor role (instructor/student). If the visitor is a instructor, the subsystem provides functionalities to monitor and manage the evolution of reward-based strategies (*e.g.*, gamification analytics, manual rewarding) (DR1). If the visitor is a student, the interface displays a predefined gamification template with information about the rewards configured (*Design & Implementation* DB), the rewards already earned (*Student Gamification Info* DB), mechanisms to claim them, and the possibility to disable the gamification contents (DR6).

When the students claim the rewards ⑤, the *Management subsystem* receives the requests and initiates the rewarding process. First, the *Management* subsystem retrieves the conditions of the reward claimed from the *Design & Implementation* DB ⑥. Either if the conditions involve built-in or third-party tools, the subsystem will use the *MOOC platform adapters* (DR3, DR4) or the *External tool adapters* (DR5) to query their databases ⑦, and to convert the retrieved information into the data model supported by GamiTool ⑧. In case the conditions are satisfied, the *Management subsystem* issues the reward to the student by storing it into the *Student gamification info* DB ⑨, and by displaying it in the gamification page. Furthermore, if the reward involves course privileges (*e.g.*, deadline extensions, unlock content) [17], the *Management subsystem* will automatically apply such privileges through the *MOOC platform adapters* ⑩.

B. GamiTool-DM: THE DATA MODEL

The expressiveness of GamiTool-DM regarding gamification goes beyond the data models supported by existing MOOC platforms, thus contributing to a higher flexibility in its design. Moreover, GamiTool-DM includes some components supporting the automatic functionality of the aforementioned architectural features (*e.g.*, automatic reward-issuing procedure). Figure 2 depicts a UML class diagram of GamiTool-DM. The elements of the data model have been classified into six categories for better understanding:

- The **white classes** of Fig. 2 refer to the users of the system: *Instructor* and *Student*. While instructors are responsible for the design and orchestration of gamification, students interact with the MOOC contents trying to earn the configured rewards. The *gamification* attribute of the *Student* class stores the student decision to activate or deactivate the gamification features (DR6). Additionally, it stores the student identifier in the MOOC platform (*idInstance*) to query those actions associated to gamification conditions.
- The **red class** represents the MOOC where the reward-based strategies are applied. This class stores relevant information to locate the course (*instanceUrl*, *courseID*), and to identify the GamiTool internal adapters that will be used to connect with the MOOC platforms (*instanceType*). Moreover, it also stores the instructors' authorization bearers to query the student actions within the MOOC platform DB automatically at run-time (*bearer*).
- The **blue classes** represent the elements of the *Learning Designs* over which the reward-based strategies are applied. The *Module* class includes attributes that allow to sort out the course *Resources* into different learning units, thus facilitating its visualization for graphical configuration. The *Resource* class specifies the *resourceType* (*e.g.*, video, quiz, assignment, discussion forum) so different gamification conditions can be applied depending on the type of resource (*e.g.*, get a specific score can be configured as a condition in quizzes but not in videos). Additionally, the resources configured in an *ExternalTool* need to specify the third party tool (*toolType*), the location (*instanceID*) and the credentials of the instructor (*credentials*), enabling the automatically interaction with the tool at run-time (DR5).
- The **purple classes** represent information related to MOOC *Gamification Designs*. A *GamificationDesign* is associated with the *LearningDesign* over which gamification is added. The *GamificationAssociation* class represents the relationship between one or more *Conditions* and one or more *Rewards*. This class enables a many-to-many relation between conditions and rewards, *i.e.*, multiple rewards can be issued under a single condition and, conversely, one single reward can be issued under multiple conditions (DR2). Gamification associations contain a *name* and a *description* describing the conditions and the rewards of such association. Additionally, the *conditionOperand* and *rewardOperand* attributes enable the configuration of complex reward-condition associations (*e.g.*, let students choose the reward to

[3]We refer to *deployment* as the process of configuring the externally-created gamification design into the target MOOC platform (*e.g.*, the addition of a gamification page in the course where students can visualize and claim the configured rewards).

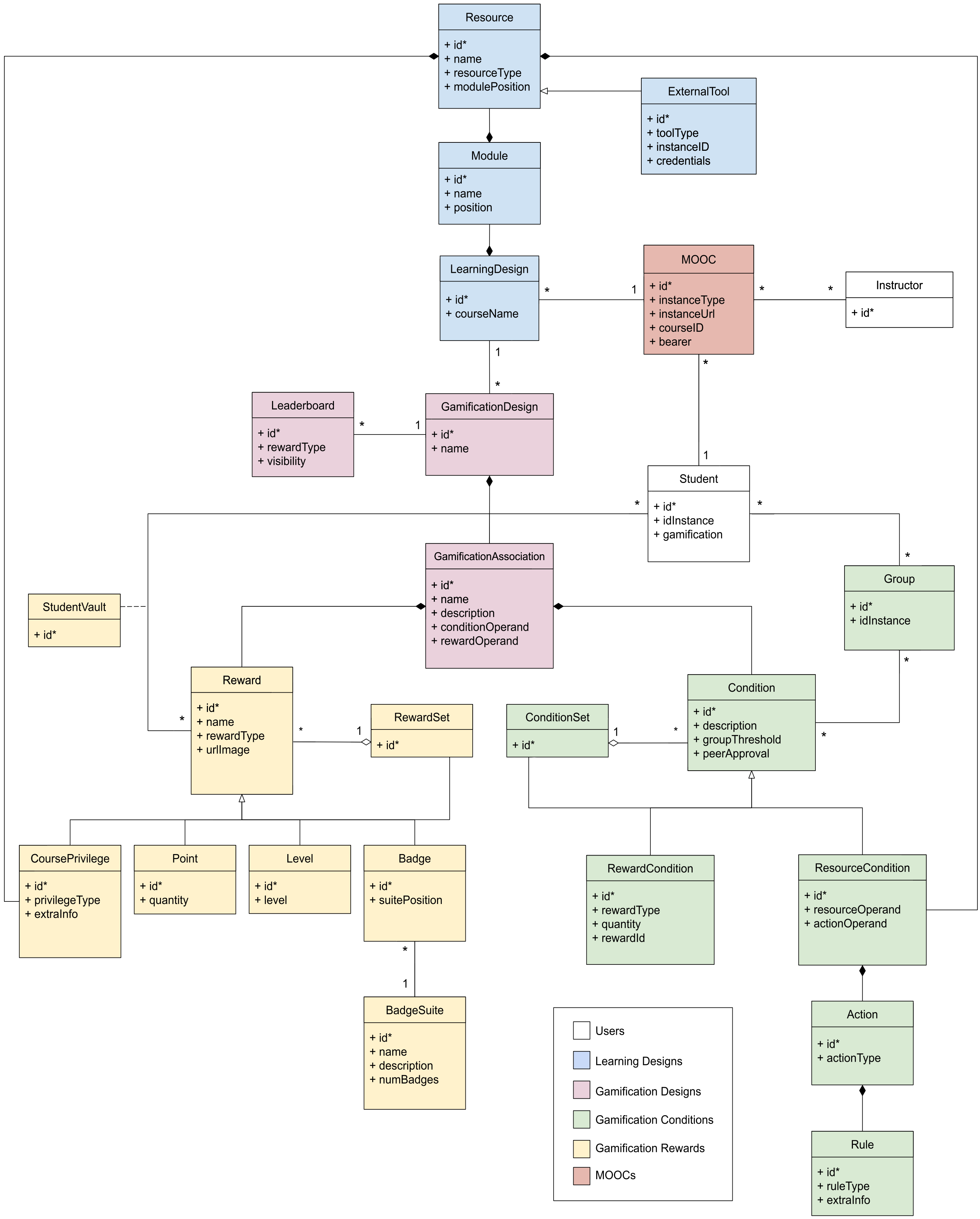

FIGURE 2. **Overview of GamiTool-DM using UML notation.**

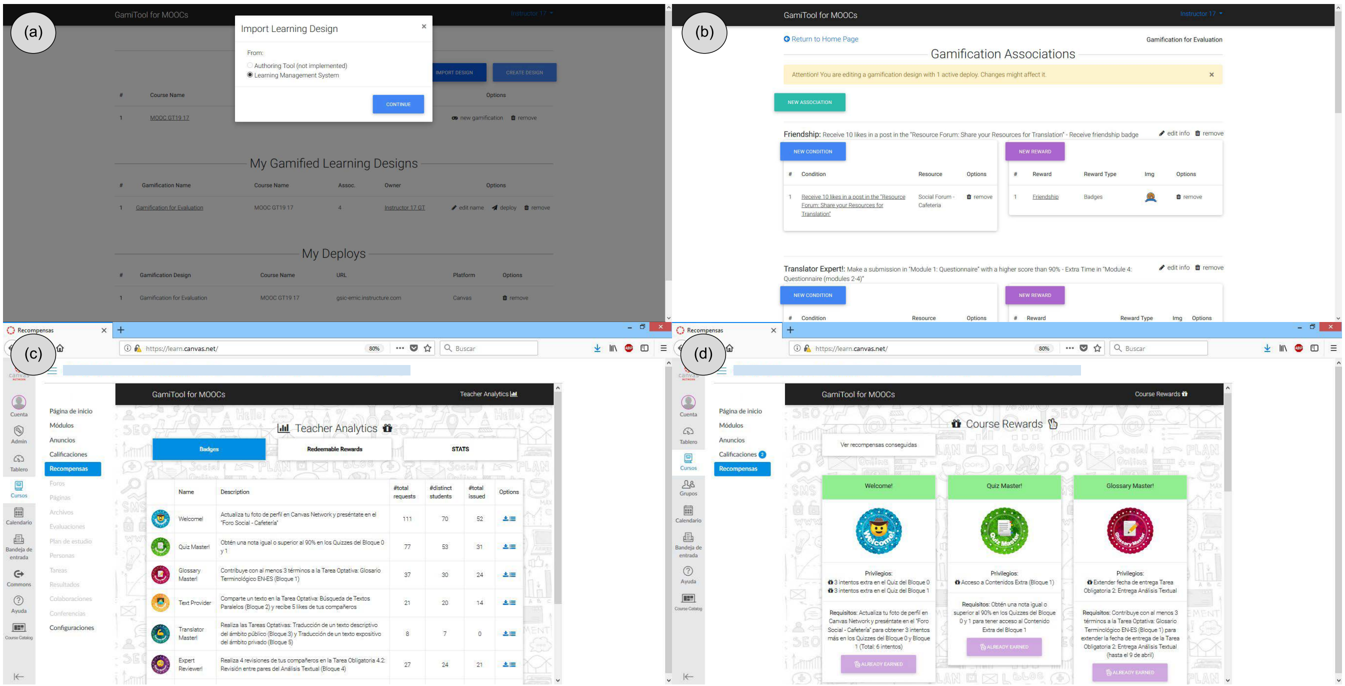

FIGURE 3. **Screenshots of GamiTool: (a) homepage, (b) condition and reward configuration page, (c) instructor interface of a gamified learning design deployed with GamiTool in a MOOC in Canvas Network, and (d) student interface of the same gamified design in Canvas Network.**

be earned among a set of rewards). Furthermore, the *Leaderboard* class allows the configuration of rankings within the *GamificationDesign*. Multiple leaderboards can be added to a gamification design considering the different *rewardTypes* (*e.g.*, points, badges). The *visibility* attribute allows instructors to decide whether student names will be anonymously displayed in such leaderboards or not.

- The **yellow classes** model the *Gamification Rewards*. The *Reward* class contains the attributes common to all supported reward types (*name*, *rewardType*, *urlImage*). Currently, the model supports the three reward types most used in online environments (*Points*, *Badges* and *Levels*) [8] and course privileges [17], thus supporting a high design expressiveness of the system (DR2). More reward types (*e.g.*, trophies, ribbons) could be easily added by mapping these reward types to existing elements (*e.g.*, *Points*) or by defining the reward type and creating a new class inhering from the *Reward* class. In order to automate the rewarding procedure of course privileges, the model specifies the type of privilege (*e.g.*, extend the deadline submission), and the resource/s over which the privileges will be applied (*e.g.*, the assignment of the second module). Finally, the *RewardSet* class permits the definition of *Rewards* composed by multiple rewards.
- The **green classes** model the *Gamification Conditions*. Similarly to the *Reward* class, the *Condition* class includes all the shared parameters among the different condition types. The *groupThreshold* attribute applies to group-based gamifications, enabling the definition of a minimum percentage of *Group* members that have to satisfy the configured condition. The *peer-Approval* attribute allows the definition of conditions based on peer assessment (*i.e.*, group peers validate the attainment of the reward). The model also supports two frequent condition types: conditions based on previous earned rewards (*RewardCondition*) and conditions based on student actions performed within course resources (*ResourceCondition*) (DR2). The first condition type allows the definition of either a *quantity* of a specified *rewardType* (*e.g.*, student will get the reward when reaching 100 points), or a specific reward (*e.g.*, student will get the reward when the badge "Accepted" is earned). The second condition type allows the definition of student *Actions* performed within course resources (*e.g.*, submit the quiz of the first module). Student *Actions* can be further specified by the definition of concrete *Rules* (*e.g.*, submit the quiz of the first module before a specific date and get a 100% score). Finally, the *ConditionSet* class permits the definition of *Conditions* composed by multiple conditions.

C. GamiTool PROTOTYPE

GamiTool has been developed as a web-based tool, in order to not impose any additional requirement to those of MOOC platforms, *i.e.*, an Internet connection and a web browser. The client side was developed in HTML5, CSS, AJAX, and JavaScript. The graphical interfaces were designed following the guidelines of usability proposed by [40], and were refined through iterative cycles of design with beta-testers and TEL experts. Figure 3 displays some of the graphical interfaces developed for both the *Design & Implementation* (top) and the *Management* (bottom) subsystems.

The server side was developed in PHP under the Laravel framework.[4] PHP is a widely-used open source scripting language suited for web-based applications that can be embedded into HTML.[5] Currently, the prototype includes adapters for courses in Canvas and Moodle instances. Further information about GamiTool can be found in its webpage.[6]

IV. EVALUATING GamiTool

As described in the previous section, GamiTool was developed considering the design requirements stated in Table 3. In this section, we report an evaluation of GamiTool regarding the posed RQ: *How can instructors be supported to keep the orchestration workload of reward-based strategies in MOOCs manageable?* More concretely, we performed a user experience evaluation [40] to understand the extent to which GamiTool supports instructors in the manageable orchestration of reward-based strategies in MOOCs. From a general perspective, the evaluation involved a set of MOOC instructors who, following a given guide, used GamiTool to design and deploy gamification designs in a MOOC.

A. PARTICIPANTS

The participants of the evaluation were selected following a *purposive sample* approach. Purposive sampling methods use investigators' personal judgment to conveniently select the sample that matches with the specific purposes of the research [41]. In this case, the sample included participants with previous experience as MOOC instructor and/or gamification designer since they are the main expected profiles using GamiTool. According to [40], traditional user experience evaluations typically involve from 5 to 50 participants, observing the most significant usability findings with the first 6 participants. Furthermore, although participants' geographical location is unlikely to have an impact on usability information [40], participants from different countries and institutions were selected to help us understand the perceptions of participants that follow different MOOC procedures and use different MOOC platforms. Attending to the previous requirements, 23 potential participants were contacted via email, out of which 19 agreed to participate in the study. The participants of this study are from 10 different institutions, located in 6 different countries: USA (1), Germany (1), France (1), Norway (1), UK (2) and Spain (13). Further information about the evaluation participants is presented in Figure 4.

B. RESEARCH DESIGN

This research employed a mixed-method design. According to Greene [42], one of the rationales behind the use of mixed methods regards the clarification or elaboration of the results obtained with a different method. In this study, we triangulated the quantitative results obtained in the questionnaires with the participants' perceptions about the associated orchestration workload, thus trying to better understand the reasons for such scores and getting insights on what system features could be improved in upcoming refinements. To help answer the aforementioned research question and to structure the evaluation, we performed an anticipated data reduction process (see Fig. 6) [43]. This process helped particularize the general research question into the specific question addressed in the evaluation (*i.e.*, issue), and into its associated topics and informative questions. In this case, two topics were identified as relevant: *orchestration workload* and *design expressiveness*.[7]

The evaluation protocol was divided into four sequential happenings which involved three different data-gathering techniques, supporting evidence triangulation (see Fig. 6). The four happenings were designed to be completed online by instructors within two hours without limiting the time that participants could dedicate to each happening.

- H1. The first happening (Previous steps) involved the completion of a questionnaire about participants' demographic and previous experience information. This information aimed at profiling the participants, and to understand whether some results can be attributed to their previous experience.
- H2. In the second happening (Own-design), participants were introduced to the evaluation topic. During this happening, participants were also requested to create their own gamification design over a given MOOC that incorporates frequent MOOC resources such as discussion forums, content pages, self-contained videos, submissions, quizzes, peer reviews, etc. The main purpose of this happening was to understand the extent to which the reward-based strategies designed by MOOC instructors can be represented with GamiTool-DM, and therefore automated during course run-time. The designs created by the participants were analyzed by the leading researcher to assess whether they could be modeled with GamiTool-DM.
- H3. During the third happening (Representation & Implementation), participants were asked to digitally represent, deploy and preview a given gamified MOOC design with GamiTool. Participants' experience using GamiTool in a potential real situation can help understand its usability and workload. Additionally, we collected the actual time devoted to represent, deploy and preview the gamification design to help understand the temporal demand of GamiTool.
- H4. The fourth happening (Post steps) involved a set of questionnaires regarding participants' experience with

[4]Laravel LLC: https://laravel.com/, last access: December, 2022.

[5]The PHP Group. What is PHP? https://www.php.net/manual/en/intro-whatis.php, last access: Dec. 2022.

[6]GamiTool: https://www.gsic.uva.es/gamitool/, last access: December, 2022.

[7]Design expressiveness is also evaluated since the level of computer-interpretable representation of gamification designs serves to understand if instructors' conceived designs can be automated by GamiTool, thus supporting its manageability.

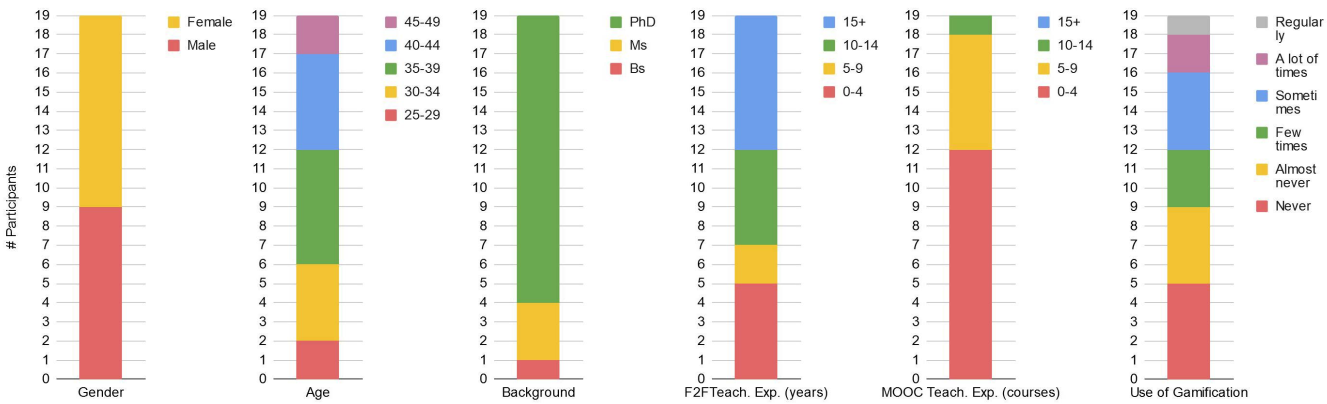

FIGURE 4. Participants' demographic and previous experience information.

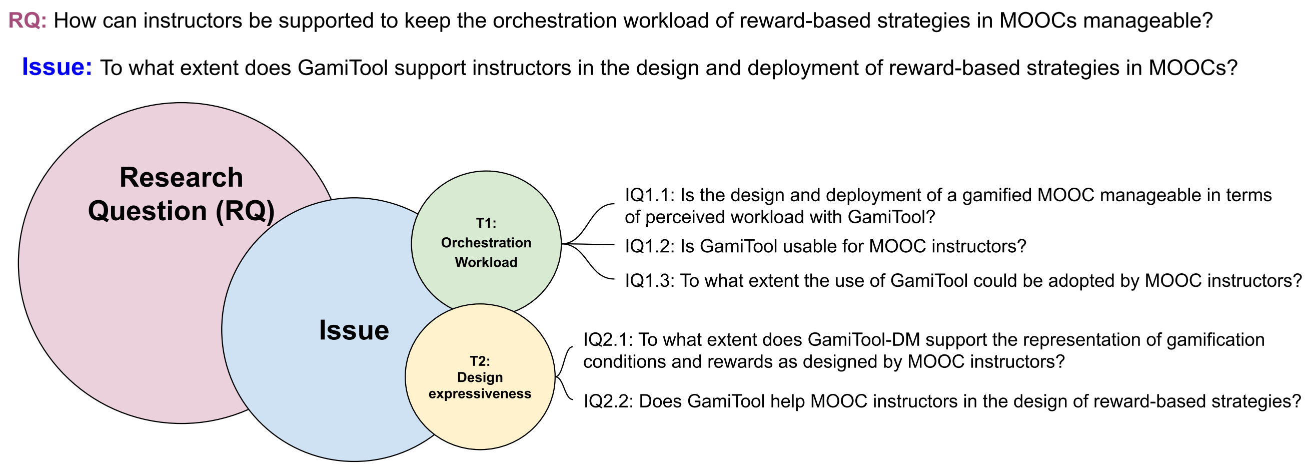

FIGURE 5. Research question, issue, topics and informative questions of the evaluation study.

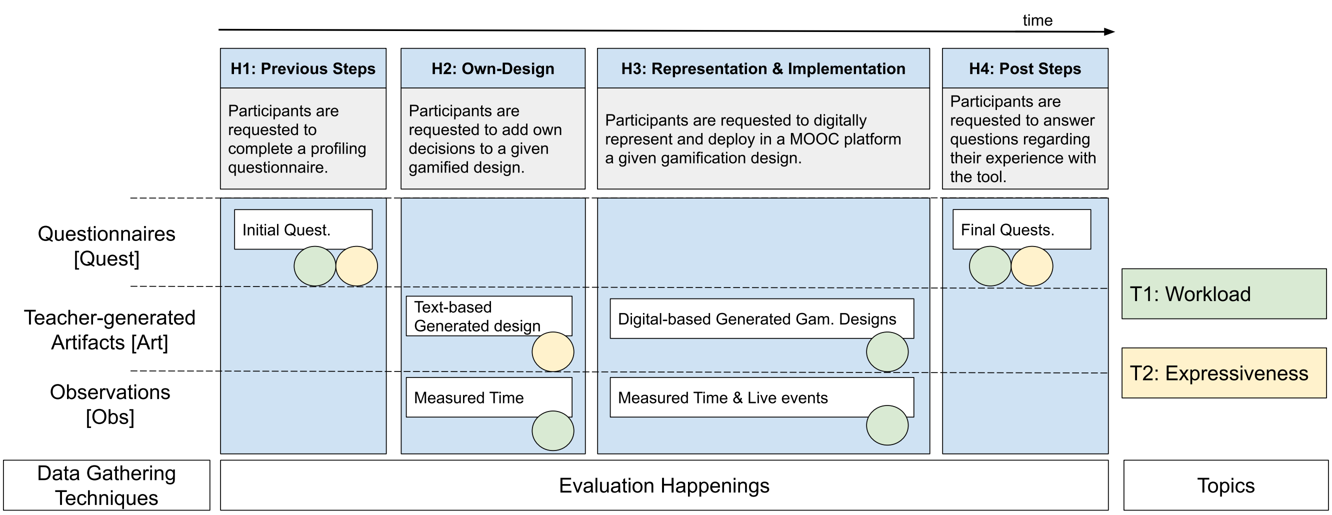

FIGURE 6. Evaluation happenings, topics, and data sources used during the evaluation study.

GamiTool, including the perceived usability, the perceived workload and some personal perceptions regarding reward-based strategies and the tool. The System Usability Scale (SUS) [44] was selected as the most appropriate instrument measuring perceived usability due to its length (keeping the evaluation short), and due to the high number of technological systems already evaluated with this instrument [45]. Additionally, the Net Promoter Score (NPS) item [46], frequently used to measure user loyalty and adoption, was added after

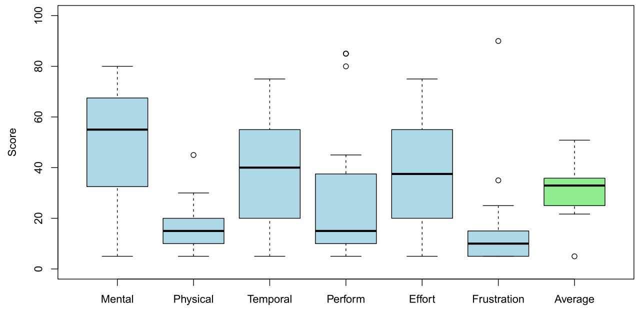

FIGURE 7. Boxplots of NASA-RTLX obtained results (N=19).

the SUS questionnaire. The popularity of this metric and the single likelihood-to-recommend item keeping again the evaluation short, made it suitable to measure the potentiality of GamiTool for its adoption. Furthermore, the Raw version of the NASA Task Load Index (RTLX) [47] was selected to measure the perceived workload of a task (*i.e.*, designing and implementing a gamified MOOC with GamiTool) following the same considerations (length and number of systems evaluated with this instrument). Finally, further personal perceptions were measured through four statements, using a likert-like scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). For every questionnaire, open-ended boxes for additional comments and clarifications were included to help understand the reasons for the scores given to the previous questionnaires, and to collect participants' opinions for future tool enhancements.

An evaluation guide including the evaluation tasks and instruments was developed to homogenize and guide participants throughout the whole process.

V. RESULTS

This section presents the results of the evaluation following the same structure of the research design (see Fig. 6).

A. ORCHESTRATION WORKLOAD: PERCEIVED WORKLOAD

The workload perceived by the participants was measured with the RTLX questionnaire (see Fig. 7). Participants' final scores have been calculated as the mean value of the scores given to the six variables conforming the perceived workload of the task [47]. According to the results, the average RTLX final score is 31.57 in a 0-100 scale, where 100 is the maximum measurable workload (see Table 5). Furthermore, the maximum score obtained by a single participant is 50.83, representing that, in the worst case, the workload of the task was neither low nor high. Therefore, considering the overall scores, the task of digitally representing and deploying a gamified MOOC with GamiTool supposed a low perceived workload.[8]

[8]Please, note that although creating a new gamification does not involve a strong physical demand, this variable was kept in the questionnaire to enable workload comparisons between this and other computer-mediated tasks.

TABLE 4. Summary of the time (min) employed for the design and deployment of gamification (N=19).

	Min.	Med.	Mean	Max.
RTLX	5	32.92	31.57	50.83
SUS	72.50	85.00	84.61	100
NPS	7	10	9.42	10

TABLE 5. Summary of the scores obtained in the RTLX, SUS and NPS questionnaires (N=19).

	Min.	Med.	Mean	Max.
Design [H2]	19	30	31.63	49
Implem. [H3]	26	36	37.58	58
Total	51	66	69.21	101

Looking at the results per questionnaire item, mean values of the six variables scored under the 50-point threshold, although important differences can be observed between them. Mental and temporal demand are the variables that scored higher, while physical demand, and frustration variables scored lower (see Fig. 7). Additional comments provided in the final questionnaire helped to understand the reasons for such differences. Several participants (N=6) referred to an initial high mental demand for learning how to configure the first gamification associations and getting used to the terminology in GamiTool. The additional comments also suggest that the following times using the tool, the perceived workload will be lower than this first time (*e.g.*, *"I needed some time to read the instructions about the first reward. Then I inserted the second reward by going back and forth to the instructions. Then, it was easier for me to insert the two last rewards [..]" [H4:Quest:Part#1]*).

Furthermore, the perceived temporal workload was complemented with the actual time that participants devoted to each evaluation sub-task *[H2:Obs, H3:Obs]*, *i.e.*, designing and implementing a gamified MOOC (see Table 5). Results show that participants devoted, on average, 69.21 minutes to design, digitally represent and implement a gamified MOOC with GamiTool (first time using the tool). Participants were asked in the initial questionnaire about the approximated time employed to gamify their previous online courses (if applicable). Although the results obtained in this evaluation are not directly comparable with a real situation, the average time that instructors dedicated to design, digitally represent and implement the gamification (*i.e.*, 69.21 min.) is lower than all the answers provided in the initial questionnaire (N=5).

Despite the low RTLX final scores, large differences on participants (5 and 50.83, minimum and maximum values respectively) suggested the possibility of perceiving different workload due to prior MOOC and/or gamification experience. Accordingly, we calculated the Spearman's order-rank coefficient considering the information reported in the initial questionnaire and the RTLX final score. Results showed a non-significant statistically correlation between the RTLX final score and the previous experience regarding MOOCs and gamification ($r(18) = -0.035$, $\rho = 0.889$ and $r(18) =$

−0.029, ρ=0.908 respectively). Therefore, the perceived workload of digitally representing and implementing a gamified MOOC with GamiTool did not seem to be related to the previous MOOC or gamification experience of participants.

B. ORCHESTRATION WORKLOAD: USABILITY AND ADOPTION

A summary of SUS final scores is presented in Table 5. Results show that the average SUS score obtained (84.61) is above the threshold of 84.1 [48]. Accordingly, GamiTool instructors' perceived usability can be ranked with an A score, representing an *excellent* level of usability [48], [49]. The multiple positive comments provided in the final questionnaire (*e.g.*, GUI, intuitiveness, easiness of use, and the integration of its functionality) support this high score.

Tool adoption was measured through the NPS item [46]. The NPS is calculated as the percentage of *Promoters* (participants selecting 9 or 10 in the likelihood-to-recommend item) minus the percentage of *Detractors* (participants selecting 0 through 6) [46]. The NPS obtained in this evaluation is 89.47. According to Reichheld [46], this high score corresponds to a product from which ''companies garner world-class loyalty'', thus supporting its potential for tool adoption. Observations and additional comments in the final questionnaire seem to confirm such potential adoption for experienced and non-experienced instructors (*e.g.*, *"I would like to use it in Moodle for a project [..]" [H3:Obs:Part#18]*, *"I would love to use it in Open edX" [H4:Quest:Part#6]*).

C. DESIGN EXPRESSIVENESS: COMPUTER-INTERPRETABLE REPRESENTATION

During the second happening [H2: Own-design], participants were requested to create their own gamification designs over a given MOOC. Participants were asked to design at least 3 gamification associations (apart from the given example), including their names, purposes, conditions and rewards. A total number of 71 gamification associations were collected from participants' answers. Both, gamification conditions and rewards were analyzed to understand the extent to which GamiTool-DM supports their computer-interpretable representation and automation (see Table 6).

GamiTool-DM was able to represent 32 conditions (45.07%) as stated by the participants (*supported*); 28 conditions (39.44%) which could be implemented with GamiTool after interpretation (*partly-supported*); 10 conditions (14.08%) that could be represented with minor changes in the data model (*e.g.*, the addition of parameters or pool options for action and rule types, *supported with minor changes*), and 1 condition (1.41%) that would need major changes in GamiTool-DM for real implementation (*non-supported*).

In this context, *partly-supported* conditions involve those conditions that, as stated by the participant, would require content analysis or a more detailed description of the condition. For instance, the condition *"contribute with high-quality posts in the forums" [H2:Art:Part#19]* can be interpreted and represented in several forms, including *other peers will be responsible of judging the high-quality of the post by up- or down-voting*, which actually is supported by GamiTool-DM. Also, the condition *"active participation in group work of Module 3" [H2:Art:Part#17]* needs in fact to be described in more precise terms. In our context, we can understand *active participation* as posting every day in the group discussion forum, condition supported by GamiTool-DM.

Other examples of conditions that require content analysis are *"submit a specific number of terms to the course glossary" [H2:Art:Part#10,11,16]* or *"introduce yourself in the social forums" [H2:Art:Part#10]*. In the former case, due to the general purpose for which GamiTool-DM was created, the submission of *terms* cannot be represented rather than the submission, in a broader sense, of an assignment or a quiz. Accordingly, GamiTool cannot automatically distinguish whether student submissions include a *term*, the student name, or the word *Hello!*. Similarly, in the latter case, GamiTool cannot automatically determine whether students' posts include an introduction of themselves, or a summary of their holidays. This kind of conditions could either be represented with GamiTool-DM in the broader sense by *submitting an assignment*, *posting in a forum*, or by leaving the decision of assessing whether such contributions are *terms* or *introductions* to course peers. Consequently, all these conditions were categorized as *partly-supported*, since they might be interpreted in a way that is supported by GamiTool.

The answers provided in the final questionnaire [H4:Quest], also suggested that GamiTool enables the representation of gamified activities performed in tools frequently used in MOOCs [DEQ2], and with a fine-grain of detail [DEQ3] (see Table 7). Most additional comments provided to [DEQ2] agreed on the broad coverage of MOOC tools such as *"Absolutely, it covers even more" [H4:Quest:Part#5]* or *"I think it provides very nice/easy examples to be integrated in existing activities typically used in MOOCs" [H4:Quest:Part#13]*. Nevertheless, despite the high score provided in [DEQ3], two participants mentioned the usefulness of connecting the gamification purposes with the conditions that can be configured in a learning design: *"I was missing some connection with the conceptual design, [..] it would be nice to have some help regarding the configuration of all fine-grain details" [H2:Art:Part#1]*.

Regarding the gamification rewards, GamiTool-DM is able to represent 51 rewards (71.83%) as stated by the participants (*supported*); 4 rewards (5.63%) that can be represented with GamiTool but whose implementation would be different from what participants explicitly stated, *e.g*, instead of rewarding via email, doing it through the MOOC platform (*partly-supported*); 9 rewards (12.68%) that could be represented with minor changes in the data model (*e.g.*, the addition of course privilege types, *supported with minor changes*); and, 7 not supported rewards (9.86%, *non-supported*).

Participants' rewards involved the four different types of rewards implemented in GamiTool: points, badges, levels and

TABLE 6. Summary of conditions and rewards (N=71) defined by evaluation participants.

	Category	%	Example
Conditions	*Supported*	45.07	*Post at least one message in the two forums located at Module 0 [Part#6]*
	Partly-supported	39.44	*Contribute with high-quality posts in the forums [Part#19]*
	Minor changes	14.08	*Login and access the course for three consecutive days [Part#15]*
	Non-supported	1.41	*Group submissions include at least one term from each individual submission of group peers [Part#6]*
Rewards	*Supported*	71.83	*Get an extra attempt in the Questionnaire (Module 1) [Part#14]*
	Partly-supported	5.63	*Guest invitation to write a reflection in the discussion forum of Module 4 [Part#1]*
	Minor changes	12.68	*Guarantee that the own assignment work will be peer-reviewed by two other participants [Part#19]*
	Non-supported	9.86	*Offer access to benchmarking data, my learning behavior compared to other learners [Part#17]*

TABLE 7. H4 questionnaire items and responses regarding personal perceptions about GamiTool (N=19).

Tag	Questionnaire Statement	Med	IQR	NA
[DEQ1]	The use of GamiTool suggested me conditions and/or rewards that I did not consider before and which could be useful in my gamification design to achieve the expected gamification purposes.	4.5	1.0	1
[DEQ2]	I think GamiTool allows the design and deployment of gamified activities performed in tools that I frequently use in MOOCs (*e.g.*, discussion forums, quizzes).	5.0	0.0	2
[DEQ3]	I think GamiTool allows the creation of reward-based strategies with a fine-grain of detail (*i.e.*, conditions, rewards, actions, rules) supporting the intentions that I would encourage.	5.0	0.0	1
[DEQ4]	I think Redeemable Rewards (*e.g.*, extend a quiz deadline) can be more engaging than Traditional Rewards (*e.g.*, badge) in MOOC environments.	5.0	0.0	2

course privileges. Additionally, participants also described the use of four other types of rewards (*e.g.*, medals, gold starts) which could be represented with the *Badge* and *Reward* data-model elements, since they do not require special parameters. Participants also proposed leaderboards displaying multiple types of rewards.

The most repeated reward type was course privileges such as *unlock resources* (*e.g.*, videos, documents), *get extra time, points and attempts* in quizzes and assignments, and *extend the deadline submission* of compulsory assignments. It is worth mentioning that although participants were introduced to the concept of traditional rewards (*e.g.*, points, badges) and course privileges, most associations involved the latter type of reward. The high score provided by evaluation participants to the [DEQ4] item in the final questionnaire (see Table 7) confirms the positive perceptions toward course privileges for increasing students' engagement in MOOC environments.

Additionally, gamification designs created by participants included ten rewards that could be represented with minor changes. After performing an analysis of such rewards, we implemented such changes accordingly in GamiTool, including the configuration of a new course privilege type (*i.e.*, submissions evaluated by a different number of predefined peers) and the addition of new attributes in the data model to, for example, enable the configuration of a maximum number of students that are listed in the leaderboards.

Finally, six of the proposed rewards were identified as *non-supported* due to different reasons. Three rewards were expected to be displayed within the tools where the course activities are performed (*e.g.*, *"reward name and a trophy will appear next to student name in discussion forums" [H2:Art:Part#8]*). While such rewards can be represented with GamiTool-DM, the form of displaying such rewards within the course tools and contents is limited. The remaining three rewards involve course privileges that require the generation of specific analyses on-the-fly and which would require major changes in the GamiTool components for its automatic implementation (*e.g.*, *"Offer access to benchmarking data, my learning behavior compared to other learners" [H2:Art:Part#17]*).

D. DESIGN EXPRESSIVENESS: USEFULNESS FOR REFLECTION

In order to understand whether GamiTool is useful for reflecting and designing their gamifications, the final questionnaire incorporated the [DEQ1] statement (see Table 7). Results show that most participants strongly agreed with this statement (*Mdn= 4.5*; *IQR= 1.0*). In the additional comments associated to this item, participants stated its usefulness for experienced (*e.g. "It is interesting to have different types of configurable actions according to the different types of activities" [H4:Quest:Part#6]*) and non-experienced instructors (*e.g.*, *"I have only designed simple gamified activities (using H5P) so this exercise has been helpful with showing me the various other options related to rewards" [H4:Quest:Part#19]*). On the other hand, the only participant who disagreed with this item, and who also reported to have some previous experience with gamification argued that *"the suggested conditions and rewards are extremely useful but I saw or read them before" [H4:Quest:Part#7]*.

In order to further analyze this issue, a Spearman's rank-order correlation was run to calculate the relationship between the usefulness of GamiTool for gamification reflection and the previous gamification experience of participants, as stated in H1 questionnaire. Spearman's correlation was selected due to the monotonic relationship between both ordinal variables (usefulness and experience expressed in a likert-like item). Results show a moderate negative correlation between the usefulness of GamiTool for gamification reflection and the gamification previous experience, which was statistically significant ($r(18) = -0.470$, $\rho = 0.049$). Therefore, GamiTool is, in general, perceived as useful for the reflection of MOOCs involving reward-based strategies. However, it is likely that the more experienced the participant is with gamification, the less useful for reflection GamiTool is.

VI. DISCUSSION

This study aimed to answer the following research question: *How can instructors be supported to keep the orchestration workload of reward-based strategies in MOOCs manageable?* To this end, GamiTool was designed considering six design requirements associated to the manageable workload and adoption of reward-based strategies in MOOCs. In this study, we evaluated its design expressiveness, usability, manageable workload and potential for adoption, variables directly connected with the first two requirements and with the posed research issue (see Fig. 6).

The first design requirement (DR1) involved the incorporation of usable graphical interfaces and the provision of automatic functionality for the orchestration of gamification designs. The high scores obtained for the RTLX, SUS and NPS questionnaires in the reported evaluation suggest the successful implementation of this design requirement. Nonetheless, improvements regarding this feature were also collected for future tool enhancement (*e.g.*, a more modern interface).

The second requirement (DR2) referred to the level of design expressiveness to computationally represent the configured gamification designs, therefore, enabling their automatic implementation and management. As observed during the evaluation, the level of expressiveness of GamiTool-DM for both the gamification conditions and rewards was high but could be improved. Many instructors defined gamification conditions that would require natural language processing (*e.g.*, if an open answer questionnaire was properly answered). The modular architecture of GamiTool-ARCH enables the addition of more sophisticated analytical modules, capable of taking these requirements into account. However, further investigation is needed to understand how this type of changes in GamiTool, providing a broader functionality, could impact the high usability of the tool.

GamiTool-ARCH has been also designed taking into account the requirements associated to the support of multiple MOOC platforms (DR3), and the gamification of the built-in (DR4) and external (DR5) tools integrated within the learning design. Therefore, instructors can use GamiTool in their regular teaching platforms and tools, avoiding to learn new systems and keeping the functionality of those built-in tools of MOOC platforms for tracking students' progress. In order to achieve this requirement, GamiTool incorporates an adapter-based architectural layer responsible for converting the information coming from the MOOC platforms and external tools to GamiTool and vice-versa. This architectural approach provides the advantage of accessing to GamiTool functionality in any learning environment just by developing new adapters.

Nevertheless, this approach faces two main difficulties. The first difficulty regards the student information that is externally accessible from MOOC platforms and external tools. Platforms constraining the information that can be queried at course run-time might also restrict the automation of the configured gamification designs. The second difficulty deals with the necessity of developing such adapters beforehand. Although we have already developed adapters for Canvas- and Moodle-based instances and their built-in tools, during the GamiTool evaluation we observed the potential usefulness of developing adapters for other platforms such as Open edX. Further studies would be needed to understand whether there are significant differences on gamifying learning designs in different platforms and external tools. The results of such studies could be compared with the ones obtained in this evaluation, helping to understand similarities and differences with the Canvas platform.

Finally, the design of gamification systems should not only focus on instructors, but also on students. Systems presenting features for high usability, design expressiveness and adoption could fail in engaging students within reward-based strategies, and therefore, do not obtain the expected gamification benefits. In this context, features supporting the seamless integration between the gamification system and the learning platforms, or allowing students to claim the desired rewards can affect to the successful attainment of the expected gamification benefits (DR6). To this end, GamiTool implements the IMS-LTI standard, supporting a single sign-in process. Additionally, both the architecture and the data model were designed to allow students enable/disable the gamification features and claim the desired rewards. As future work, we plan to evaluate GamiTool from the student perspective to understand the usability of the system and the student satisfaction with such features.

VII. CONCLUSION

Despite reward-based gamification strategies can potentially increase learners' engagement in MOOCs, if the associated gamification orchestration tasks imply a high workload for MOOC instructors, it is likely they avoid its use. This paper presented GamiTool, an authoring and management tool supporting MOOC instructors in the aforementioned gamification tasks.

A first evaluation was reported on the benefits of using GamiTool regarding its design expressiveness, usability, manageable workload and potential for adoption. The positive results obtained confirmed the benefits of GamiTool for MOOC instructors, facilitating the orchestration tasks associated to reward-based strategies in these massive contexts. Additionally, the development of GamiTool has opened up new opportunities for research about the effect of different reward-based strategies (*e.g.*, course privileges, leaderboards) in MOOC environments.

Nonetheless, it is worth considering that the reported evaluation was performed within a controlled environment without real enactment. As future work, we plan to use GamiTool in real scenarios, performing longitudinal evaluation studies with MOOC instructors from the conceptualization of the gamification to the enactment of the MOOC. Therefore, we can better understand the manageability and usability of GamiTool during the whole life-cycle of MOOCs that incorporate reward-based strategies. Additionally, and considering the high temporal demand reported by participants in the NASA-RTLX questionnaire, we plan to further explore the reasons for such demand, including whether imposing a maximum time limit for completing the evaluation had a significant effect on participants' temporal pressure. Furthermore, we aim to keep improving GamiTool with the refinement insights collected during the reported evaluation.

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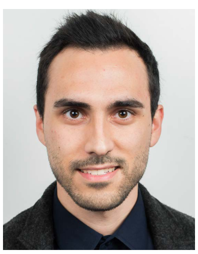

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